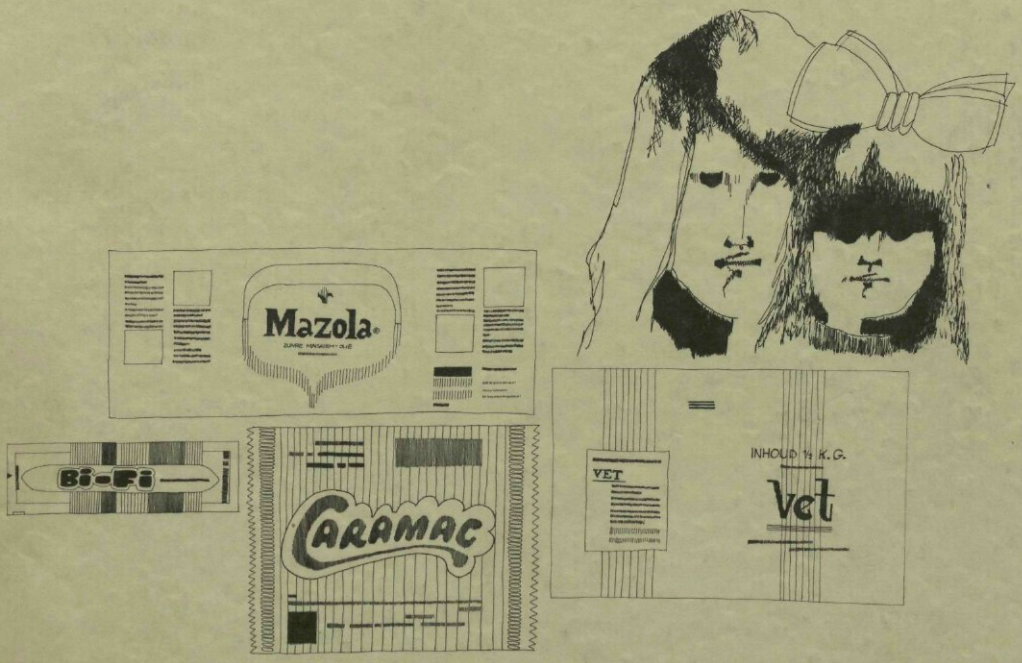
FOOD INTAKE, NUTRITIONAL ANTHROPOMETRY AND BLOOD CHEMICAL PARAMETERS IN 3 SELECTED DUTCH SCHOOLCHILDREN POPULATIONS



FRITS VAN DER HAAR and DAAN KROMHOUT

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F. VAN DER HAAR

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PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD
VAN DOCTOR IN DE LANDBOUWWETENSCHAPPEN,
OP GEZAG VAN DE RECTOR MAGNIFICUS
DR. H. C. VAN DER PLAS,
HOOGLERAAR IN DE ORGANISCHE SCHEIKUNDE
IN HET OPENBAAR TE VERDEDIGEN
OP WOENSDAG 5 APRIL 1978
DES NAMIDDAGS TE DRIE UUR IN DE AULA
VAN DE LANDBOUWHOGESCHOOL TE WAGENINGEN

H. VEENMAN & ZONEN B.V. – WAGENINGEN – 1978

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H. VEENMAN & ZONEN B.V. – WAGENINGEN – 1978

STELLINGEN

1

De afwezigheid van significante correlaties tussen nutrienten en het serum cholesterolgehalte binnen Westerse populaties is niet strijdig met de verzadigd vet-serum cholesterol hypothese.

Dit proefschrift.

2

De Q.I. (Quetelet Index) is een even onbetrouwbare schatter voor obesitas bij kinderen als het I.Q. (Intelligentie Quotient) voor de intelligentie.

3

Het is beter regelmatig matige maaltijden te gebruiken dan onregelmatig overmatige maaltijden.

4

Een orientatie op de voeding die alleen gericht is op het onderkennen van manifeste deficienties, ziet voorbij aan het chronische karakter van de huidige, mede door de voeding beinvloede, welvaartsziekten.

5

Verschillende voedselopname methodieken leveren over het algemeen dezelfde resultaten op voor de macronutrienten als deze worden uitgedrukt in energie procenten.

6

De bewering: 'De gemiddelde Nederlander consumeert 138 g vet per dag' berust op een verkeerde interpretatie van de bruto consumptie gegevens.

7

Geoordeeld vanuit de veranderingen die zich na de Tweede Wereldoorlog in onze levensstijl hebben voltrokken, met name de veranderingen in het voedselconsumptie- en het lichamelijk activiteiten patroon, lijkt de uitdrukking: 'Brood verdienen in het zweet zijns aanschijns' een anachronisme te zijn.

8

Screeningsprogramma's gericht op preventie van coronaire hartziekten door selectie van hoog risico groepen, waarbij ongeveer de helft van de hartinfarcten zou plaatsvinden, zijn noch effectief noch efficient.

9

Preventieve maatregelen toegepast door de *gehele* bevolking beneden de 60 jaar lijken, in het kader van preventie van de premature sterfte aan coronaire hartziekten de meeste kans op succes te bieden.

10

Een pleidooi voor op het gezin gerichte aanbevelingen in het kader van preventie van hart- en vaatziekten, dient niet uitgelegd te worden als een door Van Agt georganiseerde actie in het kader van het ethisch reveil.

11

Het geld besteed aan de hart-luchtbruggen had beter bestemd kunnen worden voor onderzoek naar de mogelijkheden om de epidemie van premature sterfte aan coronaire hartziekten door preventieve maatregelen terug te dringen.

12

Het blijven stijgen van de kosten van de gezondheidszorg zonder dat dit leidt tot een verbetering van de kwantiteit en de kwaliteit van het bestaan, is maatschappelijk ongewenst.

13

De problemen van onder- en overvoeding zijn onoplosbaar, niet vanwege een tekort aan voedingskundigen, maar vanwege het ontbreken van de politieke wil om te komen tot een gelijkmatiger verdeling van de welvaart over de gehele wereld.

14

Het is belangrijker de kinderen op de scholen te confronteren met de jaartallen van de momenten waarop in de geschiedenis hongersnoden zijn opgetreden dan met jaartallen waarop oorlogen zijn uitgevochten.

15

De grote belangstelling voor voedingsproblemen bij de bevolking is negatief gecorreleerd met de aandacht die aan het vak voedingsleer, binnen de medische opleiding in Nederland, besteed wordt.

16

De sterk levende ongerustheid over de toxiciteit van additieven had voorkomen kunnen worden wanneer gestandaardiseerde onderzoekingen naar de toxiciteit van toegestane additieven zouden zijn uitgevoerd.

17

Toenemende spellingsvereenvoudigingen werken onbegrip voor het door vorige generaties geschrevene in de hand.

18

Dagbladen dienen een pluriform karakter te dragen en niet gebaseerd te zijn op de formule: 'Lik de lezer en zijn vooroordelen'.

A. DEN DOOLAARD, 1974. Pers en Persvrijheid. Em. Querido's Uitgeverij B.V. Amsterdam, p. 33–44.

19

De rechtlijnigheid van denken, noodzakelijk voor het beoefenen van het damspel, zou een verklaring kunnen vormen voor de populariteit, die dit spel in (orthodox) calvinistische gezinnen geniet.

D. KROMHOUT
Food intake, nutritional anthropometry and blood chemical parameters in 3 selected Dutch schoolchildren populations.
Wageningen, 5 april 1978.

STELLINGEN

1

De academische vraag in hoeverre een kind tijdens opgroeien een risicofactor behoudt mag niet als verontschuldiging dienen om de behandeling ervan achterwege te laten.

2

De voedingsvoorlichting kan ten aanzien van de preventie van chronische ziekten met succes gebruik maken van de bij ouders algemeen levende wens dat hun kinderen het in de toekomst beter dienen te hebben dan zij nu.

3

Een op nationale schaal uitgevoerd voedselconsumptie-onderzoek kan geen bevredigend antwoord geven op de vraag: 'Welke bevolkingsgroep vertoont welke behoeften?'.

4

Het ontbreken van een volledig verklarend fysiologisch model voor de rol van voedingsvetten in de atherogenese werkt belemmerend op de effectuering van voedingsverandering met het doel atherosclerose te voorkomen.

5

Het opstellen en uitvoeren van een nationaal voedingsbeleid vergroot de geloofwaardigheid in het verantwoordelijkheidsgevoel van Nederland voor de voedselsituatie in de derde wereld.

6

Gezien het grote verschil in sterftecijfers van kanker en hartinfarct is het verwonderlijk dat de warenwet in samenhang met de eerstgenoemde doodsoorzaak een 'safety first'-, en de laatstgenoemde doodsoorzaak een 'laisser faire'-karakter draagt.

7

Anthonie Dirk van der Haar, geboren te Utrecht op 20 mei 1887, was de eerste ambtenaar die tijdens de tweede wereldoorlog op bevel van de bezettende macht uit de Nederlandse politiedienst werd ontslagen daar hij had geweigerd Joden te arresteren.

Correctie op: JONG, L. DE, 1975. Het Koninkrijk der Nederlanden in de Tweede Wereldoorlog, deel 6, eerste helft. Den Haag, Staatsuitgeverij, p. 36 en p. 232.

8

Door zich uit te spreken tegen persoonlijke decoraties, met uitzondering van postume, heeft het voormalig georganiseerd verzet zichzelf onderscheiden.

SANDBERG, H. W., 1950. Witboek van de Grote Advies Commissie der Illegaliteit. Amsterdam, Amsterdamse Boek- en Courantmaatschappij, pp. 212–214.

9

De preventieve cardiologie herbergt het kenmerk van een contradictio in terminis.

10

Momenteel gangbare normaalwaarden voor bloedlipiden hebben niet meer dan praktische waarde.

11

Mannelijke werknemers die tevens vader zijn van 0–4 jarige kinderen dienen recht te hebben op extra vrije dagen teneinde hun echtgenote bij gelegenheid te kunnen vrijmaken van de dagelijkse bezigheden thuis.

12

'Meer kinders zijn van vreten bedorven,
dan dat er van honger zijn gestorven'.

JACOB CATS (1577–1660)

F. VAN DER HAAR
Food intake, nutritional anthropometry and blood chemical parameters in 3 selected Dutch schoolchildren populations.
Wageningen, 5 april 1978.

PREFACE

The impressive past era of nutritional deficiency research has demonstrated that even in those areas where food is plentiful, man has not always been able to avoid certain illnesses caused by deficiencies in the diet. The fear of malnutrition, being the inevitable result of specifically maintained defective food intake patterns, has for a long time been the most important guide for government policies and actions taken by the food industry, health information services and research institutes. The majority of people living in the Western countries, including The Netherlands, still believe that the main nutritional problem is that of undernourishment. In the meantime, however, the food situation has changed considerably in these countries. The enormously productive agricultural and cattle-breeding industries, the highly developed food technology, the efficient and widespread distribution system and the accompanying marketing and advertising, offer the consumer an overwhelming variety of food and food products, all of which he is able to buy because of his high purchasing power. It might be worthwhile, therefore, to consider in this situation the possibility of malnutrition due to abundancy of the diet.

Perhaps the most important conclusion we would like to suggest to the reader is that on the basis of our results the above possibility may be highly probable.

The initials of the authors, mentioned in the contents, do not mean that the author of the chapter is only interested in the subject(s) dealt with in that chapter. The placing of these initials was considered essential due to the fact that this thesis is rather unusual in that it has two authors who are both interested in all aspects of the study as they studied at the same time, gained their Masters degrees at the same time, and did this investigation together.

This research was made possible by the participation of many schoolchildren and a great number of their parents from three selected towns in The Netherlands. They inspired us to continue and assisted us in our efforts to bring the investigation to a conclusion as reported here.

We would like to thank all those who contributed in one way or another to the initiation, organization, execution and conclusion of this study, especially:

Professor Hautvast who taught us the concept of nutrition as an anthropobiological science. This certainly helped us in our joint, initially hesitant, ideas concerning the desirability of carrying out epidemiological research on groups of healthy Dutch schoolchildren. His stimulating optimism when we failed to regard the organizational aspects of doing this work, and his rapid critical reading of the manuscript, supplying it with valuable suggestions, were invaluable.

We remember with pleasure the co-operation of Wila van Hulzen, Theo Koopman and Jelly Dijkstra during the pilot study carried out in Wageningen

under the direction of the School Health Organization, district Ede-Wageningen.

The co-operation of the school physicians, G. B. Boerma (Heerenveen), G. H. Wiegers (Roermond) and W. F. E. Smelik (Harderwijk) is recalled with gratitude. They confided in us from the very beginning and took part in the investigation with enthusiasm.

Examination of the children was made possible by the willingness and permission of many headmasters, parents committees and local health authorities. We also appreciate the valuable contributions made by the local welfare workers of 'De Terp' in Roermond.

Many blood samples were skilfully collected by Feikje Schregardus-de Vries, Mia Scheepers, Lène Biermans, Hanke Wijnen-Runeman, Cock Germing-Nouwen and Bea Nijhof. Thanks to them, the venepuncture turned out to be a much less painful experience than was expected by the majority of the children and their parents.

Those participants unfortunate enough to be 'hyper-responders', received nutritional advice from Janna Boersma, Corrie Pronk-Harmsen and Ria de Haan-Brand. These dieticians impressed us by performing their difficult task in more than just a routine way.

Many university students gained some of their practical experience in the town projects. They shared with us the joys and sorrows associated with the execution of field-work. Their names, in alphabetical order: Resi van Agthoven-Kraat, Louise Anten, July de Bats, John Bevers, Froukje Geertsma, Onne Haitsma, Hetty van Liere-Veerman, Josine Oude Ophuis-Veltkamp, Rini Plusjé-van Heel, Ton Tanis, Fons Toorop, Sari de Vlaming, Inge van Walsum-Swen, Hannie van der Werff, Helmi van der Wiel-Wetzels and Marcel Worms. We are very grateful to Hannie van der Werff who performed the computer analysis of the demographic data of the present study after finishing her university education.

André de Bont, student and colleague, has been an exceptional friend and we would like to thank him for his personal involvement in many aspects of this work.

We also wish to thank the Departmental staff who trained us during our over-protected existence as students of Human Nutrition, many of whom later helped and supported us with their advice and practical involvement.

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The dieticians, Ypie Blauw, Anneke Geerts-van der Weij and Wija van Staveren, who enthusiastically trained all three dietary survey teams. Their help in solving problems encountered during the survey is very much appreciated.

The patience shown by Mrs. Edema in training the mainly natural science orientated investigators in the art of interviewing is also very much appreciated.

Bert Gundlach was helpful by solving technical problems.

Finally, we would like to thank Heleen van den Berge-de Nooij for the endless typing of drafts immediately before and during the surveys and for typing final parts of the manuscript. Hanny Lamster for typing the preliminary text of this thesis, Mrs. Van der Wal who typed the majority of the manuscript and Ann Chadwick who translated our often literary efforts into a form suitable for publication.

Wageningen, November 1977

Frits van der Haar
Daan Kromhout

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ABBREVIATIONS

bic	biceps skinfold (measurement)
CDC	Center for Disease Control
CHD	Coronary Heart Disease
CVD	Cardio-Vascular Disease
FAO	Food and Agricultural Organization
HDL	High Density Lipoproteins
HVN	Heerenveen
HWK	Harderwijk
LDL	Low Density Lipoproteins
LRC	Lipid Research Clinic
PUFA	Poly-Unsaturated Fatty Acids
RMD	Roermond
SFA	Saturated Fatty Acids
sca	subscapular skinfold (measurement)
SES	Socio-Economic Status
sil	suprailiac skinfold (measurement)
tri	triceps skinfold (measurement)
UFE	Uniform Food Encoding
VLDL	Very Low Density Lipoproteins
WHO	World Health Organization

1. INTRODUCTION

The interest in children in atherosclerosis research has been the consequence of confluent evidence that certain atherogenetic processes may have their roots in infancy and childhood.

RUSSEL HOLMAN (1961), practising 'geographical pathology', was among the first to draw attention to this concept by explicity expressing his conviction that atherosclerosis may be a 'pediatric nutrition problem'. His opinion was based on the then still scanty evidence that initial events, related to atherosclerosis, could be detected in the arterial wall during childhood.

The search for the early lesion of atherosclerosis has been pursued by many investigators. MCMILLAN (1973) summarized: 'It now appears that there is no exclusive or unique early lesion for all atherosclerosis but a variety of initial changes such as endothelial injury, platelet adhesion, altered endothelial permeability with insudation of blood proteins, infiltration of lipotroteins and the like which can lead to injury repair reactions and, in some circumstances, to plaque building'. This description draws attention to the variety of interacting influences in the genesis of lesions, to the concept of repair reactions of the arterial wall to injury and to the dynamics of the processes involved. The difficulty in gaining a comprehensive picture of the chain of events underlying the stages of atherosclerosis remains in the inevitably static nature of the kind of descriptions provided by post-mortem material. In order to understand the reasons for progression from the initial stages to the pathological complications it is inevitable to enter into the cellular level in morphological and biochemical terms. The large amount of knowledge which has accumulated since the early research of Holman, in particular at cellular level, has been summarized by WISSLER et al. (1976). It provides a link between the mechanism of atherosclerosis and the risk factors for the disease.

The role of lipoproteins especially has received considerable attention. The next chapter deals with some recent developments.

1.1. SERUM LIPOPROTEINS AND ATHEROGENESIS

The atherosclerotic lesion of the arterial wall is characterized histologically by the accumulation of lipid. The early lesion seems to have relatively high amounts of phospholipids (SMITH, 1965), the advanced lesion is characterized by increasing concentrations of cholesterol and its esters. The overwhelming amount of data implicating the serum lipoproteins, particularly low density (LDL) and very low density lipoproteins (VLDL), with the development of atherosclerosis suggests that these may be a specific stimulus for the initial lesion and the subsequent atherogenic process. The reactions of arterial smooth muscle cells have been extensively studied (ST. CLAIR, 1976b). In most of these

studies VLDL and LDL were used, i.e. the hypothesized atherosclerosis promoting lipoproteins. The major responses of arterial muscle cells to the exposure of these lipoproteins were the stimulation of both cell proliferation (WISSLER et al., 1976) and cholesterol esterification (HASHIMOTO et al., 1973). Ultimately, however, the concentration of cholesterol esters in the arterial wall must depend on the balance of forces resulting in accumulation and removal of cholesterol esters.

In a series of recently conducted *in vitro* studies a variety of peripheral cell types, including human fibroblasts (BROWN and GOLDSTEIN, 1976), rat (STEIN et al., 1976) and swine (STEINBERG et al., 1976) arterial smooth muscle cells and human vascular endothelium (STEIN and STEIN, 1976), have been shown to be able to take up and degrade LDL which is in accordance with earlier studies using tissue cultures (BONDJERS and BJÖRKERUD, 1975; ST. CLAIR, 1976a). In contrast, both rat and human liver parenchymal and non-parenchymal cells were unable to catabolize significant amounts of LDL (VAN BERKEL et al., 1977). Thus, LDL catabolism must take place peripherally, while high density lipoproteins (HDL) are assumed to be broken down by the liver (GLOMSET, 1968). In human fibroblasts, the catabolism of LDL involves the binding of LDL to the cell surface followed by its internalization and uptake in lysosomes. Here the protein component is degraded to small particles which leave the cell. The cholesterol esters of the lipoprotein are hydrolyzed and the liberated cholesterol inhibits the endogeneous cholesterol synthesis through suppression of its key-enzyme: 3-hydroxy-3-methyl-glutaryl coenzyme A reductase (BROWN and GOLDSTEIN, 1976).

Further studies on the interaction of HDL with this process of LDL-catabolism indicated that HDL reduces the binding of LDL to the surface of aortic smooth muscle cells (STEINBERG et al., 1976) and of human fibroblasts (MILLER et al., 1977a) and thereby reduces its catabolism. HDL was shown to bind at the surface as effectively as LDL but was internalized and degraded in insignificant amounts, because HDL alone had no net effect on cell cholesterol content. Furthermore, at molar ratios of approximately 25 HDL : 1 LDL no increase in cell content of cholesterol could be observed in these studies which was explained by either a blockade of LDL-internalization or by promotion of efflux of LDL cholesterol from the cell by HDL as proposed by GLOMSET (1968). Of course, both mechanisms may have contributed to this effect.

It may be important to speculate on the significance of these findings, because these mechanisms provide possible explanations for the consistently observed negative relationship of HDL-concentrations with atherosclerotic complications, either by case-control (BERG et al., 1976), by prevalence (RHOADS et al., 1976; CASTELLI et al., 1977), longitudinally retrospectively – ambispectively – (MILLER et al., 1977b) or by incidence (GORDON et al., 1977). Serum HDL:LDL molar ratios of 5:1 to 25:1 are common in Western adult populations (NICHOLS, 1967) and it is known that the vascular endothelial lining is transmigrated more easily by HDL than by LDL due to its smaller size (STEIN et al., 1976; EISENBERG, 1976). Thus the molar

HDL : LDL ratios to which peripheral cells, including arterial smooth muscle, are exposed *in vivo* are likely to be in a range similar to those at which significant alteration of LDL catabolism by HDL may occur. At the same time, the results of these studies suggest that for a proper evaluation of risk attributable to cholesterol elevations in the blood it may be necessary to distinguish between the relative contributions of LDL and HDL to the serum total cholesterol.

The digression made above into the potentially preventive action of HDL should not divert the attention from the risk promoting effect of the lipoproteins of lower density. A variety of studies, animal, experimental, clinical and epidemiological, have proved the prime importance of these lipoproteins in the development of atherosclerotic complications (STAMLER, 1967; INTER-SOCIETY COMMISSION FOR HEART DISEASE RESOURCES, 1970). Elevated levels of serum total cholesterol, highly correlated on a population basis with elevated levels of low density lipoproteins, separately as well as in combination with other risk factors, promote the extension of atherosclerosis and therefore the probability of premature disease. The finding that arterial lesions of the human type cannot generally be produced experimentally in animals without substantial modification of the diet, is regarded to be of central importance in the evaluation of the association between serum total cholesterol and atherosclerotic complications. Human populations with diets rich in animal protein, saturated fat, cholesterol, sugar and salt have, with very few exceptions, high mean serum total cholesterol levels and high incidence and mortality of premature atherosclerotic disease. Populations not exposed to this combination of dietary characteristics generally exhibit low mean serum total cholesterol levels and enjoy low incidence and mortality rates of premature atherosclerotic disease. Furthermore, within any population, the risk of developing premature atherosclerotic disease increases as the serum total cholesterol level rises, and there does not seem to be any evidence of a critical level of serum total cholesterol which separates individuals with high risk from those with low risk.

Main attention has been paid in the foregoing to the relationship between serum total cholesterol and atherosclerosis. This was thought to be justified on the basis of the recognition that the prevalence of elevated serum total cholesterol levels appeared to be the single most important characteristic of epidemic importance in investigated schoolchildren populations from industrialized countries. In addition to this, a high prevalence of obesity characterizes most surveys reported from Western schoolchildren populations. The other major risk factors established in adults, e.g. hypertension and cigarette smoking, affect these schoolchildren populations while growing up into adolescence and young adulthood on top of the highly prevalent elevated serum total cholesterol levels. The observation of these events, occurring in chronological order in populations of growing children, may lend support to the concept of the mass occurrence of sustained elevated serum total cholesterol levels in the population being the essential metabolic prerequisite for the mass occurrence of severe atherosclerosis and premature atherosclerotic disease in young and middle-aged adults in these populations (STAMLER et al., 1972).

The relationship between diet, serum total cholesterol and the development of atherosclerotic complications described above may be obscured easily by a variety of influences. The evaluation of the three-way relationship between habitual diet, levels of serum total cholesterol and premature occurrence of severe atherosclerotic disease requires the consideration of difficulties in techniques and methods for ascertainment of the habitual diet, of influences related to the observed serum total cholesterol levels and of difficulties in diagnosing the cause of death. In the present investigation, the related matters centre around the first two difficulties. Because of these, and because of their possible impact upon the results presented in this report, a review of these aspects will be given.

1.2. Dietary survey methods

One of the objectives of this regional comparative schoolchildren study was to investigate the relationship between diet and serum total cholesterol. In order to make a proper evaluation of this relationship possible literature reviews were made concerning:

- the value of results obtained by different dietary survey methods;
- intra-individual variation of food intake;
- variations in serum total cholesterol in populations and individuals;
- relationships between diet, serum total cholesterol and coronary heart disease.

From the food intake data, collected in this study, total energy and the following nutrients were calculated:

- vegetable, animal and total proteins;
- C_{12-16}-saturated, total saturated, total mono-unsaturated, total poly-unsurated and total fats;
- oligo- and polysaccharides;
- dietary cholesterol;
- dietary fibre.

These nutrients were chosen because several studies have shown that each plays an important role in the dietary etiology of atherosclerosis (Keys, 1970; Stamler et al., 1972; Burkitt et al., 1974). In the literature reviews information about diet will be restricted to these nutrients.

Results obtained by different dietary survey methods will be compared on the basis of group data. Before such comparisons are made information concerning the accuracy of these methods is needed. Accuracy has to do with the difference between the estimate and the true value of the parameter (the total error in the estimate); high accuracy meaning small total error (Miettinen, 1977). Generally, accuracy is divided in two components: Validity and reliability.

The validity of a method is assessed by comparing it with an independent method of unquestionable accuracy. Validity is defined as 'the true accuracy

of a method as a measurement of the variable it is supposed to measure' (KEYS, 1965). Dietary survey methods of unquestionable validity do not exist (PEKKARINEN, 1970; MARR, 1971).

When the object of a study is the comparison of results from different populations, relative validity or reliability, i.e. information about the repeatability of the method may suffice (KEYS, 1965). Reliability is defined as: 'A procedure is reliable if it gives the same results when used repeatedly in the same situation (i.e. when it is reproducible)' (MOORE, 1960).

There is general agreement that chemical analysis of duplicate portions of all foods eaten is the most accurate dietary survey method available. In this review the duplicate portion technique has been used as the 'gold standard' (MARR, 1971) and the validity of the other methods has been evaluated against this 'gold standard' as far as possible. The method that should be used in dietary surveys depends not only on the validity and the reliability of the method but also on the objectives of the study and on the resources available (YOUNG, 1965).

In this review the 'strength and weaknesses' (YOUNG and TRULSON, 1960) of different dietary survey methods will be discussed (Table 1). First, the methods using chemical analysis of food samples will be described and discussed. Subsequently, the limitations of food tables will be discussed. After describing the record methods, the results obtained by these methods will be compared to results obtained by those using chemical analysis of food samples. This procedure will also be used regarding interview and short cut methods. After describing these methods the results obtained by them will be compared to results obtained by other methods.

TABLE 1. The most commonly used dietary survey methods

Dietary survey methods characterized by			
Chemical analyses of food samples	Calculation of food intake data from food tables		
	Record	Interview	Short-cut
Duplicate portion technique Aliquot sampling technique Equivalent composite technique	Precise weighing Weighed inventory Present intake recorded in household measures	Recall Dietary history	Record Recall

1.2.1. *Chemical analysis of food samples*

1.2.1.1. Duplicate portion technique

The duplicate portion technique is considered to be the most accurate dietary survey method among field conditions (THOMAS et al., 1950; HUNSCHER and MACY, 1951; PEKKARINEN, 1970; BORGSTRÖM et al., 1975). However, this method is not absolutely accurate because the duplicate taken for analysis is not necessarily identical to the serving of food allocated to the subject (LEITCH and AITKIN, 1950; SAMUELSON, 1970). A study into the reliability of chemical analysis of duplicates has shown that differences between analyses of different duplicates are small for energy and protein but considerable for fat (THOMAS et al., 1950). The greatest differences between duplicates occur when composite dishes like soup, and fat-containing foods such as French fried potatoes, are served. This source of variation may be reduced when quantities of individual food components of a mixed dish are combined in proportions relative to those of the food to be served, cooked separately, and the entire amount taken for analysis (THOMAS et al., 1950). However, application of the technique in this way is very time-consuming and can only be done in metabolic studies.

Another source of variation may be the possible non-inclusion of the duplicate of small items taken with or between meals (LEITCH and AITKIN, 1950). It is also possible that the housewife has forgotten to cook an additional amount of food, so that the person under survey may perhaps eat less than he would have done normally (PEKKARINEN, 1970).

The duplicate portion technique is time-consuming and can only be used in a study with very motivated subjects. Consequently, it is difficult to select a random sample of the general population for such a study. It is also possible that the subjects alter their purchasing and cooking habits (MARR, 1971). However, there are no data to substantiate the idea that subjects to whom the objectives of the study are clearly explained and who are willing to participate in such a study are actually changing their purchasing and cooking habits. YOUNG and TRULSON (1960) summarized this problem as follows: 'Individuals who are careful in keeping dietary records are careful throughout, just as those who are careless are careless early in the process as well as later'.

Finally, the accuracy of the results is also influenced by measurement errors due to chemical analysis (WHITING and LEVERTON, 1960; KEYS et al., 1966; KEYS and KIMURA, 1970; CHAN CHILY YULI et al., 1975). Although these errors are presumably relatively small compared to the sources of variations involved in the calculation of the nutrient content of foods from food tables, it is clear that even the most accurate method available for dietary surveys does not give absolutely valid results.

1.2.1.2. Aliquot sampling technique

During the survey period the weights of all foods eaten and the volumes of all beverages drunk, except water, are recorded and aliquot samples, e.g. one tenth of all foods and beverages consumed, are collected daily. Subsequently,

the combined aliquot samples of the whole survey period are chemically analysed (DEN HARTOG et al., 1965; BUZINA et al., 1966; KEYS et al., 1966). Studies comparing this method with the duplicate portion technique were not done. This method is probably less accurate than the duplicate portion technique because the recording of weights and volumes and the possibility that the foods of the aliquot sample are not necessarily identical to the foods eaten cause additional sources of variation. Yet, the aliquot sampling technique is sometimes preferred above the duplicate portion technique for financial reasons because less food is needed and only one analysis has to be made in the combined aliquot samples of foods from the whole survey period.

1.2.1.3. Equivalent composite technique

The equivalent composite technique consists of two parts. The weights of all foods eaten and the volumes of all beverages drunk, except water, are recorded during the whole survey period. Afterwards, a sample of raw foods, equal to the mean daily amounts of foods eaten by an individual during the survey period, is taken for chemical analysis (ROINE et al., 1964; BUZINA et al., 1966; FIDANZA and FIDANZA ALBERTI, 1967; PEKKARINEN, 1967). The samples of raw foods may be purchased locally when the differences in nutrient content of the quantitatively most important foods are expected to be small (ROINE et al., 1964; BUZINA et al., 1966; FIDANZA and FIDANZA ALBERTI, 1967). If these differences are large, the samples of raw foods should be collected at home (PEKKARINEN, 1970).

A comparative study between the equivalent composite technique and the duplicate portion technique was done by PEKKARINEN (1967). The results of this study showed very small differences between the averages of total energy, proteins, fats and carbohydrates obtained by both methods. In another study the equivalent composite method was compared with the aliquot sampling technique (BUZINA et al., 1966). In that study the results of the equivalent composite technique gave higher average values for total energy, proteins, fats and carbohydrates of which only the differences for energy and proteins reached statistical significance. The authors suggested as a possible explanation for these differences that the foods of the equivalent composite were not prepared for the table before chemical analysis, in contrast to the foods collected for the aliquot samples. Another explanation for this difference could be that the equivalent composite does not correspond qualitatively to the foods eaten, due to differences in the nutrient composition between the foods eaten and the foods of the equivalent composite (PEKKARINEN, 1970).

It is not possible to draw unequivocal conclusions from the two aforementioned comparative studies. Different results have been obtained in different countries. In Finland the equivalent composite technique gave the same results as the duplicate portion technique, but in Yugoslavia higher average values were found for certain nutrients by the equivalent composite technique compared to the aliquot sampling technique. These discrepancies may be caused by different ways of food preparation in these countries. Definite conclusions

can only be drawn when more comparative studies are done.

Equivalent composites of raw foods are homogenised before chemical analysis. It is assumed that homogenisation is easier after raw foods have been boiled. PEKKARINEN (1967) investigated whether or not boiling improves the results. This study showed that identical samples of raw and boiled foods gave very similar results for total proteins, total fats and different fatty acids. It cannot be concluded from this experiment that boiling improves the results.

Compared to the aliquot sampling technique, additional sources of variation are introduced when the equivalent composite method is used. Firstly, unprepared raw foods are chemically analysed instead of prepared foods. Secondly, it may be possible that the foods of the equivalent composite do not correspond qualitatively to the foods eaten. A drawback from an organizational point of view is that the food samples can be collected only after computation of the average daily consumption of different foods and the average total consumption during the whole period (PEKKARINEN, 1970). However, this method also has advantages. The food samples are easy to collect and the equivalent composite technique is cheaper than the duplicate portion or aliquot sampling technique (PEKKARINEN, 1970).

1.2.2. *Food intake data calculated from food tables*

1.2.2.1. Food tables

In dietary surveys food tables are very frequently used for the conversion of food intake to nutrient intake because chemical analysis of food samples is expensive, time-consuming and can only be done for a limited number of subjects. However, the use of a food table instead of chemical analysis introduces an additional source of variation. Several authors have discussed the limitations of food tables (WIDDOWSON and MCCANCE, 1943; THOMAS et al., 1950; HUNSCHER and MACY, 1951; MAYER 1960; HARRIS, 1962; KEYS, 1965).

MAYER (1960) pointed out the pitfalls in the calculation of available energy from proteins, fats and carbohydrates using fixed fuel values. Based on the digestibility studies described by ATWATER, average fuel values of 4, 9 and 4 Kcalories per gram for proteins, fats and carbohydrates respectively are general used. Ideally, different ATWATER figures should be used for different foods, because the fuel values for proteins vary greatly from food to food. The range of variation is somewhat less for fats and carbohydrates. The ATWATER figures are based on the results of studies in adults. When dietary surveys are carried out in children it is uncertain if the calculated amount of nutrients is actually available to the children. This may be an additional source of variation in studies carried out in children (MAYER, 1960).

The nutrient content of vegetable products is dependent on species, geographic origin, type of soil, mode of cultivation, amount of water available, ripeness, storage conditions, method of processing, marketing conditions and way of preparation (THOMAS et al., 1950; HUNSCHER and MACY, 1951; MAYER, 1960; WHITING and LEVERTON, 1960; HARRIS, 1962). The nutrient content,

especially the fatty acid composition of animal products, is dependent on the rations fed to the animal (KEYS, 1965). The fat content of meat is also an important source of error (MAYER, 1960; KEYS, 1965). According to the Netherlands Food Table, the fat content of beef and pork varies between 3–23 g and 9–35 g per 100 g respectively (NEDERLANDSE VOEDINGSMIDDELEN TABEL, 1975). Also taking into account the different cooking practices for meat it can be seen that this source of error may be considerable. In contrast to the fat content of meat, the fat content of milk, cheese, lard and margarine, the other major sources of fat intake in the Western countries, is rather constant. 'Meat fat is by far the major source of error in the use of tables of food composition to estimate total fat intake' (KEYS, 1965).

Another source of variation introduced by using food tables is the nutrient content of cooked composite dishes (LEITCH and AITKIN, 1950). Even when these dishes are based on standard recipes it may very well be possible that the nutrient content of the observed composite dishes differ from those presented in the food table. GRANT (1944) showed that the energy content of rice pudding, porridge and meat stew can differ by as much as 100% when different recipes are used. The nutrient variation in dishes such as fried eggs or soups, which are not prepared from a fixed recipe, may be even greater (STOCK and WHEELER, 1972). However, this problem can be overcome by asking the individual under survey for the recipe of the dish and by calculating the nutrient content from the ingredients (GRANT, 1944; WHITING and LEVERTON, 1960).

The accuracy of the data recorded in food tables is also dependent on factors associated with chemical analysis of foods. The samples of foods collected for chemical analysis should be as representative as possible. The most accurate and critical procedures should be used for the determination of different nutrients (THOMAS et al., 1950). When food tables are compiled, results of chemical analyses for different nutrients should be taken as much as possible from one laboratory, because analytical results from different laboratories may vary considerably (KEYS et al., 1966; KEYS and KIMURA, 1970).

Taking all these possible sources of variation into account pessimists might easily conclude that food tables are valueless. On the other hand, there are also some optimists who tend to regard the figures in food tables as having an unquestionable accuracy (WIDDOWSON and MCCANCE, 1943). However, even those who use carefully composed food tables should be aware that 'Food tables neither present data with an accuracy of an atomic weight determination nor are so unreliable as to be worthless' (HARRIS, 1962).

1.2.2.2. Record methods

1.2.2.2.1. Precise weighing method

There is general agreement that the most accurate food intake data, calculated from food tables, can be obtained by the precise weighing method (HUENEMANN and TURNER, 1942; WHITING and LEVERTON, 1960; ROINE and PEKKARINEN, 1968; PEKKARINEN, 1970; MARR, 1971). This method consists of

weighing all ingredients used in the preparation of the dishes as well as the inedible wastage. The weight of the individual's cooked portion and his table waste are also recorded (PEKKARINEN, 1964; MARR, 1971). Any food eaten outside the home should be recorded in household measures (LEITCH and AITKIN, 1950). Whenever possible, information about the recipes of composite dishes eaten outside the home should also be obtained.

The main advantage of this method is that the weights of the foods eaten are recorded as accurately as possible. When the investigator carries out the time-consuming weighing procedures, very exact data can be obtained and the participation rate in the survey may be increased. One of the major drawbacks of the precise weighing method is its time-consuming procedure and its demand of a high degree of co-operation from the surveyed individual. Therefore, in studies using this method a random sample of a population might be difficult to obtain (PEKKARINEN, 1970; MARR, 1971). The precise weighing method is also expensive especially when the investigator carries out the weighing procedures himself (PEKKARINEN, 1964). Weighing the foods during the meal disturbs normal eating, especially when many foods are taken. This may lead to simplification of the diet (PEKKARINEN, 1970). This problem can be overcome to a certain extent by using containers with weighed amounts of sugar, butter, etc. It is also possible that the quality of the diet is changed because the subject wants to impress the investigator by using more luxurious foods during the period of the investigation (KEYS, 1965). However, it is not known to what extent, if any, these factors alter the food intake (MARR, 1971).

Another source of variation may be introduced when different investigators carry out a dietary survey. However, in studies done by CHURCH et al. (1954) and TOPP et al. (1972) significant differences between investigators could not be observed. It has also been shown that nutritive values calculated by different investigators did not differ (YOUNG et al., 1952; BROWE et al., 1966).

1.2.2.2.2. Weighed inventory method

In this method the prepared food is only weighed immediately before consumption and any plate waste is measured at the end of the meal (MARR, 1971). The weighing of the foods can be done by the subjects themselves. This method requires therefore a minor degree of supervision than the precise weighing method. The degree of supervision needed is dependent on the accuracy required to fulfil the objectives of the study. The weighed inventory method is less time-consuming than the precise weighing method. This may favourably influence the participation rate in the survey. The former method is also cheaper because the weighing procedures are done by the subjects themselves and not by the investigator, introducing an additional source of variation because subjects not accustomed to this type of work may forget or make easy errors in recording weights (FIDANZA, 1974). These simplifications have the inevitable drawback that the data collected by the weighed inventory method are very probably less accurate than the data collected by the precise weighing technique.

The reliability of the weighed inventory method was tested in a selected group of 25 motivated middle-aged British bank clerks (MARR et al., 1959). In these men, two individual seven-day dietary surveys were carried out six months after each other. The results of these two surveys were very similar with respect to total energy, proteins, fats and carbohydrates. From this study it may be concluded that in a selected group of motivated people reliable (repeatable) results can be obtained by the weighed inventory method.

1.2.2.2.3. Present intake recorded in household measures

This method consists of a description of the foods eaten in household measures or of an estimation of the weight of foods with the aid of food models (KITCHIN et al., 1949; PEKKARINEN, 1970; MARR, 1971). Direct supervision is not required for this method, but careful instruction before the survey and a detailed interview after the survey period is desirable in order to obtain accurate quantitative data. This method costs less time than the weighing method so it may be expected that the participation rate in this type of survey may be higher. However, earlier studies are not unequivocal in this respect (MARR, 1971). A major disadvantage of this method compared to the weighing method is the introduction of an additional source of variation namely the estimation of the weight of foods in household measures. This inevitably decreases the accuracy of the collected food intake data.

Comparative studies carried out in children have shown that the average intake of total energy, proteins and fats calculated from estimated diets exceeded the intakes from the weighed diets. The amount of carbohydrates calculated from both methods did not differ. Scatter diagrams indicate that the calculated nutrients from both types of records were highly correlated (BRANSBY et al., 1948; EPPRIGHT et al., 1952). From these studies it may be concluded that diets recorded in household measures give comparable but somewhat higher results than weighed diets. All problems associated with diets recorded in household measures have been summarized by LEITCH and AITKIN (1950) in the following way: 'A survey of a type intermediate between weighing and questioning in which diets are recorded in household measures by intelligent subjects and translated into weights during cross-examination by painstaking investigators, can provide a week's record in accordance with conventional requirements'.

1.2.2.2.4. How many days and which days?

Several studies carried out in children and adults have shown that the average values for different nutrients of three or five-day dietary surveys are in close agreement with the average values of seven-day surveys (EPPRIGHT et al., 1952; YOUNG et al., 1952; YOUNG and TRULSON, 1960; HEADY, 1961; FIDANZA and FIDANZA ALBERTI, 1967; PEKKARINEN, 1970). It has also been shown that for characterizing a *group* by its mean intake only a one-day record is needed (ANDERSON and SANDSTEAD, 1947; EADS and MEREDITH, 1948; POTGIETER and FELLINGHAM, 1967; PASSCHIER and VAN DE REEP, 1977). When the

inter-individual variation is large, a more precise estimate of the mean intake of a *group* can be obtained by taking a larger number of subjects rather than more days (CHALMERS et al., 1952; CHRISTAKIS, 1972).

It is often stated that dietary surveys should not be undertaken during weekends, because food habits during the weekend differ from food habits during the week. However, in some studies carried out in children and adults a 'day effect' could not be established (CHALMERS et al., 1952; POTGIETER and FELLINGHAM, 1967). EPPRIGHT et al. (1952) showed that a group of Iowa children consumed less milk and more meat during the weekend compared to the schooldays. Failure to include the weekend in this sample would result in an overestimation of the calculated calcium and an underestimation of the calculated protein intake of the children in this community. In The Netherlands two studies, one in schoolchildren aged 4–6 years and another in young adults, have been published in which a 'day-effect' could be clearly demonstrated. Subjects participating in these studies showed on average about 10% higher energy intakes during the weekend compared to weekdays (HEZEMANS et al., 1977a; PASSCHIER and VAN DE REEP, 1977). The higher energy intake in the children during the weekend was entirely derived from a higher fat and carbohydrate intake (HEZEMANS et al., 1977a). In the young adults the higher energy intake during the weekend was mainly caused by a higher fat intake, but the protein and carbohydrate intake were also increased, although to a lesser extent (PASSCHIER and VAN DE REEP, 1977).

From the results of the reviewed studies it cannot be concluded that a 'day-effect' is not present. Therefore it seems desirable to carry out a pilot study in a sub-sample of the group to be surveyed immediately before starting the extensive study in order to select the most suitable day of the week.

1.2.2.2.5. Dietary information of children

Before dietary surveys are carried out in children the following questions related to this age group have to be answered. Should the dietary records be kept by the mother or by the child? When school lunches are served, in what way can accurate information about these lunches be obtained?

Whether the records are kept by the mother or by the child depends on the age of the child. Record keeping is a difficult task for children below Grade 4 (EADS and MEREDITH, 1948). According to SJÖLIN (1969) accurate records may be obtained in children older than 15 years of age. When the record is kept by the mother it is essential that she asks her child about the snacks consumed between meals in order to increase the accuracy. When the record is kept by the child, it is also necessary to interview the mother in order to get information about the preparation and cooking practices. A comparative study reported by EPPRIGHT et al. (1952) did not show significant differences between records of the same day's diet kept by the mother and by the child. When the child participates in a school lunch programme, accurate information about this lunch may be obtained by asking for the recipes used and by measuring and weighing standard portions of the foods eaten.

1.2.2.2.6. Comparisons with chemical methods

Comparisons between food intake data obtained by calculation and by chemical analysis. In order to get an impression about the accuracy of the food intake data obtained by record methods, the results of studies comparing food intake data calculated from food tables and those determined by chemical analysis will be reviewed. In several studies the description of the method used was not unambiguous. Consequently it is not possible to discuss separately the results of studies comparing the precise weighing or the weighed inventory method with the duplicate portion or the aliquot sampling technique. Therefore comparative studies concerning these methods are discussed together. Subsequently, the results of studies comparing the weighing method with the equivalent composite technique are reviewed. Finally, the results of a study comparing food intake data recorded in household measures with data obtained by the duplicate portion technique are discussed.

Comparison of food intake data collected by weighing methods and calculated from food tables with data obtained by duplicate portion or aliquot sampling technique. The results of a considerable number of comparative studies carried out in both children and adults before 1960 have been summarized by TRULSON (1960) and by WHITING and LEVERTON (1960). The results of these studies tended to an overestimation of total energy and carbohydrates and an underestimation of proteins, when these data were calculated from food tables compared to data obtained by chemical analysis (BRANSBY et al., 1948; HUNSCHER and MACY, 1951; TRULSON, 1960; WHITING and LEVERTON, 1960). These studies also showed a substantial overestimation of the amount of fat calculated from food tables compared to the chemically determined amount of fat (TRULSON, 1960; WHITING and LEVERTON, 1960). Comparative studies carried out in the second part of the sixties confirmed these trends with respect to total energy and fats (GROOVER et al., 1967; STOCK and WHEELER, 1972). STOCK and WHEELER's investigation, however, showed an overestimation of proteins calculated from food tables, in contrast to the studies summarized by TRULSON and by WHITING and LEVERTON.

In the sixties several comparative dietary surveys were carried out in the Seven Countries Study (KEYS, 1965). The major purpose of these surveys was to characterize the diets of middle-aged men in terms of nutrients that may be relevant to atherogenesis and its complications (KEYS, 1968). In order to fulfil this objective special attention was paid to the development of food tables in countries participating in this study, by incorporating in these food tables accurate analytical data concerning relevant nutrients. Therefore the results of comparative dietary surveys carried out in the Seven Countries Study may be considered to be as accurate as possible within the limits of this kind of investigation.

These dietary surveys tended towards an underestimation of total energy and carbohydrates and an overestimation of proteins calculated from food

tables compared to those data obtained by chemical analysis. No difference could be observed between the amount of fat calculated from food tables and that determined by chemical analysis (DEN HARTOG et al., 1965; BUZINA et al., 1966; KEYS et al., 1966; KEYS and KIMURA, 1970).

It is very difficult to summarize all the comparative studies reviewed. With respect to total energy all comparative studies, except those carried out in the Seven Countries Study, showed an overestimation of total energy calculated from food tables. The less recent studies (TRULSON, 1960; WHITING and LEVERTON, 1960) showed an underestimation and the more recent studies (BUZINA et al., 1966; KEYS et al., 1966; KEYS and KIMURA, 1970; STOCK and WHEELER, 1972) an overestimation of proteins calculated from food tables. With respect to fats, no difference could be observed between data calculated from food tables or chemically determined data in studies carried out in the Seven Countries Study. All other studies showed a considerable overestimation of fat calculated from food tables (TRULSON, 1960; WHITING and LEVERTON, 1960; GROOVER et al., 1967; STOCK and WHEELER, 1972). Very little is available concerning carbohydrates. Less recent studies, in contrast to more recent studies, showed an overestimation of carbohydrates by calculation from food tables (BRANSBY et al., 1948; HUNSCHER and MACY, 1951; DEN HARTOG et al., 1965; BUZINA et al., 1966).

Generally, it may be concluded that total energy and fats are overestimated by calculation from food tables. Most of these differences may be attributed to the figures used for the fat content of meat (TRULSON, 1960; WHITING and LEVERTON, 1960). As already stated, the fat content of raw meats differs considerably. Differences in the fat content of cooked meats can be even greater, depending on the cooking methods used (KEYS, 1965). The overestimation of the fat intake may be caused by using food tables providing information about the fat content of raw meats only. The difference between analysis and calculation of meat fat may be reduced by introducing in the food tables the nutritive values of cooked meats (TRULSON, 1960). Other possible explanations for these differences, like incomplete ether extraction from lyophilized material in the chemical analysis, the problem of obtaining true aliquots from the composites before lyophilization and the loss of fat on the walls of the containers, have been put forward by KEYS et al. (1966).

Comparison of food intake data collected by weighing methods and calculated from food tables with data obtained by the equivalent composite technique. In the Seven Countries Study, several of such comparative studies were carried out (ROINE et al., 1964; BUZINA et al., 1966; FIDANZA and FIDANZA ALBERTI, 1967; PEKKARINEN, 1967). All these studies showed that the intake of proteins, fats and carbohydrates and consequently also of total energy was underestimated by the weighing method compared to the equivalent composite technique. These differences may be caused by the fact that the results obtained by the equivalent composite technique are based on chemical analysis of uncooked foods. In studies published by PEKKARINEN (1967) a comparison was also made

between both methods with regard to the fatty acid composition of the diet. In these studies, the intake of saturated fatty acids was very slightly underestimated, the intake of mono-unsaturated fatty acids did not differ and the intake of poly-unsaturated fatty acids was significantly overestimated by the weighing method compared to the equivalent composite technique. The underestimation of the poly-unsaturated fatty acid intake by chemical analysis of equivalent composites may be caused by the very small amount of poly-unsaturated fatty acids present in the Finnish diet. From the results of these studies PEKKARINEN drew the conclusion that: 'Calculations can give a fairly reliable picture of the fatty acid composition of the diet, provided that the calculations are based on the analysed fatty acid values of such local foods which constitute the major sources of fats'.

Comparison between food intake data recorded in household measures and calculated from food tables with data obtained by the duplicate portion technique. To our knowledge only one study has been reported in which these methods were compared (BRANSBY et al., 1948). This was carried out in schoolchildren and did not show any difference between the protein intake determined by either method. However, the carbohydrate and especially the fat content of the diet, and consequently also the total energy intake, were considerably overestimated when food intake data were recorded in household measures. This study also showed that the standard deviations for all nutrients except for proteins are greater when dietary intake data are recorded in household measures, indicating that these data are less accurate than the data obtained by the duplicate portion technique. Based on these results BRANSBY et al. (1948) concluded that: 'No survey method which gives substantial errors in the estimated weight of individual foods and of which the apparent accuracy depends on those errors cancelling each other out, can be considered satisfactory, even if the error in the final results is small'.

It is not justified to draw general conclusions from one comparative study. The only preliminary conclusion may be that when very accurate dietary intake data are needed in order to fulfil the purpose of a study, recording food intake data in household measures may not be the most suitable method.

Accuracy of the results concerning animal and vegetable proteins, fatty acids, oligo-saccharides and polysaccharides, dietary cholesterol and dietary fibre calculated from food tables. Studies in which the intake of animal and vegetable proteins, oligo- and polysaccharides and dietary fibre calculated from food tables is compared with intake data obtained by chemical analysis, have not been published. With respect to fatty acid and dietary cholesterol intake, a few comparative studies have been reported.

In one study, carried out in 10 men and 11 women, the calculated nutrient content of a menu was compared to the chemical analysis of that menu (MARSHALL et al., 1975). The calculated saturated fatty acid, oleic acid, linoleic acid and dietary cholesterol content was overestimated compared to the data

obtained by chemical analysis. In the already mentioned studies done by PEKKARINEN (1967) similar results were found regarding poly-unsaturated fatty acids, but the calculated saturated and mono-unsaturated fatty acid intake did not differ significantly from the data obtained by chemical analysis.

In a sample of 20 Swedish men and women dietary cholesterol intake was determined by the duplicate portion technique (BORGSTRÖM et al., 1975). The cholesterol intake of these subjects was surprisingly low compared to the values reported by other investigators. The authors suggested as a possible explanation for this discrepancy that the food habits of their subjects at the time of sampling in 1969 may have been different from those of other populations studied. Alternatively, the cholesterol content of the foods eaten may be different from that given in currently used food tables. This point could be substantiated by the fact that according to the daily dietary records kept by the subjects some occasionally eat several eggs a day. The cholesterol intake determined by chemical analysis was higher during such days but not as high as expected from the egg cholesterol content given in food tables.

General conclusions cannot been drawn from the few data available. The only justified conclusion may be that more comparative studies with respect to these nutrients are needed, in order to gain more insight into the accuracy of the results for these nutrients calculated from food tables.

1.2.2.3. Interview methods

1.2.2.3.1. Recall method

The recall method as introduced by WIEHL in 1942 consists of recalling the actual food intake of the past two days prior to the interview (LEITCH and AITKIN, 1950). In this way an attempt to obtain a complete description of all foods eaten during each meal and between meals is made. Quantities are estimated in household measures. Different recall periods were used depending on the objectives of the study. Generally, a 24-hour period is taken but the recall period was sometimes extended to several days or even to a week (ADELSON, 1960; PEKKARINEN, 1970).

The recall method has several advantages. Generally, an interview takes only about 30 minutes. It is also a relatively cheap method, because it does not require large numbers of trained personnel. Another advantage is that it is less inconvenient to the respondent. Finally, the normal diet of the respondent is not changed by the interview (YOUNG et al., 1952; PEKKARINEN, 1970; LINUSSON et al., 1974). The recall method is therefore very suited to epidemiological studies because food intake data can be obtained from a large and representative sample.

However, the recall method also had several drawbacks. One of the most important disadvantages is the suppression or distortion of memory. People tend to suppress from memory those aspects which do not fit their own general image of the situation. People are likely to remember and report what is socially acceptable in contrast to what is not socially acceptable (FIDANZA,

1974). They also tend to report themselves as being more constant than they actually are. The recollection of food consumption is also distorted by food preferences. People are likely to state that they eat their favorite foods more often and in larger quantities than is really the case (KEYS, 1965). Finally, there is a tendency to overestimate small quantities and to underestimate large quantities (MEREDITH et al., 1951; LINUSSON et al., 1974; MADDEN et al., 1976).

One investigation has been published in which the influence of memory aids was tested (BRANSBY et al., 1948). This study investigated whether results improved when 12 year-old schoolboys used memory aids during the interview. No differences could be observed in the average intake of total energy, proteins, fats and carbohydrates between the groups of boys interviewed with or without memory aids.

It has frequently been stated that in order to obtain accurate information by the interview method the personal characteristics of the investigator are of paramount importance (DEN HARTOG et al., 1965; BEAL, 1969; PEKKARINEN, 1970). He or she is required to be the very monument of skill and tact in handling people (LEITCH and AITKIN, 1950). It is out of question that well-trained and dedicated investigators should be selected for this kind of research. However, the qualities required in the investigator should not be overstated. LEITCH and AITKIN (1950) summarized: 'Given the necessary opportunity for practice and such enthusiasm for the purpose as will outlast the training, there can be no quality more important for investigators than integrity and a great capacity for taking pains'.

Another source of variation is introduced by the estimation of quantities in household measures. In a study carried out in 20 pregnant women the total energy calculated from food intake data collected by recall and recorded in household measures was highly underestimated compared to total energy calculated from the precise weighing method (THOMSON, 1958). This difference may be due to defects of memory or lack of precision in the use of household measures. In order to eliminate the latter source of error quantities derived from the weighed record were substituted and the energy intake was still 5% underestimated. Thomson concluded from these findings that: 'The memory, being fallible, does not yield an accurate record of previous food habits and that even aids to memory, such as demonstration food servings and household measures, do not permit a reliable estimation of food quantities'. From the results in this study the conclusion may be drawn that the accuracy of the food intake data is negatively influenced when the quantities are estimated in household measures. The accuracy of food intake data obtained by interview may improve when the contents of spoons, cups etc. are measured and the weights of slices of bread, butter or margarine, sugar etc. are determined (GUGGENHEIM et al., 1964).

1.2.2.3.2. Dietery history method

The dietary history, originally developed by BURKE (1947), provides information about the average nutrient intake of an individual during a consider-

able period of time, generally 6–12 months. This method is frequently used when the purpose of a study requires information about the *usual* dietary intake of an individual. The dietary history consists of three parts. In the first part information is obtained about the individual's usual eating pattern both during and between meals. Accurate information can only be acquired when variations in the eating pattern are not extreme. The next step is called the 'cross-check'. In this step a detailed list with specific foods is checked with the subject. When the 'cross-check' is carefully executed possible omissions can be anticipated and errors in estimating amounts of foods eaten can be minimized. The importance of this step is nicely worded by READ and BURKE (1954): 'The "cross-check" is an important aspect of this technique and when properly used by a skilled interviewer contributes greatly to the reliability of the dietary data obtained'. The third part consists of a three-day record kept by the subject. BURKE (1947) considered this record as the least valuable part of the dietary history. Several variations in the third part of the dietary history has been described. In the method described by BEAL (1967) this three-day record was extended by a 24-hour recall obtained during the interview. Information on the quantities of the various foods purchased per day and per week for the whole family may also be used instead of the three-day record (DEN HARTOG et al., 1965). Food intake data obtained by dietary history are generally recorded in household measures (BURKE, 1947). In order to get more accurate data the estimation of quantities is sometimes facilitated by using food models or by weighing the foods eaten (DEN HARTOG et al., 1965; LUBBE, 1968; PEKKARINEN, 1970).

The most important difference between the dietary history and all other dietary survey methods is that the dietary history provides information about the *usual* intake of an individual while other methods give information about the actual past intake of an individual. Compared to the 24-hour recall the dietary history is time-consuming and consequently relatively expensive. Accurate dietary histories can only be obtained by careful interrogation taking at least one hour (MARR, 1971).

In a study carried out in middle-aged men and women the reliability (repeatability) of the dietary history was examined (RESHEF et al., 1972). The time interval between the two interviews was $6^1/_2$ to $8^1/_2$ months. Significant differences in average daily intake for total energy, proteins, fats and carbohydrates could not be observed between the two interviews. In addition, variability of the diet e.g. number of foods eaten did not affect the reliability. Two similar comparative studies, carried out in men, have been reported (TRULSON and MCCANN, 1959; DAWBER et al., 1962). In these studies the interviews were taken with an interval of two years. Also in these studies, no significant differences in average intake for total energy, proteins and fats could be established between the two interviews.

Only one study has been reported in which both reliability and validity of the dietary history were examined (REED and BURKE, 1954). A statistical analysis, based on data collected in a longitudinal study of health and development of

children from the prenatal period to 18 years of age, showed that the protein intake determined by the dietary history was highly reproducible within a range of ± 10 g per day. The validity of the dietary history was tested by correlating the protein intake with the child's rate of growth of muscle in the lower leg. This correlation was 0.46 and 0.68 for girls and boys respectively. From these results REED and BURKE concluded that: 'Dietary interview techniques are capable of producing measurements of high quality'. At the same time they emphasized that: 'It is worthwhile in any study using dietary interview methods to attempt to assess the quality of the measurements obtained'.

1.2.2.3.3. Dietary information of children

Several investigators have tried to answer this question. Accurate 24-hour recalls may not be obtained in children below about 9 years (BOSLEY, 1947; SJÖLIN, 1969). A study as to the accuracy of 24-hour recalls of children, aged 6–12 years, has been published by EMMONS and HAYES (1973). The results of this study showed that the ability to correctly recall a school lunch, known to have been eaten, improved with age. The younger children remembered on average 60.5% of the foods eaten. For the older children this figure amounted to 80.6%. The authors concluded from these data that: 'Young children, especially above Grade 2, can give comprehensive dietary information'. This study further indicated that there was good agreement between mothers and children in recalling the number of times different food groups were included in the child's diet. However, there were more significant correlations between the nutritive levels calculated from the child's recall of lunch and the lunch actually eaten than between the nutritive levels calculated from the mother's and the child's recall. The results of this study suggest that young children can provide information on their diet as accurately, or even more accurately, than their mothers.

With respect to the dietary history BEAL (1967) stated that: 'With a few exceptions, girls under 12 years of age and boys under 13–14 years are unlikely to give reliable nutritional histories'. Accurate dietary histories, as already mentioned, can only be obtained when the variations in eating patterns are not extreme. Especially in young children the variation in food intake from day to day may be large. Differences in energy intake between different days range from 400–600 Kcalories in children aged 2–10 years (BEAL, 1967). Due to these large variations in energy intake accurate dietary histories cannot be obtained in children below 10 years.

From these literature data the general conclusion may be drawn that the 24-hour recall does not provide accurate dietary intake data in children below the age of 10. Accurate information about the usual eating pattern collected by dietary history cannot be obtained in children below 15 years.

1.2.2.3.4. Comparisons with record and chemical methods

Comparative studies with respect to interview and record methods. Studies

comparing the 24-hour recall with the dietary history showed higher intakes for total energy, proteins, fats and carbohydrates in students and civil service employees (YOUNG et al., 1952; BALOGH et al., 1971). In pregnant women higher intakes for total energy and proteins were obtained by dietary history (YOUNG et al., 1952). Similar results were also found for children (YOUNG et al., 1952; TRULSON, 1954).

Several studies, in which the 24-hour recall was compared to the seven-day record, did not show significant differences in total energy, proteins, fats and carbohydrates between either method in adults (YOUNG et al., 1952; ADELSON, 1960; PEKKARINEN et al., 1967). In two comparative studies from the United Kingdom, 6% and 17% lower values for total energy were obtained by the 24-hour recall compared to the seven-day record (MORRISON et al., 1949; THOMSON, 1958). Two studies in children did not show significant differences in total energy, proteins, fats and carbohydrates between these methods (YOUNG et al., 1952; HEZEMANS et al., 1977a). Studies reported by BRANSBY et al. (1948) and TRULSON (1954) tended towards slightly lower values for these nutrients by 24-hour recall. In another comparative study carried out by BRANSBY et al. (1948) higher intakes for total energy, proteins, fats and carbohydrates were found by 24-hour recall. These differences reached statistical significance for total energy, proteins and carbohydrates.

The child's ability to recall its diet has also been studied by comparing school lunches actually eaten with the child's recall of its school lunches. In the already mentioned study of EMMONS and HAYES (1973) it was shown that the number of foods remembered by children aged 6–12 years increased with age. In an investigation carried out by MEREDITH et al. (1951) a tendency towards greater underestimation of foods was observed when the number of foods increased. However, the differences in total energy, proteins, fats and carbohydrates between the school lunches actually eaten and the child's recalls were surprisingly small.

In comparative studies concerning the dietary history and the seven day record methods, significantly higher values for total energy, proteins, fats and carbohydrates were found by dietary history in men (YOUNG et al., 1952; DEN HARTOG et al., 1965). Similar results were reported for pregnant (YOUNG et al., 1952) and for obese women (BEAUDOIN and MAYER, 1953; VAN DEN BERG and MAYER, 1954). However, in BEAUDOIN and MAYER's investigation no significant differences between either method could be established for non-obese women. In comparative studies carried out in children higher values were also found by dietary history (HUENEMANN and TURNER, 1942; YOUNG et al., 1952; TRULSON, 1954; TALMA et al., 1964). In one study in children no difference could be observed between either method (LUBBE, 1968).

From these comparative studies the following general conclusions may be drawn. In both adults and children the 24-hour recall gives similar or slightly lower results than the seven day record. The food intake data obtained by dietary history were generally significantly higher compared to those obtained by the seven day record. From these results it may be deduced that higher results

should be obtained by the dietary history than by the 24-hour recall. This conclusion was substantiated by the results of comparative studies carried out in children, but could not be corroborated by the results of studies carried out in adults. A possible explanation for the overestimation of the food intake by the dietary history may be that the amounts of small or infrequently used foods are overestimated.

Comparative studies with respect to interview methods and duplicate portion technique. In the literature only one study has been published in which the 24-hour recall was compared to the duplicate portion technique (BRANSBY et al., 1948). Children aged 10–15 years participated in this study. Duplicate portions of all foods eaten during three days were collected for chemical analysis. Each evening the children were asked to describe the foods they had eaten during the previous 24 hours. The results of this study showed that total energy, fats and carbohydrates in contrast to proteins were overestimated by the 24-hour recall method.

In another study the children's ability to recall their consumption of the school lunch was examined (SAMUELSON, 1970). This study was carried out in children aged 8 and 13 years respectively. All children overestimated their fat intake on recall. This difference in fat intake could not be ascribed to the fact that food tables give too high values for fat, since the results calculated from the tables for duplicate portions were in good agreement with the results of chemical analysis of the same portions. Concerning proteins and carbohydrates the results were different for the children aged 8 and 13 years. In the 8 year-old children there was no difference in protein intake between either method. On the other hand these children overestimated their carbohydrate intake. The 13 year-old children underestimated both their protein and carbohydrate intake. Owing to these differences there was also a difference in energy intake between both methods in the two age groups. The younger children significantly overestimated the energy intake from the school lunch on recall. In the older children significant differences in energy intake could not be observed.

From these studies it may be concluded that children overestimate their fat intake on recall compared to the duplicate portion technique. The results with respect to proteins and carbohydrates are not unequivocal. There seems to be a tendency to underestimate the protein intake and to overestimate the carbohydrate intake. On account of these differences in nutrient intake the energy intake tends to be overestimated on recall.

Only one study is known in which the dietary history is compared to the aliquot sampling technique (DEN HARTOG et al., 1965). In this study, carried out in middle-aged men, total energy, proteins and fats were overestimated by dietary history. No difference between either method could be established with respect to carbohydrates. From these results it may be concluded that food intake tends to be overestimated by the dietary history compared to that obtained by the aliquot sampling technique.

1.2.3. *Short-cut methods*

It has frequently been stated that short dietary survey methods are needed for epidemiological studies, because the traditionally used methods are time-consuming and can therefore be applied to a small number of subjects only (WIEHL and REED, 1960; HEADY, 1961; STEFANIK and TRULSON, 1962; ABRAMSON et al., 1963; YOUNG, 1965; BROWE et al., 1966; HANKIN and HUENEMANN, 1967; BALOGH et al., 1968; EPSTEIN et al., 1970; MARR, 1971). The short-cut methods are characterized by the collection of information about the frequency with which certain foods are eaten during a given period. The frequencies are sometimes multiplied by the weight of these foods, estimated during the surveys or by average portion sizes obtained from earlier studies in order to calculate the so-called 'food-scores'. From these food-scores, 'nutrient-scores' can be calculated by formulae derived from multiple regression analysis of foods making important contributions to the nutrients being 'scored' (MARR, 1971). Qualitative classifications of frequencies, food-scores and nutrient-scores in e.g. low, medium and high intakes of certain foods or nutrients can be used for testing hypotheses on the association between dietary factors and biological parameters.

The short-cut methods commonly used were reviewed by HANKIN and HUENEMANN (1967) and by MARR (1971). In this review the attention will be focussed on studies examining the accuracy of short methods. In the literature only those studies have been published in which the short methods were compared to the seven day record and dietary history. Investigations comparing the short methods with the duplicate portion technique have not been reported.

The short methods, like the more elaborate dietary survey methods, can also be divided into record and recall methods. Some studies have been published, in which the validity of short dietary questionnaires was evaluated. In the investigations carried out with British bank clerks, aged 40–55 years, the validity of food and nutrient-scores was tested by comparing intakes predicted from these scores with the measured intakes (HEADY, 1961; MARR et al., 1961). The criterion, used in these studies, was that the men with scores in the top third of the distribution would have higher measured intakes than the men with scores in the lowest third of the distribution. The food-scores correlated very well with the measured intakes. This was not always the case for nutrient-scores. Although all the men with highest and lowest scores for vegetable and marine fat and all but one for animal fat were correctly classified, this criterion does not seem to be very specific. With respect to animal fat the men with the lowest scores had measured intakes between 55 and 90 g and the men with the highest scores ranged from 85 to 140 g, so a clear distinction between these extreme groups did not result.

A questionnaire was developed for the Albany Cardio-vascular Health Centre Study for the entire male population under investigation in order to assess the relationship of diet to the development of future disease (BROWE et al., 1966). The men participating in this study were encouraged to get help from their wives regarding methods of food preparation as well as the kinds and brands

of fats used. The accuracy of the Albany questionnaire was tested by comparing this method with the dietary history as applied in the Framingham Study. Lower average values were obtained with the questionnaire compared to the dietery history for total energy, fats, carbohydrates and dietary cholesterol. However, no difference could be observed between the methods with respect to energy percentage from proteins, fats and carbohydrates. The high correlations between total energy and fats and between total energy and carbohydrates were interpreted by the investigators 'as a re-enforcement of the confidence in the questionnaire'. However, these high correlations are self evident and cannot be interpreted as a measure of the accuracy of the method (HANKIN and HUENEMANN, 1967).

Several short-cut methods of the recall type have been developed. In a study into the adequacy of diets of pregnant women in Kauai (Hawaii), the validity of a short-cut method was also evaluated (HUENEMANN et al., 1961). Based on the information of an interview, the intake of different food and nutrient groups was estimated in terms of 'low', 'medium' or 'high'. High was defined as equal to or exceeding the Recommended Dietary Allowance for the different nutrient groups. The intake of a food group was called low when it was below 50% of these allowances. Intakes between these extremes were called medium. The results of this short method were compared with the findings of a dietary history that provided information on the food intake of these women during the previous months. The results of both methods agreed in only about 20–50% of the cases for the various food and nutrient groups.

In a study with Irish and Italian Americans, the validity of a short dietary interview was tested by comparison with the seven-day dietary record and the dietary history respectively (STEFANIK and TRULSON, 1962). The frequencies of food eaten, obtained by these methods did not show significant differences. On the other hand, in this study differences in the frequency of the consumption of different food-groups between Irish and Italian Americans could be established.

In a group of pregnant women, high correlations between frequencies and amounts of foods such as milk, eggs, etc. were observed (ABRAMSON et al., 1963). These correlations were lower for foods more variable in size, like meat, poultry, bread and rolls etc. Significant correlations were also found between certain food-groups and the haemoglobin levels of these women.

In order to assess the food intake of 10,000 civil servants and municipal employees aged 40 years and over in a long-term prospective epidemiological investigation of ischaemic heart disease a short dietary interview was developed (BALOGH et al., 1968). This interview provided information about the frequency with which foods were eaten over a weekly period. The quantities were estimated with the aid of food models. The validity of this method was tested by comparison with the dietary history and the seven-day record in groups of 48 and 14 persons respectively. The mean values for total energy, animal proteins, saturated, poly-unsaturated and total fats were similar to the mean values obtained by dietary history and seven-day record.

The validity of the method developed by BALOGH et al. has also been tested with a more heterogenous population, consisting of Jewish people of different sex, age, region of birth and education (EPSTEIN et al., 1970). In this study food intake data, obtained by the short interview and by dietary history, were compared. The mean intake of total energy, proteins, fats and carbohydrates was not influenced by sex, age, region of birth or education. However, the intake of these nutrients was consistently underestimated by the short interview compared to the dietary history. These disparities were related to the number of foods eaten and being largest among persons taking the most varied diet. On the other hand, both methods yielded similar average values concerning the energy percentage from proteins, fats and carbohydrates. Only the proportion of animal proteins was somewhat overestimated by the short interview.

Virtually all reviewed studies showed that the frequency with which foods are eaten within a given period, can generally be estimated rather accurately by the short methods (HEADY, 1961; STEFANIK and TRULSON, 1962). The average intake of total energy, proteins, fats and carbohydrates obtained by short methods tended to be lower than intake data calculated from the dietary history (BROWE et al., 1966; EPSTEIN et al., 1970) except in one study carried out in an homogeneous population (BALOGH et al., 1968). However, the energy percentage of proteins, fats and carbohydrates did not differ between either method (BROWE et al., 1966; EPSTEIN et al., 1970).

General conclusions concerning the short methods are difficult to draw. As stated by ABRAMSON et al. (1963): 'These methods may be of particular use in the "clue-seeking" stage of an epidemiological study or as an indicator of the comparability of subgroups with respect to diet'. When information about the average diet of groups is needed, accurate data cannot be obtained by the short methods. In this case it seems preferable to use more intensive and time consuming dietary survey methods in representative samples of the population under survey (EPSTEIN et al., 1970). This dilemma has been summarized by THOMSON (1958): 'Some sort of results may be obtained from most subjects, with methods that avoid measurement, but large numbers of inaccurate estimates are no substitute at all for a few accurate measurements'.

1.3. INTRA-INDIVIDUAL VARIATION OF FOOD INTAKE

Variation in energy intake between individuals can be very large. In every age-group one individual can be found who eats twice as many calories as another (WIDDOWSON, 1947; BURKE et al., 1959; WIDDOWSON, 1962). Day-to-day variations in energy intake within an individual can be as large as variations between individuals (BEAL, 1967).

It has been shown in several studies carried out within the framework of the Seven Countries Study that for the energy percentage from proteins and fats the intra-individual variation was almost as large as the inter-individual variation (BUZINA et al., 1964; KEYS et al., 1966; FIDANZA and FIDANZA

ALBERTI, 1967). The intra-individual variance (s.d.^2_w) amounted to 57 and 78 per cent of the total variance for the energy percentage from proteins and fats respectively (BUZINA et al., 1964). With respect to fatty acids the intra-individual variance tended to be even greater than the inter-individual variance (KEYS, 1965).

These results imply that the position of an individual in the distribution of food intake data can differ very much from one survey to another. Therefore it may be expected that correlations between food intake data collected in consecutive surveys are low.

In adults the correlation coefficients between food intake data collected by the weighing method during two separate weeks and calculated from food tables ranged between 0.73 and 0.90 for total energy, between 0.53 and 0.78 for proteins, between 0.63 and 0.85 for fats and between 0.82 and 0.89 for carbohydrates (HEADY, 1961; MARR, 1971). The time period between two surveys varied from consecutive weeks to as much as one year. Similar results have been reported for studies carried out in children concerning proteins and fats (HUENEMANN and TURNER, 1942; EPPRIGHT et al., 1952). However, lower correlations were observed for total energy and carbohydrates in these studies. Correlation coefficients in the order of 0.30 were found for total energy and for the energy percentage from proteins and fats between the results of surveys carried out in middle-aged men two or three years after each other (TRULSON and MCCANN, 1959; KEYS et al., 1966).

Several studies, carried out in both men and women, have been published in which the results of dietary histories repeated within periods ranging between two and four years, were reported (TRULSON and MCCANN, 1959; DAWBER et al., 1962; RESHEF and EPSTEIN, 1972). In these studies the correlation coefficients varied from 0.59 to 0.92 for total energy, from 0.49 to 0.89 for proteins, from 0.43 to 0.89 for fats, from 0.57 to 0.79 for carbohydrates and from 0.59 to 0.87 for dietary cholesterol. The correlation coefficients for the energy percentage from fats ranged between 0.27 and 0.90 (TRULSON and MCCANN, 1959; DAWBER et al., 1962). The correlations in these studies, except for the energy percentage from fats, were in the same order of magnitude as the correlations in the already mentioned studies using the weighing method. Higher correlations were obtained for the energy percentage from fats by the dietary history method compared to the weighing method.

It may be concluded from these results that an accurate estimation of the total energy and nutrient intake by the individual cannot be obtained from a *one week* dietary record or dietary history. The generally observed correlation coefficients for total energy and nutrient intake of about 0.7 suggest that the intake by individuals in one survey period is in agreement only for 50% with intake in the other period.

These rather low correlations reflect the great intra-individual variation in total energy and nutrient intake. When dietary surveys are repeated in different seasons, the large intra-individual variation may be caused by seasonal variations. It has been shown in several studies that in spite of the changes in

foods eaten during the different seasons the differences in total energy, proteins, fats and carbohydrates were surprisingly small (EPPRIGHT et al., 1952; HEADY, 1961; BUZINA et al., 1964; ROINE et al., 1964; DEN HARTOG et al., 1965; KEYS et al., 1966; FIDANZA and FIDANZA ALBERTI, 1967). So the large intra-individual variations can hardly be explained by seasonal differences and are very probably a reflection of real variations in food intake of individuals.

According to WIDDOWSON (1962): 'A week is long enough to give a *general* idea of a person's diet'. However, several studies have shown that the diet of an individual can vary considerably from week to week (YUDKIN, 1951; YOUNG et al., 1952; CHAPPEL, 1955). Six women, studied by YUDKIN (1951) recorded their food intake over a period of 4 consecutive weeks according to the precise weighing method. The weekly variations in energy intake of an individual varied from 2 to 68%. From the figures in YUDKIN's paper it could be calculated that the weekly individual differences ranged between 25 and 60% for proteins, between 20 and 75% for fats and between 15 and 95% for carbohydrates. In a study published by CHAPPELL (1955) a woman and a man recorded their food intake, according to the precise weighing method, for 70 and 13 weeks respectively. The weekly differences in energy intake within periods of 4 consecutive weeks for these two subjects varied from 2.3 to 30.0% and from 14.0 to 24.1%. This study also showed that the coefficients of variation for total energy and certain nutrients could be reduced to about half their value when the length of the surveyed period was extended from 1 to 12 weeks. These reductions varied from 7.6 to 3.8% for total energy, from 10.0 to 6.3% for proteins, from 10.5 to 5.1% for fats and from 7.7 to 3.7% for carbohydrates. In a study reported by YOUNG et al. (1952) 16 women and 2 men kept dietary records in household measures for 28 consecutive days. This study showed that in nearly all individuals the weekly averages for total energy and proteins fell within ± 20% of their 28 day averages. The maximum positive and negative percentage deviations of the weekly variations of individuals from their 28 day averages were 21 and 19% for total energy and 24 and 24% for proteins. It can be concluded from the results of these 3 studies that the weekly variation in total energy and nutrient intake of an individual is considerable. Consequently, an accurate estimation of the total energy and nutrient intake of an individual can only be obtained when the length of the surveyed period lasts longer than a week.

Some investigators have tried to estimate the number of days needed in order to get accurate information about an individual's food intake. CHALMERS et al. (1952) calculated that a precise estimation of total energy and proteins could be obtained when the dietary record covered a period of 11 days in women and 14 days in men. This calculation was based on a required precision of ± 15% of the Recommended Dietary Allowances and related to a 95% confidence limit. When a physically active man has an estimated mean energy intake of 2800 Kcalories (11.7 MJ), his actual intake would range between 2800–15% and 2800 + 15% of 3000 Kcalories (12.5 MJ), in other words be-

tween 2350 (9.8 MJ) and 3250 (13.6 MJ) Kcalories, because 3000 Kcalories is his Recommended Dietary Allowance. This calculation makes it clear that, even with this not very precise criterion, still about 2 weeks are required in order to obtain reasonably accurate food intake data.

The food intake of a woman was recorded for 70 weeks in the previously mentioned study done by CHAPPELL (1955). It could be calculated from these data that 4 single weeks, selected independently at random or a systematic sample of 3 one-week periods should provide estimates of average intakes over the year with coefficients of variation of about half those for a one-week survey. Such samples would estimate the mean intake of total energy, proteins, fats and carbohydrates with coefficients of variation of $\pm$ 5% or less.

Besides investigations in which food intake data were obtained by record, one has also been published in which the intake data were collected by recall (BALOGH et al., 1971). In 71 Israelian male civil service employees 8 or more 24-hour recalls were obtained. They were contacted on a random day once a month for a year in order to obtain information about what they had eaten on the preceding day. The authors calculated from their data the number of recalls needed to estimate an individual's diet with 95% probability of being within $\pm$ 20% of its own mean (Table 2). In order to fulfil this criterion for 90% of the population the number of recalls needed varied between 9 and 45 for total energy and dietary cholesterol respectively. Taking into account that this criterion is not very specific, because a true dietary cholesterol intake of 500 mg could vary between 400 and 600 mg, the results of this study also show that accurate individual food intake data can only be obtained in long lasting surveys.

MARR (1973) calculated that 80% of a group of men could be classified in the 'true' third of the total energy distribution, when the food intake was recorded for 3 days. With respect to total fats, sucrose and dietary cholesterol

TABLE 2. Approximate number of 24-hour recall reports, collected at random, required for a 95% probability that the sample average is within $\pm$ 20% of the true individual mean for the specified nutrients (adapted from BALOGH et al., 1971).

Nutrient	For 50% of population	For 90% of population
Total energy	4	9
Animal proteins	11	27
Vegetable proteins	7	13
Total fats	8	23
Saturated fats	9	22
Oleic acid	10	30
Linoleic acid	23	44
Dietary cholesterol	20	45
Total carbohydrates	5	10
Sugar	11	23
Starch	8	23

periods of 4, 2 and 20 days respectively were needed. Even according to this not at all stringent criterion many days were needed in order to classify these men correctly.

In the majority of the afore-mentioned studies the total energy and nutrient intake had been calculated from food tables. As discussed earlier this introduces an additional source of variation compared to data determined by chemical analysis (see also p. 8–9). Two studies have been published in which the intra-individual variation of food intake data calculated from food tables was compared to those determined by chemical analysis (KEYS et al., 1966; FIDANZA and FIDANZA ALBERTI, 1967). The results of these studies indicate that the intra-individual and inter-individual variances for the energy percentage from proteins and fats determined by chemical analysis were larger compared to data calculated from food tables. This difference could not be observed for total energy. These results imply that even longer periods than the periods calculated from food intake data collected by record or recall methods, are required in order to get an accurate estimation of an individual's intake of proteins and fats.

It may be concluded from the results of the reviewed studies that accurate food intake data of an individual cannot be obtained from surveys covering only one week. The question of how long this period should be is difficult to answer and is dependent on the nutrients surveyed. Evidence exists that accurate information about an individual's intake of total energy and total carbohydrates can be obtained from food intake data recorded over 2 single weeks, selected independently at random during a one year period. With respect to animal, vegetable and total proteins, saturated and total fats, oleic acid, oligo-saccharides and polysaccharides a sampling period of 4 single weeks seems to be required. The same sampling period is presumably needed for dietary fibre, because foods rich in dietary fibre are generally also rich in polysaccharides.

The sampling period required for nutrients like linoleic acid and dietary cholesterol, present in foods eaten very irregularly, can be as long as 7 weeks. The final conclusion may be that accurate information about an individual's intake of total energy and certain nutrients can only be obtained from carefully conducted long lasting surveys. The suggested sampling periods are based on the results of only a limited number of surveys, so more research in this field is needed.

1.4. VARIATION IN SERUM TOTAL CHOLESTEROL

1.4.1. *In populations*

The mean serum total cholesterol concentration of some national and international well-known prevalence studies carried out in infancy, childhood and adolescence are summarized in Table 3. In the Western countries the mean total cholesterol level rises from about 70 mg/100 ml in new borns to 160–210 mg/100 ml in childhood and adolescence. A summary of findings in adult males is

TABLE 3. Average serum total cholesterol concentrations (m ± s.d.) in infancy, childhood and adolescence

Ref.	Origin	Country	Year of investigation	Age years	Serum total cholesterol					
					boys		girls		boys + girls	
					N	m ± s.d.	N	m ± s.d.	N	m ± s.d.
1.	Cincinatti	USA	1970	New borns					1800	64 ± 19
2.	Seattle	USA	1970	New borns					2000	82 ± 20
3.		Belgium	1974	New borns					303	72 ± 19
				5 weeks					45	131 ± 21
4.	Wisconsin	USA	1968	5–9					163	188 ± 31
				10–14					165	185 ± 40
5.	Muscatine	USA	1971–1974	6–18					4829	182 ± 29
6.	Bogalusa	USA	1973–1974							
			white	5–14	1142	161 ± 29	1030	164 ± 27		
			black	5–14	669	169 ± 31	605	171 ± 30		
7.	Health Examination	USA	1966–1970	12	643	181 ± 28	547	178 ± 28		
	Survey			17	489	171 ± 30	469	185 ± 34		
8.	Wageningen	The Netherlands	1973	4–13	490	176 ± 30	413	180 ± 30		
	Heerenveen	The Netherlands	1974	4–13	378	170 ± 26	322	176 ± 28		
	Roermond	The Netherlands	1975	4–13	401	176 ± 29	344	184 ± 31		
	Harderwijk	The Netherlands	1976	4–13	449	182 ± 31	382	185 ± 30		
9.	Westland	The Netherlands	1973	9–12	1194	188 ± 31	1146	191 ± 31		
10.	National Sample	The Netherlands	1973–1974	8	465	198 ± 29	431	208 ± 31		
11.	Urban Private School	Guatemala	1954	7–12	48	187 ± 27	48	188 ± 30		
	Urban Public School			7–12	48	143 ± 29	48	156 ± 30		
	Rural Public School			7–12	48	121 ± 24	48	128 ± 24		
12.	Amerindians	Surinam	1970	0–10	11	139 ± 29	8	135 ± 15		
				10–20	29	128 ± 20	37	138 ± 23		
13.	Huxquilucan	Mexico	1968	5–9					106	100 ± 28
				10–14					103	100 ± 24

References:

1. GLUECK et al., 1971
2. GOLDSTEIN et al., 1974
3. KESTELOOT et al., 1975
4. GOLUBJATNIKOV et al., 1972
5. LAUER et al., 1975
6. FRERICHS et al., 1976
7. LEVY et al., 1976
8. KROMHOUT et al., 1977 and present investigation
9. UPPAL, 1974
10. DE WIJN and PIKAAR, 1976
11. SCRIMSHAW et al., 1957
12. GEERDINK et al., 1973
13. GOLUBJATNIKOV et al., 1972

TABLE 4. Some reported serum total cholesterol concentrations (m ± s.d.) in adult men.

Ref.	Place	Country	Year of investigation	Age years	N	Serum total cholesterol (mg/100 ml)
1.	Chicago	USA	1958	40–59	1465	238 ± 44
2.	Tecumseh	USA	1959–1960	40–44	242	229 ± 42
				45–49	225	229 ± 38
				50–54	167	238 ± 43
				55–59	155	232 ± 44
				60–64	94	225 ± 41
3.	California	USA	1960–1961	38–49	2249	224 ± 44
4.	Albany	USA	1969–1972	40–49	905	232 ± 42
				50–59	361	218 ± 34
				60–69	728	217 ± 35
				≥ 70	122	210 ± 36
4.	Framingham	USA	1969–1972	50–59	506	219 ± 37
				60–69	423	218 ± 36
				≥ 70	284	211 ± 36
4.	Honolulu	USA	1971–1972	50–59	1182	217 ± 34
				60–69	621	218 ± 38
4.	California	USA	1969–1972	40–49	319	225 ± 36
				50–59	221	229 ± 38
4.	Puerto Rico	USA	1969–1972	50–59	456	191 ± 35
				60–69	424	187 ± 34
5.	North Karelia	Finland	1972	25–59	2097	269 ± 50
6.	Zutphen	The Netherlands	1960	40–60	912	232 ± 42
			1977	57–77	470	227 ± 40
7.	Vlagtwedde	The Netherlands	1970	20–49	915	254 ± 48
8.	Tilburg	The Netherlands	1973–1974	40–42	648	240 ± 46
9.	Doetinchem	The Netherlands	1973–1974	40–44	412	237 ± 44
				45–49	398	242 ± 41
10.	Tanushimaru	Japan	1964	46–65	24	147 ± 31
11.	Nasioi	Solomon Islands	1966	15–69	59	155 ± 34
	Nagovisi	Solomon Islands	1970	15–70+	109	161 ± 35
	Lau	Solomon Islands	1968	15–70+	77	149 ± 27
	Baegu	Solomon Islands	1968	15–70+	126	115 ± 27
	Aita	Solomon Islands	1970	15–69	81	135 ± 29
	Kwaio	Solomon Islands	1966	15–70+	127	114 ± 29
12.	Amerindians	Surinam	1970	20–30	22	114 ± 29
				30–40	32	138 ± 29
				40–50	20	142 ± 28
				≥ 50	17	136 ± 26

(11. Nasioi … Kwaio: ↑ increasing degree of acculturation)

References:

1. STAMLER et al., 1972
2. JOHNSON et al., 1965
3. ROSENMAN et al., 1975
4. CASTELLI et al., 1977
5. PUSKA, 1974
6. NETHERLANDS NUTRITION COUNCIL, 1974 and 1977
7. MAY, 1974
8. STYBLO et al., 1976
9. STYBLO et al., 1976
10. KEYS and KIMURA, 1970
11. PAGE et al., 1974
12. GEERDINK et al., 1973

given in Table 4. Only the results of studies of which both the mean and the standard deviation were reported were considered for inclusion in this Table.

Substantially higher serum total cholesterol levels (220–270 mg/100 ml) were observed in middle-aged men compared to male adolescents, children and infants. After the age of 60 the serum total cholesterol levels show a slight tendency to decrease. It can be concluded from these findings that in Western countries a more than threefold increase in serum total cholesterol level can be observed in males from birth to middle-age.

The positive relationship between age and serum total cholesterol observed in the Western countries was not found in Amerindians in Surinam (Tables 3 and 4). Positive relationships between mean serum total cholesterol level and socio-economic status related to the type of school and between serum total cholesterol and the degree of acculturation were observed in Guatemala and the Solomon Islands respectively (Tables 3 and 4). Low mean serum total cholesterol levels were not only found in people living in primitive societies but also in populations in Japan, Greece and Yugoslavia (KEYS, 1966).

In the Western countries the standard deviation of serum total cholesterol increases from about 20 mg/100 ml in new borns to about 30 mg/100 ml in children and adolescents, except for the Wisconsin children aged 10–14 years, who had a standard deviation of 40 mg/100 ml (Table 3). In middle-aged men the standard deviation ranged between 34 and 50 mg/100 ml (Table 4). In the developing countries an increase in the standard deviation from 15–30 mg/100 ml in children and adolescents to 26–35 mg/100 ml in adults was observed (Tables 3 and 4). These data clearly show a positive relationship between the standard deviation of serum total cholesterol and age in both Western and developing countries although to a much lesser extent in the latter.

Differences in serum total cholesterol level between new borns may be ascribed mainly to genetic differences. With increasing age, however, the influence of environmental factors, like diet, on serum total cholesterol becomes more and more pronounced. Thus, differences in serum total cholesterol levels between children, adolescents and middle-aged men reflect besides genetic differences also life long differences between individuals in susceptibility to environmental factors. The observed increase of standard deviation with age suggests an increased influence of environmental factors in individuals.

1.4.2. *In individuals*

The serum total cholesterol concentration within an individual varies considerably (KEYS et al., 1957; KEYS, 1967; STATLAND and WINKEL, 1976). The intra-individual standard deviation increases from ± 12 mg/100 ml on a rigidly constant diet in a metabolic ward unit to ± 20 mg/100 ml on an ostensibly constant diet in free-living clinically healthy subjects (Table 5) (KEYS, 1967). When constant diets are eaten the variation in serum total cholesterol concentration within an individual can be ascribed to variations in sampling techniques, i.e. physical status, technique of blood drawing, serum preparation etc., laboratory error and 'spontaneous' variation due to biological influences. The

TABLE 5. Average intra-individual standard deviation ($s.d._w$) in serum total cholesterol when constant diets are eaten (adapted from KEYS, 1967).

Living condition	$s.d._w$ (mg/100 ml)
Metabolic unit	12
Free living, but on dietary prescription	15
Ostensibly constant diet, clinically healthy subjects	20

laboratory error under well-controlled conditions may be cut down to about 4 mg/100 ml (KEYS et al., 1957). It has recently been shown that in children the standard deviation of duplicate measurements, including both variations in sampling technique and laboratory error, was 9 mg/100 ml (FRERICHS et al., 1976). A major part of the variation in serum total cholesterol within an individual can be ascribed to 'spontaneous' variation. In a study reported by STATLAND and WINKEL (1976) the average intra-individual standard deviation in 11 healthy male students was estimated independently of variation in sampling technique and laboratory error. The main results of this study are summarized in Table 6. The within-hour and within-day intra-individual standard deviation did not differ. This study showed that the day-to-day intra-individual standard deviation in students who were not on a prescribed diet amounted to $\pm$ 10 mg 100 ml. These data on intra-individual standard deviations in serum total cholesterol should not be interpreted as absolute figures valid under every condition. The investigators themselves already pointed out the limitations of their findings by stating that the within-hour, within-day and day-to-day variations neither covered complete within-hour and within-day variations nor prolonged day-to-day variations. Furthermore, 'spontaneous' variations due to biological influences, may vary considerably from individual to individual (HARRIS, 1976). Thus, the within-hour, within-day and day-to-day standard deviations found by STATLAND and WINKEL (1976) only represent approximations.

The general conclusion may be that *in adults* who are not on a prescribed diet the long-term intra-individual *variance* ($s.d.^2$) in serum total cholesterol (20^2) may be assessed to be about one quarter of the total variance (40^2). *In children*

TABLE 6. Average intra-individual standard deviation ($s.d._w$) in serum total cholesterol, independent of variations in sampling technique and laboratory error (adapted from STATLAND and WINKEL, 1976).

Time period	Actual interval studied	Number of venepunctures	$s.d._w$ (mg/100 ml)
Within-hour	11.00–11.30 h	2	7
Within-day	8.00–14.00 h	3	7
Short-term day-to-day	Oct. 31–Nov. 13	5	10

with a mean serum total cholesterol concentration of 180 mg/100 ml and an observed total standard deviation of 30 mg/100 ml, this could mean that the average long term intra-individual standard deviation is about 15 mg/100 ml. When repeated blood samples are taken over a period of months, in a child with a mean serum total cholesterol concentration of 220 mg/100 ml, all the observed serum total cholesterol values will then vary between 190 and 250 mg/100 ml with a probability of 95%. If we further assume that the short-term intra-individual variance is about one half of the long-term intra-individual variance in children not on a prescribed diet (Table 5), then an estimate of about 10 mg/100 ml is obtained for the average standard deviation between replicate measurements of serum total cholesterol concentrations in the same children on the same day. This means that, if these considerations are applicable to children, 95% of the results in a child with, for instance, an assumed serum total cholesterol concentration of 220 mg/100 ml will vary between 200 and 240 mg/100 ml. These calculations clearly demonstrate the large impact of intra-individual variations in serum total cholesterol on the probability of misclassification when fixed cut-off points are used for a parameter of which only single determinations have been done. Furthermore, studies designed to investigate the relationship between diet and serum total cholesterol are seriously hampered by the large intra-individual variations in serum total cholesterol if results of only one assessment of the serum total cholesterol concentration are to be used.

1.5. Diet, serum total cholesterol and cononary heart disease

1.5.1. *Between populations*

Generally, the diets of people in economically developed countries with high coronary heart disease (CHD) death rates are rich in saturated fats, dietary cholesterol, animal proteins, sugar and salt. On the other hand the intake of vegetable proteins, polysaccharides and dietary fibre is low in these countries. The diet of countries with low CHD death rates are generally characterized by a high intake of vegetable proteins, polysaccharides and dietary fibre and by a low intake of saturated fats, dietary cholesterol, animal proteins and sugar. On account of these data it may be expected that CHD death is positively related to the intake of saturated fats, dietary cholesterol, animal proteins and sugar. An inverse relationship can be expected between CHD death and the intake of vegetable proteins, polysaccharides and dietary fibre. Relationships between diet and CHD death in middle-aged men are frequently investigated on the basis of FAO food balance sheet data and WHO CHD mortality data (Katz et al., 1958; Masironi, 1970; Connor and Connor, 1972; Stamler et al., 1972; Armstrong et al., 1975). Indeed, these studies showed statistically significant positive associations between saturated fat, dietary cholesterol, animal protein and sugar consumption on the one hand and CHD death on the other. Inverse associations were observed between vegetable protein and

CHD death and between polysaccharide consumption and CHD death. When associations between diet and CHD death are calculated from FAO and WHO data the limitations of these data have to be taken into account. Food balance sheet data do not give information about the actual food intake of people and CHD mortality data from different countries may be influenced by differences in diagnostic criteria used by physicians in these countries.

In the Seven Countries Study information about food intake and CHD incidence in middle-aged men was gathered in all countries according to a uniform protocol (KEYS, 1970). The food intake of representative sub-samples of the cohorts under survey was estimated by weighing all foods eaten over a period of seven days. The nutrient intake was calculated from food tables and was also estimated by chemical analysis of aliquot samples of all foods eaten or by the equivalent composite technique. The same criteria were used in all cohorts for establishing CHD morbidity and mortality. In this way highly comparable CHD incidence data could be obtained. The Seven Countries Study showed a very strong positive relationship between the energy percentage from saturated fats and CHD incidence. The correlation coefficient between these parameters amounted to 0.84.

In the International Atherosclerosis Project the participating population groups were ranked to severity of atherosclerosis, serum total cholesterol, energy percentage from total fats, percentage of total fats from animal origin and the amount of sugar consumed (SCRIMSHAW and GUZMAN, 1968). The ranking of serum total cholesterol and nutrient intake data was done by one of the investigators, based on the results of investigations already published. The Spearman rank correlation coefficient between the severity of atherosclerosis and the energy percentage from total fats was 0.668. This correlation coefficient was statistically significant.

The strong positive correlations between the energy percentage from saturated fats and CHD incidence in the Seven Countries Study and between the energy percentage from total fats and the severity of atherosclerosis in the International Atherosclerosis Project are consistent with the associations between diet and CHD death calculated from FAO and WHO data. Correlations between diet and atherosclerosis or CHD death do not provide information about how metabolism is involved in the genesis of atherosclerosis or CHD.

Since the beginning of this century it has been shown in many experiments with a variety of animals that high saturated fat – high cholesterol diets elevate serum total cholesterol levels leading to severe premature atherosclerosis. From these investigations it could be concluded that diet-induced hypercholesterolaemia is the prerequisite for the occurrence of atherosclerotic disease and its clinical expressions. In this concept the other risk factors are to be considered as contributory secondary causes. In other words, once the nutritional metabolic prerequisites for premature atherogenesis are present, hypertension, cigarette smoking, obesity, physical inactivity and emotional stress accelerate the atherosclerotic process (KATZ et al., 1950; STAMLER et al., 1972). This con-

cept is known as the saturated fat – serum cholesterol – CHD hypothesis. On account of this concept, positive relationships between saturated fat intake and atherosclerosis or CHD death may be expected in population studies.

In the International Atherosclerosis Project strong positive relationships between the energy percentage from total fats and serum total cholesterol and between serum total cholesterol and the severity of atherosclerosis were observed. The Spearmen rank correlation coefficients were 0.741 and 0.755 respectively (SCRIMSHAW and GUZMAN, 1968). In the Seven Countries Study the correlation coefficients between the energy percentage from saturated fats and serum total cholesterol and between serum total cholesterol and CHD incidence were 0.89 and 0.81 respectively (KEYS, 1970). The strong positive relationship between the energy percentage from total fats and serum total cholesterol was also found in middle-aged Japanese men from Japan, Hawaii and from the United States (KATZ et al., 1958). These correlations are also consistent with the saturated fat – serum cholesterol – CHD hypothesis.

A positive relationship between social class and CHD death is present in the developing countries (see also p. 41). In these countries the diets of the more well-to-do people are high in saturated fats and dietary cholesterol compared to the diets of the poor, which are rich in dietary fibre. In these countries a positive relationship between saturated fats and CHD death and an inverse relationship between dietary fibre and CHD death may be expected (KATZ et al., 1958; BURKITT et al., 1974).

A decrease in CHD death during World War II was observed in England, The Netherlands, Finland, Sweden, Norway and Denmark (see also p. 41). This decrease in CHD death was coupled with severe restrictions of some foods, notably fats (KEYS, 1975). Of course this was not the only change in lifestyle during that period. However, the decrease in CHD death observed in several countries during World War II and the increase in total fat consumption and CHD death after World War II (STAMLER et al., 1970) are consistent with the saturated fat – serum cholesterol – CHD hypothesis.

1.5.2. *Within Western populations*

Within Western populations significant associations between nutrient intake data and serum total cholesterol could not be shown in middle-aged men. This conclusion emerged from correlations between cross-sectional data concerning nutrient intake and serum total cholesterol obtained in several prospective studies like the Evans County, the Israel Ischaemic Heart Disease, the Framingham and the Tecumseh Study (STULB et al., 1965; KAHN et al., 1969; KANNEL and GORDON, 1970; NICHOLS et al., 1976). Furthermore, differences in the average intake of nutrients could not be established between men with high and low serum total cholesterol levels (STULB et al., 1965). These findings seem to negate the saturated fat – serum cholesterol – CHD hypothesis. In order to judge whether these findings are really contradictory to the relationships between populations, the role of confounding factors in cross-sectional comparisons within populations will be discussed.

In all afore-mentioned studies dietary information was obtained by recall methods. In two studies, a modification of the dietary history was used (STULB et al., 1965; KANNEL and GORDON, 1970). In the other studies, food frequency methods were used (KAHN et al., 1969; NICHOLS et al., 1976). It was shown in the Framingham Study that the correlation coefficients between repeated dietary histories carried out by the same nutritionist 2 or 3.5 years after the first interview were 0.90 and 0.57 for the energy percentage from total fats and 0.65 and 0.59 for dietary cholesterol. When the subjects were interviewed by a different nutritionists two years after the first interview, these correlation coefficients were 0.27 for the energy percentage from total fats and 0.87 for dietary cholesterol. These rather low correlations must, at least in part, be attributed to the large intra-individual variation in the intake of these nutrients.

The results of the dietary investigations carried out in the Framingham Study show that an accurate estimation of an individual's intake of the energy percentage from total fats and of dietary cholesterol cannot be obtained from one dietary history (see also p. 24–28). Sampling periods covering several single weeks, selected independently at random during a one year period, are required in order to obtain an accurate estimate of the intake of these nutrients in an individual (see also p. 24–28).

In middle-aged men the total standard deviation of serum total cholesterol is about 40 mg/100 ml (Table 4). The intra-individual standard deviation amounts to about 20 mg/100 ml, in a free-living population not on a prescribed diet (Table 5.). In other words, the serum total cholesterol level within an individual varies considerably.

On account of similar information concerning the intra-individual variation of nutrient intake data and serum total cholesterol, JACOBS et al. (1977) concluded that: 'If diet is linearly related to serum cholesterol but if large sources of variation cannot be controlled (as thus in fact seems to be the situation in cross-sectional studies), then the *expected value* of the correlation coefficient measuring this linear relationship is not 1 but is 0.1'. Hence, zero correlations do not disprove that diet has an effect on serum total cholesterol. A positive relationship between diet and serum total cholesterol within population groups may be expected when all important sources of variation are controlled. These sources of variation are summarized in Table 7. The sources of variation in diet are due to weaknesses in dietary survey methods which can never be controlled completely. Sources of variation in serum total cholesterol with respect to sampling technique and laboratory error can be reduced nowadays to 9 mg/100 ml. A further reduction is not to be expected. Biological day-to-day variations in serum total cholesterol are even found in subjects on a rigidly constant diet, so it is impossible to control for this factor.

The influence of these uncontrolled factors can be controlled for in intervention studies. It can be postulated that a *change* in diet is related to a *change* in serum total cholesterol levels, because the influence of some confounding factors concerning diet and serum total cholesterol may be eliminated. Indeed, a statistically highly significant correlation of 0.4 between a change in diet and

TABLE 7. Sources of variation which confound the relationship between diet and serum total cholesterol in cross-sectional studies.

Diet	Serum total cholesterol
Errors in:	
– the collection of food intake data	Variation in sampling technique
– encoding of food intake data	Laboratory error
– food tables used	Biological day-to-day variation
Variation in other nutrients than saturated fats and dietary cholesterol which influence serum total cholesterol	

a change in serum total cholesterol was observed in a study reported by JACOBS et al. (1977). The difference between the observed correlation coefficient of 0.4 and the expected correlation of 1.0 may be caused by still existing sources of variation in diet. In several intervention studies similar changes in serum total cholesterol were shown by a change from the current diet to a low saturated fat-low cholesterol diet (STONE and CONNOR, 1962; NATIONAL DIET HEART STUDY, 1968; FARINARO et al., 1977).

Another possible explanation for the absence of a relationship between diet and serum total cholesterol in cross-sectional studies may be the homogeneity in diets within these populations. The importance of this point may be illustrated by data from the Seven Countries Study (KEYS and KIMURA, 1970). Low correlations between the energy percentage from saturated fats and serum total cholesterol were observed within cohorts of middle-aged men from Japan, Greece and The Netherlands. The average energy percentage from saturated fats in these countries was 3, 8 and 19% respectively. There was almost no overlap in the ranges of the energy percentage from saturated fats between these countries. The mean serum total cholesterol levels in these countries were 170, 200 and 230 mg/100 ml respectively. When the individual data of all the men from these countries were combined, the correlation between the energy percentage from saturated fats and serum total cholesterol increased from 0.228 to 0.657. These data clearly show that a positive relationship between diet and serum total cholesterol may be expected only when there is a wide range in nutrient intake data and in serum total cholesterol level.

It may be concluded that zero correlations between diet and serum total cholesterol within populations do not negate the saturated fat-serum cholesterol hypothesis. Zero correlations are the expected consequence when cross-sectional data concerning diet and serum total cholesterol are correlated. Potentially present relationships are hidden by confounding factors and when these factors are eliminated, as in intervention trials, the concealed relationships see daylight again.

Studies between populations showed strong positive relationships between the energy percentage from saturated fats and CHD, between serum total

cholesterol and CHD and between the energy percentage from saturated fats and serum total cholesterol. These results are consistent with the saturated fat – serum cholesterol – CHD hypothesis. This hypothesis was also confirmed by studies within populations carried out in developing countries and by changes in total fat consumption and CHD mortality in different countries during World War II. Studies within populations in Western countries showed zero correlations between diet and serum total cholesterol. However, these correlations do not disprove the relationship between diet and serum total cholesterol because confounding factors concealed these relationships. These confounding factors may be controlled for in intervention trials. It has been shown in such trials that a change from the current diet to a low saturated fat – low cholesterol diet lead to a concomitant change in serum total cholesterol. The general conclusion may be that the results of the studies reviewed are consistent with the saturated fat–serum cholesterol–CHD hypothesis. The attractiveness of this hypothesis is that it can be expected that the high CHD death rates observed in Western countries may be reversed by changes in the diet. To prove that these changes in diet are really effective and efficient may be the main challenge for today's nutritionists.

1.6. Socio-economic status, risk factors and coronary heart disease

Studies into the relationships between socio-economic status, risk factors and coronary heart disease can provide important clues about the way in which the life style is involved in the etiology of coronary heart disease. Based on results from such studies hypotheses can be formulated about (causal) relationships between some aspects of the life style and coronary heart disease. In this review attention will be paid to:

- geographic differences in coronary heart disease (CHD);
- relationship between socio-economic status (SES) and CHD within countries;
- relationship between SES and the major CHD risk factors;
- relationship between SES and physical activity;
- relationship between SES and obesity.

1.6.1. *Geographic differences in coronary heart disease*

Vital statistics. The most recently available vital statistics reported by the WHO are those from 1967 (Keys, 1975). In Tables 8 and 9, CHD mortality data from countries with reliable vital statistics are presented (Stamler et al., 1970; Keys, 1975). These tables show striking differences in CHD death in middle-aged men and women in different countries. There are some remarkable features in the distribution of CHD death over the world. Most of the highest death rates are present in countries consisting mainly of European immigrants (USA (White), Canada, South Africa (White), Australia and New Zealand).

TABLE 8. CHD death/100,000 men aged 55–64 years
(adapted from STAMLER et al., 1970 and KEYS, 1975).

CHD death/100,000	Country
High: 700–1050	USA (white), Canada, South Africa (white), Australia and New Zealand Finland and Scotland
Medium: 350–699	Scandinavian Countries: Norway, Sweden and Denmark; Western European Countries: England and Wales, Ireland, Belgium, The Netherlands, Western Germany, Switzerland, Austria; Eastern European Countries: Czecho-Slovakia and Hungary; Southern European Countries: Italy.
Low: 0–349	Southern European Countries: France, Spain, Portugal, Greece; Eastern European Countries: Poland, Romania and Bulgaria; Asia: Japan and Taiwan; Southern America: Columbia and Chile.

TABLE 9. CHD death/100,000 women aged 55–64 years
(adapted from STAMLER et al., 1970 and KEYS, 1975).

CHD death/100,000	Country
High: 250–375	USA (white), South Africa (white), Australia and New Zealand; Finland, Scotland and Ireland*
Medium: 125–249	Canada** Scandinavian Countries: Norway, Sweden and Denmark; Western European Countries: England and Wales, Belgium, The Netherlands, Western Germany, Switzerland, Austria; Eastern European Countries: Czecho-Slovakia, Hungary, Romania*** and Bulgaria***; Southern America: Chile*** and Columbia***.
Low: 0–124	Southern European Countries: France, Spain, Portugal and Greece; Eastern European Countries: Poland; Asia: Japan and Taiwan.

* Countries with medium CHD death in middle-aged men.
** Countries with high CHD death in middle-aged men.
*** Countries with low CHD death in middle-aged men.

Northern and Western European countries dominate the picture with respect to medium death rates. Low CHD death rates are prevalent in Eastern and Southern European countries, Asia and Latin America. Judged from the point of view of Christian religions the high, medium and low CHD death rates are present in protestant countries, protestant and roman catholic countries and roman catholic countries respectively. There is also a strong positive relationship between CHD death in middle-aged men and per capita income between

countries with different CHD death rates (BRUMMER, 1967; STAMLER et al., 1970). To what extent these relationships give clues to factors etiologically involved in the development of CHD is difficult to judge, but they indicate that environmental factors may play an important role. In countries with medium and high CHD death rates, CHD mortality in middle-aged men is 3–4 times higher than in women of the same age. This sex difference is reduced to 2–3 times in countries with low CHD death rates (see Tables 8 and 9). These data clearly show that women in this age range are less susceptible to CHD than men. However, on a relative scale countries with high, medium or low CHD death rates are generally the same in both men and women. The correlation coefficient between CHD death rates in men and in women is as high as 0.93 (SOUKUPOVA and PROUSOVA, 1970). From these data it may be concluded that environmental factors play an important role in the genesis of CHD in both men and women although women seem less susceptible.

Autopsy studies. Questions regarding the accuracy of vital statistics can only be answered by comparing data from vital statistics with data from other sources; data from autopsy studies for example. In the fifties, autopsy studies were carried out in the USA and in Japan. These studies showed that high grade coronary sclerosis was much more prevalent in the USA than in Japan. The sex difference in CHD death observed in vital statistics was also confirmed by results from these autopsy studies (KATZ et al., 1958).

One of the most carefully conducted autopsy studies carried out was the International Atherosclerosis Project (MCGILL, 1968). In this project the quantitative grading for atherosclerosis of aorta and coronary arteries was done according to a rigidly standardized protocol. Pathologists from 15 cities throughout the world participated in this project. The results based on autopsies from more than 21,000 victims aged between 10 and 69 years and dying in 1960–1965, confirmed the trends observed in vital statistics. The extent of coronary atherosclerosis was higher in persons from cities in North America and Scandinavia compared to persons from cities in Africa and Latin America. In all cities, except one, coronary atherosclerosis was more prevalent in men than in women. This study also confirmed the sex difference in CHD death noted in vital statistics.

Prospective studies. Data on 10 years follow-up in the Seven Countries Study recently became available (KEYS, 1976). CHD death in 12,087 cardiovascular disease-free men aged 40–59 years at entry, was low in Japan and Greece, medium in Yugoslavia, Italy and The Netherlands and high in USA and Finland (Table 10). These mortality data are also consistent with the data from vital statistics.

In this review it has been shown that data from vital statistics, autopsy and prospective studies are consistent with each other. Generally, high CHD death rates are present in countries mainly consisting of European immigrants, medi-

TABLE 10. Death per 1,000 men in 10 years in 12,087 cardiovascular disease-free men, aged 40–59 years at start of the Seven Countries Study (adapted from KEYS, 1976).

Populations studied in:	Death from all causes	CHD-death
Japan	99.4	6.0
Greece	55.0	6.6
Yugoslavia	79.6	14.3
Italy	102.6	20.3
The Netherlands	106.4	31.7
USA	89.2	42.4
Finland	112.6	45.5

um death rates in Scandinavian and Western European countries and low death rates in Southern and Eastern European countries, Japan and in the developing countries of Asia, Africa and Latin America. From this distribution of CHD death throughout the world it may be inferred that there is a positive correlation between economic prosperity and CHD death.

1.6.2. *Socio-economic status and coronary heart disease within populations*

Studies in developing countries like Mexico, Guatemala, Nigeria, India and Indonesia showed a positive relationship between SES and the prevalence of atherosclerosis. In these countries atherosclerosis is rare in the poor but in the affluent reaches the level observed in the developed countries. The results of these studies have been summarized excellently by KATZ et al. (1958), STAMLER et al. (1970) and GROEN (1976).

Autopsy studies in Israel revealed a death rate from myocardial infarction twice as high in Jews, who emigrated from Europe or America to Israel compared to Jewish immigrants from Asia and Africa (GROEN and DRORY, 1967). Similar results were found in comparisons between Japanese in Japan, Hawaii and the USA and between Italians in Italy and in the USA (STAMLER et al., 1970).

During World War II CHD death decreased in Great Britain, The Netherlands, Finland, Sweden, Norway and Denmark (KEYS, 1975). The decrease in CHD death during the war was paralleled by severe restrictions of food together with other changes in the way of life.

The results of studies from the developing countries, immigrant studies and the observed decrease in CHD death during World War II strongly indicate that environmental factors are responsible for the difference in the distribution of CHD death throughout the world.

The positive relationship between SES and the prevalence of atherosclerosis observed in the developing countries cannot be corroborated by recent findings in the developed countries. At the beginning of this century a positive relationship between SES and CHD was present in England and Wales. At that time this relationship could not be substantiated in the USA (ANTONOVSKY, 1967).

Before reviewing changes in the relationship between SES and CHD in the Western countries methodological problems related to SES and diagnostic problems regarding CHD will be discussed.

Defining social class is a difficult task because: 'There are almost as many definitions as there are sociologists' (SUSSER and WATSON, 1975). Prestige and power are the major components of all types of social stratifications. A social class can be defined as: 'A set of families of about equal prestige who are or would be 'acceptable' to one another for social interaction that is regarded as symbolic of equality' (LEHMAN, 1967). Several studies have shown that occupation is the best single indicator of social class (LEHMAN, 1967). Using occupation as an indicator of social class is of course a simplification, because someone's prestige does not only depend on his occupation. However, information about occupation can be obtained easily and can be used as a basis for ranking populations by social class.

In order to establish relationships between social class and cardio-vascular diseases (CVD) a differentiation in myocardial infarction, angina pectoris, other myocardial degeneration, vascular lesions of nervous systems, hypertensive heart disease and chronic rheumatic heart disease is necessary. It is possible that social class trends in these diseases are blurred out when all cardio-vascular diseases are taken together.

Several extensive reviews concerning the relationship between social class and CVD in the Western countries have appeared in the literature since 1967 (LEHMAN, 1967; MARKS, 1967; ANTONOVSKY, 1968; JENKINS, 1971; GROEN, 1976). At first sight the reviewed studies show a confusing picture. LEHMAN (1967) has made an attempt to clarify this picture by distinguishing between studies based on:

- ecological approach
- organizational approach
- community, regional or nationwide approach.

In the ecological approach relationships between collective properties of groups are studied. The organizational approach refers to studies carried out in an organizational framework such as companies, factories, etc. The third category consists of studies carried out in communities, regions or nations.

Studies in the USA based on the ecological approach tended to show an inverse relationship between social class and CHD (LEHMAN, 1967; MARKS, 1967; ANTONOVSKY, 1968).

Inferences from such studies should be drawn very carefully owing to problems regarding the so-called 'ecological fallacy' (SUSSER and WATSON, 1975). This means that results from ecological studies are interpreted as direct associations between attributes of individuals. Such studies also raise questions regarding the accuracy of the data used. Information obtained from death certificates and census tracts is used for this kind of investigation. Concerning death no differentiation is made between the first major coronary event and final CHD death. Information from census tracts is not always up-to-date, so information about someone's recent occupation may be lacking. Therefore

results from such studies should be viewed with suspicion.

An inverse relationship between social class and CHD was also found in studies based on the organizational approach (LEHMAN, 1967; MARKS, 1967; ANTONOVSKY, 1968). A drawback to these studies is the narrow span (the distance) between the social classes within these institutions. This may influence the relationship between social class and CHD (LEHMAN, 1967; SUSSER and WATSON, 1975).

Studies, carried out in the USA and in the UK based on the community, regional or nationwide approach showed different results regarding the relationships between social class and CHD. No clear picture emerged from such studies in the USA (MARKS, 1967; ANTONOVSKY, 1968). The relationships between social class and CHD were generally weak and inconsistent. The only exception was the repeatedly shown difference in CHD death between rural and urban men (SYME et al., 1967; MARKS, 1967; ANTONOVSKY, 1968). CHD mortality rates were significantly lower in rural men compared to their urban counterparts. In the UK a similar difference in CHD mortality rate between rural and urban men was found (MORRIS, 1959). In The Netherlands the lowest CHD mortality rates were observed in villages with less than 5,000 inhabitants and the highest CHD mortality rates were noted in cities with 100,000 to 500,000 inhabitants (DE HAAS, 1971).

Analyses concerning the relationships between social class and CVD in the UK in men showed a strong positive relationship between social class and CHD and between social class and angina pectoris in 1910–12, 1921–23, 1930–32 and 1949–53 (ANTONOVSKY, 1968). However, the ratio of CHD mortality of the highest (I) to the lowest (V) social class declined from 3.5:1 in 1930–32 to 1.65:1 in 1949–53. Among married women this positive relationship was also present in 1930–32 but had disappeared completely by 1949–53. Age-specific analysis of the 1949–53 mortality rates for the male population showed a strong positive relationship between social class and CHD for men aged 55–64. To a lesser extent this relationship was also present in men aged 45–54 years. No relationship could be observed in men aged 35–44 years, and in the young men, aged 25–34 years, an inverse relationship was noted. Similar analyses have been carried out on data from the USA. Slight positive relationships were present in the older men, aged 45–74, and an inverse relationship was observed in men aged 35–44 years. In the youngest men, aged 25–34 years, death rates did not differ very much in social classes I-IV but were substantially higher in social class V (ANTONOVSKY, 1968).

These results suggest that changes have occurred in the relationship between social class and CHD death since the beginning of the century. In the UK the strong positive relationship between social class and CHD present up to 1930 diminished in the next 20 years. Age-specific analyses of the 1949–53 mortality data showed a change from a positive to a slightly inverse relationship in men with decreasing age. Similar results were obtained in the USA. However, there are some marked differences between the results from the USA and the UK. The positive relationship between social class and CHD in older men is

less pronounced in the USA than in the UK and the inverse relationship between social class and CHD is present in the USA in men aged 35–44 years and in the UK in men aged 25–34 years.

Of the remaining cardio-vascular diseases, the group of other myocardial degenerations showed a consistent inverse relationship with social class. Vascular lesions of the nervous system and hypertensive heart disease did not show consistent relationships with social class (ANTONOVSKY, 1968).

In some studies education was used as an indicator for social class. The results of these studies were conflicting (MARKS, 1967). In the Western Electric Company Study an inverse relationship between education and myocardial infarction or CHD death was found. A tendency to a positive relationship was present with respect to angina pectoris (SHEKELLE et al., 1969). The Western Collaborative Group Study showed an inverse relationship between education and CHD (ROSENMAN et al., 1975; ROSENMAN et al., 1976).

General conclusions about the relationship between social class and CHD in the Western countries are difficult to draw. Judged from a historical perspective not all the studies in the USA showed a consistent relationship between social class and CHD. More recent studies tended towards an inverse relationship. Studies in the UK showed a decrease in the strong positive relationship between social class and CHD in the period between 1930–32 and 1949–53. Age-specific analyses of the British data from 1949–53 showed a change from a positive to an inverse relationship with decreasing age. These data suggest that trends observed in the USA also occurred in the UK, although at a later date. The observed changes in the relationship between social class and CHD ran parallel with marked changes in these Western societies. With increasing affluence more and more people were offered the possibility of enjoying the pleasures of the 20th century, e.g. cars, television, cigarettes and a diet rich in energy, saturated fats, dietary cholesterol, animal proteins and sugar. These changes in the mode of life are a very probable explanation for the fact that in Western countries high CHD death rates no longer appear only in the highest social classes. Nowadays there is even a tendency towards an inverse relationship between social class and CHD. This may be explained by the fact that people from the highest social classes are more sensitive to preventive measures regarding CHD. Another possible explanation may be that people of the highest social classes utilize medical care more frequently than people from the lower social classes (SUSSER and WATSON, 1975).

1.6.3. *Socio-economic status and major CHD risk factors*

The relationships between SES and blood pressure, cigarette smoking and total cholesterol are not the same for each of these parameters. Differences in blood pressure levels between different social classes were small and inconsistent (STAMLER, 1967; SHEKELLE et al., 1969). Clear-cut inverse relationships between social classes and the number of cigarette smokers have been shown in several studies (STAMLER, 1967; SHEKELLE et al., 1969; HOLME et al., 1976;

DEBAKKER et al., 1977). With respect to total cholesterol the picture is somewhat confusing. Studies in the USA did not show a relationship between social class and total cholesterol level except for the difference in total cholesterol level between rural and urban men (MARKS, 1967; STAMLER, 1967; TAYLOR et al., 1967; SHEKELLE et al., 1969; CASSEL et al., 1971). Rural men had significantly lower total cholesterol levels than urban men. This observation was consistent with the observed difference in CHD mortality between rural and urban men (MARKS, 1967; CASSEL et al., 1971). Studies in New Zealand, USSR, England and Belgium, carried out in industrial populations, showed a positive relationship between social class and total cholesterol level (MARKS, 1967; HOWELL, 1970; DEBAKKER, 1977). An inverse relationship between social class and total cholesterol was found in Oslo men (HOLME et al., 1976).

In the majority of the studies reviewed, the relationship between social class and the major CHD risk factors was absent for blood pressure, inverse for cigarette smoking and positive for total cholesterol. Hence, differences in multiple risk score between social classes were generally small and this might be an explanation for the absence of a relationship between social class and CHD death in the Western countries. However, one study carried out in Oslo men aged 40–49, showed an inverse relationship between social class and all major risk factors (HOLME et al., 1976). This relationship was very pronounced for the number of cigarette smokers and the total cholesterol level. The multiple risk score of the lowest social class was more than double compared to the highest social class. In addition, fairly good agreement was found in various occupational groups, between the multiple risk factor score and the 1970 CHD mortality data of Norway (HOLME et al., 1977). If this study, carried out in a general population of males, is indicative of future developments it may be extrapolated that the inverse relationship between social class and CHD death, already observed in the USA, may also be expected in Europe in the foreseeable future.

1.6.4. *Socio-economic status and physical activity*

Occupation is the most commonly used indicator for social class. Occupation is also used as an indicator for physical activity. Relationships between occupation and risk factors and between occupation and CHD death have to be interpreted carefully, because occupation is an indicator for the mode of life and not for physical activity only. These problems have been reviewed extensively by TAYLOR (1967) and KEYS (1975).

In several prevalence studies an inverse relationship between on-the-job physical activity and CHD death has been observed (MORRIS, 1959; TAYLOR, 1967; CASSEL et al., 1971; KEYS, 1975). However, this relationship could not be substantiated in incidence studies (TAYLOR, 1967; KEYS, 1970; CASSEL et al., 1971). This difference in results between prevalence and incidence studies may be explained by the so-called 'selective bias' in jobs. People who had experienced angina pectoris, hypertension or dyspnoea before the start of the study, were generally transferred to less physically active jobs (KEYS, 1975).

In the European cohorts of the Seven Countries Study information was available on both physical activity and social class, based on occupational information (KEYS et al., 1967b). A strong inverse relationship between physical activity and the prevalence of obesity, hypertension and hypercholesterolaemia was observed when differences in social class were not taken into account. These relationships were much less marked when allowances for differences in social class were made. It cannot be concluded from the data available that a high level of on-the-job physical activity protects against CHD. The negative results concerning the relationship between physical activity and CHD may be caused by the fact that only on-the-job physical activity is taken into account. In the Evans County Study it was shown that the prevalence of CHD in white non-farmers with a high level of physical activity both on-the-job and during leisure time was considerably lower than in the less active men (CASSEL et al., 1971). In this study the incidence of CHD in farmers was lower than in non-farmers. On the basis of these findings CASSEL and his collaborators drew the conclusion that: 'Sustained physical activity above a certain critical threshold value was protective against CHD'. This conclusion was based on prevalence data, suffering from the already mentioned limitations, so caution is needed. A protective influence of vigorous exercise in leisure time on CHD was shown in a case-control study reported by MORRIS et al. (1973). The results of these two studies are encouraging but a protective influence of physical activity on CHD can only be established by prospective studies and by intervention trials in order to anticipate the influence of selection (TAYLOR, 1967).

1.6.5. *Socio-economic status and obesity*

A positive relationship between affluence and body weight, skinfold thickness and the prevalence of obesity has been observed in the developing countries (STUNKARD, 1975). In the Western countries results of studies about the relationship between social class and obesity in men are conflicting (SHEKELLE et al., 1969; ABRAHAM et al., 1975; STUNKARD, 1975; DEBAKKER, 1977). Selected groups were studied in the majority of these investigations. However, community studies, including a wide span of social classes, showed a strong positive relationship between social class and obesity (KEYS et al., 1967b; HOLME et al., 1976; GARN et al., 1977). A very consistent inverse relationship between social class and obesity was observed in women (ABRAHAM et al., 1975; STUNKARD, 1975; GARN et al., 1977).

Studies in children generally confirmed the trends seen in adults. A positive relationship between the level of acculturation and prevalence of obesity was observed in Navajo Indian children (CARB et al., 1975). The Ten State Nutrition Survey in the USA was focussed on the less privileged groups (GARN et al., 1975a). In this study higher skinfold values were found in children from families with medium per capita income levels compared to children from families with per capita income levels below 'poverty level' (GARN et al., 1975a). These two studies showed a positive relationship between affluence and prevalence of obesity in less privileged groups. In the more well-to-do a consistent-

ly strong inverse relationship between social class and the prevalence of obesity was found in girls (STUNKARD et al., 1972; STUNKARD, 1975). Although to a lesser extent, a similar relationship was noted in boys (WHITELAW, 1971; STUNKARD et al., 1972; STUNKARD, 1975). The inverse relationship between social class and the prevalence of obesity in girls is fully consistent with the results found in women. The tendency towards an inverse relationship in boys is in contrast to the positive relationship observed in men. It is impossible to explain this difference, since the results of the reviewed investigations were collected in cross-sectional studies. Longitudinal studies are needed in order to explain the observed difference between boys and men in the relationship between social class and the prevalence of obesity.

Different trends in the relationship between social class and the prevalence of obesity in children from less privileged and more well-to-do families strongly indicate the influence of environmental factors on the prevalence of obesity. The influence of environmental factors on the etiology of obesity is also substantiated by the results of a study published by GARN et al. (1976). In this study correlations for biological parent-child pairs and for adoptive parent-child pairs concerning height, weight and skinfold thickness were in the same order of magnitude. These results emphasize the importance of environmental factors in the etiology of obesity.

Geographic differences in CHD death and the relationships between socio-economic status and CHD death within countries strongly support the importance of environmental factors in the etiology of CHD. Relationships between SES and CHD risk factors are also consistent with this hypothesis. Changes in CHD mortality patterns show that nowadays in the Western countries CHD death rates are high in all social classes. Recent studies showed an inverse relationship between social class and the major CHD risk factors. From these data it may be extrapolated that in the foreseeable future the highest CHD death rates may be expected in the lowest social classes.

1.7. FAMILY STUDIES

Many studies suggest that coronary heart disease aggregates in families (for review see ARO, 1973). This invariably leads to discussions about heredity as one of the factors involved in the pathogenesis of atherosclerosis, but evidence to substantiate a pure genetic component leaves much to be desired (PHILLIPS et al., 1974). Apart from the report on familial patterns in CHD complications in the Tecumseh Study (DEUTSCHER et al., 1970), investigations studying this relationship have so far relied upon verbal information acquired from relatives of cases and from controls, which in turn have often been selected in a way open to criticism (CARTER, 1976). Nevertheless, all studies were consistent in the hypothesis that CHD aggregates in families, although genetic predisposition and environmental convergency must both have contributed

to the observed results.

A powerful tool in assessing the quantitative contribution of heredity and environment to aggregation may be provided by the study of twins. This requires a thorough evaluation of concordance rates in monozygotic and dizygotic twins with respect to CHD complications and risk factors, together with a comparison of the proportion affected in the general population. Results reported from the 2 most extensive twin registers are regarded as being conflicting (CARTER, 1976), on the one hand because of limited validity of methods used for ascertainment of illness and cause of death, on the other hand because of questionable comparability with the general population. Nevertheless, both twin series provided evidence for some degree of genetic determination of ischaemic heart disease because monozygotic twins were more often affected concurrently than dizygotic (CEDERLÖF et al., 1971). In a first attempt to quantify the contribution of genetics to the observed variability of CHD risk factors, FEINLEIB (1976) reported highly significant heritability indices (= proportion of total variation attributable to heredity) for a great number of risk factors in twins, including blood pressure and triglycerides. The highest heritability index observed was for attained standing height. No significant genetic component was detected in the variation of plasma total cholesterol nor its distribution among the lipoprotein sub-classes. It was, however, concluded that the sample of the National Heart, Lung and Blood Institute Twin Register used would have been too small to detect heritability for cholesterol sub-fractions if relatively rare genes were involved.

It is biologically doubtful that abnormalities in the variety of major risk factors could originate from defects in any single gene (HATCH, 1974). Many enzymes and body proteins are polymorphic, due to variation in information carried in multiple allelic or corresponding genes having the same (synthetic) function and the same or slightly different base sequence. This polymorphism is regarded as being the reason for differences among humans in their response to a given environment. In the case of, for instance, the regulation of the serum total cholesterol level the primary genetic determinant can be considered to be a number of genes affecting the absorption, synthesis, transport and catabolism of cholesterol in the various tissues of the body, many of these genes being subject to variation in efficiency. This complex mechanism, called 'polygenic' control, results in a continuous distribution of magnitude of such characteristics in a population, even under environmentally rigidly controlled conditions (KEYS, 1967).

The classic example to illustrate polygenic inheritance is standing height, which is predominantly under genetic control even in those instances where malnutrition interfered in both generations (MUELLER and TITCOMB, 1977). That the same pattern observed for standing height was also followed by serum total cholesterol, relative body weight, systolic blood pressure and glucose tolerance has been shown by the Tecumseh Study (DEUTSCHER et al., 1966). Some of these findings have since been corroborated by studies of blood pressure in children (ZINNER et al., 1971) and in infants (HENNEKENS et al.,

1977) and of serum total cholesterol in schoolchildren (GODFREY et al., 1972). The subject of parent-child resemblance for standing height and body weight among schoolchildren was reviewed by MUELLER (1976) who derived a mean figure for the heritability of stature by the mid-parental-child regression of about 50%. It is important to note here that all these studies reported the effect of both shared genes and shared environment. If one of these components is not shared, no parental-child resemblance is revealed, as shown for blood pressure in adopted children by BIRON et al. (1975) and for blood lipids including cholesterol, and uric acid by BRUNNER et al. (1971) in parents and children living in different collective settlements in Israel. With respect to stature, MALINA et al. (1976) speculate that greater step-parentage among black fathers may have caused the observed lower heritability index in Blacks compared to Whites in their samples. Furthermore, the resemblance of CHD risk factors among spouses was either absent (JOHNSON et al., 1965) or was attributed to the influence of progressive duration of common marital environment and/or assortative mating (SACKETT et al., 1975).

It may be inferred that concordance in families of coronary heart disease complications has to be attributed to both shared genes and common environment. Clearly, whether or not a certain physiological state might be attained will primarily be determined by inheritance but the environment will moderate the extent to which the genetic make-up can express its potential.

The repeatedly shown familial aggregation of coronary heart disease risk factors forms a logical transition from the genetic entities of the hyperlipoproteinaemias (FREDRICKSON et al., 1967) and their relationship to atherosclerosis, to the subject of familial aggregation of the disease itself (EPSTEIN, 1976). The importance of the family approach relates to the possibility of detection as early in life as possible of those who are more likely to develop into high-risk individuals, to the possibility of detecting not only susceptible individuals but also high-risk families as the target for prevention and to the possibility of indentifying those environmental factors powerful enough to overcome genetic predisposition. A high degree of familial resemblance in CHD risk factors will result in a high concordance of the disease but it will also permit predicting, from risk assessment in the parents, the probabilities for their children to grow up into low intermediate or high-risk individuals (GODFREY et al., 1972). A further disentangling of the parent-child situation with respect to nature and nurture will be needed in order to increase our knowledge of preventive strategy.

1.8. EPILOGUE

There is hardly any difference in opinion that only primary prevention can favourably alter, to a major extent, the severe burden of premature atherosclerotic diseases upon the health of adult populations in industrialized countries. Primary prevention must be conceived in this context as all those

measures which delay, arrest or, ideally, avoid the initial events in atherogenesis which progress to the abnormal state, e.g. the complications causing lesions. The considerable evidence relating the mechanism of atherosclerosis to its risk factors inevitably intrudes the application of measures aimed at the reduction of those risk factors which are amendable to modification. The cause of high risk factor levels appears to be largely environmental and rooted in the modern, affluent way of life. The reasonable hope of conferring benefit to the community by well-implemented recommendations intended to reduce the generally elevated risk factor levels in the populations of industrialized countries, have lead many authoritative boards from these countries to recommend modification of the diet in the whole community. The inclusion of children into these recommendations is justified because, in addition to the already mentioned recognition that the elevated serum total cholesterol levels seem to be the single characteristic of epidemic occurrence in Western schoolchildren populations, the education to an affluent way of life by family, school and community starts in childhood. As a consequence, the deleterious effect of risk-promoting factors is present not only in adult life but originates in childhood.

The present investigation was initiated to describe the situation with respect to the prevalence of hypercholesterolaemia and obesity in selected schoolchildren populations in The Netherlands. In these children, the food intake was also estimated, in order to gain insight into the relationship between dietary factors and these risk factors. It was hoped that the results of this study would point to preventive measures, applicable to the situation found to be present in children. The fact that this investigation was carried out by nutritionists explains the main emphasis put upon the nutritional aspects of the ascertained health status with respect to the possible development of future disease in these Dutch schoolchildren.

2. METHODS

2.1. STUDY DESIGN

In The Netherlands fairly distinct differences are present in CHD mortality patterns between the different provinces (VAN DEN BERG et al., 1976). The highest CHD mortality rates were reported for a Southern province, Limburg and for an Eastern province, Overijssel. The South-western province, Zeeland, showed the lowest CHD mortality rate. In the remaining provinces intermediate CHD mortality rates were observed. These differences in CHD mortality rates may be caused by socio-cultural differences between the various provinces in The Netherlands.

The objective of this study was to investigate whether differences in food intake patterns between schoolchildren from different regions in The Netherlands, which were known to exist (VAN SCHAIK, 1962; VAN SCHAIK and DRENTH, 1968; VAN SCHAIK and KENTER, 1972), would lead to differences in nutritional status, measured by anthropometry and serum lipids. The study was carried out using three selected schoolchildren populations from towns in a Northern, Eastern and Southern region (Fig. 1). The Western region was excluded from the present study because in 1974 a WHO pilot study into the level of CHD risk factors was carried out in Westland schoolchildren (UPPAL, 1974).

In all the selected schoolchildren the nutritional status was thoroughly

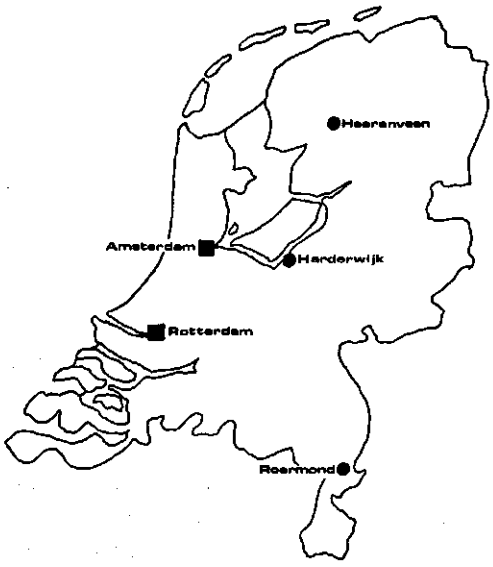

FIG. 1. Geographic topography of selected towns in The Netherlands.

evaluated by anthropometric measures and serum lipids. In a sub-sample of the children the food intake was estimated. In these children relationships between food intake, body fatness and serum lipids could be studied. In another sub-sample of the children the parents were also invited to participate in the investigation. Parent-child relationships concerning body composition and serum lipids could be analysed in this sub-sample. These relationships may provide information about the determinants of risk factors in schoolchildren and about the meaning of risk factor levels in youth with respect to risk factor levels in the future.

2.2. Selection of schoolchildren populations

The schoolchildren populations were selected according to the following procedure:

- selection of towns.
- selection of schools.

Selection of towns. In the three regions the provinces of Friesland, Gueldern (especially the North-west Veluwe) and Limburg were chosen because it could be expected that the differences in food intake pattern between schoolchildren from these provinces would be relatively large (Van Schaik, 1962; Van Schaik and Drenth, 1968; Van Schaik and Kenter, 1972).

In the three provinces each town with 25–40,000 inhabitants was considered for selection. From all potentially available towns, the conformity with the province at large on account of some demographic data such as socio-economic status and mobility of the population from the 1971 census, was examined. Finally a priority list of towns was made, based on the degree of resemblance with the province at large. Whether the first or the second town on this list was chosen depended on the co-operation with the local school health organization. In the provinces of Friesland and Gueldern the surveys were carried out in the first towns on the list namely Heerenveen and Harderwijk (Fig. 1). In Limburg the second town, Roermond, was chosen because in the first town, Weert, the position of the director of the local school health organization was vacant during the period in which the survey was planned. Table 11 gives some demographic data of each participating town and its province.

Selection of schools. In each town the survey was carried out in three nursery schools and four primary schools. The number of children aimed at was at least 700. The schools were selected by the director of the school health organization. Only those schools having a majority of autochthonous children were chosen. A lot of attention was paid to this criterion for selection because differences between regions can only be observed in autochthonous children. Attention was also paid to the representativeness of the selected children compared to all children available for the survey in each town, concerning the socio-economic status of their parents.

TABLE 11. Percentual distribution of the male occupational population according to educational level, occupational position and period of settlement in each project town and its province*.

Category	HVN	Friesland	RMD	Limburg	HWK	Gueldern
Educational level						
Elementary	36.3	31.6	28.0	30.5	23.8	28.0
Low occupational	8.9	9.0	8.7	9.2	8.2	8.3
Adv. elementary	36.5	34.3	33.6	34.8	37.1	34.6
Secondary	7.6	8.0	9.4	7.7	8.7	8.4
Higher	6.5	6.1	9.3	7.4	7.3	7.4
Still studying	0.4	0.5	1.0	1.1	0.6	0.9
Unknown	3.9	10.5	10.0	9.3	14.3	12.4
Occupational position						
Self-employed	17.0	19.9	12.5	13.3	12.7	15.2
Co-operating family member	1.0	1.3	0.5	1.0	0.7	1.1
Civil servant	28.4	24.7	37.1	29.6	37.8	31.4
Labourer	51.9	50.4	47.8	54.2	47.8	51.4
Temp. unemployed	1.6	1.6	2.1	1.9	1.0	0.9
Period of settlement						
Born in town/prov.	47.7	52.0	47.4	53.5	40.6	53.3
Before 1960	22.4	22.2	23.7	21.8	17.8	20.0
After 1960	29.9	25.8	28.9	24.8	41.6	26.8
Number of inhabitants	33,750	525,915	36,670	1,008,800	25,595	1,525,425
Number of occupational male population	8,215	134,835	9,850	264,405	6,795	409,895

* Source: Selected data per town or province. 14th general census, February 28, 1971. Central Bureau of Statistics, Voorburg, 1977.

2.3. GENERAL QUESTIONNAIRE

A general questionnaire concerning demographic data of the family was filled in by the parents of the children. In Heerenveen this questionnaire was limited to information concerning the educational level and occupation of both parents. In Roermond and Harderwijk the general questionnaire was extended with additional questions concerning socio-economic status of the family and with questions about the native town of the parents and their children in order to get a more detailed description of the surveyed population.

The socio-economic status of the family was estimated according to the Attwood statistics method frequently used in The Netherlands. This classification is based on the father's occupation in the first place. The final allocation to a certain social class was also dependent on the following occupation-related information:

- kind of industry
- wage-earning or self-employed
- non-executive or executive position; if executive, responsible for how many people
- occupational education
- father's age

2.4. Anthropometric methods

2.4.1. *Protocols*

Standing height (nearest 0.1 cm). A microtoise Nr 4116 (Stanley Mabo, France) was used during the Heerenveen project. The correct height of fixation to the wall of the instrument was checked daily before measurements were performed. In the Roermond and Harderwijk projects a height board, connected to an automatic registration unit (Nutrition Group, Health Education Project, University of Nijmegen) was used. This instrument was calibrated before each measuring session.

On examination the child stood erect, with his back firmly against the wall or backboard, his chin parallel to the floor, heels together, and his feet forming an angle of 45°.

Body weight (nearest 0.1 kg). This was measured during the Heerenveen project using a beam balance metric scale (Physicians scale Seca, obtained from Laméris, Utrecht). The scale was calibrated daily. An electronic scale was used during the Roermond and Harderwijk projects connected to the automatic registration unit. This instrument was also calibrated daily.

The child stood still in the centre of the platform during examination. No correction was made for undergarment worn.

Knee width (nearest 0.1 cm). This was measured during the Heerenveen project using a Martin type sliding caliper (Hegner, Switzerland) with adjustable 2 cm wide stainless steel plates attached to the bits. A Harpenden Anthropometer (Hegner, Switzerland) equipped with straight branches, with 1 cm wide stainless steel plates attached to the bits, was used in the Roermond and Harderwijk projects. The Harpenden Anthropometer was connected to the automatic registration unit. The apparatus was checked daily for correct performance of measurements.

During examination the child was asked to bend his knee slightly. The measurement was taken with the branches of the device placed firmly against the medial and lateral condyles of the tibiae at the height of the apex of the fibula head (bicondiloid tibia). Measurements of the left and right knee were made and the sum of both results was used (further referred to as *knee widths*).

Upper arm circumference (nearest 0.1 cm). In Heerenveen this measurement

was performed at the left side of the body. The midpoint between the acromion and olecranon processes was measured with a steel tape (Circumeter, Martin, Germany) and marked on the skin of the lateral surface of the arm. The circumference was measured at the marked point with the steel tape applying compression from the circumeter, while the child's arm hung loosely at his side. In Roermond and Harderwijk the measurement was performed in the same way with the measuring device connected to the automatic registration unit. The measuring device was checked daily.

The mid-arm muscle circumference was calculated from the upper arm circumference, taking the skinfold thicknesses at two sites (biceps and triceps) of the arm into account, by JELLIFFE's (1966) formula. This derivation was used for further calculations (further referred to as *arm muscle*).

Skinfold thickness (nearest 0.1 mm). Skinfold thicknesses were measured at the left side of the body using a Holtain skinfold caliper (Hegner, Switzerland). The apparatus was attached to the registration unit of the Nijmegen University during the measurements in Roermond and Harderwijk. The calipers were calibrated daily. The measurements were done in duplicate. If the duplicates differed more than 10% of the lowest value, a third measurement was performed. Then, the 2 closest readings of 3 were recorded.

The child being measured stood erect and relaxed. A skinfold was formed by picking up a fold of skin and its attached subcutaneous tissue firmly between the thumb and finger(s) of the left hand and by pinching it away from the underlying muscle. With the right hand, the jaws of the caliper were applied to the skinfold just beside or below the pinching point and the grip of the right hand was relaxed so that the caliper jaws could exert their full pressure. The left hand maintaining its grip on the skinfold throughout the measurement.

Measurements were performed at 4 sites. The triceps skinfold was measured over the posterior surface of the triceps muscle with the caliper jaws placed at the level marked during the arm circumference measurement. At the same level the biceps skinfold was measured over the anterior surface of the biceps muscle. During the measurement of the subscapular skinfold, the caliper was applied just below the inferior angle of the left scapula with the fold slightly inclined in the direction of the lateral border of the scapula, following the natural cleavage of the skin. The suprailiac skinfold was pinched just above the iliac crest, with the fold along its superior border. The jaws of the caliper were applied in the mid-axillary line.

2.4.2. *Adjustement of results to a joint level.*

The measurements taken by the different investigators were corrected before analysis for their mean differences which occurred compared to those obtained by the investigator who measured the children from Roermond. For the results of measurements obtained in children from Heerenveen, this implied first the correction to a joint level comparable to the level of measurement by one single investigator. This was achieved by correcting all results obtained by the others

for their observed mean differences compared to those obtained by the specific investigator from Heerenveen. In addition, this specific investigator also took duplicate measurements in 48 Roermond children during one of the initial and one of the last weeks of the Roermond project. Mean differences in results of measurement which existed in this comparison of the Heerenveen investigator and the Roermond investigator were used to correct the joint level of measurement in Heerenveen children to the level of measurement in Roermond children. In the same way, a comparison was made between results obtained by the Roermond investigator and the Harderwijk investigator. The investigator who had taken all measurements in Roermond children performed duplicate measurements in 42 Harderwijk children, equally divided over one of the initial and one of the last weeks of measurement in the Harderwijk project. Mean differences in results obtained between the Harderwijk and Roermond investigators were used to correct the level of measurement in Harderwijk children to that in Roermond children. Table 12 shows the mean differences observed if results were compared to the Roermond investigator.

2.4.3. *Quality of measurements*

The results of measurements obtained by the investigators of the different projects in the same children could be taken as an indication of repeatability of measurements by different observers. In addition to the measurements performed by the regular investigator of the Roermond project, one of the investigators of the Heerenveen project performed the same measurements in 48 children from Roermond. Table 13 gives the results of the comparison between measurements obtained by both observers.

The same comparison was made between measurements obtained by the regular investigators of the Roermond and Harderwijk project in a total of 42 Harderwijk children. Table 14 gives the results of this comparison.

In addition to the analysis of repeatability in results obtained by two different investigators for the various measurements, the same analysis could be made

TABLE 12. Mean differences observed in results of specified measurements in the comparison of investigators taking measurements in Heerenveen and Harderwijk children, and the investigator taking measurements in Roermond children.

Measurement	Heerenveen project Investigator						Harderwijk project
	1	2	3	4	5	6	
Knee widths (cm)	−1.1	−1.1	−1.3	−1.2	−1.1	−1.2	−0.6
Arm circumference (cm)	+0.5	+0.3	+0.1	+0.1	+0.4	+0.3	+0.6
Biceps skinfold (mm)	−0.9	−1.0	−0.8	−0.9	−1.3	−0.6	−0.1
Triceps skinfold (mm)	+0.4	−0.3	−0.8	+0.6	+0.7	−0.2	−0.7
Subscapular skinfold (mm)	−0.3	−0.2	−0.1	−0.5	−0.2	−0.1	−0.1
Suprailiac skinfold (mm)	−0.3	+0.3	+0.4	+0.1	+0.6	+1.1	+2.3

TABLE 13. Comparison of measurement results obtained in 48 Roermond children by one of the Heerenveen investigators and the regular Roermond investigator.

Measurement	Mean results by investigator		Standard deviation between investigators	
	HVN	RMD	absolute	% of mean
Knee widths (cm)	14.7	15.9	0.46	3.0
Arm circumference (cm)	17.6	17.5	0.36	2.0
Biceps skinfold (mm)	4.4	5.2	0.65	13.5
Triceps skinfold (mm)	8.5	9.3	0.53	6.0
Subscapular skinfold (mm)	5.2	5.2	0.27	5.2
Suprailiac skinfold (mm)	7.9	7.5	1.08	14.1

TABLE 14. Comparison of measurement results obtained in 42 Harderwijk children by the regular investigators of the Roermond and Harderwijk projects.

Measurement	Mean results by investigator		Standard deviation between investigators	
	RMD	HWK	absolute	% of mean
Knee widths (cm)	15.8	16.3	0.27	1.7
Arm circumference (cm)	19.3	18.7	0.49	2.6
Biceps skinfold (mm)	6.1	6.1	0.43	7.0
Triceps skinfold (mm)	11.2	12.0	0.71	6.1
Subscapular skinfold (mm)	7.3	7.3	0.55	7.5
Suprailiac skinfold (mm)	11.6	9.2	1.53	14.7

TABLE 15. Comparison of results obtained by duplicate measurements of skinfold thicknesses by the same investigator during the 3 projects.

Project	Skinfold measurement (mm)	Mean results of measurements		Standard deviation between measurements	
		first	second	absolute	% of mean
HVN (n = 723)	Biceps	4.4	4.4	0.17	4.0
	Triceps	9.2	9.2	0.26	2.8
	Subscapular	5.5	5.5	0.17	3.1
	Suprailiac	8.5	8.5	0.28	3.3
RMD (n = 768)	Biceps	5.0	5.0	0.29	5.8
	Triceps	9.7	9.6	0.36	3.7
	Subscapular	6.1	6.1	0.27	4.5
	Suprailiac	9.6	9.6	0.51	5.3
HWK (n = 886)	Biceps	5.2	5.2	0.22	4.1
	Triceps	9.6	9.5	0.37	3.9
	Subscapular	6.1	6.1	0.25	4.1
	Suprailiac	10.0	10.0	0.32	3.2

of the repeatability of results obtained in the same children for the skinfold measurements only. The same statistics as given in Tables 13 and 14 were calculated for the duplicate results obtained by single investigators from the 3 projects in the measurement of skinfold thicknesses. The results are given in Table 15. It should be mentioned here that firstly, the duplicates taken in the analysis of differences between duplicate measurements in Heerenveen children were the mean results of the first measurements and the mean results of the second measurements taken by two investigators and secondly, that the results given in Table 15 were obtained after adjustment of all measurement results to the measurement level of the Roermond investigator.

Finally, a study was made of the effect of summation of results obtained for skinfold measurements in the 3 projects. The analysis pertained to the mean results of the first and second measurements, obtained by two investigators in Heerenveen children, and to the results after correction to the measurement level of the Roermond investigator, as described above in the analysis of repeatability of individual skinfold measurements by the same investigator.

The analysis proceeded in stages: First, according to British investigators (TANNER and WHITEHOUSE, 1975), the first measurements of the triceps and subscapular skinfold thicknesses and the second measurements at these sites were added together. Next, the results of the first and those of the second measurements at the suprailiac skinfold site were added to these sums (MAASER et al., 1972) and finally the same was done with respect to the biceps skinfold measurement (EDWARDS et al., 1955). Arbitrarily, the sums of the first and the sums of the second measurements were compared to each other in the analysis and in addition, the influence of sex and the level of body fatness of the investigated children on the measures of repeatability of measurement results was evaluated. Table 16 gives the results separately for the total group and for boys and

TABLE 16. Effect of summation of results of skinfold thickness measurements by project and sex on the comparison of duplicates obtained by the same investigators.

Project	Addition of skinfold	Total group			Boys			Girls		
		mean (mm)	s.d.		mean (mm)	s.d.		mean (mm)	s.d.	
			abs.	% of mean		abs.	% of mean		abs.	% of mean
HVN	tri + sca	14.7	0.31	2.1	13.4	0.27	2.0	16.2	0.31	2.1
	+ sil	23.2	0.41	1.8	21.1	0.35	1.7	25.6	0.47	1.8
	+ bic	27.6	0.42	1.5	24.9	0.37	1.5	30.5	0.48	1.6
RMD	tri + sca	15.7	0.45	2.8	14.4	0.41	2.8	17.3	0.49	2.9
	+ sil	25.3	0.66	2.6	22.8	0.59	2.6	28.2	0.75	2.7
	+ bic	30.3	0.67	2.2	27.2	0.59	2.2	33.8	0.76	2.2
HWK	tri + sca	15.7	0.45	2.9	14.4	0.40	2.7	17.1	0.50	2.9
	+ sil	25.7	0.54	2.1	24.0	0.50	2.1	27.6	0.59	2.2
	+ bic	30.9	0.59	1.9	28.8	0.55	1.9	33.3	0.63	1.9

girls from each project. It can be seen that the standard deviation between duplicates, expressed as the percentage of the mean results of each skinfold sum formed, diminished with the inclusion of each additional skinfold.

Table 17 gives results of the same analysis by level of body fatness. Groups differing in level of body fatness were formed on the basis of the results of the sum of the 4 skinfold thickness measurements as indicated by the categories in the Table.

The results of this analysis show again the diminishing of percentual standard deviation between duplicates achieved by the addition of each individual skinfold thickness. An additional feature appears in the comparison of the measure of repeatability by level of body fatness, which is shown in Fig. 2. The stepwise addition of skinfold measurements results also, in addition to the decrease of the percentual standard deviation between duplicates, in a loss of the apparent dependency of this statistic upon the level of body fatness. From Fig. 2 it may be seen that a clear increase in relative standard deviation by level of body fatness occurred for the combination of the triceps and subscapular skinfold

TABLE 17. Effect of summation of results of skinfold thickness measurements by project, sex and level of body fatness on the comparison of duplicates obtained by the same investigators.

Project	Sex	Category of skinfoldsum (mm)	n	Combinations of skinfolds					
				tri + sca		+ sil		+ bic	
				mean	s.d. %	mean	s.d. %	mean	s.d. %
HVN	Boys	≤ 20.0	142	10.0	1.7	14.9	1.5	27.4	1.4
		20.1–29.5	170	13.0	1.9	19.9	1.5	23.6	1.5
		≥ 29.6	76	20.6	2.1	35.4	1.6	42.1	1.3
	Girls	≤ 24.0	117	11.6	1.8	17.1	1.7	20.3	1.6
		24.1–37.0	146	15.9	1.9	24.6	1.5	29.4	1.6
		≥ 37.1	72	24.2	2.2	41.3	1.9	49.5	1.6
RMD	Boys	≤ 20.0	107	10.3	2.4	14.8	2.2	17.9	1.9
		20.1–29.5	198	13.1	2.4	19.7	2.3	23.7	2.0
		≥ 29.6	108	20.6	3.0	36.3	2.5	43.0	2.1
	Girls	≤ 24.0	76	11.8	2.6	17.1	2.1	20.8	1.9
		24.1–37.0	177	15.7	2.6	24.2	2.5	29.2	2.1
		≥ 37.1	102	24.2	2.9	43.4	2.6	51.4	2.2
HWK	Boys	≤ 20.0	55	9.1	2.6	15.4	1.8	18.4	1.9
		20.1–29.5	269	12.4	2.7	20.3	2.0	24.4	1.8
		≥ 29.6	147	20.0	2.6	34.1	2.0	40.7	1.9
	Girls	≤ 24.0	81	11.3	2.6	18.2	1.8	22.0	1.7
		24.1–37.0	233	15.3	2.6	24.5	2.0	29.6	1.7
		≥ 37.1	101	25.8	3.0	42.2	2.2	50.7	1.9

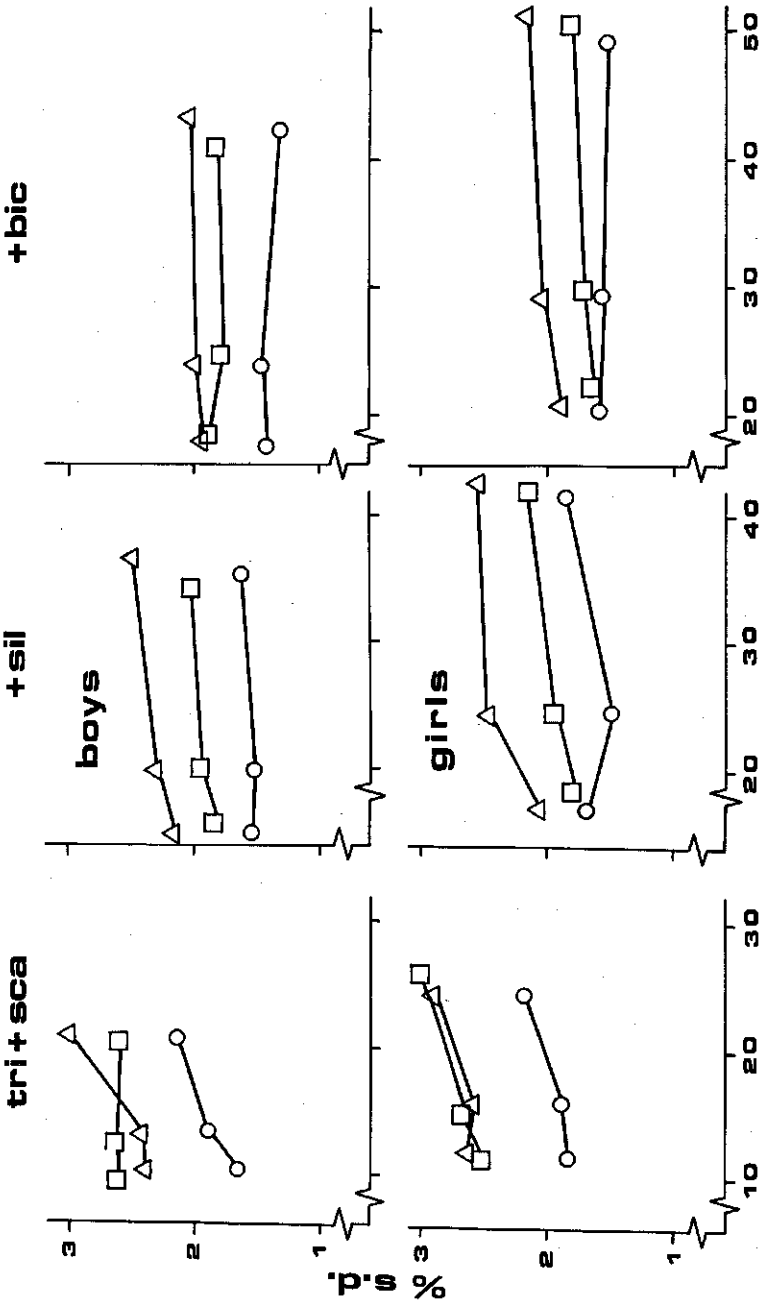

FIG. 2. The effect of summation of skinfold thickness measurement results upon repeatability by sex and level of body fatness.
○ = HVN; △ = RMD; □ = HWK.

thickness. This relationship disappeared almost completely with the addition of the results of both other skinfold measurements which suggests an independency of the level of measurement upon the repeatability of the measurement if the results of the 4 skinfold thicknesses were added. As a consequence, in all further computations the sum of mean results of duplicate measurements from all 4 skinfold thicknesses was used (in the following referred to as *skinfold sum*).

2.5. Blood determinations

In order to carry out as conveniently and quickly as possible some of the intended blood determinations, a specially equipped field laboratory was arranged during each project. The laboratory of the Department of Human Nutrition of the Agricultural University in Wageningen served as a standard of reference with regard to the methods and equipment to be used.

All blood determinations were carried out in the field laboratory during the execution of the Heerenveen project. These determinations were: blood haemoglobin, serum total cholesterol and serum triglycerides. In Roermond, the determination of the serum HDL-cholesterol was added to the protocol, and in the field laboratory the precipitation step belonging to this determination was carried out. The serum total cholesterol determination was performed in the home laboratory during the execution of this project. The blood haemoglobin and serum triglycerides determinations were carried out in the field laboratory during the Harderwijk project.

Serum preparation and handling. Blood obtained by venepuncture was allowed to clot at room temperature for at least 1 hour. In order to release the clot from the wall of the collecting tube, a thin glass rod was moved in a single sweep around the periphery of the tube. The clot was separated from the remaining serum by low speed centrifugation at room temperature for approximately 10 minutes. After centrifugation, the serum was drawn off by a Pasteur pipette with suction bulb. The serum was stored in stoppered Vacutainer tubes at 4 °C.

After the satisfactory completion of all determinations, the remaining serum specimen was transferred into glass ampoules. The ampoules were closed in a gas flame after removal of the air by nitrogen flow, after which they were stored at −20 °C.

2.5.1. *Protocols*

Haemoglobin determination (g/100 ml). The haemoglobin concentration was determined in whole blood as cyanomethaemoglobin according to the recommendations of the International Committee for Standardization in Haematology (Henry et al., 1974).

For purposes of calibration, haemoglobincyanide solutions were obtained from the National Institute for Public Health (RIV), Bilthoven. The potassium-hexacyanoferrate (III) colour reagent was prepared in the field laboratory in batches of 1 litre and kept in the dark. Concentrations were read from a Vitatron Digital Colorimeter in g Hb (Fe)/100 ml.

Concentration in g/100 ml, divided by 1.61 gives concentration in mmol/1.

Cholesterol determination (mg/100 ml). The method described by ABELL et al. (1952) was used as the reference method and concentrations were subsequently expressed as ABELL-values, although most of the serum specimens were assessed by a direct method using the reagent described by HUANG et al. (1961). ABELL's method was modified in our laboratory, so a description follows: 0.2 ml of serum (or 0.2 ml water as a blank) were added to 2 ml of 0.35 M KOH in ethanol in a teflon-stoppered evaporation tube of 15 ml and the mixture was incubated for at least 2 hours or overnight at 40°C. After cooling, 2 ml water and 4 ml petroleum-ether 60–80°C were added. After shaking and settling, 3 ml of the petroleum-ether layer were evaporated in a second tube under airstream at 80°C. The residue was dissolved in 2 ml chloroform and 2 ml of an ice-cold mixture, composed of 2 vol sulphuric acid and 40 vol acetic acid anhydride, were added. Absorbances were read at 616 nm in 1 cm cuvettes against the blank after colour-development at 30°C for exactly 25 min. Standards of pure cholesterol in chloroform were evaporated and used throughout the whole procedure.

Each series of determinations was calibrated on cholesterol standards at 3 different levels of concentrations. The calibration was checked by the results of 2 control sera in triplicate during the Heerenveen project and by the results of 2 control sera in duplicate during the Roermond and Harderwijk projects.

The cholesterol determination used for the assessment of specimens from the Heerenveen project was the manual ABELL method described above. During the execution of the Roermond and Harderwijk projects the cholesterol concentration in serum specimens was determined mechanically using the direct method of HUANG which was calibrated on serum standards, aliquots of which had been assessed for their cholesterol concentration by the manual ABELL method. By this calibration, observed concentrations were expressed as ABELL-values. A sample of about 10% unknown specimens drawn at random was also determined by the manual ABELL method.

A Meyvis Prestomatic Model 8 Automatic Chemical Analyser was used for the cholesterol determination in the mechanized version. The procedure consisted of the powerful mixing of 0.1 ml of a probe (or air as a blank) with 5 ml of an ice-cold mixture, composed of 1 vol sulphuric acid, 3 vol glacial acetic acid and 6 vol acetic acid anhydride, stabilized with 20 g/l of disodium sulphate. After incubation at 25°C for 15 min the absorbance was read at 627 nm in 1 cm cuvettes.

The calibration of this indirect procedure was checked during the Roermond project by the insertion of control sera on 3 levels in every tray of determinations

during each day's workload. During the Harderwijk project the number of determinations in 2 control sera in one day's workload was held constant to 4. Control limits for these sera had already been established and when the mean of 4 results of a control serum fell outside a 3-sigma interval, the whole day's workload was repeated. This also applied to the situation in which 2 successive mean values fell between the 2-sigma and 3-sigma limits, and to the situation in which 7 mean values in succession fell either all above or all below the mean result previously established. The internal quality control was also guarded by the evaluation of the range, or difference between the highest and lowest result in each pool. Control limits for this statistic had also been established before. The whole day's workload was repeated when a single range value felt outside the 3-sigma limits, when two successive range values of a control serum fell between the 2-sigma and 3-sigma limits or when 7 range values in succession of a control serum fell above the mean result previously established. These procedures of calibration control were adapted from recommendations as described in the LRC-manual (MANUAL, 1974).

Concentrations were calculated in mg/100 ml. Division of these values by 38.6 give concentrations in mmol/l.

Triglycerides determination (mg/100 ml). The concentration of triglycerides in serum was determined by the method described by SOLONI (1971). The procedure was as follows: Triglycerides were extracted from a 0.2 ml sample by the addition of 3 ml extraction solvent, composed of 2 : 3.5 (v/v) *n*-nonane : isopropanol, followed by the addition of 0.5 ml of 0.04 M sulphuric acid. For the blank determination, 0.2 ml water was used in the extraction step. After mixing vigorously for 15 sec and settling, 0.5 ml of the upper phase was pipetted into a second test tube, and 0.5 ml of a 0.1 M sodium ethoxide solution in isopropanol was added. The mixture was incubated for 15 min in a water bath at 60°C for transesterification. The glycerol formed was extracted by the addition of 1 ml of 0.8 M sulphuric acid and 2 ml of chloroform. After mixing vigorously for 15 sec and settling, 0.5 ml of the upper phase was transferred into a third test tube. The liberated glycerol was oxidized by the addition of 0.1 ml of a 0.02 M sodium metaperjodate solution. After exactly 10 min, 0.1 ml of a 0.2 M sodium arsenite solution was added. The colour reagent used was freshly made for each series of determinations by the addition of 3 to 5 drops of 2,4-pentanedione (acetylacetone) to a 3 M stock solution of ammonium acetate in water, adjusted to pH 6.0 with glacial acetic acid. Colour development occurred in a water bath of 60°C for 10 min after the addition of 2 ml of the freshly-made acetylacetone reagent. Absorbances were read at 405 nm in 1 cm cuvettes against the blank. Standards of pure triolein in extraction solvent were carried through the whole procedure and in the extraction step 0.2 ml of water was added for comparison with the procedure used for unknown samples and the blank.

Each series of determinations was calibrated on triolein standards at 3 different levels of concentration. All unknown specimens were determined in duplicate in one run. When results of unknown specimens differed more than 5%

from their lowest value, the specimen was re-analysed The calibration was checked by results of 2 control sera, each in triplicate. A specimen with a high, and a specimen with a low triglyceride concentration were also included in the next day's workload in order to check the level of the series of the previous day.

Concentrations were calculated in mg/100 ml. Division by 88.5 gives values in mmol/l.

HDL-cholesterol determination (mg/100 ml). The HDL-cholesterol determination was introduced in the Roermond project for the first time. The procedure consisted of two distinct steps: a precipitation step, performed on the day of blood collection and a determination step, performed in the laboratory of the Department. During the period August–December 1974 experience was gained with this determination. The precipitation step was based on the selective formation of an insoluble complex of the apo B-carrying lipoproteins with heparine and manganese (II)-ions (BURSTEIN and SAMAILLE, 1960). During the initial experiments, performed at room temperature mainly with sera from non-fasting adults, problems were encountered in obtaining complete precipitates. After reaching the final concentrations of reagents as described in the original procedure of BURSTEIN and SAMAILLE, a further precipitation could be observed following the addition of more heparine or manganese-ions. This was attributed to a possible marginal concentration of added reagents. Further experiments showed that the 1:1 dilution of the serum sample with isotonic saline before the addition of reagents prevented these problems. A further observation during the initial experiments was that the heparine and manganese-ions could be added in a single step without any loss of accuracy. Finally the following method for the precipitation step, to be carried out in the field laboratory, was accepted: Add 0.5 ml of a 0.15 M sodiumcholoride solusolution (saline) to 0.5 ml of the serum sample. Mix well. Add 0.1 ml of a mixture, composed of equal volumes of heparine 5,000 IU/ml (Leo Pharmaceuticals) and of 1 M manganese (II)-chloride, mix well and leave the mixture at room temperature for at least 15 min. Centrifuge the tubes at low-speed (approx. 1500 *g*) for 10 min. Decant the clear supernatant into analyser cups which, after labelling and closing, were stored at 4°C before analysis in the Departmental laboratory.

For the cholesterol determination step, a similar procedure as for the total cholesterol determination was adopted. Serum pools were prepared by pooling sera obtained from healthy volunteers having different levels of HDL-cholesterol. The precipitation step as described above was performed batchwise on these sera, and aliquots of the HDL-supernatants were ampouled in glass and stored at −20°C after removal of the air by nitrogen gas flow. Target values were assigned to the pool sera, designed for standard sera, using results of a number of analyses by ABELL's method. Further, the determination step was automated and the same apparatus configuration used as for the total cholesterol determination. However, because the colour-yield would have been too low for accurate measurements without modification, 0.2 ml of the superna-

tant was used for mixing and absorbances were read in 2 cm cuvettes. Each tray of determinations was calibrated by standard sera at 3 different levels. The calibration was checked by the frequent insertion in each day's workload of 2 control sera at different levels, prepared as described above for the standard sera.

The experience gained with the above-described methodology during the Roermond project was, however, not totally satisfactory. First, the carrying out of the precipitation step in the field laboratory on the day of blood collection meant a great deal of work which was unsatisfactory from an organizational point of view. Secondly, after a period of about 6 months the quality of the control and/or standard sera deteriorated, which was assumed from the shift in values of the control sera. As a consequence, the procedure and conditions of the precipitation step were studied in greater detail during the period August-December 1975. In the consecutive Harderwijk project the following procedure was adopted (MANUAL, 1974). In the Departmental laboratory, during the week after blood collection, both the precipitation and the determination steps were carried out. The precipitation step was performed by adding 0.045 ml of a heparine-Mn^{2+} mixture (4 vol heparine 5,000 IU/ml and 5 vol 1 M $MnCl_2$) to 0.5 ml of serum. The mixture was shaken vigorously and immediately placed in an ice-bath for 30 minutes. The precipitate was spun down by centrifugation for 30 min at 4°C and 1500 *g* in a MSE Model High Speed 18 centrifuge, using an angle head capacity 8 × 50 ml rotor equipped with specially designed adaptors. The clear supernatant was decanted into auto-analyser cups.

In order to quantify the supernatant cholesterol, the precipitation procedure was performed simultaneously on specially prepared pool sera, which had previously been targetted by the ABELL method. Some of these sera were designed to act as standard sera in the determination step, some as control sera. In the determination step, each tray of determinations was calibrated by 3 sera on different levels. The calibration was checked by the inclusion of 2 control sera in quadruplicate during each day's workload. Criteria for satisfactory completion of a day's workload were the same as for the system of internal quality control described for the total cholesterol determination. In order to validate results, both during the Roermond project and during the Harderwijk project an about 10% random sample of unknown specimens was also determined by the ABELL method after a completely repeated precipitation.

Concentrations in both projects were calculated in mg/100 ml. To obtain values in mmol/l these figures have to be divided by 38.6.

2.5.2. *Adjustment of results to a joint level*

The results of the determinations of the various blood lipid concentrations were gathered over a period of 3 years, each year confined to the first 5 months of the year. The results of determinations had been checked only by a system of internal quality control and the results were discarded, or the determinations were repeated after unsatisfactory performance.

However, the repeated arrangement of a new field laboratory for each project and the introduction of new batches of standard and control sera for each project introduced an uncertainty with regard to the comparability of results from the different projects. In addition, the determination of triglycerides according to the method of SOLONI yielded values considerably lower than those of the internationally accepted reference method of CARLSON (1963), and only part of this difference could be attributed theoretically to methodological differences. Finally, even the maintenance of the internal quality control system as described does not preclude the possibility of a faulty general level of results of these determinations when compared to an internationally accepted standardization programme.

Consequently, it was considered necessary to evaluate in retrospect the comparability of results between projects and the general level of performance for the total cholesterol determination, and to convert the results of the triglycerides determinations to a common level comparable to CARLSON values. The Johns Hopkins University Lipid Research Clinic (LRC) Laboratory was willing to analyse a number of sera according to the LRC Protocol (MANUAL, 1974).

The Lipid Research Clinics Program is a collaborative contract research programme funded by the National Heart, Lung and Blood Institute, Bethesda, Maryland, USA. In October 1976 a total of 180 sera on dry ice was sent by air for analysis to the Johns Hopkins University LRC. The shipment consisted of randomly chosen serum specimens from the 3 projects, supplemented by a number of aliquots of control sera used in the different projects. A total of 70 random sera and 6 aliquots of 1 control serum was included from the Heerenveen project. From both the Roermond and the Harderwijk project the shipment contained 40 randomly chosen sera and 4 aliquots of 3 control sera each. All sera were received in a frozen condition and all were analysed for both their total cholesterol and triglycerides concentration on 3 separate days under the quality control regulations governing the LRC project. The values for both the cholesterol and triglycerides determinations in control sera used for internal quality control in the LRC, were all within limits, and therefore the results of determinations in unknown samples considered acceptable by the management of the LRC.

In order to test the comparability of results obtained by the different methodologies used for the HDL-cholesterol quantification during the Roermond and Harderwijk projects, a comparison of both procedures was carried out in April 1976 using sera of parents and children from the Roermond project. In a total of 46 sera complex-formation was carried out by the 2 different methods used. All sera were analysed for their supernatant cholesterol content in 11 runs on one day. Of each serum pair, the diluted serum specimen concentration was calibrated on the basis of the standard sera used during the Roermond project and the HDL-concentration in the undiluted serum specimen, in which complex-formation was carried out at 4°C, was calibrated on the standard sera from the Harderwijk project. Control sera from both pro-

jects were interspersed throughout all runs, and the results did not deviate from the expected values.

Total cholesterol. The results of the comparison between values obtained for the total cholesterol determinations in the 3 town-projects and those in the LRC Laboratory of the Johns Hopkins University are presented in Tables 18 to 20 and in Figs. 3 to 5. First, mean results of paired measurements in sera from the different projects were compared (Table 18). Mean results obtained during the Heerenveen project were about 3 mg/100 ml lower, those from the Roermond project were about 5 mg/100 ml higher and the mean results from the Harderwijk project were about 5 mg/100 ml lower than their respective means obtained in the Baltimore LRC. All these differences were statistically significant.

Next, the results of the total cholesterol determinations by the Baltimore LRC in control sera were inspected (Table 19). The estimated mean concentrations in these sera are surprisingly equal to those obtained during the several projects and, in addition, the assessments of the total analytical variation for the various sera were of the same order of magnitude as those found during the execution of the 3 projects (see Table 26).

Finally, linear regression coefficients were computed between values obtained in the Baltimore LRC and values found during the 3 projects. In all instances the 95% confidence interval of these statistics contained the value 1. Taking all this evidence into account, it was decided to correct the individual concentra-

TABLE 18. Results of total cholesterol determinations in random sera obtained in the specified town-projects and in the Johns Hopkins University LRC Laboratory, Baltimore.

Statistic (mg/100 ml)	Laboratory		
n = 70	Heerenveen project		Baltimore LRC
Mean	179.6		182.6
total s.d.	31.7		31.3
$s.e._{diff}$		6.01	
corr. coeff.		0.959	
n = 40	Roermond project		Baltimore LRC
Mean	184.1		178.9
total s.d.	27.8		26.7
$s.e._{diff}$		5.14	
corr. coeff.		0.968	
n = 40	Harderwijk project		Baltimore LRC
Mean	192.9		197.6
total s.d.	45.7		41.5
$s.e._{diff}$		4.87	
corr. coeff.		0.988	

TABLE 19. Results of total cholesterol determinations by the Johns Hopkins LRC Laboratory in control sera used in the different town projects.

Project of origin	Control pool ident.	Number of determinations	Mean (mg/100 ml)	Total s.d.
Heerenveen/Roermond	K	6	216	3.7
Roermond	W	4	174	7.8
Roermond	X	4	275	3.2
Roermond/Harderwijk	A	4	214	2.5
Harderwijk	R	4	182	3.9
Harderwijk	U	4	259	3.8

TABLE 20. Linear regression analysis by project of results of serum total cholesterol determinations.

Variable to be explained	Regression coefficient		Intercept*
	estimate	95% conf. interval	
Heerenveen results	0.9663	(0.931 ; 1.061)	−2.3
Roermond results	1.0083	(0.938 ; 1.078)	+4.5
Harderwijk results	0.9903	(0.953 ; 1.028)	−4.6

* Calculated under the assumption of a regression coefficient equal 1.

TABLE 21. Results of triglycerides determinations in random sera obtained in the specified town-projects and in the Johns Hopkins University LRC Laboratory, Baltimore.

Statistic (mg/100 ml)	Laboratory		
n = 67	Heerenveen project		Baltimore LRC
Mean	52.9		72.3
total s.d.	30.1		32.5
$s.e._{diff}$		14.7	
corr. coeff.		0.975	
n = 39	Roermond project		Baltimore LRC
Mean	49.4		64.4
total s.d.	17.3		18.9
$s.e._{diff}$		13.2	
corr. coeff.		0.805	
n = 40	Harderwijk project		Baltimore LRC
Mean	58.9		72.1
total s.d.	39.4		40.1
$s.e._{diff}$		10.2	
corr. coeff.		0.986	

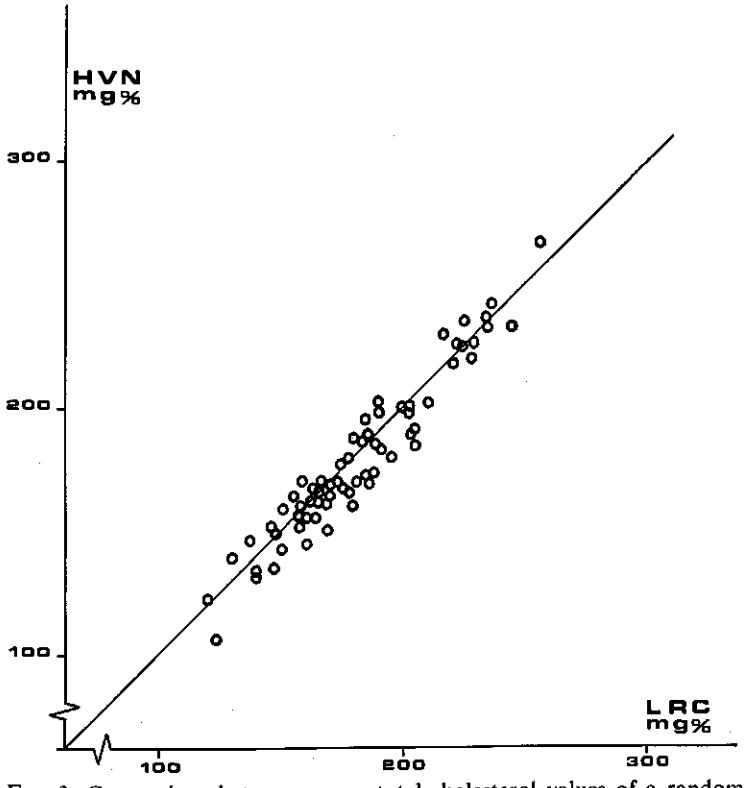

FIG. 3. Comparison between serum total cholesterol values of a random sample of sera determined during the Heerenveen project and by the Johns Hopkins University LRC Laboratory, Baltimore. (See also Tab. 18–20). The line was drawn with an angle of 45°.

tions for the mean differences found between the results from the Johns Hopkins Laboratory and the results from the 3 projects separately. The mean correction is given in Table 20 by the intercept of the regression line calculated under the assumption of a regression coefficient being equal to 1.

Triglycerides. In Tables 21 to 23 the results of the triglycerides determinations of the various project towns are compared to the values found in the same sera by the Johns Hopkins LRC. In all project towns the SOLONI method was used, whereas in the Baltimore LRC a mechanized version of the KESSLER and LEDERER method was used calibrated to give results according to CARLSON (MANUAL, 1974). Results in Tables 21 to 23 were calculated while omitting some exceptionally deviant values which have been characterized in Figs. 6 to 8 by drawing them between brackets.

Large differences were found between mean results in the same sera by the 3 town-projects and by the Baltimore LRC. At least some of these differences must be attributed to differences in determination techniques, and as a conse-

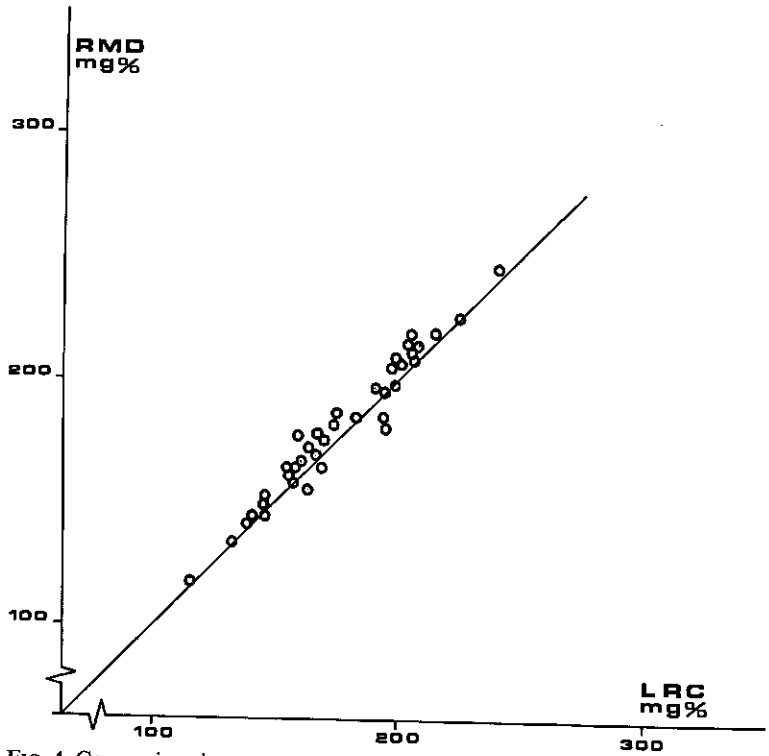

FIG. 4. Comparison between serum total cholesterol values of a random sample of sera determined during the Roermond project and by the Johns Hopkins University LRC Laboratory, Baltimore. (See also Tab. 18–20). The line was drawn with an angle of 45°.

TABLE 22. Results of triglycerides determinations by the Johns Hopkins LRC Laboratory in control sera used in the different town projects.

Project of origin	Control pool ident.	Number of determinations	Mean (mg/100 ml)	Total s.d.
Heerenveen/Roermond	K	6	136	5.5
Roermond/Harderwijk	MX-1	4	57	4.3
Roermond/Harderwijk	A	4	155	9.2
none*	R	4	70	7.0
none*	W	4	79	2.0
none*	U	4	155	1.5
none*	X	4	191	6.6

* Pools used for cholesterol determinations. Consequently, no information is available for the triglycerides concentration according to the 3 projects.

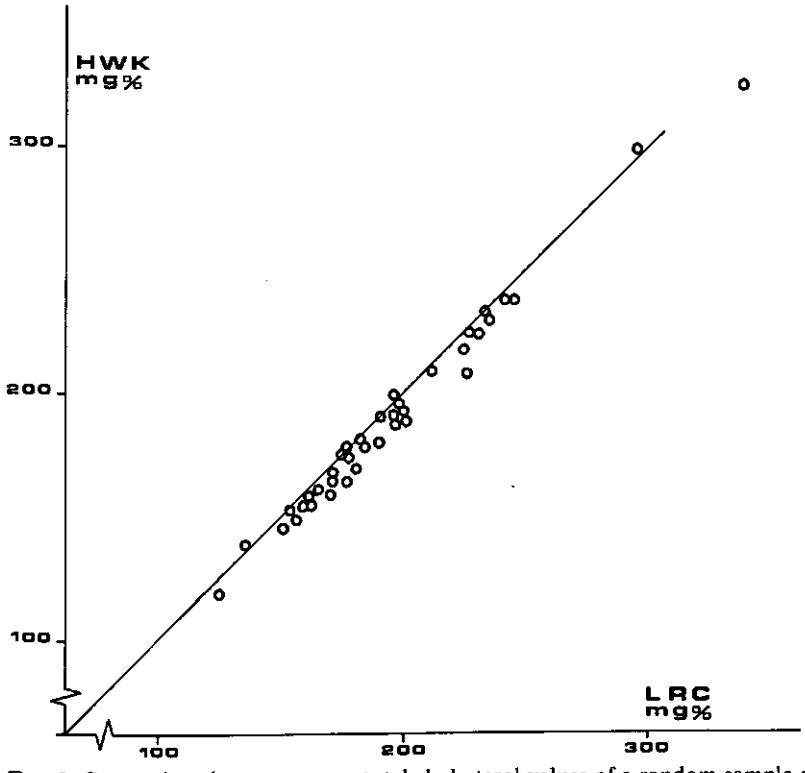

FIG. 5. Comparison between serum total cholesterol values of a random sample of sera determined during the Harderwijk project and by the Johns Hopkins University LRC Laboratory, Baltimore. (See also Tab. 18–20). The line was drawn with an angle of 45°.

quence, the large values for $s.e._{diff.}$ in Table 21 seem to be partly methodologically explainable. Further, the 95% confidence interval for the regression coefficient of project results on the Baltimore results did not contain the value 1 in 2 out of 3 comparisons (Table 23). Consequently, results from the 3 town-projects were corrected to a joint level using the regression formulae shown in Table 23.

TABLE 23. Linear regression analysis by project of results of serum triglycerides determinations.

Variable to be explained	Regression coefficient		Intercept*
	estimate	95% conf. interval	
Heerenveen results	0.9043	(0.854 ; 0.955)	−12.5
Roermond results	0.7998	(0.636 ; 0.964)	− 2.9
Harderwijk results	0.9725	(0.925 ; 1.020)	−11.2

* Given b, the estimate of the regression coefficient.

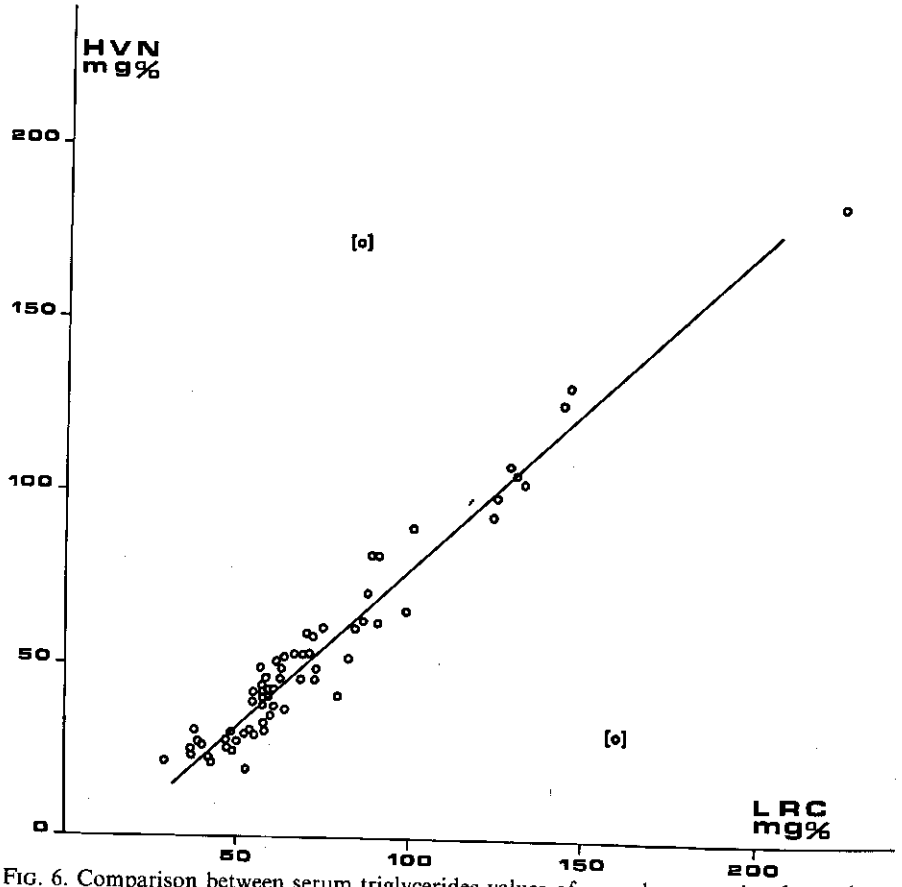

FIG. 6. Comparison between serum triglycerides values of a random sample of sera determined during the Heerenveen project and by the Johns Hopkins University LRC Laboratory, Baltimore. (See also Tab. 21–23).

HDL-cholesterol. The different methodologies used for the HDL-cholesterol quantification during the Roermond and Harderwijk projects have been compared in an experiment using 46 sera. Results of this comparison are shown graphically in Fig. 9. Although, on the basis of a paired t-test, the results did not differ on the mean level, the regression coefficient did differ significantly from the expected value of 1. It can be seen from Fig. 9 that the method used during the Roermond project underestimates the HDL-cholesterol content in sera on a high level and also possibly overestimates it in the low ones. On the basis of the differences observed in analytical error (depicted in Tables 28 and 29) and of considerations of comparability with other investigations supervised by the WHO Reference Laboratory in Atlanta, USA, it was decided to recalculate the Roermond results into values that would be expected when obtained by the method used during the Harderwijk project. The conversion formula

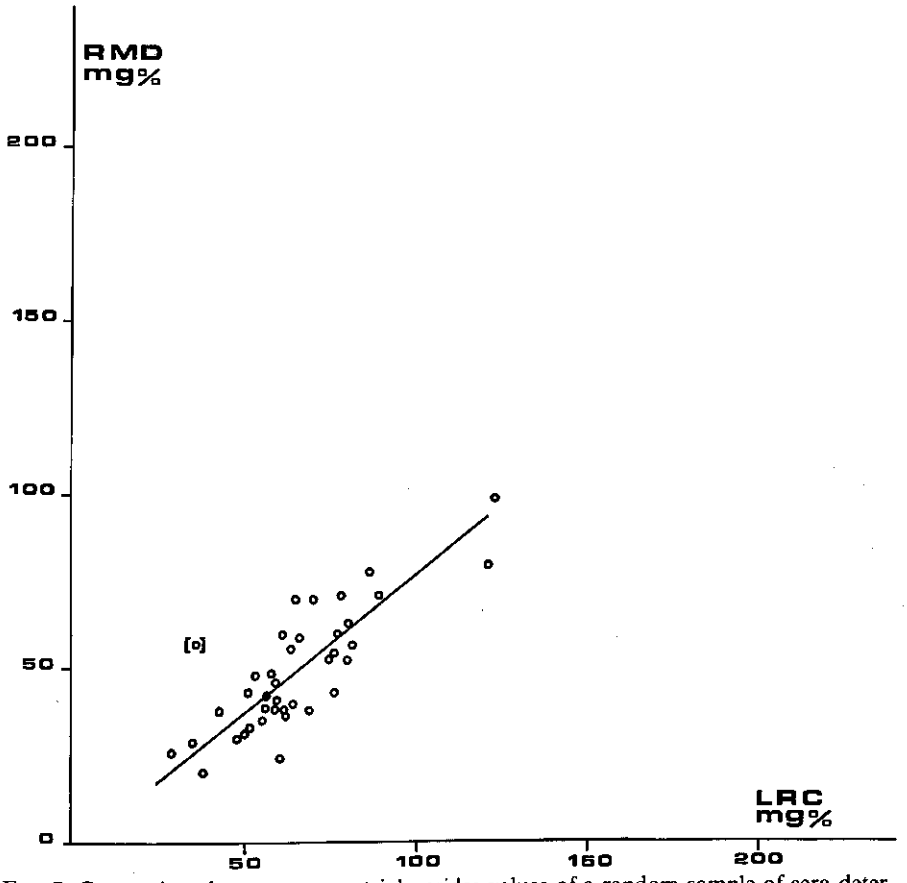

FIG. 7. Comparison between serum triglycerides values of a random sample of sera determined during the Roermond project and by the Johns Hopkins University LRC Laboratory, Baltimore. (See alsó Tab. 21–23).

used is shown in Fig. 9 and was calculated while taking the observed differences in analytical variation into account.

2.5.3. *Quality of measurements*

Serum standards

Total cholesterol. Total cholesterol concentrations in unknown specimens were determined during the Roermond and Harderwijk projects by a mechanized direct method calibrated on serum standards. Because in the standard sera the total cholesterol content had been determined by the ABELL method, it was inferred that resulting concentrations in unknown specimens were directly comparable to their values, which would be expected to be obtained by

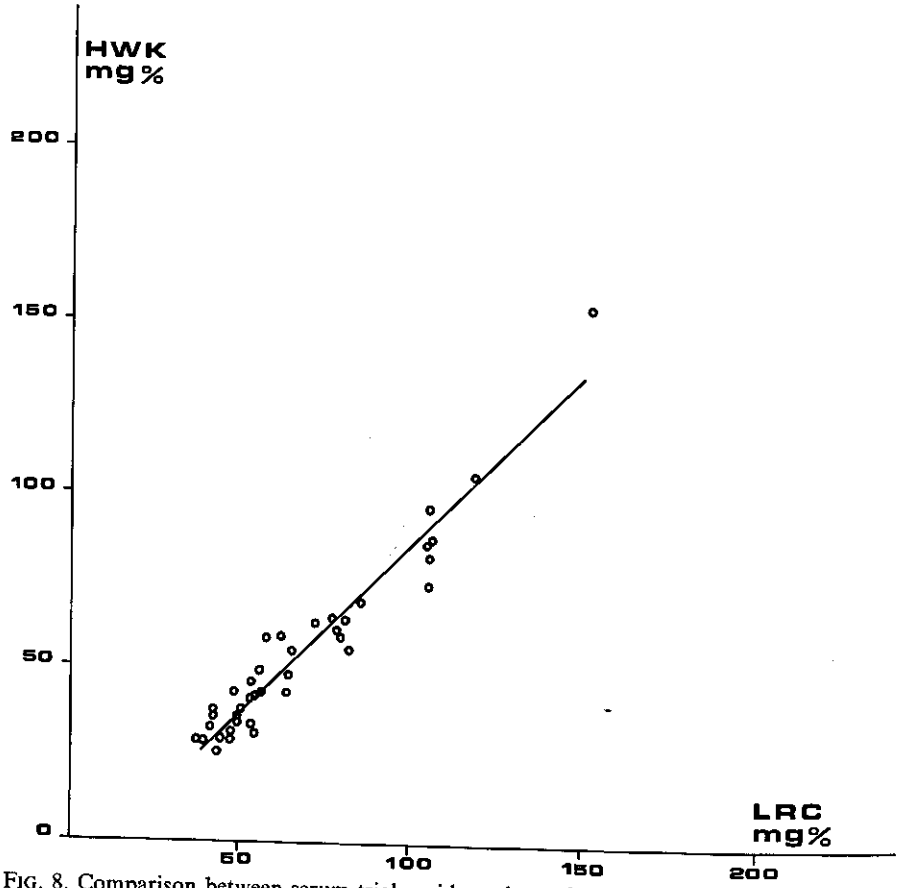

FIG. 8. Comparison between serum triglycerides values of a random sample of sera determined during the Harderwijk project and by the Johns Hopkins University LRC Laboratory, Baltimore. (See also Tab. 21–23).

TABLE 24. Results of targetting procedure by the Abell method in sera used for calibration in the direct total cholesterol determination during the Roermond and Harderwijk projects.

Project	Standard designation	Number of		Statistic (mg/100 ml)		
		runs	determinations	Mean	s.d.	
					total	within run
RMD	C	6	20	86	1.6	0.9
	A	11	40	213	4.1	1.9
	Z	6	20	313	5.0	4.9
HWK	P	13	50	109	2.8	2.2
	A	13	40	213	5.2	4.9
	Y	13	46	308	5.4	4.2

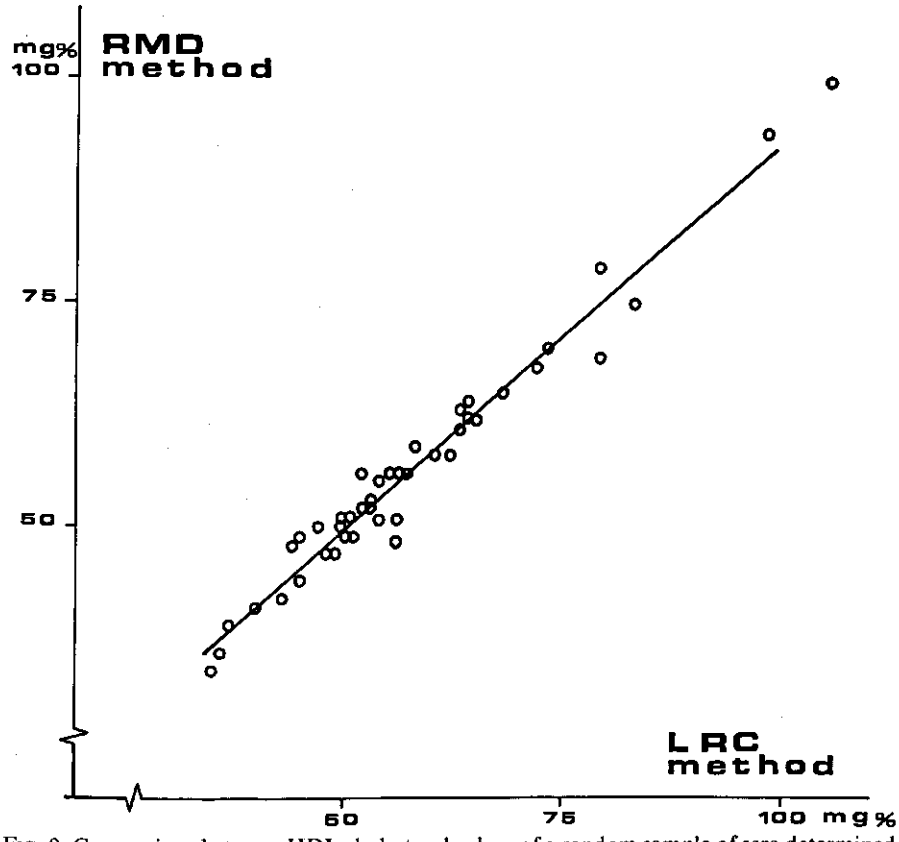

FIG. 9. Comparison between HDL cholesterol values of a random sample of sera determined according to the Roermond and LRC method. (Conversion formula: RMD = 0.872 × LRC + 6.1; r = 0.983).

the ABELL method. Table 24 describes results obtained during the previously performed targetting procedure in the standard sera. Mean values were used for purposes of calibration.

HDL-cholesterol. In a similar way, HDL-cholesterol concentrations in unknown specimens were analysed during the Roermond and Harderwijk projects by the mechanized direct addition of the reagent according to HUANG to the supernatant of serum after precipitation of the apo B-carrying lipoproteins. Sera were diluted 1:1 during the Roermond project only. Determinations were calibrated on standard sera, which were complexed before the start of the Roermond project, and which were completely carried through the whole procedure during the Harderwijk project.

Table 25 describes the results of the targetting procedure according to Abell in standard sera used during the Roermond and Harderwijk projects. Mean results were used for calibration purposes.

TABLE 25. Results of the targetting procedure by the Abell method in standard sera used for the mechanized direct HDL-cholesterol determination during the Roermond and Harderwijk projects.

Project	Standard designation	Number of		Statistic (mg/100 ml)		
		runs	determinations	Mean	s.d.	
					total	within run
RMD	G	6	14	33.1	1.0	0.5
	F	6	14	52.8	1.0	0.8
	D	6	14	79.2	1.8	1.4
HWK	α_1	11	37	37.0	1.4	0.9
	α_2	11	38	52.4	1.6	1.3
	α_3	11	39	84.5	2.2	1.6
	α_4	10	40	44.1	1.3	0.9
	α_5	10	40	58.6	1.7	1.3
	α_6	10	37	95.0	1.7	1.1

Control sera

Total cholesterol. A summary of results in control sera during the 3 projects is given in Table 26.

In the field laboratory, during the Heerenveen project, a total of 287 determinations were performed in 2 control sera during 40 runs, resulting in mean values for Serum MX: 126 mg/100 ml (3.26 mM) and for Serum K: 207 mg/

TABLE 26. Results of control sera determinations; serum total cholesterol.

Project	Statistic (mg/100 ml)	Serum specimen identification		
Heerenveen		MX		K
	Mean	126		207
	Within run s.d.	4.7		5.6
	Total s.d.	7.4		6.1
Roermond		W	K	X
	Mean	181	218	273
	Within run s.d.	2.7	3.5	3.2
	Total s.d.	3.1	4.2	3.7
Harderwijk		R		U
	Mean	182		261
	Within run s.d.	1.7		2.3
	Total s.d.	2.0		2.7

100 ml (5.36 mM). The total analytical variation (s.d.) was estimated to be 6.8 mg/100 ml (0.176 mM) and within-run s.d. (further referred to as precision) 5.2 mg/100 ml (0.134 mM).

A total of 145 determinations during 14 runs in 3 control sera were performed in the Departmental laboratory for the Roermond project. Resulting mean values were: Serum W: 181 mg/100 ml (4.69 mM), Serum K: 218 mg/100 ml (5.70 mM) and Serum X: 273 mg/100 ml (7.07 mM). From the results of these 145 determinations a total analytical variation of 3.6 mg/100 ml (0.094 mM) and a precision of 3.0 mg/100 ml (0.077 mM) were derived.

During the execution of the Harderwijk project a total of 120 determinations distributed over 15 runs in 2 control sera were performed during the total cholesterol determinations in the Departmental laboratory. Mean values of 182 mg/100 ml (4.71 mM) for serum R and of 261 mg/100 ml (6.77 mM) for Serum U were found. The total analytical variation was estimated to be 2.5 mg/100 ml (0.064 mM). A precision of 2.0 mg/100 ml (0.053 mM) was found.

Triglycerides. Results of control sera determinations are summarized in Table 27.

A total of 289 determinations in 2 control sera distributed over 52 runs were performed during the Heerenveen project. Mean values, according to the SOLONI method were: Serum MX: 47 mg/100 ml (0.53 mM) and Serum K: 104 mg/100 ml (1.18 mM). Estimates for the total analytical variation and for the precision were 4.0 mg/100 ml (0.045 mM) and 3.8 mg/100 ml (0.043 mM) respectively.

During the Roermond project a total of 302 determinations in 3 control sera during 42 runs were carried out. Resulting mean values were: Serum

TABLE 27. Results of control sera determinations; serum triglycerides.

Project	Statistic (mg/100 ml)	Serum specimen identification		
Heerenveen		MX		K
	Mean	47		104
	Within run s.d.	2.1		4.8
	Total s.d.	2.9		6.1
Roermond		MX-1	K	A
	Mean	33	112	127
	Within run s.d.	1.7	3.2	3.2
	Total s.d.	2.9	4.3	5.6
Harderwijk		MX-1		A
	Mean	34		125
	Within run s.d.	1.1		2.7
	Total s.d.	2.7		5.3

MX-1: 33 mg/100 ml (0.37 mM); Serum K: 112 mg/100 ml (1.25 mM) and Serum A: 127 mg/100 ml (1.44 mM). Results of all control sera determinations yielded estimates of 4.4 mg/100 ml (0.049 mM) for the total analytical variation and 2.7 mg/100 ml (0.030 mM) for the precision.

A total of 148 determinations were done in 2 control sera during 50 runs in the execution of the Harderwijk project. Mean concentrations found were 34 mg/100 ml (0.38 mM) for Serum MX-1 and 125 mg/100 ml (1.41 mM) for Serum A. A total analytical variation of 4.4 mg/100 ml (0.049 mM) and a precision of 2.2 mg/100 ml (0.025 mM) were calculated on the basis of these determinations.

HDL-cholesterol. A total of 120 determinations were carried out on 11 days in 2 control sera during the Roermond project. Results for mean values were: Serum S: 42 mg/100 ml (1.09 mM) and Serum J: 64 mg/100 ml (1.65 mM). The total analytical variation was calculated to be 4.2 mg/100 ml (0.108 mM) and for the precision a value of 3.0 mg/100 ml (0.079 mM) was found. These results are summarized in Table 28.

A total of 96 determinations were carried out in 4 control sera during 12 days of determinations in the Harderwijk project. Mean values in these control sera were: Serum α_4: 45 mg/100 ml (1.16 mM); Serum α_5: 55 mg/100 ml (1.41 mM); Serum α_9: 44 mg/100 ml (1.14 mM) and Serum α_{10}: 68 mg/100 ml (1.77 mM). A total analytical variation of 1.6 mg/100 ml (0.042 mM) and a precision of 1.2 mg/100 ml (0.031 mM) were found. Table 29 provides a detailed survey of the findings in these control sera.

Comparisons

Total cholesterol. A total of 57 unknown specimens were analysed, besides their mechanized direct determination according to HUANG, by the manual ABELL method, distributed over 6 runs during the Roermond project. Results are given in Table 30. Table 30 also contains similar information gained in 84 randomly selected sera assessed in 8 runs from the Harderwijk project. In neither instance did the results significantly differ statistically on their mean level.

In addition, the pool sera, used for calibration and control during the Roermond project were analyzed for their cholesterol content by the WHO

TABLE 28. Results of control sera determinations; serum HDL-cholesterol; Roermond project.

Statistic (mg/100 ml)	Serum specimen identification	
	S	J
Mean	42	64
Within run s.d.	2.8	3.2
Total s.d.	4.6	3.8

TABLE 29. Results of control sera determinations; serum HDL-cholesterol, Harderwijk project.

Statistic (mg/100 ml)	Serum specimen identification			
	Serum α_4	Serum α_5	Serum α_9	Serum α_{10}
Mean	45	55	44	68
Within run s.d.	1.4	1.2	0.9	1.3
Total s.d.	1.4	1.9	1.1	1.8

Reference Laboratory in the Center for Disease Control, Atlanta, USA. Results from these determinations are summarized in Tables 31 and 32.

HDL-cholesterol. In order to test the validity of the level of observed values in unknown specimens for the HDL-cholesterol analysis a number of sera were analysed by both the routine automated direct method and by the manual ABELL method. During the Roermond project a total of 97 specimens in 7 different runs were analyzed by both methods and the same was done in a total of 66 sera in 10 runs for the Harderwijk project. Results of these comparisons are given in Table 33. The differences between mean results obtaind by both methods during both projects were not statistically significant.

In addition, during the execution of the Harderwijk project a total of 33

TABLE 30. Comparison of results obtained by the manual Abell method and the mechanized direct method for the total cholesterol determination in random specimens; total cholesterol.

Statistic (mg/100 ml)	Roermond project method		Harderwijk project method	
	Abell	routine	Abell	routine
n	57		84	
Mean	188.1	188.2	188.4	186.5
s.d.	25.4	24.3	31.0	31.0
$s.e._{diff}$	4.85		6.40	
corr. coeff.	0.959		0.960	

TABLE 31. Determination of total cholesterol concentration in standard sera by the WHO Reference Laboratory, Atlanta, USA.

Standard designation	Number of		Statistic (mg/100 ml)		
				s.d.	
	runs	determinations	Mean	total	within run
C	7	27	86	1.6	1.3
A	7	27	216	2.2	2.0
Z	7	28	311	3.9	3.5

TABLE 32. Determinations of total cholesterol concentration in control sera by the WHO Reference Laboratory, Atlanta, USA.

Statistic (mg/100 ml)	Control serum identification		
	Serum W	Serum K	Serum X
Mean	179	218	273
within run s.d.	1.4	2.7	3.5
total s.d.	2.0	3.1	4.0

TABLE 33. Comparison of results obtained by the manual Abell method and the mechanized direct method for the HDL-cholesterol determination in random specimens.

Statistic (mg/100 ml)	Roermond project method		Harderwijk project method	
	Abell	routine	Abell	routine
n	97		66	
Mean	56.0	56.5	59.5	59.0
s.d.	10.9	11.2	13.2	12.9
$s.e._{diff}$	3.4		2.2	
corr. coeff.	0.909		0.982	

determinations were performed over 9 series of determinations in a pool serum AQ-2, provided by the WHO Standardization Laboratory, Atlanta, USA. The mean of values for the HDL-cholesterol content of this serum reported by several LRC's was indicated to be 54 mg/100 ml. In the Departmental laboratory a mean value of 54 mg/100 ml was also found, with a total analytical variation of 1.8 mg/100 ml (0.047 mM) and a precision of 1.1 mg/100 ml (0.028 mM).

2.6. EXAMINATION OF PARENTS

All parents of the participating children from 2 elementary schools were invited to take part during the Heerenveen project. During the Roermond and Harderwijk projects all parents of those children from Grades 4–6 of the primary schools, who had already participated, were invited. Invitation was by letter specifying the kind of examination to be done and the dates on which these were planned. After return of the confirmation of participation, the parents were asked to report at a specified time. They were requested not to eat anything in the morning before the examination. All examinations took place between 6.30 a.m. and 10.30 a.m.

The examination procedure comprised a short questionnaire, some anthropometric measurements and a venepuncture. The questionnaire covered items of fasting period, regular alcohol usage, smoking patterns and specific diseases,

known or suspected to be related to risk factor levels. The use of oral contraceptives by the participating women was recorded. Standing height was measured with a Microtoise Nr 4116 (Stanley Mabo, France). Body weight was measured on a beam balance metric scale (Seca Laméris). The subjects were measured without shoes, coats or jackets and with empty pockets. No adjustment was made for the remaining clothing. A blood sample of about 10 ml was taken from the antecubital vein by means of a Vacutainer system with the subjects in a sitting position. The same blood determinations were performed as in the children. The procedures of quality control as regards checks on calibration of measuring devices, and processing of blood samples and blood determinations were the same as those described for methods of examinations in children.

On the basis of questionnaire results, those parents were excluded from the subsequent analysis who reported the following diseases: myocardial infarction, thyroidal disorders plus medication, diabetes plus medication and/or diet, 'gallbladder complaints' plus medication and/or diet, medical treatment for high blood pressure.

Main emphasis during the analysis of parent-child resemblances was paid to the results of measurements of body fatness and blood lipids. Standing height, the measurement known to be under polygenic control, served as a reference.

2.7. Dietary survey

2.7.1. *Population*

The children participating in the dietary survey were chosen in the following way. All children from Grades 1–3 of the primary schools, aged 6–10 years, who participated in the anthropometric survey, were eligible for the dietary survey. Children in this age range were selected because they had not yet reached puberty and were assumed to be in a rather stable growth period. In addition, the majority of previously carried out dietary surveys into the food intake of schoolchildren in The Netherlands were performed in children aged 6–10.

Only one child from any family was invited for participation in the dietary survey, as the aim was to include as many families as possible. If a family had more than one child in Grade 1–3, the youngest or oldest child was selected alternately.

2.7.2. *Method*

The aim of the dietary surveys was to characterize the selected schoolchildren populations by their mean food intake. Therefore a one-day record or recall may suffice (see also p. 11–12). For the present study a two-day record, filled in by the mother, was chosen in order to have the possibility of calculating the intra-individual variance for total energy and relevant nutrients. The record method was preferred above the recall method because children below

the age of 10 are not able to accurately recall the foods eaten during the previous day (see also p. 19). A survey period of not more than 2 days was chosen for practical reasons. A period of 2 days is not too long to keep the children and the mothers interested in the survey and is also convenient from an organizational point of view.

Information about food intake during the weekend was not collected because it was impossible from an organizational point of view to ask all mothers to record their children's food intake during a weekday and a weekend. It was therefore decided to collect information about the food intake of the children during weekdays only.

2.7.3. *Encoding of food intake data*

All food intake data were encoded according to the Uniform Food Encoding (UFE) system developed in The Netherlands (HAUTVAST, 1975). In this system each food has a code number of 6 figures. All foods, together with their code numbers, are summarized in alphabetical order in a book in order to facilitate encoding by the investigators. The backbone of this system is the Netherlands Food Table. However, compared to the Netherlands Food Table, the number of foods in the UFE system has been considerably extended and amounts nowadays to about 700. The UFE system covers almost all frequently used foods in this country. For this survey the UFE system was extended by some foods frequently used in one part of the country only. Chemical analysis of these foods were, if needed, done in the laboratory of the Department of Human Nutrition.

All records were encoded initially by the investigator who collected the booklet. As far as was possible, the records were encoded on the same day as the booklets were collected. Each investigator wrote down problems concerning quantities or code numbers of infrequently used foods in a 'problembook'. These problems were discussed regularly with the dietitians, who also organized the training course preceding the survey. The solutions of these problems were taken over by each investigator in order to get the data encoded as uniformly as possible. When, for one or other reason, the weights or volumes of important foods were unknown, mean values, based on all data collected during each survey and calculated after the survey was finished, were substituted.

A great deal of attention was paid to the working-out of the main meal. Mixed dishes like soups, puddings, etc. were encoded into the ingredients, if these data were available, otherwise standard recipes were used. Standard quantities were used for small, medium and large potatoes. The amount calculated in this way was cross-checked by the total amount eaten by the whole family. The edible portion was calculated by multiplying the total amount of purchased potatoes by a factor for the edible part. This factor was taken from the Netherlands Food Table. The same procedure was applied with respect to vegetables, although in this case the matter was even more complicated because the Netherlands Food Table is based on 100 g of the

cleaned, raw product. The cleaned, raw product is defined as the amount of vegetables left over after removing the inedible wastage and after washing with water. In the records cooked vegetables were noted. Special 'cooking factors', based on the results of a study reported by LASSCHE et al. (1964), were calculated in order to create the possibility of converting the quantities of cooked vegetables into quantities of cleaned, raw products. The reason that so much attention was paid to the vegetables was because they provide an important contribution to the amount of dietary fibre, one of the nutrients calculated in the present study. 'Cooking factors', based on experiments carried out in the Department of Human Nutrition, were also calculated for rice, macaroni and spaghetti, in order to convert the quantities of cooked products into quantities of raw products.

Special problems were observed in the encoding of meat and fish eaten, because the fat content is dependent on the fat content before preparation and on the method of preparation (see also pp. 8–9 and 13–14). The mother was asked for information about the kind of meat or fish eaten by the child and about the method of preparation. The most frequently used domestic way of preparing both meat and fish in The Netherlands is frying. Some investigations were carried out in The Netherlands in which changes in the fat content of different kinds of meat or fish by different methods of preparation were examined (VAN STAVEREN, 1970; MEESTER, 1974). The results of these investigations are summarized in Table 34. In the Netherlands Food Table, only figures for uncooked meats are recorded. Problems were caused by high-fat meats cooked, loosing fat. It was therefore decided to encode these meats when cooked as mean-fat meats uncooked, because high fat meats when cooked have about the same fat content as uncooked mean-fat meats. Furthermore, the protein content of these kinds of meat differs only slightly.

Owing to its very variable composition the gravy also caused problems. Attempts were made to get as accurate information as possible by asking the mother how many grams of margarine or butter she used for frying the meat and how many cups of water she added to make the gravy. Also, by taking into

TABLE 34. Changes in fat content of different kinds of meat and fish by different methods of preparation (adapted from VAN STAVEREN, 1970 and MEESTER, 1974).

Kind of meat or fish	Method of preparation	Change in fat content
lean meat	fried	+ 5%
mean-fat meat	fried	0
sausage meat	fried	- 5%
high-fat meat	fried	- 10%
lean meat	crumbed + fried	+ 15%
lean fish	stewed	0
	fried	+ 5%
	crumbed + fried	+ 10%

account the quantity of margarine that has been absorbed by or has dripped from the meat, depending on its fat content and the method of preparation, the ratio between margarine, butter or fat and water could be calculated. Based on this ratio and on the size of the gravy ladle the amount of margarine, butter or fat derived from the gravy could be calculated.

A decision also had to be made about the fat content of fried potatoes and eggs. It was assumed that the amount of fat taken up by these products amounted to 10% of their weight. The percentage of fat for fried potatoes is lower than the 17% in French fried potatoes, caused by differences in the way of preparation. More fat and a longer cooking time are needed for the preparation of French fried potatoes. Consequently, the percentage of fat in French fried potatoes is higher than the percentage of fat in fried potatoes. The mother was asked if the fat left in the pan was added to the meal. If this was the case, this additional amount of fat was also recorded.

All encoded records were finally checked by one of the principal investigators (DK). Then all codes and quantities of the foods eaten were transferred to a specially prepared punch-sheet by three coders, one coder for each survey. From these sheets punch-cards were punched. Mistakes concerning code numbers could be tracked by a control programme because each code number of 6 figures is composed of a code of 4 figures for each food and of 2 figures, forming the sum of the first 4 figures multiplied by 1, 2, 3 or 4 respectively. The quantities were checked by selection of the extreme values of the distribution of each food. The original records were verified whether these quantities were correct.

2.7.4. *The food table used*

The UFE food table. Total energy and the nutrients relevant for this study were calculated from the UFE food table. At the beginning of this study sufficient information was available about animal, vegetable and total proteins, total fats and total carbohydrates. The information was incomplete with respect to saturated, mono-unsaturated and poly-unsaturated fatty acids, dietary cholesterol, oligo- saccharides and polysaccharides. Information about C_{12_16}-saturated fatty acids and dietary fibre content of foods was not present in the table at that time.

The cholesterol content of frequently used foods, except dairy products, was determined in the laboratory of the Department of Human Nutrition in 1973 (KELLER and VAN DE BOVENKAMP, 1974). In 1974 fatty acid analyses were carried out in meat and meat products, fresh and tinned fish, margarines, vegetable oils and cooking fats, salad dressings, cakes, biscuits, cocktail-snacks, crisps and nuts (VAN DE BOVENKAMP, 1975). The results of these cholesterol and fatty acid analyses served as a basis for the UFE food table. The information about the cholesterol content of foods was extended by data from the Netherlands Food Table (NEDERLANDSE VOEDINGSMIDDELEN TABEL, 1975). Additional information about the fatty acid composition of milk, eggs, bread and other cereal products was obtained from the Netherlands Institute for

Dairy Research (Ede), the Spelderholt Institute for Poultry Research (Beekbergen) and from the Institute for Cereals, Flour and Bread TNO (Wageningen). Information about fatty acid composition of some infrequently used foods was lacking. For these foods recently published data from the USA were substituted, after checking whether the American figures correspond well to the Dutch figures for other foods analysed in both countries (ANDERSON et al., 1975; POSATI et al., 1975; ANDERSON, 1976; FRISTROM and WEIHRAUCH, 1976). For composite products the cholesterol content and fatty acid composition were calculated from the ingredients.

Information about the oligo- saccharide and polysaccharide content of foods was obtained from analyses carried out in the USA (HARDINGE et al., 1965). The oligo-saccharide and polysaccharide content of composite products was calculated from the ingredients.

The UFE food table also provides information about the dietary fibre content of foods. Nowadays several definitions for dietary fibre exist. The definition of dietary fibre used in the UFE food table is based on physiological considerations. According to TROWELL (1972) dietary fibre is defined in terms of physiology as: 'The remnants of plant cells resistant to hydrolysis by the alimentary enzymes of men'. This definition has recently been extended to include undigested storage polysaccharides, present within the contents of the cell (TROWELL et al., 1976). In chemical terms dietary fibre contains pectins, celluloses, hemi-celluloses and lignins as major components and algal polysaccharides, gums and mucilages as minor components (SOUTHGATE, 1976).

The figures for dietary fibre in the UFE food table are derived mainly from analyses carried out in the United Kingdom (MCCANCE and WIDDOWSON, 1960; SOUTHGATE, 1976) because their analytical methods were in agreement with the afore-mentioned definition of dietary fibre. Only figures concerning cereal products were taken from a Dutch publication because these investigators used an enzymatical method for the determination of dietary fibre (HELLENDOORN et al., 1975). The pectins are not determined by this method, but this is unimportant, because cereal products do not contain pectins. The dietary fibre content of cereal products determined by the analytical and enzymatical method did not differ (SOUTHGATE, 1977). The dietary fibre content of composite products was calculated from the ingredients.

Frequently the carbohydrate content of foods, reported in the UFE food table was not determined by analysis but by calculation. Initially, this was done according to the formula: carbohydrates = 100 – (proteins + fats + water + ash + crude fibre). Crude fibre is defined as 'The residue of plant food left after sequential extraction with solvent, dilute acid and dilute alkali' (TROWELL, 1977). During the crude fibre analysis part of the undigestible carbohydrates is lost. Consequently the amount of digestible carbohydrates calculated from this formula is higher when crude fibre is used instead of dietary fibre. The old figures for digestible carbohydrates also included a part of the undigestible carbohydrates. Hence, the sum of the values for proteins, fats, carbohydrates, ash and water together with the new values for dietary fibre, reported in the

UFE food table, were calculated again for each food. When the sum of nutrients for a food exceeded the arbitrary limit of 105 g, the carbohydrate content of a food was corrected in such a way that the sum of nutrients amounted to 100 g.

2.8. Organization and execution of the study

Contact with local authorities. After selecting a town, contact was made with the director of the local school health organization. The school physicians in Heerenveen, Roermond and Harderwijk were enthusiastically willing to co-operate in the organization and execution of the survey. Next, local general practitioners and municipal authorities were informed by letter about the intention, nature, aims and procedures of the survey to be carried out. The selection of schools asked to participate was done by the school physician in the way described already. After school selection, headmasters and, if existing, parent committees were asked for their permission and co-operation. Co-operation was never refused.

Recruitment of the children. Names and addresses of the children to be invited for participation were taken from school registers obtained from the headmaster. The general questionnaire, accompanied by a covering letter, was given to each child about one week before the measurements were to take place. The covering letter, signed by the school physician and the Head of the Department of Human Nutrition, explained the nature of the study and of the measurements and requested consent from the parents for their child(ren) to take part. If the parents refused their consent, they were asked to inform the headmaster. The children returned the questionnaire to the class teacher after completion. The questionnaires were collected by the investigators on the day of examination and were checked for completeness and for presence of all children who were participating.

The primary schoolchildren in Heerenveen and Harderwijk were recruited according to the procedure described above. Some modifications to this procedure were made in the Roermond survey. The primary schools there consisted of both boys' and girls' schools. Therefore, in the two selected districts of the town, both a boys' and a girls' school had to be examined. In general in these two districts, the children from schools 1 and 2 came from a higher social class and the children from schools 3 and 4 from a lower social class. During the first meeting with the headmasters of the latter schools the expectation of low participation rates was put forward if the parents of these children were contacted in the conventional way. The advice was given to contact a team of welfare workers, employed in this district, because they were highly regarded by the local families. Together with this team of welfare workers, the following procedure was worked out in order to inform the parents about the survey and to ask consent for participation of their children. An informative letter

written by the headmaster of the school was given to all the children. This letter explained the nature of the survey and also stated that one member of the team of welfare workers, or one of the investigators intended to visit the family in order to ask consent for participation.

The Heerenveen nursery schoolchildren were recruited in the same way as the Heerenveen- and Harderwijk primary schoolchildren. In Heerenveen the participation rate of the nursery schoolchildren was low compared to the participation rate of the primary schoolchildren. After the Heerenveen survey the decision was made to intensify contacts with the parents of the children from the nursery schools in Roermond and Harderwijk. An informative letter, signed by the headmaster of the school, was given to all the children. This letter explained the nature of the survey and also stated that one of the investigators intended to visit the family in order to ask consent for participation.

Execution of the study. All surveys took place in the period between January and June. In Heerenveen the survey was conducted in 1974, in Roermond in 1975 and in Harderwijk in 1976.

Execution of the school examination. A short training course preceded each town project. All participating investigators in a certain project were instructed how to perform the anthropometric measurements. A number of measurements were then performed and the results compared to those obtained by the experienced instructor. Special attention was paid to the correct positioning of the child being measured, to the exact localisation of the several body marks and to the correct application of the measuring devices during the measurement, in an effort to make the several investigators comparable to each other with respect to the results obtained.

The measurements in children of the Heerenveen project were obtained by all investigators participating in this town project. Single measurements of standing height and body weight were performed. Next, the remaining measurements were performed by two different investigators in a random sequence. In addition, each single investigator took duplicate measurements of skinfold thicknesses. All participating children from Roermond and Harderwijk were measured by a single female investigator. This investigator was selected by the instructors during the training course on the understanding that she would, presumably, perform measurements the most satisfactorily according to the opinion of the instructors.

The school examination of the children was performed under close supervision of the school physician responsible. Examinations took place school for school and class for class. A total number of about 25 children was invited each survey day to participate in the anthropometric examination and blood sampling. The children came to school that morning at 8.00 a.m. and were asked not to eat or drink anything after rising. Measurements were usually made in an unused classroom or in the headmaster's room. Due to lack of rooms on one occasion a nearby facility had to be rented in the building of a

regional health organization (Groene Kruis, Harderwijk). The children were examined one by one, and the sequence of participation was left to the children. First, anthropometric measurements were taken while the children wore undergarment only. Then, in a separate place, a 10 ml blood sample was drawn from the antecubital vein by a Vacutainer system with the children in sitting position. Finally, breakfast was offered to all the children.

Execution of the dietary survey. Before each survey, the team of investigators, consisting of the principal investigators and 5 or 6 post-graduate students in Human Nutrition, were given a week's training by two experienced dietitians. Before the training week, all team members recorded their food intake for two days. During the training course each record was checked for completeness by another team member, who also encoded the record. A lot of attention was paid to a uniform encoding of the records. A standard list containing information about quantities of different foods and about the composition of mixed dishes was used by each team member. One principal investigator took part in all three surveys. The other principal investigator and one student member of the team participated in two surveys. The remaining student members of the team changed each year.

A letter was sent to the parents of the selected children. In this letter the objectives of the dietary survey were clearly explained and a suggestion for a home visit by one of the investigators was made. On the agreed day and time, a booklet was brought to the child's home and explained to the mother. On the first page of the booklet the objectives of the survey were shortly summarized and some hints given in order to get as accurate data as possible. On the following pages, an example of a child's daily food intake was given in order to show the mother how to fill in the record. On the pages following this example, the foods eaten by the child could be filled in. The mother was instructed how to record, in household measures, all foods eaten and all beverages drunk, except water, by a child for two consecutive days. Special attention was paid to the foods and beverages taken between meals and to the main meal. The mother was instructed to ask the children for information about foods and beverages taken between meals. Concerning the main meal, information was asked about the quantities of raw foods and all ingredients used for the preparation of this meal. The prepared foods and the left-overs were recorded in household measures. The mother was also asked to record how many adults and children partook of this meal.

On the day after the two days surveyed, the booklet was collected by one of the investigators. The record was checked with the mother for completeness. Information was asked about the kind of foods e.g. bread, margarines, milk, meat, etc. and about the preparation of meat and gravy. Also the weights of a slice of bread and a spoon of sugar and the capacities of cups, glasses, dishes and gravy spoons were determined as much as possible.

Follow-up of hyperlipidaemic children and parents. All children and parents

with a serum total cholesterol level exceeding 220 and 270 mg/100 ml respectively, and/or a serum triglycerides level exceeding 100 and 150 mg/100 ml respectively during the first examination, were invited for a second examination. All children and parents whose blood lipid levels remained above these cut-off points were offered nutritional advice by a local dietitian.

After discussion between the investigators, the dietitian and the school physician, the decision was made to advise the hyperlipidaemic children and parents to use a prudent diet low in saturated fat, dietary cholesterol and oligosaccharides and high in polysaccharides and dietary fibre, compared to the current diet. The dietitian emphasized during the talks with the children and their parents that the prudent diet could be used by all family members and should not be restricted to the hyperlipidaemic member of the family only.

Three and six months after the first talk with the dietitian, the hyperlipidaemic children and parents were re-examined in order to evaluate the effect of the recommended diet on the level of blood lipids. After each examination, the children and their parents were invited for a talk with the dietitian in order to discuss the results. The results of the hyperlipidaemic children and parents, before and after dietary intervention, were sent to the school physician and to the general practitioner of the family, if the parents consented.

The results of the follow-up study will be reported separately.

2.9. Concordance of measurement levels in relatives

The concordance of levels of measurements among siblings, among parents and children, and among spouses was studied by analysing the concordance of these measurements with respect to classification in quartiles of the respective distributions. The participants, both parents and children, were grouped into 3 categories – low, intermediate and high – according to their specific percentile distributions. 'Low' corresponded to the lower quartile, 'high' to the upper quartile and 'intermediate' to the middle two. This arrangement identified parents in relationship to the others belonging to the same project and sex-group. The children were thus identified relative to their peers belonging to the same project, sex-group and age-category.

Three different types of analysis were used. The first deals with relationships between measurements obtained in spouse-pairs. The second is concerned with relationships between measurements obtained in combinations of siblings. The third analyses relationships between parents and children, by several combinations of these, e.g. each individual parent vs. each individual child (sexes separated), each individual parent vs. their children (irrespective of sex), and the combination of spouse-pairs and their children (likewise irrespective of sex).

The analysis of concordance in measurement levels among spouses had to be confined, of course, to only the participating spouse-pairs of parents of

the participating children. The analysis of resemblance of measurement levels between parents and children was carried out by comparing the levels observed in all fathers and mothers individually to those of their participating children, both dependently and independently of their sex. All sibships comprising two or more participating children were considered in the analysis of relationships of measurement levels between siblings. In sibships with more than two participating children, pairs of siblings were formed of all possible age-consecutive pairs, i.e. the measurements of the eldest were compared to those of the next eldest only, which in turn were compared to the next-in-age, etc. This was done in order to avoid over-representation of the larger sibships while still retaining all information contained in the larger sibships. Finally, in the analysis of the relationship between spouses and their children, the information available from each participating married couple was combined and consecutively compared to the measurement level in all of their participating children with respect to the variables under investigation.

The level of body fatness in parents was assessed by the ratio weight/height^2 (kg/m^2), called the Quetelet Index. In children the level of body fatness was measured by the skinfold sum. In the combination of levels of body fatness between parents and children both these indirect assessments were used, and were referred to as 'body fatness'.

In most of the analyses, visual evaluation of the resemblance of measurement levels in the couples formed was done by grouping variables into nine categories according to the combination of levels (low, intermediate and high) between both members of each couple. In order to facilitate the construction of tables, the couples were then classified into six categories, rather than nine, as follows: both with low levels; one low and one intermediate; one low and one high; both intermediate; one intermediate and one high; both high. The number of couples observed in each category was compared to the number expected on the basis of 'no association' between the levels in couples.

In the analysis of the relationship between spouse levels and those of their children, the classification of levels among married couples into 6 categories as described above was used as a starting point. Thereafter, all children corresponding to a determined parental category were in turn classified as having high, intermediate and low levels. The number observed for each of these three levels was compared to the number expected under the assumption that a child's level is independent of its parents' levels.

2.10. Statistical methods

The investigation reported here was basically exploratory, meaning that generally no prior hypotheses were formulated which could be tested in the statistical sense. The findings were therefore primarily described by means of the observed distributions of the examined parameters. Because most parameters were 'naturally' dependent upon the stage of physical development

(or age), distributions were usually presented by age-categories. As is usual, the statistics reported to describe the observed distributions were: mean, standard deviation, standard error of the mean and selected percentiles, in addition to the numbers of observations on which the distributions were based.

Coefficients of skewness and coefficients of curtosis (SOKAL and ROHLF, 1969) were computed in order to assess the form and shape of the distributions, in addition to the reported statistics. In some instances, notably for the measurements of skinfold thicknesses and triglycerides concentrations, values for these statistics were found which, by common testing, would indicate non-normality of the observed distributions. This however, did not prove to be consistently the case for the distributions in all age categories. It was further observed that after transformation of these measurements to their natural logarithms, the non-normality remained in some instances and that, in other instances, non-normality appeared just after such transformation. Consequently, normalizing transformations prior to further calculations were not applied.

Associations between the examined parameters were usually evaluated by the magnitude of correlation coefficients. In cases where measurements were affected by growth, the original observations were transformed to their normal deviates. Reference to this was made in the text. The question of whether or not observed parameters were dependent upon age was tested by the magnitude of their correlation coefficient. Multiple regression analysis was performed in order to test the dependency of the observed body weights of the children upon results of anthropometric measurements. The same technique was also used to evaluate the relationship between observed nutrient intakes and a variety of parameters, referred to as 'confounders', including sex and age-group of the children, weekdays on which the food intake was recorded, interviewer, risk factors of the child, demographic data of the child's family and the home town. All these independent variables were treated as 'dummy' variables in the analysis, i.e. presence has been coded as 1 (one) and absence as 0 (zero). Analysis of variance was used to compute within-run and between-run components of the total variation observed in results of control serum measurements obtained in the blood lipids determinations. The same technique was used to assess the between-person and between-days components of the total variation observed in the intake of nutrients. The standard error of the differences between paired determinations of blood lipids by different methods was calculated with the formula: $s.e._{diff} = [\Sigma(d^2)/2n]^{1/2}$; where d was the difference between, and n the number of paired determinations.

The χ^2-statistic was computed to test associations between socio-economic parameters and the level of body fatness or lipaemia in the children. An explanatory theory about all the statistics used can be found in the excellent textbook written by SNEDECOR and COCHRAN (1973).

In the analysis of the relationships between results obtained by two different methods for blood lipid determinations, which was done by simple regression analysis, allowance was made for differences between analytical error associated with the two methods (DAVIES and GOLDSMITH, 1972). The results of these

analyses were used for the adjustment of measurement results of blood lipid determinations to a joint level. Reference was made to this in the text.

The term 'statistically significant' was only used in those instances where the level of statistical significance was at least at 5%.

Most calculations were performed on the DEC-10 computer system of the Agricultural University in Wageningen. The construction of data files and the verification of the information in the files was done by means of self-written FORTRAN IV programmes. Statistics presented for the description of the observed distributions of the examined parameters were calculated by programmes described by SOKAL and ROHLF (1969). Standard Statistical Packages (DIXON, 1973; NIE et al., 1975) were used in most of the additional calculations. For the calculation of nutrient intakes from food intake data, the recently developed computerized Uniform Food Encoding system was used (HAUTVAST, 1975). The analysis of nutrient intakes attributable to different food groups was done by means of self-written programmes.

3. RESULTS

3.1. DESCRIPTION OF THE SELECTED TOWNS

Heerenveen. Heerenveen is the oldest Dutch peat-moor colony. In the 17th and 18th centuries Heerenveen, because of its markets, became the centre of South-east Friesland. It is nowadays an industrial centre. Electronic apparatus, (motor) bikes and ice-skates are the most important products made in the Heerenveen factories. Heerenveen also fulfils a function as regional centre for educational and administrative institutions.

Roermond. In the 14th and 15th centuries Roermond was famous for its prosperous cloth-trade. At that time Roermond belonged to the so-called Hanze towns. In the 19th century Roermond became the religious centre of a Roman Catholic Diocese. Roermond is nowadays the educational, administrative, industrial and trade centre of Middle Limburg. Roermond is well-known for its egg market, being the biggest in Europe. It is also a tourist centre for aquatic sports.

Harderwijk. In the 15th and 16th centuries Harderwijk was a well-known trading, industrial and fishing town and belonged, like Roermond, to the Hanze towns. Harderwijk was also known as an educational centre. In the period 1647–1811 Harderwijk was a University town. Well-known scientists such as the physician Boerhaave, the paediatrician Rosen Von Rosenstein and the botanist Linnaeus defended their theses at the University of Harderwijk. At the present time Harderwijk is the rapidly growing educational, administrative, and industrial centre of the North-west Veluwe. Harderwijk is also a tourist centre.

It can be seen that all three towns are regional centres. Heerenveen differs from Roermond and Harderwijk concerning the degree of urbanization (Table

TABLE 35. Some demographic characteristics of Heerenveen, Roermond and Harderwijk.

Town	Year of investigation	Number of inhabitants on the first of January	Degree of urbanization*
Heerenveen	1974	33,865	B_2
Roermond	1975	36,692	C_3
Harderwijk	1976	28,508	C_2

* Degree of urbanization of a town:
B_2: urbanized-countryside, largest residential district 5,000–20,000 inhabitants.
C_2: city character, residential district 10,000–30,000 inhabitants.
C_3: city character, residential district 30,000–50,000 inhabitants.
Source: List of towns to degree of urbanization on February 28, 1971 C.B.S., Voorburg 1977.

35). Heerenveen is characterized as urbanized-countryside. Roermond and Harderwijk both have a city character.

3.2. Description of the schoolchildren populations

All children of each selected school were invited to participate in the study. The statistical analyses of the results were restricted to children of parents born in The Netherlands. The eligible children were divided into four categories.
Category I: those children, who did not participate because they were ill during the survey. Children who were not judged 'apparently healthy' by the school physician because they had diabetes mellitus or congenital heart disease, etc., also belonged to this category.
Category II: those children, who exceeded the previously established age range of 3.5 to 13.5 years. These children were examined but their results were discarded from the statistical analyses.
Category III: those children, who did not participate in the survey because their parents refused to give permission.
Category IV: all remaining children who participated in the anthropometric survey at least.

In Heeenveen the participation rate from all primary schools was above 90% (Table 36). On the other hand the participation rate from the nursery schools

Table 36. Review of (non) participation rates of Heerenveen schoolchildren eligible for the survey.

School number	Eligible n	Schoolchildren*							
		Cat. I		Cat. II		Cat. III		Cat. IV	
		n	%	n	%	n	%	n	%
Primary school									
1	129	–	–	–	–	9	7.0	120	93.0
2	163	3	1.8	–	–	11	6.7	149	91.4
3	107	–	–	–	–	5	4.7	102	95.3
4	202	1	0.5	–	–	4	2.0	197	97.5
Total	601	4	0.7	–	–	29	4.8	568	94.5
Nursery school									
1	72	–	–	–	–	18	25.0	54	75.0
2	69	1	1.4	–	–	17	24.6	51	73.9
3	70	1	1.4	–	–	19	27.1	50	71.4
Total	211	2	0.9	–	–	54	25.6	155	73.5

* Categorization:
Cat. I: children who did not participate due to illness.
Cat. II: children who exceeded the previously established age range.
Cat. III: children who did not participate due to parental refusion.
Cat. IV: children who participated in the anthropometric survey at least.

did not exceed the 75% level. In Roermond the participation rate from primary schools 1 and 2 was about 10% lower than from schools 3 and 4 (Table 37). In Roermond the average participation rate from both primary and nursery schools was about 85%. In Harderwijk the participation rate among primary and nursery schoolchildren both exceeded the 90% level (Table 38).

TABLE 37. Review of (non) participation rates of Roermond schoolchildren eligible for the survey.

School number	Eligible n	Schoolchildren*							
		Cat. I		Cat. II		Cat. III		Cat. IV	
		n	%	n	%	n	%	n	%
Primary school									
1	196	5	2.6	1	0.5	22	11.2	168	85.7
2	182	8	4.4	1	0.5	31	17.0	142	78.0
3	121	3	2.5	3	2.5	3	2.5	112	92.6
4	200	6	3.0	3	1.5	7	3.5	184	92.0
Total	699	22	3.1	8	1.1	63	9.0	606	86.7
Nursery school									
1	55	2	3.6	–	–	8	14.5	45	81.8
2	74	1	1.4	–	–	9	12.2	64	86.5
3	58	1	1.7	–	–	5	8.6	52	89.7
Total	187	4	2.1	–	–	22	11.8	161	86.1

* See footnote table 36.

TABLE 38. Review of (non) participation rates of Harderwijk schoolchildren eligible for the survey.

School number	Eligible n	Schoolchildren*							
		Cat. I		Cat. II		Cat. III		Cat. IV	
		n	%	n	%	n	%	n	%
Primary school									
1	155	5	3.2	–	–	10	6.5	140	90.3
2	174	1	0.6	–	–	2	1.1	171	98.3
3	118	3	2.5	–	–	3	2.5	112	94.9
4	233	1	0.4	–	–	6	2.6	226	97.0
Total	680	10	1.5	–	–	21	3.1	649	95.4
Nursery school									
1	60	2	3.3	–	–	2	3.3	56	93.3
2	130	8	6.2	–	–	2	1.5	120	92.3
3	66	1	1.5	–	–	4	6.1	61	92.4
Total	256	11	4.3	–	–	8	3.1	237	92.6

* See footnote table 36.

TABLE 39. Chronological age of the examined schoolchildren.

Age category	Heerenveen			Roermond			Harderwijk		
	n	mean	s.d.	n	mean	s.d.	n	mean	s.d.
Boys									
4–5	35	4.9	0.34	41	4.8	0.44	70	4.8	0.43
6–7	96	6.6	0.53	82	6.5	0.56	107	6.5	0.55
8–9	96	8.5	0.61	85	8.5	0.52	112	8.4	0.54
10–11	104	10.5	0.59	114	10.5	0.62	111	10.5	0.59
12–13	57	12.3	0.55	90	12.2	0.48	71	12.2	0.52
Girls									
4–5	40	5.0	0.37	46	4.8	0.42	71	4.9	0.36
6–7	77	6.6	0.58	51	6.4	0.49	95	6.5	0.56
8–9	80	8.4	0.65	88	8.6	0.57	95	8.6	0.52
10–11	76	10.6	0.57	104	10.4	0.60	99	10.5	0.56
12–13	62	12.1	0.43	66	12.2	0.49	55	12.1	0.39

In Heerenveen and Harderwijk the same average participation rates were found in primary schoolchildren. In Roermond the participation rate was about 10% lower. The variation in average participation rates between the nursery schoolchildren from the three towns was rather large. In Heerenveen the average participation rate was about 15% lower than in Roermond, which in turn was about 5% lower than in Harderwijk.

Age distribution of the participating children. The results from children aged between 3.5 and 13.5 years were used for statistical analyses. Age categories of two years were made because the number of children in the lowest and highest age classes was too small to warrant statistical analyses on the basis of one year age classes. The mean age of all age categories was similar in the three surveyed populations (Table 39). In all three populations the number of boys examined was higher than the number of girls examined.

3.3. DEMOGRAPHIC DATA

General questionnaire. Completed questionnaires were returned by 99.1, 94.9 and 98.9% of the participating families in Heerenveen, Roermond and Harderwijk respectively. The category 'unknown' in Tables 40–45 is higher than the expected percentages of 0.9, 5.1 and 1.1% because not all questions were answered in some questionnaires.

Fathers' education and occupation. The percentage of fathers with elementary school education only varied from 22% in Heerenveen to 35% in Roermond and Harderwijk (Table 40). The percentage of fathers with low occupational education was 19% in Roermond, 35% in Harderwijk and 43% in Heerenveen.

TABLE 40. Percentual distribution according to educational level of the fathers of examined schoolchildren by project town.

Fathers' education	Heerenveen	Roermond	Harderwijk
1 Elementary	22.2	35.4	35.9
2 Low occupational	43.2	19.3	34.8
3 Advanced elementary	16.5	14.4	12.3
4 Medium occupational	5.2	4.5	5.1
5 Grammar school	2.3	8.1	2.5
6 High occupational	5.6	8.4	3.3
7 University	1.1	3.6	1.0
Unknown	3.9	6.4	5.2
Number of families	558	534	612

In contrast to these large variations the percentage of fathers with advanced elementary or medium occupational education was about 20% in all three towns. The percentage of fathers with a high educational level (categories 5, 6 and 7) was about 2.5 times higher in the Roermond fathers compared to the Heerenveen and Harderwijk fathers.

The general questionnaire also provided information about the former occupation of those fathers who were unemployed during the survey. It was possible therefore to compare the occupational information of the fathers in the three towns independently of the unemployment rate (Table 41). The percentage of unskilled labourers ranged from 14% to 20%. The percentage skilled labourers was about 1.5 times higher in Heerenveen and Harderwijk compared to Roermond. The percentage of clerks was 3% in Roermond, 11% in Heerenveen and 15% in Harderwijk. The percentage of medium paid civil servants varied from about 15% in Harderwijk and Roermond to 23% in

TABLE 41. Percentual distribution according to occupation of the fathers of examined schoolchildren by project town.

Fathers' occupation	Heerenveen	Roermond	Harderwijk
Unskilled labourer	13.8	20.3	16.7
Skilled labourer	29.0	19.9	30.9
Agricultural labourer	0.7	0.	1.0
Clerk	10.6	3.4	14.7
Medium paid civil servant	23.3	17.1	14.2
Farmer	5.0	0.	0.8
Small business owner	8.2	19.1	11.8
Academic or executive professions	4.8	12.8	4.9
Unknown	4.5	7.5	5.1
Number of families	558	534	612

Heerenveen. The percentage of farmers and small buisiness owners was about 1.5 times higher in Roermond compared to Heerenveen and Harderwijk. The percentage of fathers with academic and executive professions was about 2.5 times higher in Roermond compared to Heerenveen and Harderwijk.

The socio-economic status of the family, mainly based on the father's occupation, was also estimated in Roermond and Harderwijk (Table 42). The percentage of families in social classes I and II was about 10% higher in Roermond than in Harderwijk. The percentages of the families in social classes III and IV was similar in both towns. The percentage of families in social class V was about 10% higher in Harderwijk compared to Roermond.

It can be concluded that the educational level of the fathers tended to be highest in Roermond and lowest in Harderwijk. The same trend was present in the father's occupation and in the socio-economic status of the family. The educational and occupational level of the Heerenveen fathers resembled more that of the Harderwijk than that of the Roermond fathers.

Mothers' education and occupation. The percentage of mothers with elementary school education only was about 30% in Heerenveen and about 36% in Roermond and Harderwijk (Table 43). The percentage of mothers with low occupational education was about 1.5 times higher in Heerenveen and Harderwijk compared to Roermond. The percentage of mothers with advanced elementary and medium occupational education was about 24% in Heerenveen and Roermond and about 17% in Harderwijk. The percentage of mothers with a high educational level (categories 5, 6 and 7) ranged between 5 and 7%.

The percentage of mothers, who occupied a full-time or part-time job was 13% in Heerenveen, 27% in Roermond and 15% in Harderwijk (Table 44). The difference between Heerenveen and Harderwijk was mainly caused by the 4% of Harderwijk mothers in the category of small business owners. The about twice as high employment rate among Roermond mothers compared to Heerenveen and Harderwijk mothers can be largely ascribed to higher percentages in

TABLE 42. Percentual distribution according to socio-economic status (SES) of the family of examined children in Roermond and Harderwijk.

SES* of the family (category)	Roermond	Harderwijk
I (high)	12.7	6.0
II	8.8	6.7
III	24.9	25.8
IV	20.2	21.1
V (low)	25.3	35.3
Unknown	8.1	5.1
Number of families	534	612

* According to Attwood statistics.

TABLE 43. Percentual distribution according to educational level of the mothers of examined schoolchildren by project town.

Mothers' education	Heerenveen	Roermond	Harderwijk
1 Elementary	29.4	36.0	36.6
2 Low occupational	40.3	25.5	38.4
3 Advanced elementary	19.7	19.3	13.2
4 Medium occupational	3.6	5.2	4.2
5 Grammar school	2.5	2.8	2.8
6 High occupational	2.9	4.3	1.8
7 University	0.2	0.2	0.
Unknown	1.4	6.7	2.9
Number of families	558	534	612

the categories unskilled labourers, trade people and academic or executive professions.

It can be concluded that the educational level of the Harderwijk mothers tended to be lower than that of the Heerenveen and Roermond mothers. The difference in educational level between Heerenveen and Roermond mothers was generally small. The employment rate of the Roermond mothers was about twice as high as that of the Heerenveen and Harderwijk mothers.

Autochthonous parents and children. In the Roermond survey the parents were called autochthonous when both father and mother were born and raised in the province of Limburg. In Harderwijk the parents were called autochthonous when both father and mother were born and raised in the region

TABLE 44. Percentual distribution according to occupation of the mothers of examined schoolchildren by project town.

Mothers' occupation	Heerenveen	Roermond	Harderwijk
Housewife only	86.1	64.8	81.7
Unskilled labourer	1.6	7.7	1.3
Skilled labourer	2.7	0.7	1.1
Agricultural labourer	0.	0.	0.
Clerk	3.2	3.2	6.0
Medium paid civil servant	4.8	5.8	2.6
Farmer	0.	0.	0.
Small business owner	0.	8.2	3.9
Academic or executive profession	0.4	1.5	0.2
Unknown	1.3	8.1	3.1
Number of families	558	534	612

TABLE 45. Percentual distribution according to autochthonous parents and autochthonous children of examined schoolchildren in Roermond and Harderwijk.

Autochthonous parents or children	Roermond	Harderwijk
Parents		
Yes	65.5	32.7
No	34.5	67.3
Number of families	534	612
Children		
Yes	61.4	63.6
No	38.6	36.4
Number of children	767	877

of the North-west Veluwe. The province of Limburg and the North-west Veluwe were used instead of the towns Roermond and Harderwijk because the way of life of the Roermond and Harderwijk people was assumed to be similar among all people living in Limburg and the North-west Veluwe respectively. The percentage of autochthonous parents was twice as high in Roermond than in Harderwijk (Table 45).

The Roermond children were called autochthonous if their parents had settled in Limburg before 1960. The children of Harderwijk parents who had lived in the North-west Veluwe since their marriage were called authochthonous. In both Roermond and Harderwijk about 2/3 of the children were called autochthonous.

3.4. ANTHROPOMETRY

3.4.1. *Selected measurements*

Major results of the anthropometric evaluation of body build have been summarized in Table 46 and Figs. 10–14. A description of the findings follows.

Boys from Heerenveen were on the average 3 cm taller than boys from Roermond in the age-categories used, and 1 cm taller than boys from Harderwijk. Girls from Heerenveen were 3 cm taller on the average than girls from Roermond and 2 cm taller than girls from Harderwijk. In both boys and girls, the differences in attained standing height between Heerenveen and Harderwijk were larger in the younger age-group compared to the differences in the older age-groups.

The differences in mean body height between children from the 3 project towns were only partially parallelled by differences in mean body weight. Boys from Heerenveen were on average 1 kg heavier than boys from Roermond. Mean body weights in boys from Harderwijk and Heerenveen were essentially

TABLE 46. Major results of anthropometric measurements by project-town, sex and age-category.

Measurement	Age (y)	Boys						Girls					
		HVN		RMD		HWK		HVN		RMD		HWK	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Body weight (kg)	4–5	19.6	2.2	18.8	2.3	18.4	2.2	19.8	2.1	18.8	2.2	18.3	2.4
	6–7	23.9	2.8	22.5	3.2	23.5	2.9	22.6	3.2	21.6	3.6	21.5	3.2
	8–9	27.8	4.1	27.6	4.4	28.2	4.6	27.7	3.8	27.9	5.2	28.0	4.7
	10–11	34.3	6.5	34.3	6.2	34.0	5.6	35.1	6.6	34.3	6.2	35.3	7.1
	12–13	40.9	5.9	38.8	7.2	41.7	8.4	42.7	7.5	40.9	7.2	42.9	9.1
Standing height (cm)	4–5	112.9	4.2	110.7	5.7	109.7	4.8	115.1	5.7	110.7	5.0	109.8	5.2
	6–7	124.9	5.3	121.3	6.3	123.3	4.9	122.7	5.7	119.3	5.3	120.0	6.6
	8–9	134.2	7.2	132.1	6.6	133.6	4.8	133.2	6.0	131.9	6.7	132.6	6.5
	10–11	144.7	7.9	142.4	6.7	143.7	6.4	146.1	7.4	142.9	7.5	143.7	7.9
	12–13	153.8	6.6	149.2	6.6	153.7	7.7	156.3	7.3	152.2	7.6	154.3	7.5
Sum of knee widths (cm)	4–5	13.9	0.7	13.8	0.8	13.5	0.7	13.4	0.7	13.4	0.7	13.0	0.7
	6–7	14.8	0.8	14.6	0.8	14.6	0.8	14.1	0.8	13.7	0.7	13.7	0.9
	8–9	15.5	0.9	15.1	0.8	15.6	1.0	14.9	0.9	14.5	0.8	14.9	1.0
	10–11	16.6	1.1	15.9	0.9	16.5	1.0	16.1	1.0	15.3	0.9	16.1	1.2
	12–13	17.5	1.1	16.5	0.9	17.6	1.2	16.9	1.1	16.1	0.9	16.8	1.1
Mid-arm muscle circumference (cm)	4–5	15.1	1.0	14.0	1.1	14.1	0.9	15.0	1.1	13.8	1.0	13.9	1.0
	6–7	16.0	1.1	14.9	1.2	15.1	0.9	15.6	1.2	14.6	1.3	14.7	1.2
	8–9	16.9	1.4	16.3	1.5	15.9	1.3	16.2	1.2	16.0	1.5	15.7	1.2
	10–11	18.0	1.4	17.6	1.6	17.0	1.4	17.8	1.4	17.2	1.3	17.1	1.3
	12–13	19.3	1.3	18.3	1.7	18.1	1.5	19.3	1.7	18.2	1.4	18.3	1.6
Skinfold sum (mm)	4–5	25.6	5.7	24.9	6.1	26.8	4.6	26.3	7.3	27.7	6.0	29.6	6.1
	6–7	22.1	6.4	23.7	7.7	26.1	6.8	26.9	9.6	28.6	10.3	27.6	6.6
	8–9	22.7	9.1	24.9	9.7	28.0	11.2	28.7	10.0	32.9	13.8	32.6	11.2
	10–11	26.8	14.7	29.4	13.5	29.7	13.3	34.6	17.5	36.9	16.3	38.7	15.7
	12–13	29.6	12.0	31.1	16.2	34.7	15.5	35.9	11.8	38.5	14.2	39.3	14.7

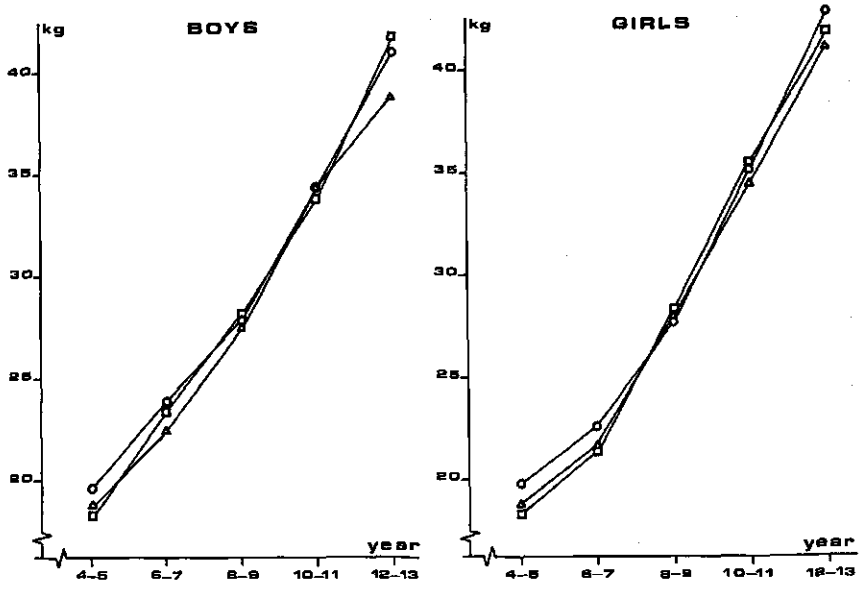

FIG. 10. Mean body weight by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

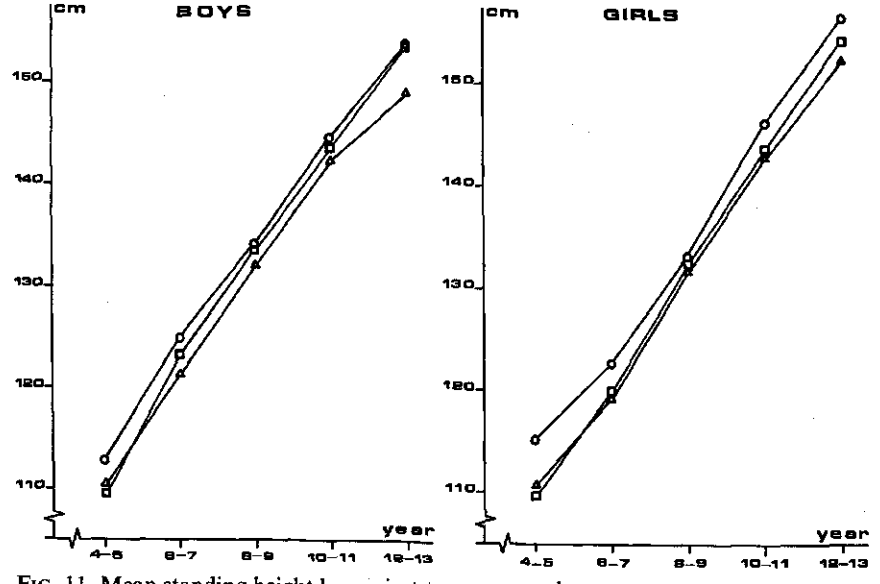

FIG. 11. Mean standing height by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

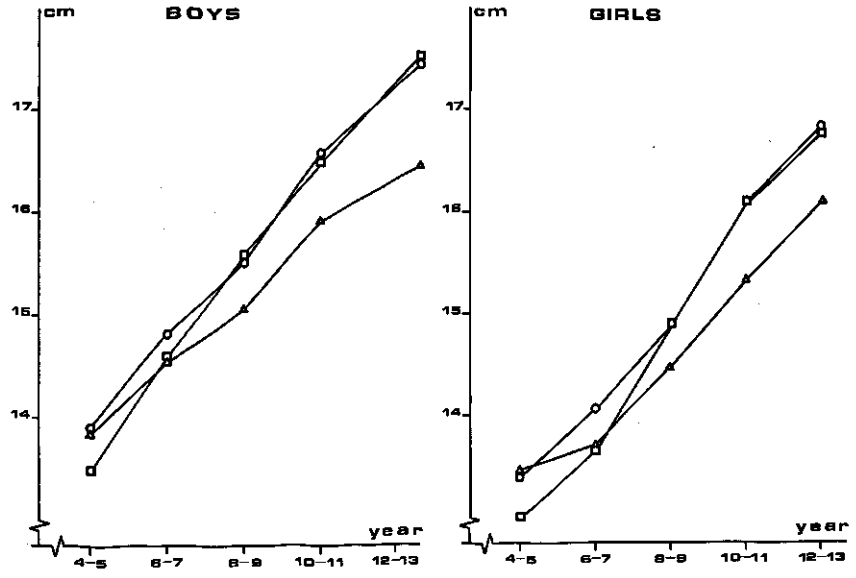

FIG. 12. Mean knee-widths by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

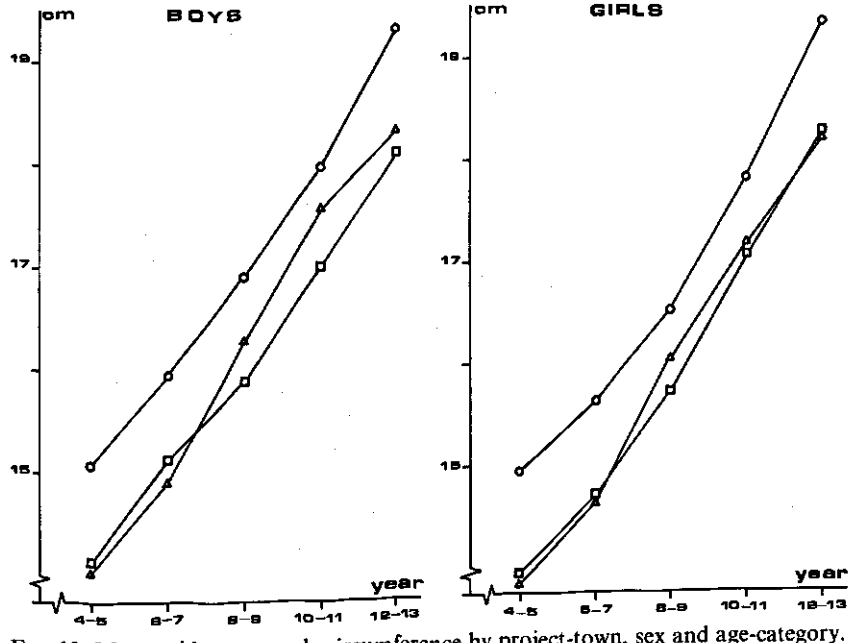

FIG. 13. Mean mid-arm muscle circumference by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

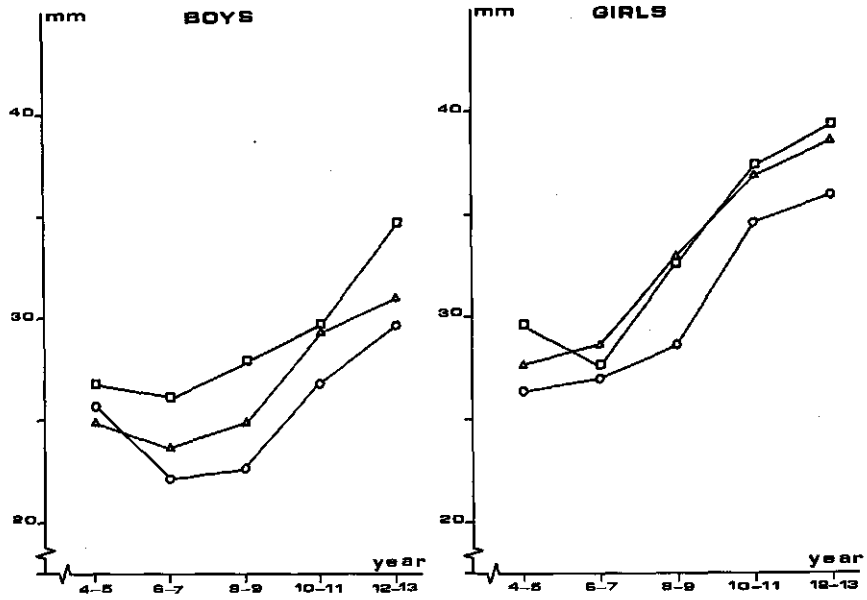

FIG. 14. Mean skinfold sum by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

equal. Girls from Heerenveen were found to weigh 1 kg more on average than girls from Roermond. In the younger age-groups, a difference of 1–1½ kg was found in body weight between girls from Harderwijk and Heerenveen, while after the age of 8 years, girls from these towns were found to have essentially equal body weights.

In comparing results of skeletal width, measured by the sum of knee widths, it was noted that both boys and girls from Roermond diverge more and more, remaining on lower levels than those from Heerenveen. A difference of about 0.1 cm was found in the younger age-categories. This difference had increased to about 1 cm in the age-categories 10–11 and 12–13 years. On average, the difference in skeletal width between children from Heerenveen and Roermond was found to be 0.5 cm, which is about 3% of the mean measurement. In both boys and girls from Heerenveen and Harderwijk, the mean of knee widths was equal after age category 8–9 years. Before that age, boys and girls from Harderwijk had a slightly lower mean of knee widths.

More pronounced differences were found in mean mid-arm muscle circumference in the children from the 3 town projects. Children from Harderwijk had the lowest values for this measurement and both boys and girls from Heerenveen consistently exhibited highest values. Children from Heerenveen had on the average a 1 cm greater arm muscle by this measurement, which is about 5% of the mean level of measurement. Mid-arm muscle circumferences in boys from Roermond and Harderwijk differed negligibly up to the age of

8–9 years. In the older age categories, boys from Roermond had approximately 0.5 cm greater mean arm muscle than boys from Harderwijk. The arm muscle differed only slightly between girls from Roermond and Harderwijk, with the girls from Roermond having the higher values.

Large differences were noted in results of mean skinfold thicknesses, expressed as the sum of the skinfold measurements at 4 sites. Boys and girls from Heerenveen had the lowest mean values of skinfold thickness, and results in children from Harderwijk were 3.0–3.5 mm higher than those in children from Heerenveen. This difference amounted to about 10% of the mean level of measurement. Boys from Roermond took an intermediate position with respect to results of skinfold measurements and were found to have on average 5% higher values than boys from Heerenveen. Girls from Roermond approached the mean results found in girls from Harderwijk and had on average 8% higher mean skinfold sum than girls from Heerenveen.

The description of results has so far been confined only to comparisons of mean values in sex and age-categories from the 3 town projects. An important point to consider is whether the above-mentioned differences in mean body measurements apply to the whole distribution of values. This question could be solved by the inspection of values for selected percentiles given in Appendix 6.1. In doing this, however, attention had to be paid to the lesser reliability of these estimates when compared to those of the mean. Nevertheless, the comparison of percentile values, both at the low (10th) and at the high (90th) level, reinforced the above comparisons of mean results found, with respect to

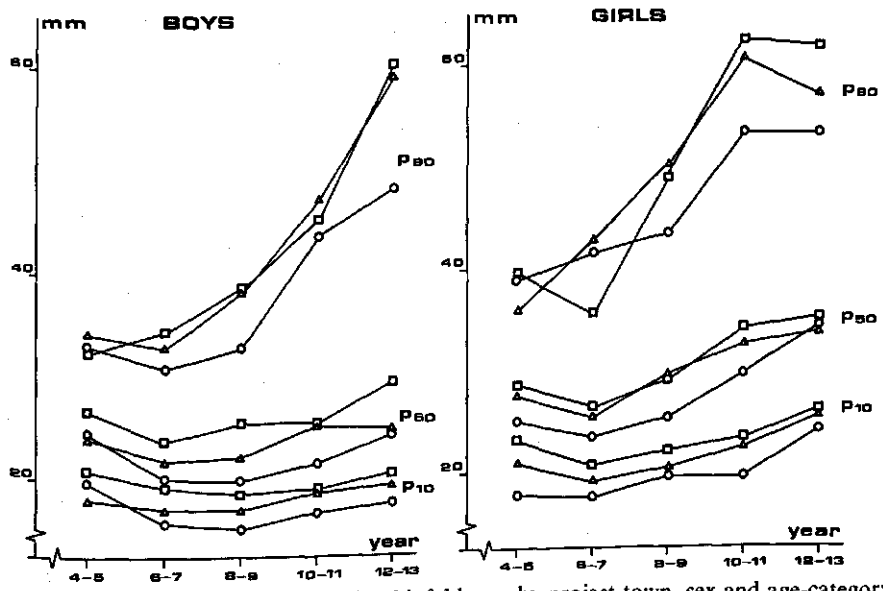

FIG. 15. Percentile distribution of the skinfold sum by project-town, sex and age-category. ○ = HVN; △ = RMD; □ = HWK.

standing height, body weight (although the differences at the selected percentiles were somewhat variable for this measure), knee widths and arm muscle. The comparison of selected percentiles for results of the sum of skinfold thicknesses gave a more complex picture. The comparison is shown in Fig. 15. As described for the mean results of these measurements, children from Roermond took an intermediate position when compared to children from Heerenveen and Harderwijk. However, this applies only, as may be seen from Fig. 15, to results on the low (10th percentile) and median (50th percentile) level. At high levels of measurements (90th percentile) children from Roermond had caught up to the level of measurement observed in children from Harderwijk, which is concluded by the general concordance of values for the 90th percentile in children from these 2 towns. So, results of skinfold measurements in children from Roermond were found to be more skewed to higher values than results in children from Heerenveen and Harderwijk, which could eventually result in a greater proportion of children with very high skinfold thicknesses in Roermond.

3.4.2. *Obesity.*

This possibility was further investigated by comparing the prevalences of children classified as obese. Results are given in Table 47 and Fig. 16. Borderline plus frank obesity was defined to be present in boys if results of skinfold

TABLE 47. Percent prevalence of obesity* by project-town, sex and age-category.

Sex	Age (y)	Borderline plus frank			Frank		
		HVN	RMD	HWK	HVN	RMD	HWK
Boys	4–5	5.7	7.3	7.1	0.	0.	0.
	6–7	5.2	4.8	8.4	1.0	2.4	1.9
	8–9	8.3	9.4	15.2	2.1	3.5	3.6
	10–11	20.2	21.9	22.5	3.8	6.1	7.2
	12–13	28.1	26.7	32.4	5.3	11.1	12.7
	All	13.4	15.5	16.8	2.6	5.3	4.9
Girls	4–5	10.0	6.5	11.3	0.	0.	0.
	6–7	10.4	11.8	4.2	2.6	2.0	0.
	8–9	12.5	26.1	20.0	3.8	8.0	8.4
	10–11	17.3	22.1	19.2	6.7	10.6	4.0
	12–13	22.5	31.8	27.3	4.8	7.6	10.9
	All	14.7	21.4	15.7	3.9	6.8	4.3

* Borderline plus frank obesity was defined to be present in boys of all age-categories if the sum of 4 skinfold thicknesses was greater than or equal to 35 mm (20% of body fat). Frank obesity was defined by the cut-off point of 52 mm of skinfold thickness (25% of body fat). In girls of 4–9 years, the cut-off point for borderline plus frank obesity was 39 mm of the skinfold sum (20% of body fat), while in girls older than 9 years the cut-off point of 44 mm skinfold sum was used for this definition (22% of body fat). In these girls, frank obesity was defined to be present if the sum of 4 skinfold thicknesses was greater than or equal to 53 mm (25% of body fat) and 60 mm (27% of body fat) respectively.

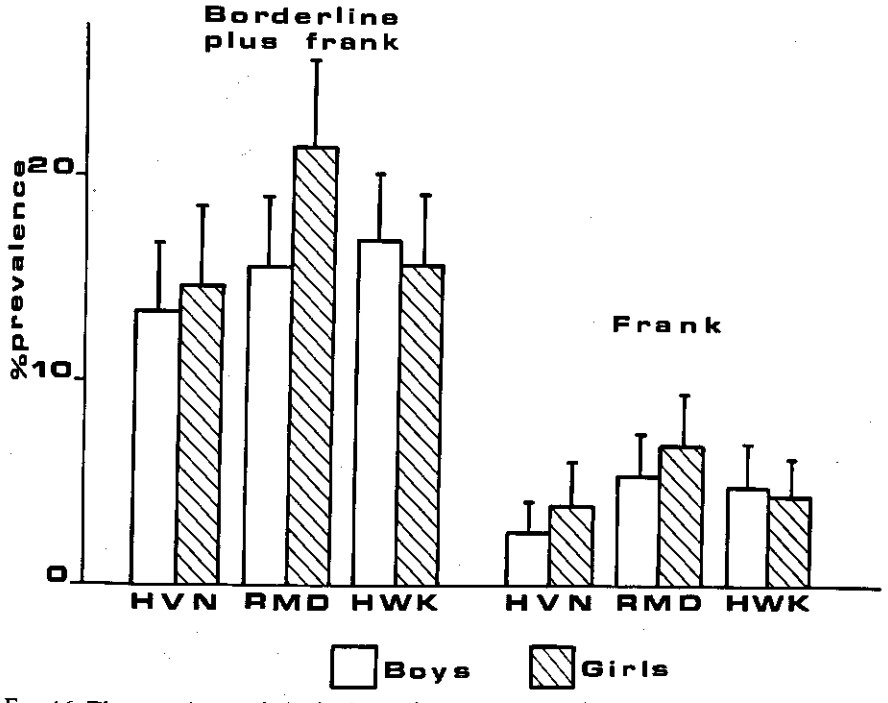

FIG. 16. The prevalence of obesity by project-town, sex and age-category.

thickness measurements were equal to or greater than 35 mm of skinfold sum. Frank obesity was defined by the cut-off point of 52 mm in boys. Using published prediction formulae (PARIZKOVA and ROTH, 1972; DURNIN and RAMAHAN, 1967; BROOK, 1971; OUDE OPHUIS et al., 1977), it was calculated that these figures yielded estimates of 20% and 25% of body fat, respectively. In girls, allowance was made for the steep increase in results of skinfold measurements after the age of 9 years. In the age-categories before the age of 10, cut-off points used for the definition of borderline plus frank obesity, and frank obesity were 39 mm and 53 mm, respectively. This was calculated to give assessments of 20% and 25% of body fat. From the age of 10 onwards, cut-off points used were 44 mm and 60 mm for the definition of borderline plus frank and frank obesity, respectively. This gave assessments of 22% and 27% of body fat.

Obesity, thus defined, was positively related to age-categories in both boys and girls from all 3 towns. The prevalence in boys of 13.4%, 15.5% and 16.8% for borderline plus frank obesity were found in Heerenveen, Roermond and Harderwijk. This prevalence ranged from 6% in the 2 younger age-categories to about 25% in the 2 older age-categories. Frank obesity was found to be present in 2.6%, 5.3% and 4.9% of all examined boys from Heerenveen, Roermond and Harderwijk. This prevalence increased from being virtually absent in the youngest age-categories to about 7.5% in the oldest age-categories. In girls, the

prevalence of borderline plus frank obesity increased in the age-categories from 9% to 30%. Mean prevalences found were 14.7%, 21.4% and 15.7% in girls from Heerenveen, Roermond and Harderwijk, respectively.

The same relationship of the prevalence of frank obesity to age-categories as noted in the boys and about the same prevalence data were found in the girls. Mean prevalences of frank obesity found in girls were 3.9%, 6.8% and 4.3% in Heerenveen, Roermond and Harderwijk. Taking the results from the 3 projects together, a prevalence for borderline plus frank obesity of 15% was found in boys and 17% in girls. Of this, 4% was frank obesity in boys and 5% was frank obesity in girls.

3.4.3. *Dependency of body weight upon anthropometric indices*

Inter-relationships between body measurements were first studied by linear correlation coefficients. Prior to calculating these, all measurements were reduced to their respective 'normal deviates' by the formula $(X-\bar{x})/s.d.$, where X is the measurement in the individual and $\bar{x}$ and s.d. are the mean and standard deviations of the individuals' measurements by project, sex and age-category. In this way it was possible to combine the results of children from all age-categories. The correlation coefficients found are reported in Table 48 by project and sex. High intercorrelations between body measurements were observed. One remarkable exception to this may be noted, namely the rather low coefficients between standing height and skinfold sum.

TABLE 48. Linear correlation coefficients between body measurements* by project and sex.

		Measurements in boys				
Project	Measurements in girls	Body weight	Standing height	Knee widths	Arm muscle	Skinfold sum
Heerenveen	Body weight		.77	.85	.73	.54
385 boys;	Standing height	.72		.73	.44	.09
332 girls	Knee widths	.85	.60		.61	.37
	Arm muscle	.70	.43	.59		.37
	Skinfold sum	.61	.10	.55	.37	
Roermond	Body weight		.76	.81	.86	.67
411 boys;	Standing height	.73		.66	.52	.25
352 girls	Knee widths	.78	.62		.66	.49
	Arm muscle	.83	.51	.68		.63
	Skinfold sum	.73	.25	.48	.62	
Harderwijk	Body weight		.78	.86	.77	.62
470 boys;	Standing height	.83		.69	.51	.22
413 girls	Knee widths	.87	.75		.64	.50
	Arm muscle	.76	.59	.66		.50
	Skinfold sum	.62	.29	.50	.44	

* Measurements were transformed to project, age-category and sex-specific normal deviates prior to calculating correlation coefficients.

TABLE 49. Multiple linear regression analysis* of body weight upon anthropometric measurements by project and sex.

Project	Independent variable	Boys		Girls	
		regr. coeff.	st. error	regr. coeff.	st. error
Heerenveen	Standing height	.44	.0235	.42	.0226
	Knee widths	.25	.0275	.28	.0280
	Arm muscle	.27	.0199	.24	.0208
	Skinfold sum	.31	.0176	.33	.0214
	Tot. pred. power (R^2)	.91		.91	
Roermond	Standing height	.38	.0168	.39	.0194
	Knee widths	.18	.0192	.15	.0227
	Arm muscle	.37	.0189	.31	.0233
	Skinfold sum	.27	.0162	.37	.0192
	Tot. pred. power (R^2)	.94		.92	
Harderwijk	Standing height	.34	.0164	.42	.0221
	Knee widths	.31	.0218	.28	.0250
	Arm muscle	.26	.0179	.22	.0194
	Skinfold sum	.25	.0162	.26	.0167
	Tot. pred. power (R^2)	.92		.92	

* Measurements were transformed to project, age-category and sex-specific normal deviates prior to performing multiple regression analysis.

Next, the relationship of the various measurements of body build to body weight was tested by multiple regression, using the above-mentioned normal deviates. A considerable mean predictive power of 92% was observed by the combinations of measurements shown in Table 49. The results of each measurement contributed significantly at inclusion in all the project-sex combinations shown. Further calculations revealed that, under the assumption of 100% predictability of body weight by the combination of these measurements, standing height contributed for about 30%, knee widths for about 20%, arm muscle for about 25% and skinfold sum for about 25% to the prediction in boys. The corresponding figures in girls were respectively 35%, 20%, 20% and 25%. The most notable difference in predictive power of these measurements between projects were the relatively low contributions by knee widths measurements in children from Roermond and the higher contributions by the mid-arm muscle circumference in children from Roermond to the prediction of body weight.

3.5. BLOOD CHEMICAL PARAMETERS

Mean results are summarized in Table 50 and shown in Figs. 17–20. Appendix 6.2. shows statistics of the observed distributions.

TABLE 50. Major results of blood chemical determinations by project-town, sex and age-category.

Measurement	Age (y)	Boys						Girls					
		HVN		RMD		HWK		HVN		RMD		HWK	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Haemoglobin (g/100 ml)	4–5	12.9	0.7	12.7	0.7	12.9	0.8	13.2	0.8	12.5	0.7	13.0	0.9
	6–7	13.3	0.9	13.0	0.7	13.3	0.8	13.0	0.8	13.0	0.7	13.4	1.0
	8–9	13.2	0.8	13.2	0.8	13.7	0.8	13.3	0.7	13.1	0.7	13.8	0.7
	10–11	13.5	0.8	13.4	0.7	14.0	0.9	13.8	0.8	13.3	0.6	14.0	0.8
	12–13	13.9	0.9	13.3	0.8	13.9	1.0	13.7	1.0	13.4	0.6	13.9	0.7
Total cholesterol (mg/100 ml)	4–5	158	25.0	177	39.6	179	31.0	169	24.9	169	26.0	186	27.9
	6–7	168	26.8	170	27.1	181	26.6	167	29.1	182	40.1	181	26.8
	8–9	172	23.5	176	24.3	179	28.8	179	27.5	190	27.9	185	27.2
	10–11	173	25.9	182	29.3	189	36.9	179	28.1	189	31.3	188	34.4
	12–13	173	28.1	176	29.9	178	26.3	181	28.6	179	26.1	187	30.6
Triglycerides (mg/100 ml)	4–5	63	24.6	65	31.1	65	27.6	69	25.2	62	21.1	68	22.6
	6–7	63	21.0	62	25.0	56	22.3	74	26.9	73	33.8	61	26.3
	8–9	60	19.9	62	20.3	57	20.5	61	18.2	65	25.7	60	17.3
	10–11	64	25.7	69	31.4	57	17.3	66	18.9	71	23.6	64	23.6
	12–13	71	21.7	67	26.0	56	18.9	69	19.9	72	26.5	64	20.7
HDL-cholesterol* (mg/100 ml)	4–5			52	13.1	52	13.0			51	11.0	51	11.8
	6–7			56	12.8	56	13.2			57	15.5	54	11.6
	8–9			62	11.4	59	13.5			60	20.6	56	10.9
	10–11			58	12.1	61	12.8			62	13.0	60	12.7
	12–13			55	13.0	59	10.2			58	12.9	60	12.8

* Not measured during the Heerenveen project.

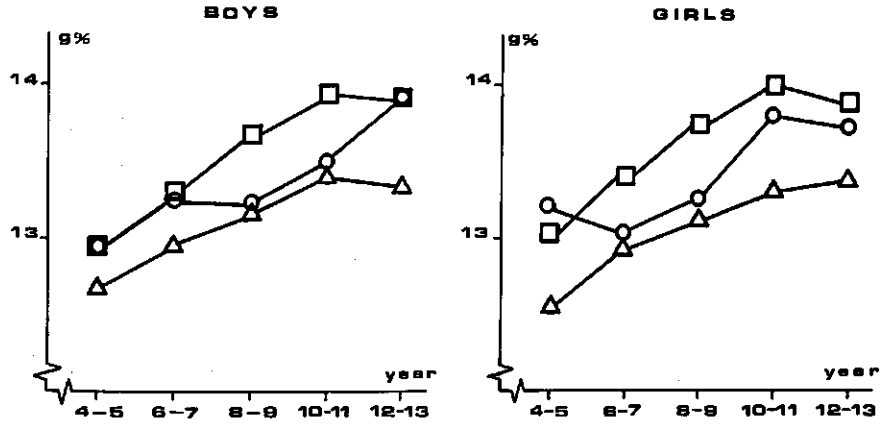

FIG. 17. Mean haemoglobin level by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

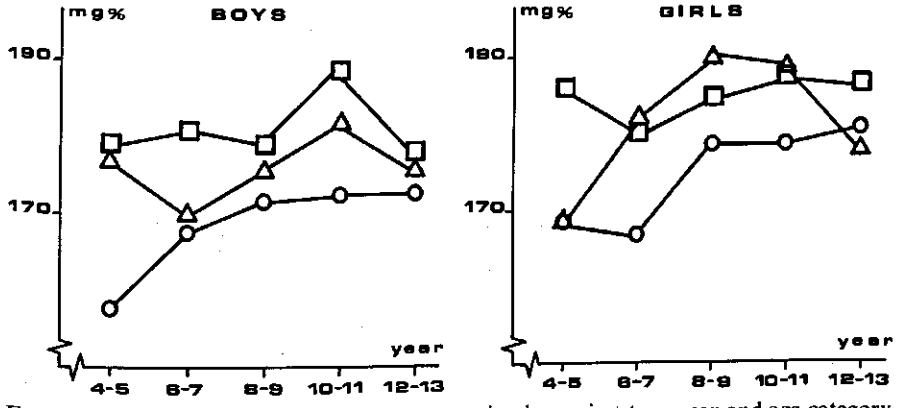

FIG. 18. Mean serum total cholesterol concentration by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

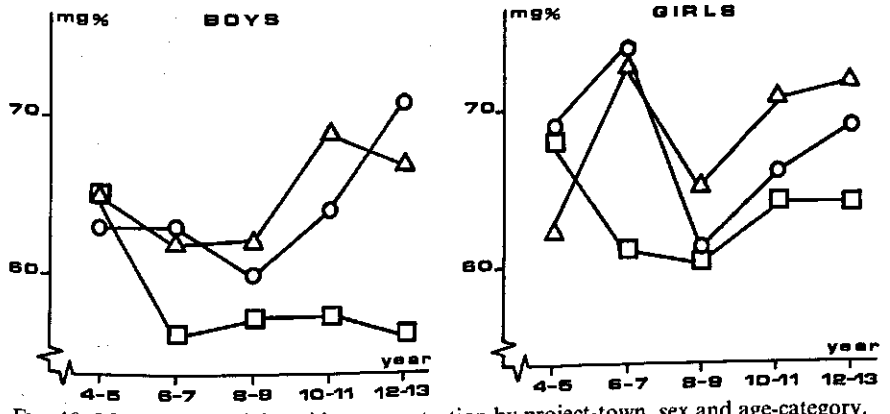

FIG. 19. Mean serum triglycerides concentration by project-town, sex and age-category.
○ = HVN; △ = RMD; □ = HWK.

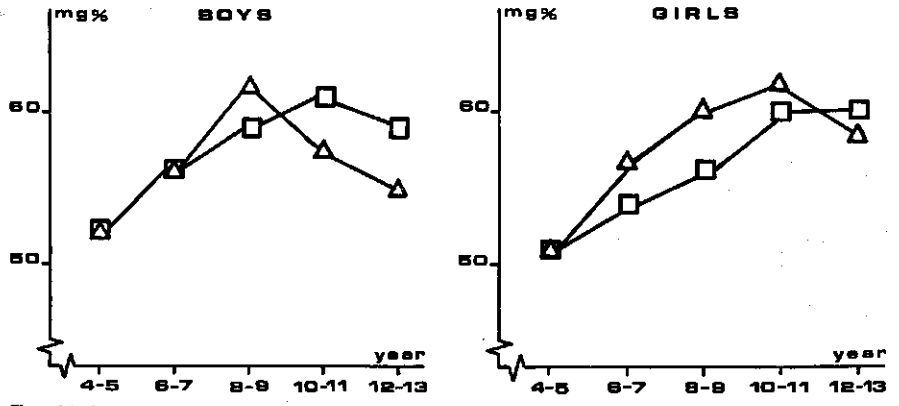

FIG. 20. Mean serum HDL cholesterol concentration by project-town, sex and age-category. △ = RMD; □ = HWK.

3.5.1. *Selected measurements*

Haemoglobin. In all age-categories, boys from Harderwijk tended towards the highest mean blood haemoglobin concentrations. This was also found in the girls with the exception of age-category 4–5 years. Boys and girls from Roermond had the lowest blood haemoglobin concentrations in all age-categories. The difference in mean concentration between children from Harderwijk and Roermond amounted to 0.5 g/100 ml. Boys and girls from Heerenveen took the intermediate position with, on average, values of 0.3 g/100 ml higher than children from Roermond.

For the 3 projects combined, the haemoglobin concentration increased from 12.8 g/100 ml in the age-category 4–5 years to 13.5 g/100 ml in the age-category 12–13 years in boys. In girls this increase was between 12.9 g/100 ml and 13.7 g/100 ml. A somewhat higher mean blood haemoglobin concentration was found in girls compared to boys.

Applying the criterion for 'clinical anaemia' suggested by DE WIJN et al. (1967) and WHO (1968), of values lower than 11.0 g/100 ml, one boy from Heerenveen and two boys from Harderwijk were found to be anaemic. Table 51 gives prevalences of 'subclinical anaemia' found by applying the criterion of 11.0 g/100 ml $\leq$ Hb $<$ 12.0 g/100 ml. As already suggested by the comparison of

TABLE 51. Prevalence of subclinical anaemia by the criterion 11.0 g/100 ml $\leq$ Hb $<$ 12.0 g/100 ml (DE WIJN et al, 1967).

Project	Boys (%)	Girls (%)
Heerenveen	4.2	3.8
Roermond	4.8	4.6
Harderwijk	2.2	2.3

mean values, highest prevalences were found in Roermond (4.7%) and lowest in Harderwijk (2.3%). Again, in Heerenveen an intermediate value of 4.0% was found.

Serum lipids. In virtually all age-categories, boys and girls from Heerenveen had the lowest serum total cholesterol values. In boys, the highest mean serum total cholesterol concentrations were found in Harderwijk, while in girls the values from Roermond and Harderwijk were about equal. On average, the difference between Heerenveen and Harderwijk amounted to 10 mg/100 ml in both boys and girls. Boys from Roermond had about 7 mg/100 ml higher mean serum total cholesterol concentrations than boys from Heerenveen, and girls from Roermond had about 8 mg/100 ml higher values than girls from Heerenveen. In all 3 projects, girls had a significantly higher average serum total cholesterol concentration of 5 mg/100 ml than boys. Only in the children from Heerenveen was a significant relationship of mean serum total cholesterol concentration with age-categories observed.

The lowest mean serum triglycerides concentrations were found in children from Harderwijk. In boys, the highest values were found in Roermond, and this was also the case in the older girls from Roermond. On average the difference between children from Roermond and Harderwijk amounted to 6 mg/100 ml. Boys and girls from Heerenveen had only slightly lower mean triglycerides concentrations than children from Roermond, leading to a difference of about 1 mg/100 ml on average. Girls had significantly higher mean concentrations than boys by about 4 mg/100 ml in all project towns. In none of the 6 project and sex-categories was a significant relationship of serum triglycerides concentrations with age found.

Positive skewness was noted in all distributions of results of serum triglycerides measurements. Therefore, the same calculations as described before were repeated after transformation of values to natural logarithms. Although the mean results after taking antilogarithm values were on average 4 mg/100 ml lower than those described for untransformed data, the same quantitative differences persisted if comparisons were made between different project and sex-groups*.

HDL-cholesterol concentrations were measured only during the Roermond and Harderwijk projects. In boys, mean HDL-cholesterol concentrations increased up to the age of 9 and were comparable until that age for both projects. After the age of 10, a decline in HDL-cholesterol was observed in both projects, with the boys from Roermond attaining the lowest levels. Differences

* Big differences between comparisons of transformed and untransformed data could not be expected if one remembers the following (see HARRIS, 1975): if $^{e}\log(x)$ is normally distributed with mean μ and variance σ^2, then $E(x) = e^{\mu+(\sigma 2)/2}$ and $Var(x) = (e^{2\mu+\sigma^2})\cdot(e.\sigma^2 - 1)$. So, if $\bar{x}$ and s^2 are estimates of E(x) and Var(x), respectively, then $Est.(\sigma^2) = {}^{e}\log[(s/\bar{x})^2 + 1]$, and $Est(\mu) = {}^{e}\log \bar{x} - [Est(\sigma^2)]/2$. Results of $\bar{x}$ and s^2 for the triglycerides distributions described in Table 50 do not vary substantially, so only minor differences in relative comparisons could be expected.

between boys from these towns were, however, only small, as were differences between age-categories. Mean serum HDL-cholesterol concentrations in girls increased with age from about 51 mg/100 ml to about 59 mg/100 ml in the youngest and oldest age-categories respectively. Mean concentrations were about 1 mg/100 ml higher in girls from Roermond compared to those from Harderwijk. In addition, no statistically significant nor consistent differences were noted between boys and girls from both towns in mean serum HDL-cholesterol concentration.

3.5.2. *Derived quantities*

Beta-cholesterol concentrations from each child in Roermond and Harderwijk were calculated by the difference between results of the total and the HDL-cholesterol determinations. In addition, the ratio of HDL-cholesterol to beta-cholesterol was calculated. Major results are shown in Table 52 and Figs. 21–22.

In general, mean results of beta-cholesterol in children from Harderwijk were 4 mg/100 ml higher than those in children from Roermond. No consistent trend with age-category could be noted. Girls from both towns were found to have about 5 mg/100 ml higher mean values than boys. All described differences did not, however, reach statistical significance.

The ratio HDL: beta-cholesterol increased in children from both towns by about 7% from the age-category 4–5 to the age-category 12–13 years. Generally, children from Roermond had the highest ratios. In girls from both towns, the HDL:beta-ratio was found to be about 2% lower than that in boys.

3.5.3. *Hyperlipidaemia*

The prevalence of hypercholesterolaemia was evaluated using 2 different cut-off points. The first cut-off point, 200 mg/100 ml, defined borderline plus

TABLE 52. Derived quantities of cholesterol concentrations by sex and age-category in Roermond and Harderwijk schoolchildren.

Measurement	Age (y)	Boys				Girls			
		RMD		HWK		RMD		HWK	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Beta-cholesterol (mg/100 ml)	4– 5	123	37.0	127	28.1	118	24.4	135	28.8
	6– 7	114	25.3	124	26.6	125	43.0	128	23.8
	8– 9	115	24.8	119	26.6	130	30.5	128	25.8
	10–11	124	29.9	128	27.3	127	25.2	127	31.5
	12–13	121	27.2	119	27.4	120	27.1	128	28.9
HDL: beta cholesterol ratio (%)	4– 5	46	15.6	43	13.5	45	12.1	40	14.5
	6– 7	52	19.9	48	15.2	51	24.1	44	13.8
	8– 9	57	20.4	53	21.0	50	20.7	46	14.4
	10–11	50	18.6	51	35.5	54	30.3	50	15.8
	12–13	48	16.0	53	19.1	52	18.6	49	15.7

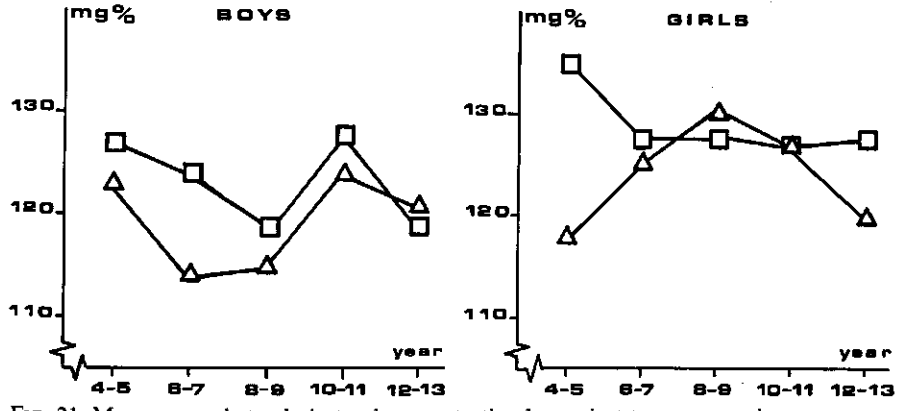

FIG. 21. Mean serum beta-cholesterol concentration by project-town, sex and age-category. △ = RMD; □ = HWK.

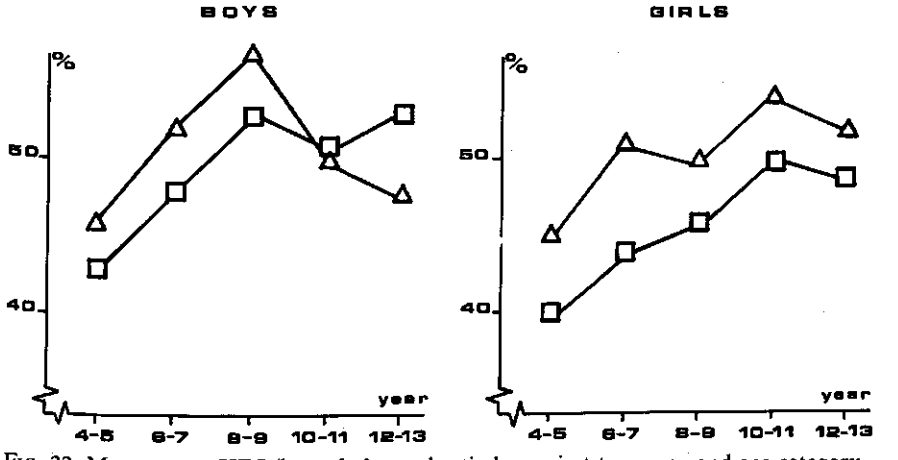

FIG. 22. Mean serum HDL/beta cholesterol ratio by project-town, sex and age-category. △ = RMD; □ = HWK.

frank hypercholesterolaemia, while the second, 220 mg/100 ml, defined the level above which frank hypercholesterolaemia was considered to be present. Results of the application of these criteria are shown in Table 53 and Fig. 23.

Only in the children from Heerenveen was the prevalence of hypercholesterolemia positively related to age-categories. Prevalences of 13.5%, 20.4% and 23.6% for borderline plus frank hypercholesterolaemia were found in boys from Heerenveen, Roermond and Harderwijk. In girls, these estimates were 21.7%, 25.3% and 27.0% respectively. This prevalence ranged from 6% to 35% in the given age-categories for boys and from 9% to 35% for girls. The prevalence of frank hypercholesterolaemia in boys was 3.4%, 7.0% and 10.5% in Heerenveen, Roermond and Harderwijk, respectively. These estimates were

TABLE 53. Percent prevalence of hypercholesterolaemia* by project-town, sex and age-category.

Sex	Age (y)	Borderline plus frank			Frank		
		HVN	RMD	HWK	HVN	RMD	HWK
Boys	4– 5	6.1	28.2	23.1	0.	12.8	12.3
	6– 7	14.0	13.8	19.4	1.1	2.5	4.9
	8– 9	11.7	14.6	20.8	2.1	2.4	8.5
	10–11	15.5	26.8	35.5	5.8	10.7	17.8
	12–13	16.4	20.5	16.2	7.3	8.0	8.8
	All	13.5	20.4	23.6	3.4	7.0	10.5
Girls	4– 5	13.5	9.1	20.0	2.7	4.5	15.0
	6– 7	18.1	16.7	29.9	4.2	10.4	4.6
	8– 9	23.4	34.5	28.1	7.8	14.9	12.4
	10–11	25.3	30.1	25.0	5.3	12.6	15.2
	12–13	24.6	22.6	25.9	13.1	8.1	9.3
	All	21.7	25.3	27.0	6.8	11.0	11.3

* Borderline plus frank hypercholesterolaemia was defined to be present if results of serum total cholesterol determinations were equal to or greater than 200 mg/100 ml. Frank hypercholesterolaemia was defined by the cut-off point of 220 mg/100 ml.

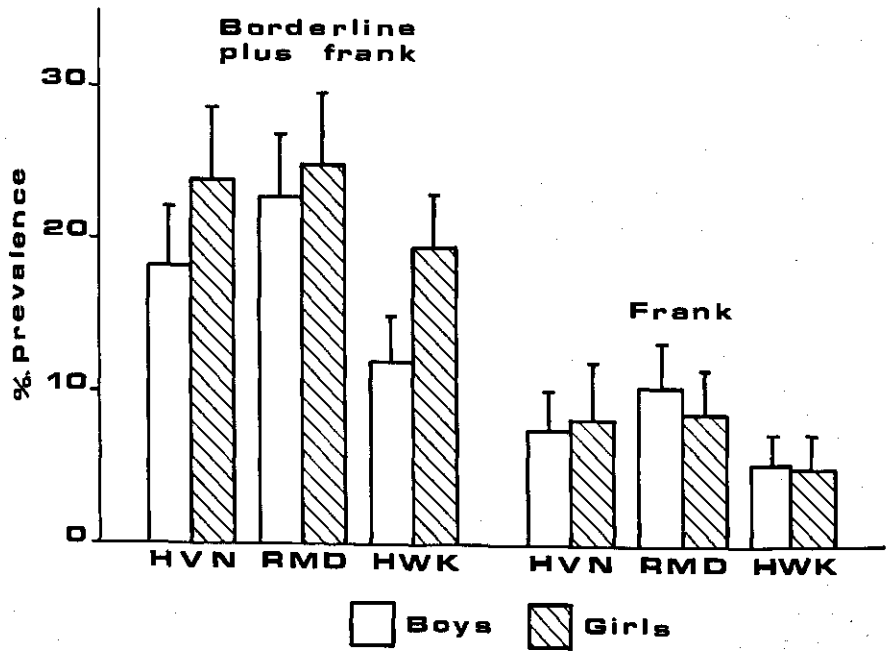

FIG. 23. The prevalence of hypercholesterolaemia by project-town and sex.

TABLE 54. Percent prevalence of hypertriglyceridaemia* by project-town, sex and age-category.

Sex	Age (y)	Borderline plus frank			Frank		
		HVN	RMD	HWK	HVN	RMD	HWK
Boys	4– 5	21.2	18.9	17.2	9.1	10.8	9.4
	6– 7	18.3	28.8	9.1	6.5	10.0	5.1
	8– 9	9.6	15.9	11.4	5.3	4.9	5.7
	10–11	18.4	25.9	11.1	6.8	12.5	2.8
	12–13	30.9	21.6	13.0	12.7	12.5	4.3
	All	18.3	22.8	11.9	7.4	10.3	5.7
Girls	4– 5	24.3	18.6	28.3	10.8	4.7	8.3
	6– 7	32.9	33.3	14.0	17.1	14.6	1.2
	8– 9	18.4	18.6	16.5	2.6	8.1	1.1
	10–11	23.0	29.1	20.7	4.1	8.7	8.7
	12–13	21.3	24.2	20.4	8.2	6.5	7.4
	All	23.9	24.9	19.3	8.2	8.5	5.0

* Borderline plus frank hypertriglyceridaemia was defined to be present if results of serum triglycerides determinations were equal to or greater than 80 mg/100 ml. Frank hypertriglyceridaemia was defined by the cut-off point of 100 mg/100 ml.

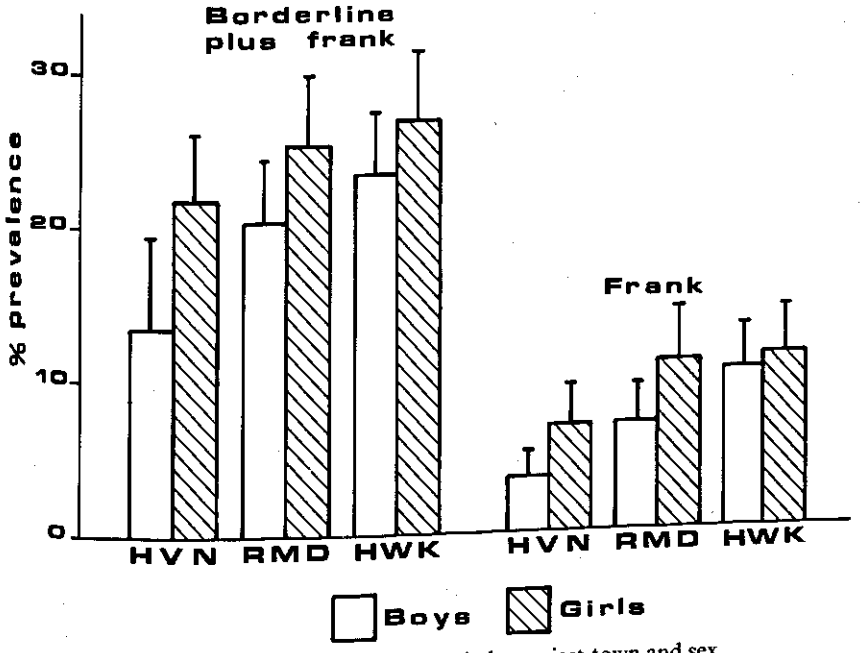

FIG. 24. The prevalence of hypertriglyceridaemia by project-town and sex.

6.8%, 11.0% and 11.3% in girls. The prevalence ranged from as low as 0% to 18% in the given age-categories for boys and from 3% to 15% for girls.

Taking all results from the 3 projects together, 19.5% of the boys and 24.8% of the girls had serum total cholesterol concentrations equal to or greater than 200 mg/100 ml. Frank hypercholesterolaemia was found to be present in 7.2% of all boys and in 9.8% of all girls.

Tentatively, the prevalence of hypertriglyceridaemia was evaluated using cut-off points at 80 mg/100 ml and at 100 mg/100 ml. Table 54 and Fig. 24 give results of the application of these criteria to the observed concentrations.

A consistent relationship of prevalences of hypertriglyceridaemia with age-categories was not observed. Group prevalences of borderline plus frank hypertriglyceridaemia, as defined, in boys were 18.3%, 22.8% and 11.9% in Heerenveen, Roermond and Harderwijk, respectively. These estimates in girls were 23.9%, 24.9% and 19.3%. Frank hypertriglyceridaemia was found to be present in 7.4%, 10.3% and 5.7% boys from Heerenveen, Roermond and Harderwijk. Of the girls, 8.2%, 8.5% and 5.0% were found to be frankly hypertriglyceridaemic in the respective project towns.

For the combined projects, 17.4% of the boys and 22.5% of the girls were the estimates for the prevalence of borderline plus frank hypertriglyceridaemia. Frank hypertriglyceridaemia was found to be present in 7.5% of all boys and in 7.1% of all girls.

3.5.4. *Relationships between lipids*

Table 55 gives linear correlation coefficients between the various lipid fractions in children from Roermond and Harderwijk. The correlation coefficient between total cholesterol and triglycerides values in all children from Heerenveen, in which both values were present (n = 694), was observed to be 0.179. All observed correlation coefficients were statistically significantly different from zero by at least 1%. The values in Table 55 suggest that in the Roermond and Harderwijk children about 85% of the variations in total cholesterol may be explained by variations in beta-cholesterol, defined as the difference between total and HDL-cholesterol. Total cholesterol values were

Table 55. Correlation coefficients between serum lipid measurements by project-town.

Project		Roermond (n = 719)			
	Lipid measurement	Total chol.	Trigly-cerides	Beta-chol.	HDL-chol.
Harderwijk (n = 794)	Total cholesterol		.213	.930	.256
	Triglycerides	.150		.194	−.291
	Beta-cholesterol	.907	.298		−.092
	HDL-cholesterol	.308	−.318	−.121	

Table 56. Partial correlation coefficients between selected serum lipid measurements by project-town.

Project		Roermond		
	Lipid measurement	Trigly-cerides	Beta-chol.	HDL-chol.
Harderwijk	Triglycerides		.176	−.280
	Beta-cholesterol	.276		−.039
	HDL-cholesterol	−.298	−.029	

also positively related to HDL-cholesterol values, although the quantitative relationship seems small, shown by an average squared coefficient of about 8%. Triglycerides and beta-cholesterol were also positively related, which is not unexpected because the estimate of beta-cholesterol still contained the variation of the triglycerides-rich pre-beta-lipoprotein. Although it may have been possible to correct for this contribution by calculating the LDL-cholesterol for each individual by the formula: LDL-cholesterol = beta-cholesterol minus triglycerides/5 (FRIEDEWALD et al., 1972), this was not done because the observed precision of the lipid determinations was regarded as being insufficient to be able to do this reliably for each child separately*. Triglycerides and HDL-cholesterol were negatively, although quantitatively weakly, correlated in both projects. Correlation coefficients of the smallest magnitude were found in both projects between results of beta-cholesterol and HDL-cholesterol. The negative sign of these correlations was consistent with the finding of a negative relationship between triglycerides and HDL-cholesterol.

Between results of triglycerides, beta and HDL-cholesterol determinations, partial correlation coefficients were calculated. Results are given in Table 56. It was noted that the negative correlation coefficient between triglycerides and HDL-cholesterol remained highly significant at all the same concentrations of beta-cholesterol. Correlation coefficients between beta and HDL-cholesterol became virtually zero after allowing for the influence of triglycerides concentrations.

3.6. MEASUREMENTS IN PARENTS

A total of 161 'apparently healthy' parents participated in the examinations during the Heerenveen project. There were 85 mothers and 76 fathers, 66 of

* An approximation of the estimate E(ρ) of the correlation coefficient between triglycerides and LDL-cholesterol was obtained by using statistics from the total distributions of values of these determinations. Approximations found were 0.032 for results of lipid determinations from Roermond and 0.114 for those from Harderwijk. Approximate partial correlation coefficients (to be compared with those in Table 56) between these lipids were 0.019 and 0.094 for results from Roermond and Harderwijk, respectively.

which were married couples. From the Roermond project, 161 parents, 94 mothers and 67 fathers, were left in the analysis. Of these, 54 were married couples. In the examinations during the Harderwijk project a total of 151 'apparently healthy' parents, 82 mothers and 69 fathers, or 63 married couples, participated.

Table 57 gives results of data obtained by a questionnaire. Mean ages of participating parents did not vary significantly, although the parents from Heerenveen were the youngest. Both the prevalence and mean amount of reported regular daily alcohol usage in Heerenveen parents were lower than those in Roermond and Harderwijk parents. Highest reported prevalences of daily alcohol usage was found in Roermond parents, but Roermond and Harderwijk parents reported the same mean intake, expressed as total alcoholic beverages in glasses per day. The mean reported intake of alcohol by parents from Roermond and Harderwijk was about 1.5 times that reported by parents from Heerenveen. The prevalence of smokers and mean amount of smoking (number of cigarettes plus cigars plus pipes per day) of parents from Roermond were the highest reported. The reported number of cigarettes smoked amounted to about 85% of the total amount of smoking in all projects. Parents from Harderwijk reported lowest usage, although they were about comparable to parents from Heerenveen with respect to the reported prevalence and amount. A somewhat lower proportion of mothers from Roermond reported the use of oral contraceptives if compared to those from Heerenveen and Harderwijk.

The results of anthropometric measurements and blood determinations of the parents are summarized in Table 58. Parents from Heerenveen showed consistently higher values for standing height than the parents from the other town-projects. Parents participating during the Roermond project were the shortest. Quetelet indices in parents from Heerenveen were lower than those in

TABLE 57. Results of data obtained by questionnaire in parents by project-town and sex.

	Mothers			Fathers		
	HVN	RMD	HWK	HVN	RMD	HWK
Number	85	94	82	76	67	69
Age (years)	38	42	40	42	44	43
Daily alcohol usage						
prevalence	.21	.29	.28	.30	.55	.46
glasses/day	1.2	1.7	1.7	1.4	2.4	2.4
Smoking pattern						
prevalence	.40	.56	.34	.67	.82	.65
number*/day	4.1	7.5	3.1	10.5	22.4	9.0
Contraceptive pills						
prevalence	.38	.28	.39	–	–	–

* number of cigarettes plus cigars plus pipes.

TABLE 58. Results of measurements in parents (m ± s.d.) by project-town and sex.

	Mothers			Fathers		
	HVN	RMD	HWK	HVN	RMD	HWK
Standing height (cm)	166 ± 5	163 ± 6	165 ± 6	180 ± 8	175 ± 6	177 ± 7
Body weight (kg)	66.3 ± 8.2	66.0 ± 10.8	67.8 ± 9.7	77.8 ± 11.6	78.8 ± 12.8	79.3 ± 11.3
Quetelet index (kg/m^2)	23.9 ± 2.7	24.6 ± 3.5	24.8 ± 3.5	24.0 ± 2.9	25.8 ± 4.2	25.3 ± 2.9
Haemoglobin (g/100 ml)	13.7 ± 0.9	13.6 ± 0.9	14.1 ± 1.2	15.5 ± 1.2	15.2 ± 1.0	15.8 ± 0.8
Total cholesterol (mg/100 ml)	202 ± 35.8	223 ± 38.8	216 ± 35.7	209 ± 38.8	237 ± 38.3	232 ± 46.4
Triglycerides (mg/100 ml)	103 ± 50.7	127 ± 71.1	96 ± 39.3	133 ± 65.0	195 ± 117.0	123 ± 99.6
HDL-cholesterol* (mg/100 ml)		54.5 ± 13.3	59.0 ± 12.9		46.8 ± 12.3	51.6 ± 12.6

* not measured during the Heerenveen project.

parents from Roermond and Harderwijk. Mean blood haemoglobin concentrations in parents from Roermond were the lowest, and mean blood haemoglobin levels in parents from Harderwijk were the highest observed. The highest levels of total cholesterol and triglycerides in serum were observed in parents from Roermond. Parents from Heerenveen showed the lowest serum total cholesterol values, while the lowest serum triglycerides concentrations were observed in parents from Harderwijk. The comparison of mean levels of HDL-cholesterol in parents from Roermond and Harderwijk revealed substantially lower values in parents from Roermond. This difference amounted to about 10% of the mean level of measurements. For all anthropometric and blood chemical measurements, with the exception of HDL-cholesterol, fathers exhibited higher mean values than mothers. Mothers had higher mean levels of HDL-cholesterol than fathers from the Roermond and Harderwijk projects.

3.7. Concordance of measurement levels among relatives

Spouses. A total of 183 married couples participated during the 3 projects. Because the number of participating couples for each separate project was rather small, the analysis of concordance of measurement levels will be confined to the combination of couples from the 3 projects. Table 59 and Fig. 25 show the results of this concordance analysis among spouses. Generally, no impressive relationships of the various measurement levels between the parents were observed, with the exception of the Quetelet index. It may be noted from Fig. 25 that, for this measurement, the percentage of 'low' mothers, married to 'low' fathers almost equals the percentage of 'high' mothers with 'high' fathers: 36% and 42% respectively, instead of the expected 25%. Similarly, the percentage of 'both intermediate' was found to be clearly greater than expected: 59% to 50%. In none of the other examined variables was this concordance of measurement levels found. Only the observed levels of HDL-cholesterol, which were not measured during the Heerenveen project, merit consideration: the observed percentage of couples with both members at a 'low' level exceeded the expected percentage clearly. However, the observed number of observations in the diverse categories was rather small for this variable.

Siblings. Table 60 gives the concordance of measurement levels among siblings for the 3 projects separately. The concordance of sibship measurements observed is depicted graphically in Fig. 26. Considerable sibship aggregation of the kind described before for the Quetelet index among spouses was found for all the examined anthropometric measurements in all three town projects. The typical picture, exemplified by the results of the standing height measurement, is the substantial over-representation of sib-pairs having equal levels of measurement at the 3 levels examined, which occurs at the expense of the percentage contributions of sib-pairs exhibiting disconcordant levels, especially those of the 'low-high' combinations. It may be further noted that

Table 59. Concordance of measurement levels among married couples.

Combination	Exp. %	Obs. n HVN	RMD	HWK	Tot	Obs. %	Obs. n HVN	RMD	HWK	Tot	Obs. %
		Standing height					*Quetelet index*				
l l	6.25	6	3	4	13	7.1	7	3	6	16	8.7
l-i	25.00	15	12	16	43	23.5	11	15	16	42	23.0
l-h	12.50	5	9	8	22	12.0	9	7	2	18	9.8
i-i	25.00	17	16	18	51	27.9	21	17	16	54	29.5
i-h	25.00	17	10	11	38	20.8	12	6	16	34	18.6
h-h	6.25	6	4	6	16	8.7	6	6	7	19	10.4
Total	100.00	66	54	63	183	100.0	66	54	63	183	100.0
		Haemoglobin					*Total cholesterol*				
l-l	6.25	3	4	7	14	7.7	3	3	4	10	5.5
l-i	25.00	16	13	13	42	23.0	20	13	14	47	25.7
l h	12.50	10	7	4	21	11.5	7	8	10	25	13.7
i-i	25.00	18	11	18	47	25.7	15	13	16	44	24.0
i-h	25.00	14	18	15	47	25.7	16	14	17	47	25.7
h-h	6.25	5	1	6	12	6.6	5	3	2	10	5.5
Total	100.00	66	54	63	183	100.2	66	54	63	183	100.1
		Triglycerides					*HDL-cholesterol**				
l-l	6.25	3	4	5	12	6.6	6	5	11	9.4	
l-i	25.00	19	13	15	47	25.7	11	16	27	23.1	
l-h	12.50	8	4	7	19	10.4	4	6	10	8.5	
i-i	25.00	15	13	16	44	24.0	13	16	29	24.8	
i-h	25.00	17	15	16	48	26.2	18	15	33	28.2	
h-h	6.25	4	5	4	13	7.1	2	5	7	6.0	
Total	100.00	66	54	63	183	100.0	54	63	117	100.0	

* Not determined during the Heerenveen project.

the rate of concordance did not vary much between the 3 project towns, although it seems as if the similarity in measurement levels between siblings from Heerenveen is generally somewhat smaller with respect to the anthropometric measurements than that between siblings from Roermond and Harderwijk.

The similarity of measurement levels between siblings observed for the examined blood chemical parameters was somewhat lower than that of the anthropometric measures in all 3 projects. It may be noted from Fig. 27 and Table 61 – which give a weighted summary of concordance estimates – that the aggregation of the haemoglobin and the triglycerides measurements among siblings is more impressive on the 'low' level, while for the total cholesterol mea-

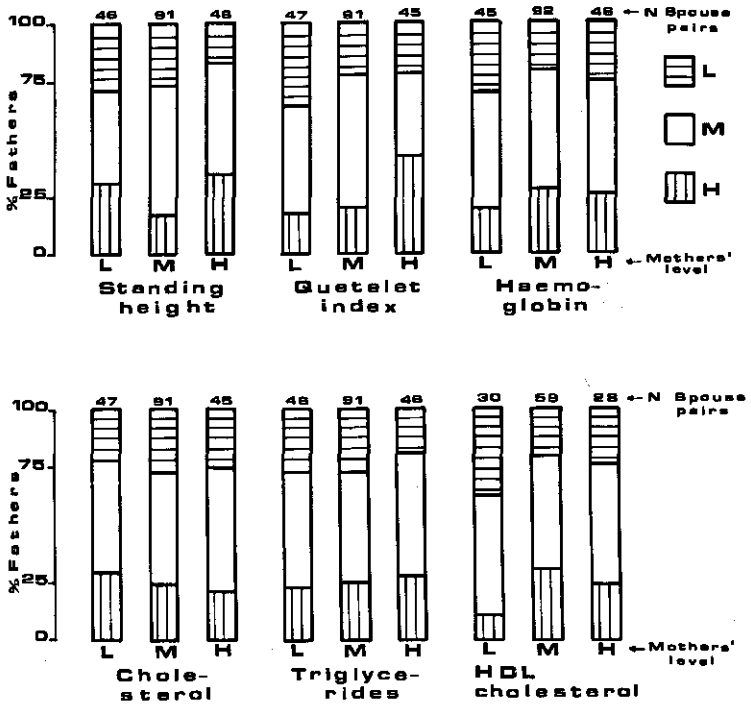

FIG. 25. Concordance of measurement levels among married couples.
L = lowest quartile; M = middle quartiles; H = highest quartile.
HDL-cholesterol was not determined during the Heerenveen project.

surement the aggregation at the 'high' level predominates. Despite the lower number of measurements of HDL-cholesterol, it is clear that the observed aggregation for this variable among siblings resides both at the 'low' and at the 'high' level.

Parents and children. First, the degree of resemblance of measurement levels between parents and children was studied by the analysis of concordance between the individual mothers and fathers with their participating children separately. The results of this analysis are given in Table 62. Generally, the concordances of measurement levels were observed to be much lower than those between siblings. The most apparent resemblances were found for standing height between mothers and their children and in haemoglobin levels between fathers and daughters. However, in most instances the concordances were only weak, or seemed even entirely absent as, for instance, in the case of the level of obesity between fathers and their children and in the case of observed total cholesterol levels between mothers and daughters. Figs. 28 and 29 summarize the observed concordance of measurement levels for the various measurements between the individual parents and their children, irrespective of their sex. This

TABLE 60. Concordance of measurement levels among siblings.

Combination	Exp. %	HVN Obs.		RMD Obs.		HWK Obs.		HVN Obs.		RMD Obs.		HWK Obs.	
		n	%	n	%	n	%	n	%	n	%	n	%
		Standing height						*Knee widths*					
l–l	6.25	15	9.3	22	9.6	33	12.1	18	11.0	27	11.8	33	12.1
l–*i*	25.00	37	23.0	52	22.8	63	23.1	40	24.5	51	22.4	61	22.3
l–h	12.50	12	7.5	17	7.5	7	2.6	6	3.7	10	4.4	11	4.0
i–*i*	25.00	45	28.0	64	28.1	68	24.9	40	24.5	61	26.8	77	28.2
i–h	25.00	34	21.1	49	21.5	75	27.5	43	26.4	54	23.7	57	20.9
h–h	6.25	18	11.2	24	10.5	27	9.9	16	9.8	25	11.0	34	12.5
Total	100.00	161	100.1	228	100.0	273	100.1	163	99.9	228	100.1	273	100.0
		Arm muscle						*Skinfold sum*					
l–l	6.25	18	11.0	27	11.8	31	11.4	16	9.8	26	11.4	29	10.6
l–i	25.00	39	23.9	44	19.3	62	22.7	38	23.3	51	22.4	64	23.4
l–h	12.50	7	4.3	15	6.6	12	4.4	14	8.6	11	4.8	14	5.1
i–i	25.00	43	26.4	69	30.3	73	26.7	45	27.6	65	28.5	73	26.7
i–h	25.00	38	23.3	48	21.1	67	24.5	35	21.5	47	20.6	62	22.7
h–h	6.25	18	11.0	25	11.0	28	10.3	15	9.2	28	12.3	31	11.4
Total	100.00	163	99.9	228	100.1	273	100.0	163	100.0	228	100.0	273	99.9
		Haemoglobin						*Total cholesterol*					
l–l	6.25	17	11.3	20	9.3	32	12.7	19	11.9	16	7.4	21	8.7
l–i	25.00	29	19.3	53	24.5	50	19.8	33	20.8	54	25.0	62	25.6
l–h	12.50	11	7.3	14	6.5	10	4.0	11	6.9	20	9.3	16	6.6
i–i	25.00	38	25.3	50	23.1	67	26.6	47	29.6	57	26.4	66	27.3
i–h	25.00	46	30.7	64	29.6	68	27.0	31	19.5	48	22.2	48	19.8
h–h	6.25	9	6.0	15	6.9	25	9.9	18	11.3	21	9.7	29	12.0
Total	100.00	150	99.9	216	99.9	252	100.0	159	100.0	216	100.0	242	100.0
		Triglycerides						*HDL-cholesterol**					
l–l	6.25	15	9.5	23	10.8	22	9.2			17	8.5	22	9.9
l–i	25.00	30	19.0	42	19.7	58	24.3			43	21.6	55	24.8
l–h	12.50	18	11.4	19	8.9	18	7.5			22	11.1	13	5.9
i–i	25.00	48	30.4	57	26.8	62	25.9			55	27.6	56	25.2
i–h	25.00	33	20.9	57	26.8	56	23.4			45	22.6	54	24.3
h–h	6.25	14	8.9	15	7.0	23	9.6			17	8.5	22	9.9
Total	100.00	158	100.1	213	100.0	239	99.9			199	99.9	222	100.0

* Not determined during the Heerenveen project.

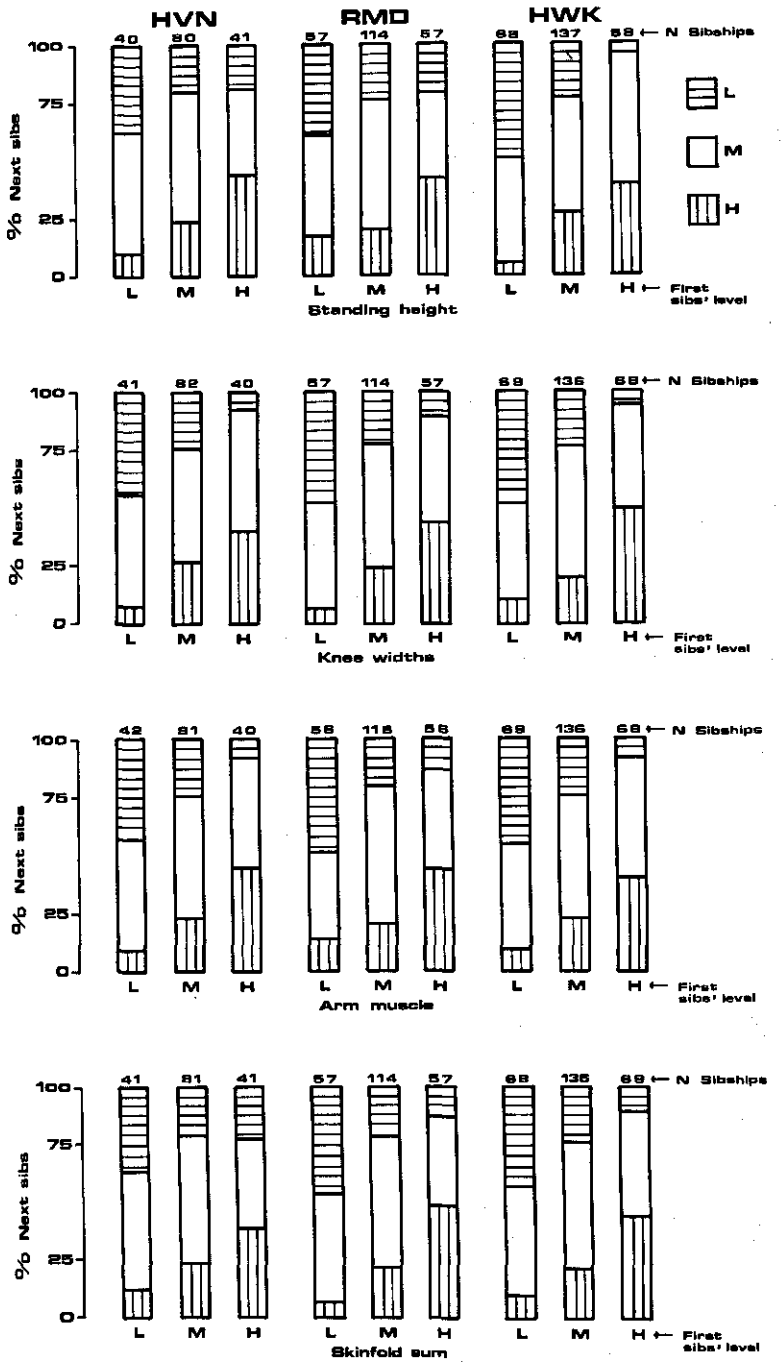

FIG. 26. Concordance of measurement levels among siblings by project-town.
L = lowest quartile; M = middle quartiles; H = highest quartile.
HDL-cholesterol was not determined during the Heerenveen project.

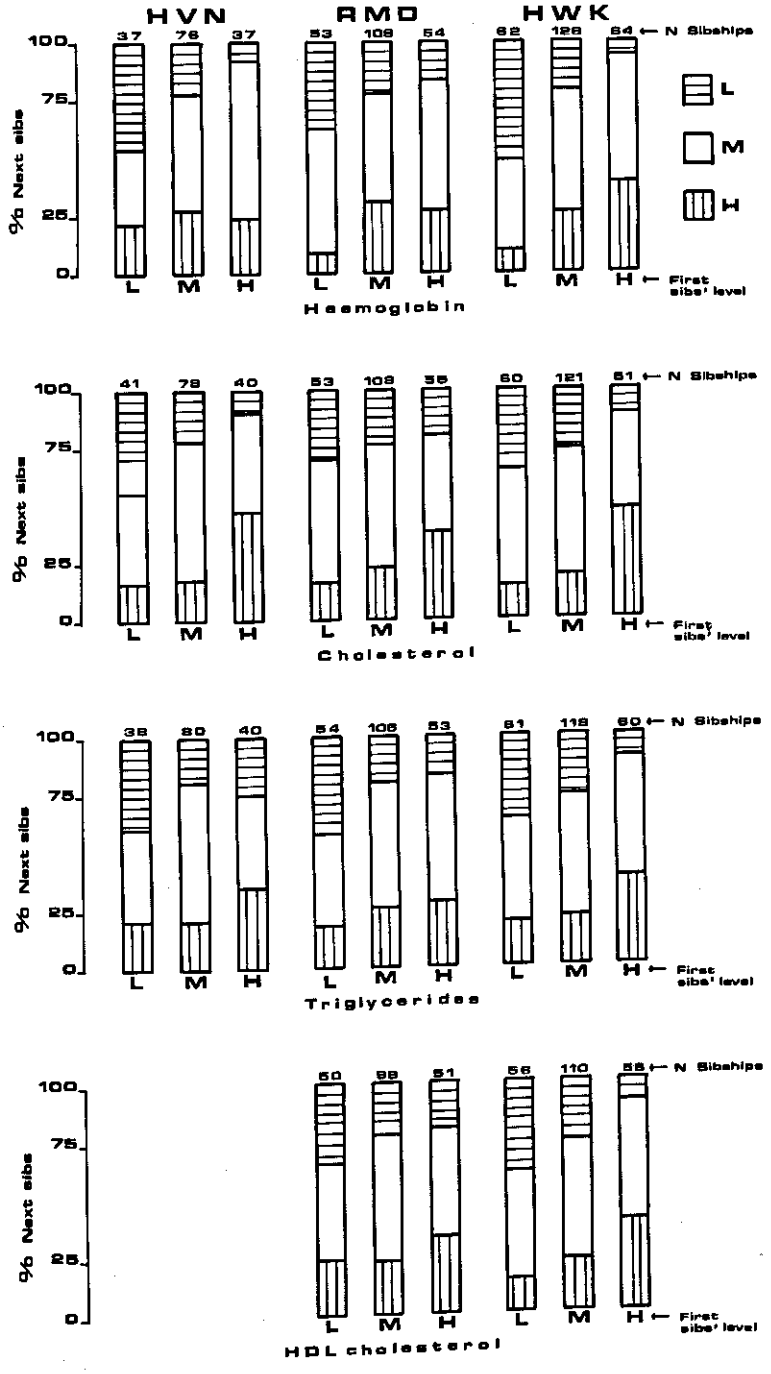
HVN
RMD
HWK
N Sibships
% Next sibs
100
75
25
0
L
M
H
First sibs' level
Haemoglobin
Cholesterol
Triglycerides
HDL cholesterol

TABLE 61. Concordance of measurement levels among siblings; summary of combined projects.

Levels for sibling pair	Exp %	Measurement* (Obs. %)							
		Standing height	Knee widths	Arm muscle	Skinfold sum	Haemoglobin	Total cholesterol	Triglycerides	HDL-cholesterol
Both low	6.25	10.4	11.6	11.4	10.4	11.2	9.1	10.0	9.3
One low, one intermediate	25.00	23.0	23.0	22.0	23.0	21.2	23.8	21.3	23.3
One low, one high	12.50	5.7	4.1	5.1	6.2	6.0	7.6	9.3	8.3
Both intermediate	25.00	27.0	26.5	27.7	27.7	25.1	27.7	28.2	26.4
One intermediate, one high	25.00	23.3	23.6	23.0	21.5	29.0	20.6	22.5	23.5
Both high	6.25	10.6	11.1	10.7	11.1	7.6	11.2	8.7	9.3
Total	100.00	100.0	99.9	99.9	99.9	100.1	100.0	100.0	100.1

* HDL-cholesterol was not determined during the Heerenveen project.

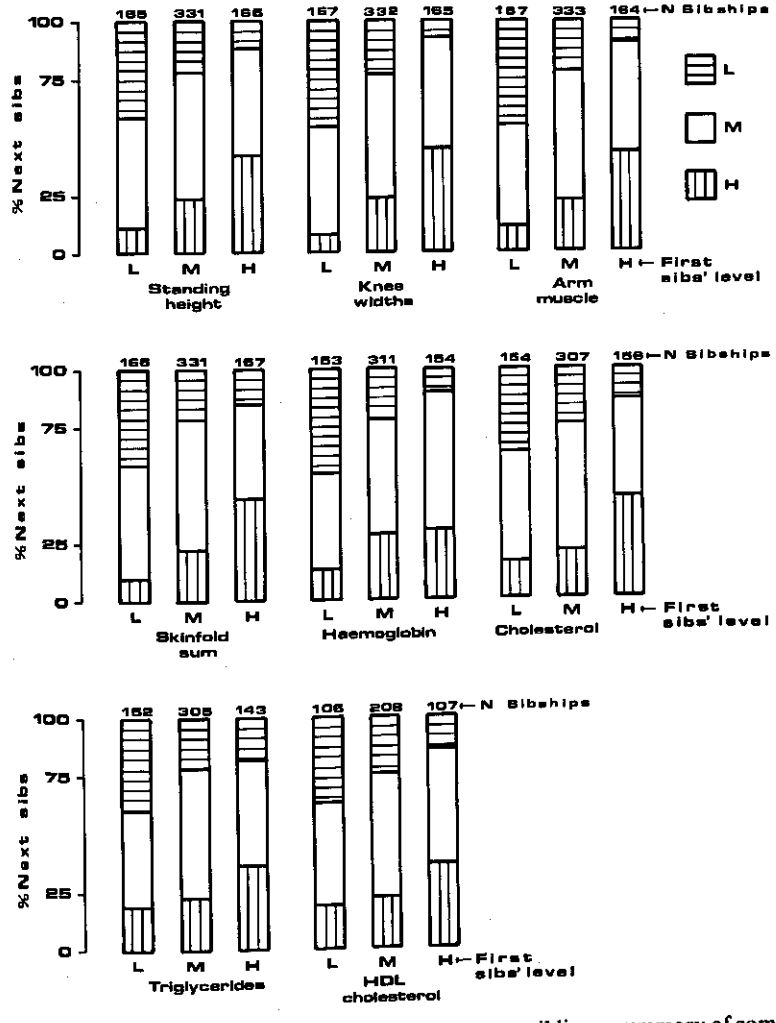

FIG. 27. Concordance of measurement levels among siblings; summary of combined project.
L = lowest quartile; M = middle quartiles; H = highest quartile.
HDL-cholesterol was not determined during the Heerenveen project.

analysis is given numerically in Table 63. It may be noted from this analysis that in the present coupling of relatives, the degree of resemblance in standing height and body fatness is greater between mothers and their children than between fathers and their children. The children's levels of haemoglobin, on the contrary, seem to be more dependent on the levels of their fathers, while the degree of resemblance in serum lipid levels between parents and their children was apparent with regard to both fathers and mothers. It should be noted, in addition, that even after combining the children's sexes in the analysis of concordance of measurement levels between parents and children, the degree of resemblance clearly remained below that observed between siblings.

TABLE 62. Concordance of measurement levels among individual parents and their children.

Combination	Exp. %	Mother – daughter Obs. n				Obs. %	Father – daughter Obs. n				Obs. %	Mother – son Obs. n				Obs. %	Father – son Obs. n				Obs. %
		HVN	RMD	HWK	Tot		HVN	RMD	HWK	Tot		HVN	RMD	HWK	Tot		HVN	RMD	HWK	Tot	
Standing height																					
l–l	6.25	7	6	6	19	10.5	7	3	3	13	9.5	5	5	7	17	10.6	4	2	5	11	8.4
l–i	25.00	11	20	14	45	24.9	10	11	10	31	22.6	15	15	9	39	24.2	12	11	9	32	24.4
l–h	12.50	4	4	1	9	5.0	2	5	7	14	10.2	3	3	2	8	5.0	3	5	4	12	9.2
i–i	25.00	15	16	14	45	24.9	14	9	14	37	27.0	16	12	9	37	23.0	15	10	8	33	25.2
i–h	25.00	16	14	14	44	24.3	11	12	7	30	21.9	12	12	20	44	27.3	9	10	11	30	22.9
h–h	6.25	4	8	7	19	10.5	6	2	4	12	8.8	7	7	2	16	9.9	8	2	3	13	9.9
Total	100.00	57	68	56	181	100.1	50	42	46	137	100.0	58	54	49	161	100.0	51	40	40	131	100.0
Body fatness																					
l–l	6.25	6	7	3	16	8.8	4	2	4	10	7.3	6	3	7	16	9.9	5	2	4	11	8.4
l–i	25.00	11	14	18	43	23.8	13	10	11	34	24.8	13	14	7	34	21.1	11	11	9	31	23.7
l–h	12.50	5	7	4	16	8.8	5	6	3	14	10.2	5	8	4	17	10.6	4	5	3	12	9.2
i–i	25.00	17	17	13	47	26.0	10	12	10	32	23.4	14	12	15	41	25.5	12	10	12	34	26.0
i–h	25.00	12	20	12	44	24.3	16	8	14	38	27.7	17	14	11	42	26.1	16	8	7	31	23.7
h–h	6.25	6	3	6	15	8.3	2	4	3	9	6.6	3	3	5	11	6.8	3	4	5	12	9.2
Total	100.00	57	68	56	181	100.0	50	52	45	137	100.0	58	54	49	161	100.0	51	40	40	131	100.2
Haemoglobin																					
l–l	6.25	5	9	5	19	10.9	5	4	3	12	9.1	4	6	4	14	8.9	6	4	4	14	10.9
l–i	25.00	13	13	13	39	22.3	10	11	14	35	26.5	14	9	11	34	21.5	11	9	8	28	21.9
l–h	12.50	3	5	6	14	8.0	2	2	1	5	3.9	3	5	5	13	8.3	3	3	4	10	7.8
i–i	25.00	14	18	15	47	26.9	13	11	11	35	26.5	16	16	12	44	27.8	14	10	12	36	28.1
i–h	25.00	14	18	10	42	24.0	13	7	8	28	21.1	19	13	14	46	29.1	10	11	7	28	21.9
h–h	6.25	6	2	6	14	8.0	5	5	7	17	12.9	2	4	1	7	4.4	6	3	3	12	9.4
Total	100.00	55	65	55	175	100.1	48	40	44	132	100.1	58	53	47	158	100.0	50	40	38	128	100.0

Total cholesterol																				
l–l	6.25	3	3	4	10	5.8	4	5	5	14	10.8	5	5	4	14	8.9	3	5	4	12	9.4
l–i	25.00	13	17	11	41	23.7	11	7	10	28	21.5	14	12	11	37	23.6	15	6	11	32	25.2
l–h	12.50	6	9	4	19	11.0	4	2	2	8	6.2	3	6	5	14	8.9	4	2	1	7	5.5
i–i	25.00	17	17	13	47	27.2	12	10	11	33	25.4	15	13	13	41	26.1	13	11	7	31	24.4
i–h	25.00	10	14	16	40	23.1	12	13	12	37	28.5	12	14	9	35	22.3	7	13	13	33	26.0
h–h	6.25	5	5	6	16	9.2	4	2	4	10	7.7	7	4	5	16	10.2	7	3	2	12	9.4
Total	100.00	54	65	54	173	100.0	47	39	44	130	100.1	56	54	47	157	100.0	49	40	38	127	99.9
Triglycerides																				
l–l	6.25	5	6	6	17	9.8	6	4	4	14	10.8	6	4	3	13	8.3	4	2	3	9	7.0
l–i	25.00	14	19	13	44	25.3	11	9	14	34	26.2	8	17	12	37	23.4	14	14	10	38	29.7
l–h	12.50	5	3	2	10	5.7	2	2	1	5	3.8	8	2	6	16	10.1	3	5	3	11	8.6
i–i	25.00	13	14	16	43	24.7	11	11	9	31	23.8	19	14	14	47	29.7	10	10	8	28	21.9
i–h	25.00	16	18	9	43	24.7	14	9	13	36	27.7	10	11	7	28	17.7	17	5	12	34	26.6
h–h	6.25	3	5	9	17	9.8	3	4	3	10	7.7	6	6	5	17	10.8	2	4	2	8	6.3
Total	100.00	57	65	55	174	100.0	47	39	44	130	100.0	57	54	47	158	100.0	50	40	38	128	100.1
*HDL-cholesterol**																				
l–l	6.25		7	5	12	10.1		4	4	8	9.8		4	3	7	6.9		5	4	9	11.7
l–i	25.00		14	12	26	21.8		4	2	6	7.3		17	12	29	28.7		8	8	16	20.8
l–h	12.50		5	4	9	7.6		4	2	6	7.3		3	4	7	6.9		0	3	3	3.9
i–i	25.00		18	14	32	26.9		10	9	19	32.2		13	11	24	23.8		8	12	20	26.0
i–h	25.00		14	16	30	25.2		7	16	23	28.0		10	13	23	22.8		14	8	22	28.6
h–h	6.25		6	4	10	8.4		4	2	6	7.3		7	4	11	10.9		4	3	7	9.1
Total	100.00		64	55	119	100.0		38	44	82	100.0		54	47	101	100.0		39	38	77	100.1

* Not determined during the Heerenveen project.

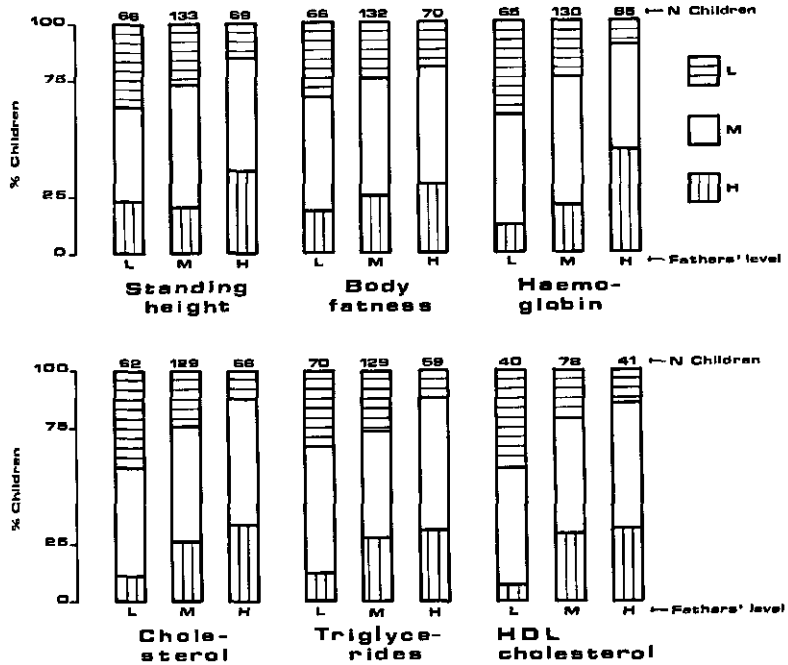

FIG. 28. Concordance of measurement levels among fathers and their children.
L = lowest quartile; M = middle quartiles; H = highest quartile.
HDL-cholesterol was not determined during the Heerenveen project.

The final analysis of concordance of measurement levels between parents and children takes into account the combination of observed measurement levels in spouses. Table 64 and Fig. 30 show the levels of measurements in children by the 6-category classification of observed measurement levels in spouses which was also used in Table 59 describing the concordances between spouses. The dependance of the observed levels of measurements in children upon the combination of levels observed in both their parents becomes quite clear from the inspection of the gradients in the percentage of children exhibiting the 3 examined levels, occurring by the classification into the same levels found in their parents (Fig. 30).

Taking the concordance in standing height as the example, it is apparent that both the characteristics 'high' and 'low' for the children present a stepwise, reciprocal change which closely follows the stepwise changes introduced in the levels of their parents, a gradient being found from two parents 'high', to one parent 'high', to neither parent 'high', and the same gradient being found at 'low' levels in married couples and their children. The patterns formed by the two extremes represent almost mirror images. This may be illustrated by the fact that the percentage of 'high' children from spouses, both also classified 'high', virtually equals the percentage of 'low' children from parents, both classified 'low': 55% and 44% respectively, instead of the expected 25%. The same mirror-

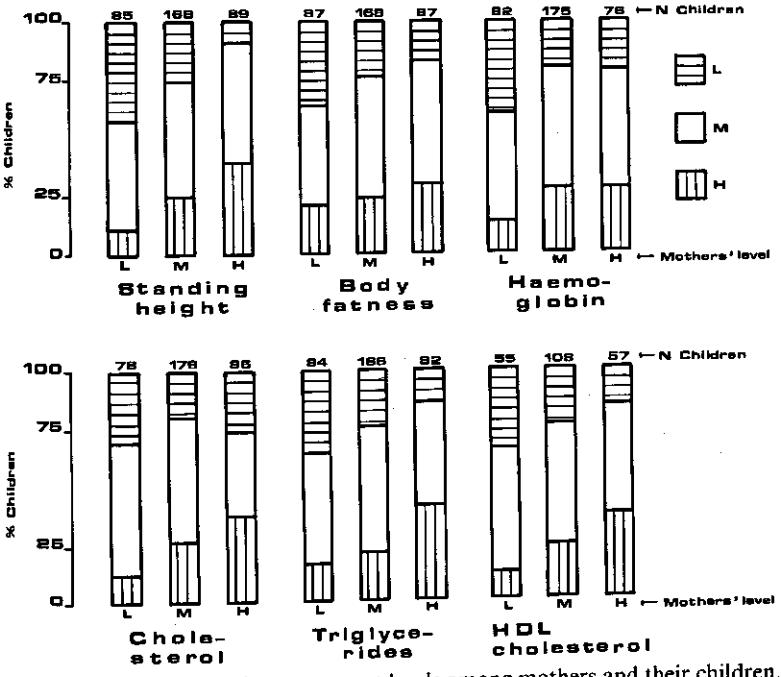

FIG. 29. Concordance of measurement levels among mothers and their children.
L = lowest quartile; M = middle quartiles; H = highest quartile.
HDL-cholesterol was not determined during the Heerenveen project.

pattern is found for the percentage of children classified 'high' or 'low', when one parent is 'high' or 'low' and the other 'intermediate'. In the remaining combinations formed by measurement levels observed in spouses, i.e. 'low-high' and 'both intermediate', the percentages of children found to be 'low' or 'high' were essentially equal to each other and were numerically intermediate between the situations in which complete concordance or complete discordance between married couples and their children occurred. The features mentioned above for the measurement of standing height were also present to varying degrees in the other examined parameters, which suggest similar modes of determination for these parameters as well. Some deviations from the model provided by the concordance in standing height did occur, presumably partly because of the small number of married couples and children involved. Thus, it seems as if the gradients for the measurements of body fatness and blood haemoglobin concentration were steeper, whereas the gradient in resemblance for the serum triglycerides concentration follows the stepwise pattern closer at the 'high' level, as opposed to that at the 'low' level, and the concordance in serum HDL-cholesterol levels seems to remain mainly at the 'low' level. But again, the numbers are small, and the general agreement in concordance patterns found between that of standing height and the other examined variables seem to point to a similar mode of determination of all the other examined parameters.

TABLE 63. Parent-child concordance of measurement levels; childrens' sexes combined.

Combi-nation	Exp. %	Mother Obs.		Father Obs.		Mother Obs.		Father Obs.		Mother Obs.		Father Obs.	
		n	%	n	%	n	%	n	%	n	%	n	%
		Standing height				*Body fatness*				*Haemoglobin*			
l–l	6.25	36	10.5	24	9.0	32	9.4	21	7.8	33	9.9	26	10.0
l–i	25.00	84	24.6	63	23.5	77	22.5	65	24.3	73	21.9	63	24.2
l–h	12.50	17	5.0	26	9.7	33	9.6	26	9.7	27	8.1	15	5.8
i–i	25.00	82	24.0	70	26.1	88	25.7	66	24.6	91	27.3	71	27.3
i–h	25.00	88	25.7	60	22.4	86	25.1	69	25.7	88	26.4	56	21.5
h–h	6.25	35	10.2	25	9.3	26	7.6	21	7.8	21	6.3	29	11.2
Total	100.00	342	100.0	268	100.0	342	99.9	268	99.9	333	99.9	260	100.0
		Total cholesterol				*Triglycerides*				*HDL-cholesterol**			
l–l	6.25	24	7.3	26	10.1	30	9.0	23	8.9	19	8.6	17	10.7
l–i	25.00	78	23.6	60	23.3	81	24.4	72	27.9	55	25.0	36	22.6
l–h	12.50	33	10.0	15	5.8	26	7.8	16	6.2	16	7.3	9	5.7
i–i	25.00	88	26.7	64	24.9	90	27.1	59	22.9	56	25.5	39	24.5
i–h	25.00	75	22.7	70	27.2	71	21.4	70	27.1	53	24.1	45	28.3
h–h	6.25	32	9.7	22	8.6	34	10.2	18	7.0	21	9.5	13	8.2
Total	100.00	330	100.0	257	99.9	332	99.9	258	100.0	220	100.0	159	100.0

* Not determined during the Heerenveen project.

TABLE 64. Concordance of measurement levels among spouse-pairs (married couples) and their children.

Parental comb.	Children's level l	i	h	Total n	Children's level l	i	h	Total n	Children's level l	i	h	Total n
	Standing height				*Body fatness*				*Haemoglobin*			
l–l	8	10	0	18	15	11	1	27	11	9	2	22
l–i	21	37	11	69	21	37	12	70	24	31	12	67
l–h	10	16	6	32	5	11	7	23	4	18	6	28
i–i	16	38	16	70	16	32	23	71	15	40	18	73
i–h	8	24	19	51	10	23	15	48	10	22	19	51
h–h	2	7	11	20	2	7	13	22	0	7	6	13
Total	65	132	63	260	69	121	71	261	64	127	63	254
	Total cholesterol				*Triglycerides*				*HDL-cholesterol**			
l–l	7	7	2	16	9	11	3	23	8	5	2	15
l–i	26	33	17	76	22	39	10	71	10	20	8	38
l–h	8	15	9	32	11	11	5	26	2	9	3	14
i–i	15	29	15	59	19	20	14	53	9	26	7	42
i–h	6	28	23	57	9	34	22	63	8	18	18	44
h–h	1	7	7	15	1	8	6	15	1	4	3	8
Total	63	119	73	255	71	123	58	251	38	82	41	161

* Not determined during the Heerenveen project.

3.8. ASSOCIATIONS BETWEEN DEMOGRAPHIC DATA AND BIOLOGICAL PARAMETERS

Parents from the lower social classes dominate the picture in the populations surveyed. Consequently, the populations could generally be divided only into two categories in order to get a reasonable number of people in both categories. Similar problems appeared concerning the categorization of the biological parameters. A reasonable number of 'high risk' children could only be obtained by taking boys and girls together. In the 'high risk'-category all children who exhibited borderline or frank obesity, hypercholesterolaemia or hypertriglyceridaemia were included (see also pp. 106–108 and 114–118). By making these broad categories it was possible to study the associations between demographic data and biological parameters. Only those associations found to be statistically significant are presented in Tables 65 - 67.

Statistically significant associations were observed between obesity in children and the mother's educational level in all three towns (Table 65). Obesity was more prevalent in children of mothers with a low educational level

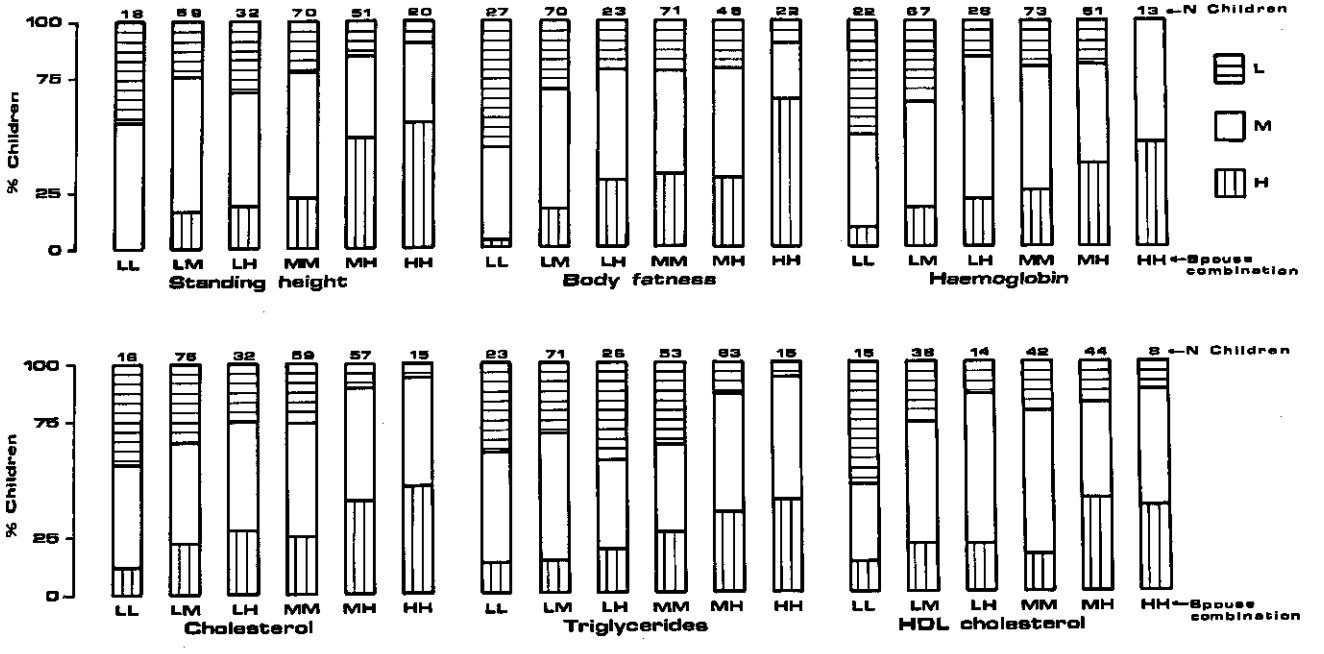

FIG. 30. Concordance of measurement levels among spouse-pairs and their children. L = lowest quartile; M = middle quartiles; H = highest quartile.
HDL-cholesterol was not determined during the Heerenveen project.

TABLE 65. Statistically significant associations between obesity in children and demographic data of the family.

Obesity in children*	Demographic parameter				Project
	*Educational level of the mother***				
	Low		High		
	n	%	n	%	
Absent	426	69.4	188	30.6	
Present	79	79.8	20	20.2	
	$\chi^2 = 4.48$				Heerenveen
	$0.01 < p < 0.05$				
Absent	321	65.2	171	34.8	
Present	99	74.4	34	25.6	
	$\chi^2 = 4.01$				Roermond
	$0.01 < p < 0.05$				
Absent	535	75.0	178	25.0	
Present	99	87.4	19	12.6	
	$\chi^2 = 10.85$				Harderwijk
	$p < 0.001$				
	Autochthonous parents				
	Yes		No		
	n	%	n	%	
Absent	261	63.0	153	37.0	
Present	105	72.4	40	27.6	
	$\chi^2 = 4.17$				Roermond
	$0.01 < p < 0.05$				

* Children with borderline or frank obesity were included in the category obesity present.
** Educational level of the mother:
Low: Elementary or low occupational education.
High: Advanced elementary, medium occupational, grammar school, high occupational or university education.

compared to children of mothers with a high educational level. In Roermond the prevalence of obesity was statistically significantly higher in children of autochthonous parents compared to children of non-autochthonous parents.

In Roermond, hypercholesterolaemia was statistically significantly more prevalent among children of mothers without a job compared to children of mothers with a full-time or part-time job. (Table 66). In Harderwijk the prevalence of hypercholesterolaemia was statistically significantly higher among children of mothers, as well as of fathers, with a low educational level compared to children of mothers and fathers with a high educational level. A similar association was observed between the prevalence of hypercholesterolaemia in Harderwijk children and the socio-economic status of the family. Hypercholesterolaemia was statistically significantly less prevalent in children of parents in high social classes compared to children of parents in medium or low social classes.

TABLE 66. Statistically significant associations between hypercholesterolaemia in children and demographic data of the family.

Hypercholesterolaemia in children*	Demographic parameter				Project
	Mother's occupation				
	Housewife		Employed**		
	n	%	n	%	
Absent	314	68.7	143	31.3	
Present	128	78.0	36	22.0	
	$\chi^2 = 5.13$				Roermond
	$0.01 < p < 0.05$				
	*Educational level of the mother****				
	Low		High		
	n	%	n	%	
Absent	495	74.7	168	25.3	
Present	172	85.6	29	14.4	
	$\chi^2 = 10.43$				Harderwijk
	$0.001 < p < 0.01$				
	*Educational level of the father*****				
	Low		High		
	n	%	n	%	
Absent	472	72.7	177	27.3	
Present	160	81.6	36	18.4	
	$\chi^2 = 6.33$				Harderwijk
	$0.01 < p < 0.05$				
	*SES of the family******				
	Low		Medium		High
	n	%	n	%	n %
Absent	384	59.0	156	24.0	111 17.1
Present	122	61.6	58	29.3	18 9.1
	$\chi^2 = 8.22$				Harderwijk
	$0.01 < p < 0.05$				

* Children with borderline or frank hypercholesterolaemia were included in the category hypercholesterolaemia present.
** Housewife = housewife only; Employed = full-time or part-time employed.
*** See footnote Table 65.
**** Same categories as for mothers.
***** SES of the family:
High: Category I and II
Medium: Category III
Low: Category IV and V
(see also Table 42)

TABLE 67. Statistically significant associations between hypertriglyceridaemia in children and demographic data of the family.

Hypertriglyceridaemia in children*	Demographic parameter				Project
	*Educational level of the father***				
	Low		High		
	n	%	n	%	
Absent	333	57.4	247	42.6	
Present	36	73.5	13	26.5	
	$\chi^2 = 4.80$				Roermond
	$0.01 < p < 0.05$				
	Occupation of the father				
	Labourer		Civil Servant		Self-employed	
	n	%	n	%	n	%	
Absent	266	45.5	123	21.1	195	33.4	
Present	13	26.5	22	44.9	14	28.6	
	$\chi^2 = 15.24$						Roermond
	$p < 0.001$						

* Children with borderline or frank hypertriglyceridaemia were included in the category hypertriglyceridaemia present.
** See footnote Table 65.

The prevalence of hypertriglyceridaemia was found to be statistically significantly higher in Roermond children of fathers with a low educational level compared to children of fathers with a high educational level (Table 67). Hypertriglyceridaemia in Roermond children of fathers who were civil servants (of all grades) was statistically significantly more prevalent compared to children of fathers with other occupations.

It can be concluded that, generally, inverse relationships between demographic data and biological parameters were observed. The inverse relationship between the prevalence of obesity in children and the educational level of the mother was consistently present in all three towns. Consistent inverse relationships between demographic data and hypercholesterolaemia were observed in Harderwijk only.

3.9. DIETARY SURVEY

3.9.1. *Description of the schoolchildren participating in the dietary survey*

The number of children eligible for the dietary surveys were divided into four categories:

TABLE 68. Review of (non) participation rates of Heerenveen schoolchildren eligible for the dietary survey.

Primary school number	Eligible n	Schoolchildren*							
		Cat. I		Cat. II		Cat. III		Cat. IV	
		n	%	n	%	n	%		%
1	45	3	6.7	1	2.2	3	6.7	38	84.4
2	69	3	4.3	5	7.2	3	4.3	58	84.1
3	46	3	6.5	1	2.2	4	8.7	38	82.6
4	92	12	13.0	15	16.3	5	5.4	60	65.2
Total	252	21	8.3	22	8.7	15	6.0	194	77.0

* Categorization:
Cat. I: Children whose mother refused to record the food intake of the child.
Cat. II: Children whose mother could not record the food intake of the child, due to legitimate reasons.
Cat. III: Children who participated in the dietary survey, but whose records were judged to be unreliable.
Cat. IV: Children of whom reliable records were obtained.

TABLE 69. Review of (non)participation rates of Roermond schoolchildren eligible for the dietary survey.

Primary school number	Eligible n	Schoolchildren*							
		Cat. I		Cat. II		Cat. III		Cat. IV	
		n	%	n	%	n	%	n	%
1	51	7	13.7	5	9.8	3	5.9	36	70.6
2	44	4	9.1	5	11.4	1	2.3	34	77.3
3	42	1	2.4	0	0.	1	2.4	40	95.2
4	67	7	10.4	4	6.0	4	6.0	52	77.6
Total	204	19	9.3	14	6.9	9	4.4	162	79.4

*See footnote Table 68.

TABLE 70. Review of (non)participation rates of Harderwijk schoolchildren eligible for the dietary survey.

Primary school number	Eligible n	Schoolchildren*							
		Cat. I		Cat. II		Cat. III		Cat. IV	
		n	%	n	%	n	%	n	%
1	57	1	1.8	3	5.3	3	5.3	50	87.7
2	69	1	1.4	3	4.3	0	0.	65	94.2
3	45	2	4.4	2	4.4	1	2.2	40	88.9
2	70	3	4.3	2	2.9	1	1.4	64	91.4
Total	241	7	2.9	10	4.1	5	2.1	219	90.9

* See footnote Table 68.

Category I: those children whose mothers refused to record the food intake of their child.
Category II: those children whose mothers did not record the food intake of their child for legitimate reasons. The following arguments were included: illness of the child, child on a prescribed diet, vacation, moved to another town in the period between the anthropometric and dietary survey, mother hospitalized, motherless child, mother had full-time outdoors employment, etc.
Category III: those children, who participated in the dietary survey, but whose dietary records were judged unreliable by the investigators. The children were allocated to this category when their dietary record was incomplete and could not be supplemented by additional information during the detailed interview with the mother after the two-day record period.
Category IV: those children of whom reliable dietary records were obtained.

In Heerenveen the participation rate (category III and IV) at schools 1, 2 and 3 varied around 90% (Table 68). At school 4 the participation rate was about 20% lower. This difference was caused by a refusal rate about twice as high and a non-participation rate because of legitimate reasons about 4 times as high, compared to the other schools. In Roermond the participation rate varied around 80% at school 1, 2 and 4 (Table 69). At these schools the refusal rate varied around 10% and the non-participation rate because of legitimate reasons ranged from 6% to 11%. At school 3 the participation rate was 98%. In Harderwijk the participation rate at all schools was higher than 90% (Table 70). Consequently the variation in refusal and non-participation because of legitimate reasons was generally small.

The percentage of children participating in the dietary survey was 83% in Heerenveen, 84% in Roermond and 93% in Harderwijk. The 10% difference in participation rate between Harderwijk compared to Heerenveen and Roermond can be explained by the about 3 times lower refusal rate and the about 2 times lower non-participation rate because of legitimate reasons in Harderwijk compared to Heerenveen and Roermond. Reliable dietary records were obtained in 194 Heerenveen schoolchildren, in 162 Roermond schoolchildren and in 219 Harderwijk schoolchildren.

3.9.2. *Food intake patterns*

The foods eaten by the Heerenveen, Roermond and Harderwijk children were divided into 7 main groups (Table 71). The percentage of children who had eaten at least once during the two day dietary survey one of the foods that contributed at least to one per cent of the total energy intake, is summarized in Table 72. Some interesting findings will be reported.

Dairy products. About 80% of the Roermond children and about 70% of the Heerenveen and Harderwijk children drank whole (3.2% fat) milk. The percentage of low-fat (1.5%) milk drinkers was about 15% in Heerenveen and Roermond and about 60% in Harderwijk. The percentage of children drinking chocolate milk (popular in The Netherlands) did not differ very much between

TABLE 71. Division of foods into food groups.

Group	Foods
I	Dairy products (including eggs)
II	Meat and meat products
III	Margarines, fats and oils
IV	Sugar, sugar-rich products and soft drinks
V	Potatoes, bread and bread products
VI	Fruits and vegetables
VII	Miscellaneous foods (including snacks)

TABLE 72. Percentage of children who ate at least once during the two-day dietary survey one of the mentioned foods.*

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Number of children	105	89	94	68	120	99
Group I						
Milk, whole	76	63	84	75	71	69
Hen's eggs	47	61	60	59	62	61
Gouda cheese	48	33	52	53	63	56
Vanilla custard, whole	50	39	35	38	50	48
Yoghurt, whole	57	52	23	21	33	33
Milk, low-fat	10	12	14	19	64	56
Choc. milk, whole	19	22	20	16	11	7
Butter	13	11	9	6	11	9
Choc. milk, low-fat	8	7	5	7	12	15
Edam cheese	23	28	< 5	< 5	< 5	7
Choc. custard, whole	5	< 5	27	16	7	5
Group II						
Pork, mean-fat	64	81	74	79	60	60
Beef, mean-fat	40	33	50	43	39	34
Luncheon meat	26	17	21	26	29	34
Group III						
Margarine, low-PUFA**	87	81	96	82	83	78
Cooking fat (Croma)	23	18	22	28	24	31
Halvarine, mean-PUFA**	< 5	< 5	39	43	36	24
Margarine, mean-PUFA**	18	27	9	19	16	17
Margarine, high-PUFA**	< 5	< 5	7	< 5	7	15
Group IV						
Crystal sugar	95	97	77	85	93	94
Soft drinks	49	43	48	60	54	54
Sweet fruit squashes	50	67	14	21	31	31
Sweet biscuits	46	33	26	22	42	39
Chocolate flakes	28	28	34	26	19	25

Group V						
Potatoes	100	98	99	96	98	96
White bread	72	66	83	82	54	59
Meal bread	47	39	38	43	70	66
Breakfast biscuit	36	41	34	46	58	55
Currant bread	8	<5	10	19	7	10
Whole meal bread	<5	<5	<5	<5	7	13
Group VI						
Apples	79	72	61	59	73	66
Oranges	51	43	43	60	37	52
Bananas	30	30	22	16	20	26
Group VII						
Peanut butter	36	24	21	22	36	37
Cake (incl. Friese koek)	50	43	6	7	14	14
Apple sauce	18	13	39	35	31	29
French fried potatoes	<5	<5	18	16	7	13
Macaroni	11	<5	<5	<5	7	5

* The foods mentioned in this table are limited to those that contributed to at least one percent of the daily total energy intake during the two-day dietary survey.
** PUFA = Poly-Unsaturated Fatty Acids
Low-PUFA margarines = <20% PUFA of fatty acid composition
Mean-PUFA margarines = 20–50% PUFA of fatty acid composition
High-PUFA margarines = >60% PUFA of fatty acid composition
Low-PUFA halvarines = <35% PUFA of fatty acid composition
Mean-PUFA halvarines = 35–55% PUFA of fatty acid composition
High-PUFA halvarines = >60% PUFA of fatty acid composition
(Halvarine is the Dutch word for low-fat margarine)

the 3 towns, if whole and low-fat chocolate milk were considered simultaneously. If Gouda and Edam cheese were considered together the highest percentage of cheese-eaters was found in Heerenveen. The percentage of egg-eaters was about 60% in all 3 towns. The percentage of children eating vanilla or chocolate-flavoured custard made from whole milk varied around 50% in all 3 towns. The percentage of children taking whole yoghurt was about twice as high in Heerenveen compared to Roermond and Harderwijk.

Meat and meat products. The percentage of children eating mean-fat pork and beef was higher in Roermond than in Heerenveen and Harderwijk.

Margarines, fats and oils. The percentage of children, using low poly-unsaturated fatty acid (PUFA) margarines varied around 85%. The percentage of children using mean PUFA and high PUFA margarines was respectively relatively high and low in Heerenveen compared to the percentage of children in the other towns. About 35% of the children in Roermond and Harderwijk used mean PUFA low-fat (40%) margarines (in The Netherlands called halvarines) compared to less than 5% of the Heerenveen children. In all 3 towns about one quarter of the children used highly saturated cooking fat (Croma).

Sugar, sugar-rich products and soft drinks. The percentage of children using crystal sugar ranged from about 80% in Roermond to about 95% in Heerenveen and Harderwijk. The percentage of children taking soft drinks varied around 50% and those taking sweet fruit squashes ranged from about 15% in Roermond to about 60% in Heerenveen. About 60% of the children ate sweet biscuits or chocolate flakes (the latter being popular in The Netherlands).

Potatoes, bread and bread products. Almost all children ate potatoes at least once during the two-day survey. The percentage of white bread eaters varied from about 55% in Harderwijk to about 85% in Roermond. The percentage of (whole) meal bread eaters ranged from about 40% in Roermond to about 80% in Harderwijk. The percentage of children who ate breakfast biscuits was about 40% in Heerenveen and Roermond and about 55% in Harderwijk. The percentage of children eating currant bread was twice as high in Roermond compared to Heerenveen and Harderwijk.

Fruits and vegetables. The percentage of children eating apples, oranges or bananas varied around 70, 50 and 25% respectively.

Miscellaneous foods. The percentage of children eating peanut butter was about 35% in Heerenveen and Harderwijk and about 20% in Roermond. The percentage of children eating cake (including Friese koek) ranged from less than 10% in Roermond to about 45% in Heerenveen. Apple sauce was eaten by about 35% of the Roermond and Harderwijk children and by about 15% of the Heerenveen children. The percentage of children eating French fried potatoes ranged from less than 5% in Heerenveen to about 15% in Roermond.

The differences in food intake patterns between Heerenveen, Roermond and Harderwijk children may be summarized as follows. In Heerenveen the percentage of children taking whole yoghurt, cake (incl. Friese koek) or sweet fruit squashes was at least twice that in the other towns. The percentage of children eating apple sauce or mean PUFA low-fat margarine was very much lower in Heerenveen compared to the other towns. In Roermond the percentage of children eating mean-fat pork and beef, white and currant bread and French fried potatoes was higher than in the other towns. The percentage of children eating peanut butter was lower in Roermond compared to the other towns. In Harderwijk the percentage of children drinking low-fat milk was 4 times higher than in the other towns. The percentage of children eating (whole) meal bread was also highest in Harderwijk compared to the other towns.

3.9.3. *Energy and nutrient intake*

3.9.3.1. General findings

The main results concerning energy and nutrient intake by the children of the three towns are summarized in Tables 73 and 74. The average total energy intake of the Heerenveen boys was lower than the average energy intake of the boys in the other two towns. This trend was also present in the protein and fat intake. The boys in Roermond and Harderwijk did not differ in average protein intake. With respect to fat the Roermond boys had the highest average intake. The average carbohydrate intake did not differ very much between the boys from the 3 towns.

From the energy percentage point of view the Heerenveen boys had the lowest intake of total proteins and total fats. The Roermond and Harderwijk boys did not differ with respect to total protein intake. The Roermond boys had the highest intake of total fats. Concerning carbohydrate intake the picture was completely reversed; the Heerenveen boys showed the highest intake and the Roermond boys the lowest.

The dietary cholesterol intake data showed the same trend as the saturated fat data. The highest intake was found in Roermond boys and the lowest in Heerenveen boys. The dietary fibre intake as well as the polysaccharide intake did not differ very much between the boys from the three towns.

TABLE 73. Energy and nutrient intake (mean ± s.d.) in boys by project-town.

	Heerenveen (n = 105)	Roermond (n = 94)	Harderwijk (n = 120)
Total energy (Kcal)	1891 ± 28	2103 ± 45	2041 ± 34
(MJ)	7.9± 1.2	8.8± 1.9	8.5± 1.5
% Energy total proteins	12.4± 1.9	13.5± 2.2	13.5± 2.2
% Energy total fats	37.8± 5.3	42.0± 5.6	39.6± 5.2
% Energy total carbohydrates	49.2± 5.4	44.2± 5.3	46.7± 5.6
Vegetable proteins (g)	20 ± 5	23 ± 7	22 ± 7
Animal proteins (g)	39 ± 10	48 ± 15	47 ± 12
Total proteins (g)	59 ± 11	71 ± 17	69 ± 14
Saturated fats (g)	38 ± 8	45 ± 14	41 ± 10
Mono-unsaturated fats (g)	29 ± 7	37 ± 12	34 ± 8
Poly-unsaturated fats (g)	11 ± 5	15 ± 7	14 ± 6
Total fats (g)	80 ± 18	98 ± 30	90 ± 21
Oligo-saccharides (g)	131 ± 30	123 ± 37	134 ± 34
Polysaccharides (g)	102 ± 20	110 ± 24	104 ± 26
Total carbohydrates (g)	233 ± 39	232 ± 48	238 ± 47
Dietary cholesterol (mg)	231 ±121	302 ±136	284 ±127
Dietary cholesterol (mg/1000 Kcal)	122 ± 59	143 ± 74	139 ± 59
Dietary fibre (g)	17.8± 4.1	18.9± 5.5	18.7± 5.1
Dietary fibre (g/1000 Kcal)	9.4± 2.1	9.0± 2.3	9.2± 2.0

TABLE 74. Energy and nutrient intake (mean ± s.d.) in girls by project-town.

	Heerenveen (n = 89)	Roermond (n = 68)	Harderwijk (n = 99)
Total energy (Kcal)	1788 ± 30	1848 ± 39	1852 ± 28
(MJ)	7.5 ± 1.3	7.7 ± 1.6	7.7 ± 1.2
% Energy total proteins	12.1 ± 1.9	13.1 ± 2.0	13.4 ± 2.2
% Energy total fats	39.2 ± 6.3	41.3 ± 5.7	40.6 ± 5.0
% Energy total carbohydrates	48.1 ± 6.3	45.3 ± 6.4	45.8 ± 5.2
Vegetable proteins (g)	18 ± 5	19 ± 6	20 ± 5
Animal proteins (g)	36 ± 9	41 ± 14	42 ± 13
Total proteins (g)	54 ± 11	60 ± 16	62 ± 14
Saturated fats (g)	36 ± 9	39 ± 11	38 ± 9
Mono-unsaturated fats (g)	29 ± 8	32 ± 10	31 ± 7
Poly-unsaturated fats (g)	11 ± 6	13 ± 5	13 ± 5
Total fats (g)	78 ± 21	85 ± 24	84 ± 18
Oligo-saccharides (g)	124 ± 31	113 ± 33	118 ± 25
Polysaccharides (g)	91 ± 21	97 ± 23	94 ± 20
Total carbohydrates (g)	215 ± 41	209 ± 46	212 ± 35
Dietary cholesterol (mg)	249 ± 130	277 ± 142	260 ± 123
Dietary cholesterol (mg/1000 Kcal)	139 ± 75	150 ± 72	140 ± 64
Dietary fibre (g)	16.1 ± 3.9	16.7 ± 4.8	17.1 ± 4.4
Dietary fibre (g/1000 Kcal)	9.0 ± 2.0	9.0 ± 2.3	9.3 ± 2.3

The trends observed in boys are also present in the girls. Generally, the trends in girls are less pronounced than in boys. In all three towns the average total energy intake in girls was lower than in boys. The average difference is about 200 Kcal (0.8 MJ). The difference in energy intake between girls and boys was parallelled by similar differences in the intake of proteins, fats and carbohydrates in each town. In Tables 75 and 76 a more elaborate analysis of the energy percentage from different nutrients is presented. It may be noted that boys and girls from the three towns did not differ with respect to the energy percentage derived from the different nutrients. The differences between the 3 towns in the energy percentage from proteins, fats and carbohydrates were generally small. These existing differences could mainly be ascribed to differences in intake of animal proteins, mono-unsaturated and poly-unsaturated fats and in oligo-saccharides.

In order to find out whether age trends were present in the energy and nutrient intake of the children aged 6–10 years the populations were divided into groups of children below and above 8 years of age. In both boys and girls a slight increase in total energy was found with age (Tables 77 and 78). Consistent trends in the intake of nutrients in relation to age were not observed, i.e. the increased energy intake found in the older age-groups could not be attributed to an increase in either protein, fat or carbohydrate intake separately, but was due to an increase in the intake of all nutrients.

TABLE 75. Percentage energy of macro-nutrients in boys by project-town.

Nutrient	Heerenveen	Roermond	Harderwijk
Proteins			
Vegetable	4.2	4.4	4.3
Animal	8.2	9.1	9.2
Fats			
Saturated	18.1	19.3	18.1
Mono-unsaturated	13.8	15.8	15.0
Poly-unsaturated	5.2	6.4	6.2
Carbohydrates			
Oligo-saccharides	27.7	23.4	26.3
Polysaccharides	21.6	20.9	20.4
Number of boys	105	94	120

TABLE 76. Percentage energy of macro-nutrients in girls by project-town.

Nutrient	Heerenveen	Roermond	Harderwijk
Proteins			
Vegetable	4.0	4.1	4.3
Animal	8.1	8.9	9.1
Fats			
Saturated	18.1	19.0	18.5
Mono-unsaturated	14.6	15.6	15.1
Poly-unsaturated	5.5	6.3	6.3
Carbohydrates			
Oligo-saccharides	27.7	24.5	25.5
Polysaccharides	20.4	21.0	20.3
Number of girls	89	68	99

3.9.3.2. Interviewer-effect

The dietary surveys in Heerenveen, Roermond and Harderwijk were carried out by 7, 8 and 8 interviewers respectively (Table 79). The small number of children examined by interviewer 7 and 8 in Roermond is caused by the fact that they participated in the dietary survey for one week only. In the comparison of the results by interviewer, the data from these interviewers are not taken into account. The number of children examined by the other interviewers ranged between 18 and 40.

For the children surveyed by each interviewer, the average total energy intake and the energy percentage from total proteins, total fats and total carbohydrates were calculated. The average total energy intake ranged from 7.3 to 8.2 MJ in Heerenveen, from 7.5 to 8.7 MJ in Roermond and from 7.7 to 8.6 MJ in Harderwijk. These data show a considerable variation in the average total energy intake observed by the different interviewers in the 3 towns. Whether these differences can be ascribed to differences in interview technique

TABLE 77. Intake (mean ± s.d.) of energy and macro-nutrients in boys by project-town and age-groups.

	Below 8 years		Above 8 years	
	abs. intake	% energy	abs. intake	% energy
Heerenveen				
Energy (MJ)	7.9± 1.1		8.0± 1.3	
Proteins (g)	58 ±11	12.3±1.9	60 ±11	12.5±1.9
Fats (g)	80 ±17	38.4±5.5	78 ±19	37.1±4.8
Carbohydrates (g)	229 ±40	48.7±5.9	237 ±39	49.9±4.8
Roermond				
Energy (MJ)	8.6± 2.1		8.9± 1.8	
Proteins (g)	68 ±16	13.3±1.6	73 ±18	13.6±2.6
Fats (g)	94 ±34	41.2±5.6	101 ±27	42.6±5.5
Carbohydrates (g)	233 ±46	45.1±5.4	232 ±50	43.6±5.1
Harderwijk				
Energy (MJ)	8.3± 1.5		8.8± 1.4	
Proteins (g)	67 ±13	13.6±2.3	70 ±15	13.3±2.1
Fats (g)	86 ±21	39.0±5.4	94 ±21	40.4±5.0
Carbohydrates (g)	234 ±53	47.2±5.7	242 ±42	46.1±5.4

TABLE 78. Intake (mean ± s.d.) of energy and macro-nutrients in girls by project-town and age-groups.

	Below 8 years		Above 8 years	
	abs. intake	% energy	abs. intake	% energy
Heerenveen				
Energy (MJ)	7.4± 1.3		7.5± 1.3	
Proteins (g)	55 ±11	12.3±1.9	53 ±11	11.8±1.8
Fats (g)	76 ±20	38.3±6.1	81 ±23	40.4±6.5
Carbohydrates (g)	217 ±43	48.8±6.1	213 ±39	47.3±6.7
Roermond				
Energy (MJ)	7.7± 1.8		7.7± 1.5	
Proteins (g)	63 ±17	13.5±1.8	59 ±15	12.8±2.0
Fats (g)	89 ±26	43.0±4.9	82 ±23	40.2±6.0
Carbohydrates (g)	199 ±44	43.1±4.9	216 ±47	46.7±6.9
Harderwijk				
Energy (MJ)	7.6± 0.9		7.9± 1.4	
Proteins (g)	62 ±10	13.7±2.0	62 ±16	13.1±2.4
Fats (g)	82 ±15	40.5±4.9	85 ±21	40.6±5.1
Carbohydrates (g)	207 ±32	45.6±5.0	217 ±37	46.0±5.3

TABLE 79. Total energy and nutrient intake (mean and total s.d.) of the schoolchildren by interviewer and project-town.

Interviewer	Mean s.d.	Heerenveen					Roermond					Harderwijk				
		Number of children	tot. energy (MJ)	% Energy			Number of children	tot. energy (MJ)	% Energy			Number of children	tot. energy (MJ)	% Energy		
				tot. prot.	tot. fats	tot. carb.			tot. prot.	tot. fats	tot. carb.			tot. prot.	tot. fats	tot. carb.
1	m	26	7.8	12.0	37.9	49.6	30	8.2	13.1	40.8	45.8	22	7.7	13.4	39.2	47.3
	s.d.		1.5	1.9	5.9	5.5		2.0	1.7	5.4	5.6		1.3	2.7	5.3	5.7
2	m	31	7.9	12.3	39.3	47.8	20	7.5	13.9	39.3	46.3	28	8.6	14.0	40.9	45.2
	s.d.		1.4	2.1	4.0	4.3		1.1	2.3	5.1	6.2		1.6	2.5	4.7	4.8
3	m	43	7.7	12.3	39.4	47.7	26	8.2	13.2	41.6	44.9	24	7.8	13.9	38.8	47.1
	s.d.		1.2	1.8	6.4	6.6		1.7	2.1	6.1	6.1		1.2	1.8	5.8	6.2
4	m	20	7.3	12.9	37.1	49.6	37	8.7	13.0	42.4	44.2	32	8.6	12.6	40.1	47.0
	s.d.		0.8	2.1	5.2	6.3		2.1	2.4	5.6	6.0		1.4	2.0	5.1	5.2
5	m	24	8.2	12.0	38.1	49.3	18	8.6	13.4	43.4	43.0	40	8.2	13.4	39.6	47.0
	s.d.		1.3	1.6	5.7	5.8		1.3	1.8	4.7	4.9		1.5	2.1	5.2	5.6
6	m	23	7.5	12.3	39.1	48.1	18	8.4	13.1	43.1	43.6	33	8.2	14.2	40.2	45.3
	s.d.		1.0	2.1	7.7	7.3		2.3	2.5	7.0	6.9		1.3	2.2	4.8	5.2
7	m	27	7.6	12.3	37.3	49.9	3	8.8	13.4	41.0	45.0	21	8.0	12.9	41.0	45.7
	s.d.		1.1	1.8	5.1	5.2		1.9	1.0	5.1	4.0		1.3	2.1	5.4	5.1
8	m						10	9.1	14.7	41.1	44.1	20	7.9	13.1	40.7	45.9
	s.d.							1.8	1.9	5.2	4.8		1.3	2.0	4.9	5.3

between the interviewers or to real differences in energy intake between the groups of children examined is difficult to judge. Some light can be thrown on this problem by comparing the results of three interviewers, namely interviewers 1, 2 and 3, who participated in both the Roermond and the Harderwijk surveys. The average total energy intake observed by interviewer 2 was the lowest in Roermond and the highest in Harderwijk. The results observed by interviewer 1 and 3 did not differ very much in either town. These results demonstrate that rather large differences in the average total energy intake observed by different interviewers may exist. However, the relative position of an interviewer was found to change from one survey to another. It may be concluded that differences in total energy intake cannot be ascribed to systematic differences between interviewers *per se*.

In contrast to the differences observed by different interviewers in average total energy intake, the differences in energy percentage intake from total proteins, total fats and total carbohydrates were rather small.

3.9.3.3. Day-effect

The distribution of the weekdays on which the food intake of the children was recorded differed between the 3 towns (Table 80). In Heerenveen the food intake was mainly recorded on Tuesdays and Wednesdays. In Roermond Monday, Tuesday, Thursday and Friday dominated the picture. In Harderwijk the food intake was most frequently recorded on a Monday, Tuesday, Wednesday and Thursday. These differences between the towns were caused by organizational differences in the execution of the surveys in the 3 towns.

In the comparison of intake data on different days, only those days in which the food intake of more than 25 children was recorded were taken into account. In Heerenveen the total average energy intake was higher on a Tuesday than on a Wednesday. In Roermond the highest intake was found on Thursdays and the lowest on Tuesdays. In Harderwijk the highest intake was observed on Mondays and the lowest on Thursdays. No clear general picture emerged from these results. There was only a tendency to a lower average energy intake on Wednesdays compared to the other weekdays in both Heerenveen and Harderwijk.

TABLE 80. Distribution by weekday and project-town of the number of reliable records obtained in the participating schoolchildren.

Weekday	Heerenveen	Roermond	Harderwijk
Monday	5	109	122
Tuesday	178	112	183
Wednesday	184	4	97
Thursday	12	47	36
Friday	9	51	–
Saturday	–	1	–
Total weekdays	388	324	438

The differences in energy intake between days were parallelled generally by similar differences in the intake of nutrients. Consequently, the percentage of energy from total proteins, fats and carbohydrates did not differ between days. The only exceptions to this rule were the Wednesday data in Harderwijk. On this day the energy percentage from total proteins was definitely lower and the energy percentage from total carbohydrates was definitely higher than on the other weekdays.

3.9.3.4. Confounder-analysis

It has already been shown that the average total energy intake of the children was dependent upon sex, age, abode, interviewer and the day of recording. It is not known to what extent these influences are independent of each other. Therefore a 'confounder-analysis' was carried out in order to differentiate between the independent contribution of these different influences observed on the average intake of total energy and nutrients. In this analysis the independent contribution of a variety of variables discerned in this study was estimated, as given in Table 81.

The 'confounder-analysis' showed that there was a statistically significant influence of these variables on the intake of total energy, vegetable, animal and total proteins, saturated, mono-unsaturated, poly-unsaturated and total fats, oligo-saccharides, polysaccharides, total carbohydrates, dietary cholesterol and on the percentage of energy from total proteins, fats and carbohydrates. However, only 9–23% of the variation in the intake of total energy and nutrients could be accounted for by variation in these variables. So, variation in analysed variables could not account for the majority of variations in intake of total energy and nutrients.

This analysis showed that:

- in boys the intake of vegetable, animal and total proteins, saturated, mono-unsaturated, poly-unsaturated and total fats and of oligo-saccharides, polysaccharides and total carbohydrates and consequently of total energy was higher than in girls;
- the energy percentage from total proteins was lower and the energy percentage from total fats was higher in girls compared to boys;
- the intake of total energy, vegetable proteins, poly-unsaturated and total fats, polysaccharides and of total carbohydrates was positively related to age;
- the energy percentage from total proteins was inversely related to age;
- the intake of total energy, vegetable and total proteins, saturated, mono-unsaturated, poly-unsaturated and total fats and of polysaccharides was lower on Wednesdays compared to Tuesdays. A similar picture was observed with respect to Mondays except for the intake of total proteins and mono-unsaturated fats;
- from the energy percentage point of view the intake of total fats was lower and of total carbohydrates higher on Wednesdays compared to Tuesdays;
- interviewer 18 was found to underestimate the intake of vegetable, animal and total proteins, poly-unsaturated fats, polysaccharides, dietary cholesterol

TABLE 81. Confounder analysis of energy and nutrient intake data[1]).

	Total energy	Proteins			Fats				Carbohydrates			Diet. chol.	% energy		
		veg.	anim.	total	sat.	mono-unsat.	poly-unsat.	total	oligo	poly	total		total prot.	total fats	total carb.
1 Girls	1***↓	1***↓	1***↓	1***↓	1***↓	1***↓	2***↓	1***↓	1***↓	1***↓	1***↓	.	7***↓	3 **↑	.
2 Age (⩾8.0 y.)	2***↑	5***↑	.	.	.	.	1***↑	4 *↑	.	2***↑	2***↑	.	10 *↓	.	.
3 Monday	5 **↓	3***↓	.	.	3 **↓	.	8 *↓	3 **↓	.	3***↓	.	.	.	.	.
4 Wednesday	3***↓	4***↓	.	7 **↓	2***↓	2 **↓	7 *↓	2***↓	.	4***↓	.	.	.	4 *↓	3 *↑
5 Thursday	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6 Friday	.	.	.	.	5 **↓	.	.	.	.	7***↓	.	.	.	.	.
7 Saturday	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8 Interviewer 1	.	9 *↓	9 *↑	.	.	.	.	.	.	.	.	.	.	.	.
9 Interviewer 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10 Interviewer 3	4 **↓	.	.	.	.	.	.	.	6 *↓	.	3 **↓	.	12 *↑	.	.
11 Interviewer 4	.	.	.	.	.	.	10 *↑	.	.	.	.	.	.	.	.
12 Interviewer 5	.	.	.	.	.	.	.	.	3 **↓	.	4 *↓	.	.	.	.
13 Interwiever 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14 Interviewer 7	.	.	5***↓	9 **↓	.	.	.	.	.	.	.	.	11 *↓	.	.
15 Interviewer 8	.	.	8 *↓	10 *↓	.	.	.	.	.	.	.	.	.	.	.
16 Interviewer 9	.	.	.	.	4 **↑	3 *↑	.	5 *↑	.	.	.	7 *↑	9 **↓	.	.
17 Interviewer 10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18 Interviewer 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19 Interviewer 12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20 Interviewer 13	.	.	4***↑	6 **↑	.	.	.	.	5 *↑	10 *↓	.	.	.	.	.
21 Interviewer 14	.	.	.	.	.	.	.	.	2 **↑	.	5 *↑	.	3***↓	.	.
22 Interviewer 15	.	.	.	.	.	.	.	.	.	.	.	.	8***↓	.	.
23 Interviewer 16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24 Interviewer 17	.	.	.	8 **↓	.	.	.	.	.	.	.	6 *↓	.	.	.
25 Interviewer 18	.	6 **↓	6***↓	3***↓	.	.	3 **↓	.	.	9 *↓	.	5 *↓	4***↓	.	.
26 Obesity	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27 Hypercholestero-laemia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28 Hypertriglyceri-daemia	.	.	.	.	.	.	.	.	.	.	.	3 **↓	.	.	.
29 Mother employed	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30 Mother low education	.	.	2***↓	4***↓	.	.	6 **↑	.	.	11 *↑	.	.	1***↓	1***↑	.

31 Mother high education	.	2***↑	.	.	.	.	9 *↑	.	.	6***↑	.	2***↓	.	.	.
32 Mother ⩾35y. at child birth	.	10 *↓	.	.	.	.	.	.	.	8 *↓	.	.	.	2***↓	2 **↑
33 Father self-employed	.	.	7 **↑	11 *↑	.	.	.	.	.	.	.	1***↑	6***↑	.	.
34 Father civil servant	.	8 *↑	.	.	.	.	.	.	.	.	.	4 *↑	.	.	.
35 Father temporary unemployed	.	7 *↑	.	.	.	.	.	.	.	.	.	.	.	.	.
36 Family incomplete	.	.	.	.	6 *↑	.	4 **↓	.	.	5***↑	.	.	.	.	.
37 Only child	.	.	.	.	.	.	.	.	4 **↑	.	.	.	.	.	.
38 Heerenveen project	.	.	3***↓	2***↓	.	.	5 **↓	.	.	.	.	8 *↓	2***↓	.	1 **↑
39 Roermond project	.	.	.	5 **↓	.	.	.	.	7 *↓	.	.	.	5***↓	.	.
F^{39}_{336} [2])	2.32	2.08	3.38	4.04	1.93	2.02	1.78	2.05	1.57	2.33	1.79	1.41	2.85	1.55	1.78
R^2 [3])	14%	13%	20%	23%	12%	13%	11%	13%	10%	15%	12%	9%	17%	10%	11%

[1]) For each dependent energy and nutrient intake, the dependency upon examined confounders is given by rank order, level of significance and direction of the association. * = $p \leqslant 0.05$; ** = $p \leqslant 0.01$; *** = $p \leqslant 0.001$; ↑ = positive; ↓ = negative.

[2]) $F^{39}_{336} \geqslant 1.40$; $p \leqslant 0.05$; * $F^{39}_{336} \geqslant 1.62$; $p \leqslant 0.01$; ** $F^{39}_{336} \geqslant 1.87$; $p \leqslant 0.001$; ***

[3]) Squared multiple correlation coefficient, percentage of variation explained.

and the energy percentage from total proteins;
- interviewer 3 underestimated the average intake of total energy, oligosaccharides and total carbohydrates. The energy percentage from total proteins was also overestimated by this interviewer;
- the most striking finding with respect to the interviewer-effect was the absence of an effect on total energy except for interviewer 3 and the underestimation of the energy percentage from total proteins by interviewers 7, 9, 14, 15 and 18;
- the Heerenveen children were found to have a lower intake of animal and total proteins, poly-unsaturated fats, dietary cholesterol and a lower energy percentage from total proteins;
- the energy percentage from total carbohydrates was higher in Heerenveen children than in Harderwijk children;
- the Roermond children showed a lower intake of total proteins, oligosaccharides and of the energy percentage from total proteins compared to Harderwijk children;
- the intake of animal and total proteins and energy percentage from total proteins was lower in children of mothers with a low educational level. These children, on the other hand, showed a higher intake of poly-unsaturated fats, polysaccharides and of the energy percentage from total fats than the children of mothers with a medium educational level;
- the intake of vegetable proteins, poly-unsaturated fats and polysaccharides was higher in children of mothers with a high educational level, but the dietary cholesterol intake of these children was lower;
- a higher intake of animal and total proteins, dietary cholesterol and a higher energy percentage from total proteins, was found in children of self-employed fathers;
- children from incomplete families had a higher intake of saturated fats and polysaccharides and a lower intake of poly-unsaturated fats compared to children from those families, in which all family members were living together.

The following conclusions may be drawn:
- the observed variations in intake of total energy could mainly be ascribed to contributions of sex, age and day of recording the food intake. These variations were found to be independent of the effect of different interviewers;
- the energy percentage from total proteins was significantly higher in
  a) children of self-employed fathers;
  b) children surveyed by one Heerenveen interviewer;
- the energy percentage from total proteins was significantly lower in
  a) children from mothers with a low educational level
  b) Heerenveen and Roermond children
  c) children surveyed by three Harderwijk and two Roermond interviewers;
- the energy percentage from total fats was found to be significantly higher in
  a) children of mothers with a low educational level
  b) girls;
- the energy percentage from total fats was significantly lower in

a) children of mothers who were older than 35 at the birth of the child
b) children whose food intake was recorded on Wednesdays;

– the energy percentage from total carbohydrates was significantly higher in
a) Heerenveen children
b) children of mothers who were older than 35 at the birth of the child
c) children whose food intake was recorded on Wednesdays.

3.9.3.5. Inter- and intra-individual variation

Generally the inter-individual standard deviation was found to be as large as the intra-individual standard deviation (Tables 82 and 83). This means that the day-to-day variation in the intake of total energy and nutrients within a child was as large as the variation between children. The dietary cholesterol intake was an important exception to this rule. The observed intra-individual standard deviation of the dietary cholesterol intake was consistently larger than the inter-individual standard deviation. The large intra-individual standard deviations observed in these children clearly demonstrate the need for prolonged dietary survey periods in order to obtain accurate estimations of the daily nutrient intake of an individual child.

3.9.3.6. Relationship with obesity

Consistent differences in total energy intake between obese and lean children were not observed (Tables 84 and 85). Generally, the total energy intake of obese children did not differ from the total energy intake of lean children.

TABLE 82. Inter-individual ($s.d._b$) – and intra-individual ($s.d._w$) standard deviation of the observed intake of total energy and nutrients in boys aged 6–10 years by project-town.

	Heerenveen		Roermond		Harderwijk	
	$s.d._b$	$s.d._w$	$s.d._b$	$s.d._w$	$s.d._b$	$s.d._w$
Total energy (MJ)	0.9	1.0	1.7	1.3	1.2	1.2
% Energy total proteins	1.5	1.8	1.7	1.9	1.8	1.7
% Energy total fats	4.2	4.4	4.2	5.2	4.0	4.7
% Energy total carbohydrates	4.3	4.8	3.8	5.2	4.3	4.9
Vegetable proteins (g)	4	4	5	6	5	6
Animal proteins (g)	7	9	13	11	10	11
Total proteins (g)	9	9	14	13	11	11
Saturated fats (g)	7	7	12	10	9	8
Mono-unsaturated fats (g)	5	6	10	10	6	7
Poly-unsaturated fats (g)	4	4	6	5	5	5
Total fats (g)	14	16	26	23	18	17
Oligo-saccharides (g)	25	23	33	23	27	28
Polysaccharides (g)	16	17	19	20	20	23
Total carbohydrates (g)	31	33	41	35	36	43
Dietary cholesterol (mg)	65	143	70	165	22	177
Dietary fibre (g)	3.1	3.7	3.8	5.5	4.1	4.3

TABLE 83. Inter-individual ($s.d._b$) and intra-individual ($s.d._w$) standard deviation of the observed intake of total energy and nutrients in girls aged 6–10 years by project-town.

	Heerenveen		Roermond		Harderwijk	
	$s.d._b$	$s.d._w$	$s.d._b$	$s.d._w$	$s.d._b$	$s.d._w$
Total energy (MJ)	1.1	1.0	1.4	1.2	0.9	1.1
% Energy total proteins	1.3	1.9	1.5	1.7	1.5	2.4
% Energy total fats	5.6	4.0	4.5	5.0	3.9	4.4
% Energy total carbohydrates	5.5	4.5	5.2	5.2	3.8	4.9
Vegetable proteins (g)	5	4	5	4	3	5
Animal proteins (g)	6	11	11	12	10	11
Total proteins (g)	8	11	14	12	10	13
Saturated fats (g)	8	8	8	10	8	7
Mono-unsaturated fats (g)	6	7	7	9	5	6
Poly-unsaturated fats (g)	5	4	4	5	4	4
Total fats (g)	18	16	19	22	15	15
Oligo-saccharides (g)	27	22	28	24	16	27
Polysaccharides (g)	19	14	21	14	16	18
Total carbohydrates (g)	36	29	41	29	22	38
Dietary cholesterol (mg)	68	156	47	190	38	165
Dietary fibre (g)	2.8	3.7	4.0	3.7	3.4	4.0

TABLE 84. Intake of energy and macro-nutrients in lean and (borderline plus frank) obese boys by project-town.

	Heerenveen		Roermond		Harderwijk	
	Lean (n=97)	Obese (n=8)	Lean (n=85)	Obese (n=9)	Lean (n=102)	Obese (n=18)
Total energy (MJ)	7.9	7.6	8.7	9.6	8.6	8.1
Proteins (g)	59	59	70	75	69	70
(% energy)	12.4	12.6	13.5	13.0	13.3	14.3
Fats (g)	79	83	97	113	91	85
(% energy)	37.6	40.3	41.8	44.1	39.7	39.2
Carbohydrates (g)	234	216	231	245	240	226
(% energy)	49.4	46.7	44.4	42.5	46.8	46.4

Differences between obese and lean children in the intake of nutrients were also small and inconsistent. In addition, in the confounder-analysis, an independent association between the presence of obesity and the total energy and nutrient intake was not observed. It may be concluded that obese and lean children did not differ with respect to the intake of total energy and nutrients in the present study.

TABLE 85. Intake of energy and macro-nutrients in lean and (borderline plus frank) obese girls by project-town.

	Heerenveen		Roermond		Harderwijk	
	Lean (n=79)	Obese (n=10)	Lean (n=46)	Obese (n=21)	Lean (n=85)	Obese (n=14)
Total energy (MJ)	7.5	7.2	7.7	7.8	7.7	7.9
Proteins (g)	55	50	59	63	62	63
(% energy)	12.2	11.5	12.9	13.4	13.4	13.4
Fats (g)	78	76	83	87	84	82
(% energy)	39.2	39.4	40.9	41.9	40.8	38.9
Carbohydrates (g)	216	210	210	206	210	224
(% energy)	48.1	48.5	45.9	44.2	45.6	47.5

3.9.3.7. Relationship with serum total cholesterol

Carefully controlled experiments have shown that saturated fats, especially saturated fats with 12–16 carbon atoms, and dietary cholesterol elevate the serum total cholesterol level and that poly-unsaturated fats lower the serum total cholesterol level (KEYS et al., 1965). Changes in serum total cholesterol level caused by dietary modifications in saturated fats, poly-unsaturated fats and dietary cholesterol can be predicted from regression equations (KEYS et al., 1965). When information about the intake of different fats and dietary cholesterol is available, it is possible to calculate Φ values for the diets (Table 86). The Φ values for different sex and age groups in this study were calculated (Table 87). The correlations between the observed Φ values and the observed serum total cholesterol levels were –0.17 and 0.05 for Φ_s and Φ_c respectively.

In addition, no independent association between the presence of hypercholesterolemia and the intake of energy and nutrients was observed in the confounder-analysis.

3.9.4. *Contribution of foods to nutrient intake*

A summary of the foods most frequently eaten that contribute to the nutrient intake is given in Tables 88–95. Some important findings will be reported.

TABLE 86. Regression equations concerning relationships between Φ values and the intake of fatty acids and of dietary cholesterol (KEYS et al., 1965).

$\Phi_s = 1.35(2S-P) + 1.5\sqrt{Z}$
$\Phi_c = 1.2(2S^*-P) + 1.5\sqrt{Z}$

Legend: S = Energy percentage derived from total saturated fatty acids
S* = Energy percentage derived from C_{12-16}-saturated fatty acids
P = Energy percentage derived from total poly-unsaturated fatty acids
Z = Dietary cholesterol (mg/1000 Kcal)

TABLE 87. Intake of selected fats, and of dietary cholesterol, and serum total cholesterol of schoolchildren by project-town, sex and age group.

Project	Sex	Age group (y)	n	SFA				PUFA		Dietary cholesterol		Φ_s^*	Φ_c^*	Serum total cholesterol (mg/100 ml)
				total		C_{12-16}		(g)	(% energy)	(mg)	(mg/Mcal)			
				(g)	(% energy)	(g)	(% energy)							
HVN	Boys	≤8	56	38	18.3	25	11.9	11	5.4	217	116	58.3	38.3	169
		>8	45	38	17.9	24	11.5	11	5.0	244	128	58.1	38.3	177
	Girls	≤8	48	36	17.9	24	11.8	11	5.4	257	145	59.5	40.2	168
		>8	36	37	18.5	25	12.2	11	5.3	236	131	58.6	39.6	175
RMD	Boys	≤8	38	43	19.0	28	12.4	14	6.0	322	156	61.6	41.1	174
		>8	53	46	19.4	30	12.8	16	6.8	290	136	60.7	40.0	178
	Girls	≤8	23	40	19.7	26	12.8	12	6.1	247	135	62.3	40.9	173
		>8	42	38	18.5	25	12.3	13	6.1	294	160	60.4	41.0	186
HWK	Boys	≤8	54	40	18.0	26	11.9	13	5.8	273	139	58.6	39.2	181
		>8	60	43	18.5	29	12.3	15	6.4	288	138	58.7	39.3	183
	Girls	≤8	43	38	18.5	25	12.3	12	6.0	257	142	59.9	40.3	177
		>8	50	39	18.4	26	12.4	14	6.6	260	137	58.3	39.3	185

* see Table 86.

Animal protein intake. The contribution of dairy products to the animal protein intake varied between about 40 and 50% (Table 88). The meat and meat products contributed about 25% in Harderwijk and about 30% in Heerenveen and Roermond. The dairy products and the meat and meat products contributed to about 70% of the animal protein intake.

Saturated fat intake. The dairy products and the group of margarines and fats contributed both about 25% to the saturated fat intake (Table 89). The meats contributed about 15% to the saturated fat intake. The contribution to the saturated fat intake of these three groups together amounted to about 65%.

Dietary cholesterol intake. Dairy products, including eggs, contributed to about 60% of the dietary cholesterol intake (Table 90). The meat and meat products contributed to about 20% of the dietary cholesterol intake. The contribution to the dietary cholesterol intake of the dairy products and of the meat and meat products amounted to about 80%.

Poly-unsaturated fat intake. Margarines and fats contributed to about 40% of the poly-unsaturated fat intake (Table 91). Mean-fat pork and peanut butter

TABLE 88. Percentage contribution of foods to animal protein intake*.

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (g)	39	36	48	41	47	42
Observed intake (% energy)	8.2	8.1	9.2	8.9	9.2	9.0
Group I						
Milk, whole	16.0	14.9	19.5	14.9	15.4	15.8
Milk, low-fat	2.8	2.3	4.7	5.9	13.6	13.9
Gouda cheese	6.6	6.1	5.7	7.1	8.2	8.3
Hen's eggs	4.5	6.4	4.7	5.8	4.9	4.9
Vanilla custard, whole	4.2	3.4	3.0	3.2	3.6	3.0
Yoghurt, whole	6.5	5.1	1.2	1.7	2.4	2.0
Edam cheese	4.0	4.2	–	–	–	0.8
Total	44.6	42.4	38.8	38.6	48.1	48.2
Group II						
Pork, mean-fat	17.0	20.7	17.1	20.6	12.7	13.9
Beef, mean-fat	11.0	8.8	8.6	8.1	8.7	6.9
Beef, low-fat	2.9	2.3	5.4	4.0	2.8	2.3
Total	30.9	31.8	31.1	32.7	24.2	23.1
Grand total	75.5	74.2	69.9	71.3	72.3	71.3

* In the Tables 88–95 only those foods are mentioned that contributed for at least 2 per cent to the total nutrient intake in one of the schoolchildren groups.

TABLE 89. Percentage contribution of foods to saturated fat intake.*

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (g)	38	36	45	39	41	38
Observed intake (% energy)	17.9	18.3	19.1	19.0	18.0	18.5
Group I						
Milk, whole	11.2	9.9	14.1	10.4	11.6	11.3
Gouda cheese	4.8	4.3	4.4	5.3	6.5	6.5
Vanilla custard, whole	2.9	2.3	2.1	2.3	2.7	2.2
Yoghurt, whole	4.4	3.3	0.9	1.2	1.8	1.5
Butter	3.6	1.8	0.7	0.8	2.1	1.7
Choc. milk, whole	1.5	2.0	1.8	1.1	1.1	0.5
Total	28.4	23.6	24.0	21.1	25.8	23.7
Group II						
Pork, mean-fat	10.9	12.8	11.6	13.5	9.0	9.6
Beef, mean-fat	4.1	3.1	3.3	3.0	3.5	2.7
Total	15.0	15.9	14.9	16.5	12.5	12.3
Group III						
Margarine low-PUFA	21.3	22.6	17.5	17.8	17.0	16.3
Cooking fat (Croma)	3.7	3.7	3.0	4.5	3.8	5.1
Margarine, mean-PUFA	2.8	4.6	1.8	3.5	2.9	3.0
Halvarine, mean-PUFA	–	–	2.2	2.5	2.1	1.2
Total	27.8	30.9	24.5	28.3	25.8	25.6
Group VII						
French fried potatoes	–	1.1	3.2	3.1	1.5	2.5
Peanut butter	1.7	1.4	1.4	0.9	2.0	1.5
Total	1.7	2.5	4.6	4.0	3.5	4.0
Grand total	72.9	72.9	68.0	69.9	67.6	65.6

* See footnote Table 88.

both contributed to about 10% of the poly-unsaturated fat intake. White and meal bread contributed less than 10% to the poly-unsaturated fat intake. The contribution to the poly-unsaturated fat intake of these products together amounted to about 70%.

Oligo-saccharide intake. The contribution of dairy products to the oligo-saccharide intake ranged between 20 and 25% (Table 92). The contribution of the sugar, sugar-rich products and soft drinks to the oligo-saccharide intake ranged between 30 and 35%. Fruits contributed to about 15% of the oligo-saccharide intake. These products together contributed to about 70% of the oligo-saccharide intake.

TABLE 90. Percentage contribution of foods to dietary cholesterol intake*.

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (mg)	231	249	302	227	284	259
Observed intake (mg/1000 Kcal)	122	139	143	150	139	140
Group I						
Hen's eggs	34.9	42.8	35.1	37.9	37.3	36.8
Milk, whole	9.2	7.2	10.4	7.3	8.5	8.3
Gouda cheese	4.6	3.7	3.8	4.4	5.6	5.6
Milk, low-fat	1.0	0.7	1.7	2.0	5.0	5.1
Vanilla custard, whole	2.3	2.9	1.6	1.6	2.0	1.6
Yoghurt, whole	3.6	2.4	0.7	0.8	1.3	1.1
Choc. milk, whole	1.8	2.2	2.0	1.1	1.2	0.5
Edam cheese	2.4	2.2	–	–	–	0.5
Butter	2.9	1.3	0.5	0.6	1.5	1.2
Total	62.7	65.4	55.8	55.7	62.4	60.7
Group II						
Pork, mean-fat	10.7	11.3	10.3	11.4	7.8	8.5
Beef, mean-fat	5.8	3.8	4.2	3.6	4.3	3.4
Pig's liver	–	–	3.3	2.9	–	–
Cow's liver	–	–	–	2.3	–	–
Chicken	1.1	0.8	2.8	1.4	2.8	1.9
Beef, low-fat	1.3	0.9	2.4	1.6	1.3	1.0
Total	18.9	16.8	23.0	22.2	16.2	14.8
Grand total	81.6	82.2	78.8	77.9	78.6	75.5

* See footnote Table 88.

Polysaccharide intake. The contribution of potatoes, bread and bread products to the polysaccharide intake ranged between 60 and 70% (Table 93). The contribution of products from the miscellaneous foods group to the polysaccharide intake ranged between about 5 and 15%. These two groups contributed to about 75% of the polysaccharide intake.

Vegetable protein intake. The contribution of potatoes, bread and bread products to the vegetable protein intake varied around 55% (Table 94). The contribution of the products from the miscellaneous foods group ranged between 5 and 15%. These two groups contributed to about 65% of the vegetable protein intake.

Dietary fibre intake. The contribution of potatoes, bread and bread products to the dietary fibre intake ranged between about 35 and 40% (Table 95). The contribution of fruit and vegetables to the dietary fibre intake ranged

TABLE 91. Percentage contribution of foods to poly-unsaturated fat intake*.

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (g)	11	11	15	13	14	13
Observed intake (% energy)	5.3	5.7	6.4	6.2	6.2	6.4
Group III						
Margarine, low-PUFA	19.6	19.9	18.1	21.5	17.4	15.4
Margarine, mean-PUFA	7.9	12.4	4.6	8.9	7.2	7.4
Margarine, high-PUFA	–	–	6.0	–	5.2	9.0
Halvarine, low-PUFA	1.1	2.8	7.6	9.1	7.1	4.0
Cooking fat (Croma)	4.0	3.8	2.9	4.4	3.5	4.7
Halvarine, mean-PUFA	3.7	2.4	–	1.7	2.3	1.6
Total	36.3	41.3	39.6	45.6	42.7	42.1
Group I						
Hen's eggs	2.4	3.1	2.3	2.9	2.5	2.4
Group II						
Pork, mean-fat	11.1	12.4	10.3	12.4	7.9	8.4
Group IV						
Sweet biscuits	2.8	2.2	1.5	1.4	1.8	1.8
Group V						
White bread	5.0	4.6	5.6	5.4	2.4	2.8
Meal bread	3.0	1.8	2.2	2.4	4.7	3.4
Total	8.0	6.4	7.8	7.8	7.1	6.2
Group VII						
Peanut butter	14.5	10.9	9.9	6.8	14.5	10.5
Mayonnaise	1.8	2.8	7.3	3.3	2.5	4.0
Salad dressing, 20% fat	2.0	1.7	1.0	0.6	1.8	1.4
Total	18.3	15.4	18.2	10.7	18.8	15.9
Grand total	78.9	80.8	79.7	80.8	80.8	76.8

* See footnote Table 88.

between about 20 and 30%. These two groups together contributed to about 60% of the dietary fibre intake.

It can be concluded that two or three food groups generally contributed to about 2/3 of the intake of different nutrients. The contribution of the different food groups to the nutrient intake did not differ very much between the children from the three towns.

TABLE 92. Percentage contribution of foods to oligo-saccharide intake*.

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (g)	131	124	123	113	134	118
Observed intake (% energy)	27.6	27.7	23.4	24.4	26.3	25.5
Group I						
Milk, whole	8.1	7.3	12.8	9.0	9.0	9.1
Vanilla custard, whole	4.9	4.0	4.7	4.7	5.1	4.3
Milk, low fat	1.0	0.8	2.3	2.7	5.9	6.2
Choc. milk, whole	2.1	2.9	3.4	1.8	1.7	0.8
Choc. milk, low-fat	1.0	1.1	0.9	0.8	1.6	2.9
Yoghurt, whole	2.6	2.0	0.6	0.8	1.1	1.0
Choc. custard, whole	0.6	0.4	2.1	1.6	0.7	0.3
Total	20.3	18.5	26.8	21.4	25.1	24.6
Group IV						
Crystal sugar	11.6	11.7	8.8	10.4	12.4	12.4
Soft drinks	7.1	5.1	8.5	9.3	9.2	7.9
Sweet fruit squashes	6.7	9.9	1.7	3.3	4.2	4.6
Sweets	1.0	1.5	1.9	3.6	1.5	2.1
Marmalade	2.6	2.5	3.4	2.0	2.6	1.9
Granulated sweets	3.2	3.0	1.2	3.5	1.6	0.9
Chocolate flakes	1.5	1.5	2.8	1.8	1.5	2.0
Apple syrup	0.3	0.5	1.3	2.3	–	0.4
Total	34.0	35.7	29.6	36.2	32.9	32.2
Group V						
White bread	1.3	1.3	2.1	1.8	0.7	0.9
Group VI						
Apples	9.9	11.2	6.3	6.7	7.6	6.4
Oranges	3.9	3.8	3.8	5.0	2.5	4.2
Bananas	2.6	2.9	2.1	1.7	1.8	2.2
Total	16.4	17.9	12.2	13.4	11.9	12.8
Group VII						
Apple sauce	1.5	0.9	3.6	2.8	2.3	2.4
Cake (incl. Friese koek)	3.3	3.2	0.4	0.4	0.6	0.6
Total	4.8	4.1	4.0	3.2	2.9	3.0
Grand total	76.8	77.5	74.7	76.0	73.5	73.5

* See footnote Table 88.

TABLE 93. Percentage contribution of foods to polysaccharide intake*.

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (g)	102	91	110	97	104	94
Observed intake (% energy)	21.6	20.5	20.9	21.0	20.4	20.4
Group V						
White bread	23.3	24.7	33.0	30.4	13.7	16.8
Meal bread	13.3	9.0	12.6	12.8	26.2	19.6
Potatoes	22.4	24.5	20.2	21.8	20.5	20.9
Breakfast biscuit	1.7	2.5	1.2	2.2	2.9	2.7
Currant bread	1.4	1.0	0.8	4.2	1.7	1.7
Rye bread	–	–	1.6	2.0	–	–
Whole meal bread	–	–	–	–	1.4	4.1
Total	62.1	61.7	69.4	73.4	66.4	65.8
Group VI						
Apples	3.5	4.1	1.9	2.1	2.7	2.2
Group VII						
Breakfast cereal	6.1	3.8	–	–	2.2	2.5
Cake (incl. Friese koek)	4.5	4.6	0.5	0.5	0.8	0.8
French fried potatoes	–	1.2	3.7	3.5	1.7	2.8
Macaroni	2.9	1.1	–	–	2.1	1.4
Rice (cooked white)	–	–	1.2	–	–	2.2
Total	13.5	10.7	5.4	4.0	6.8	9.7
Grand total	79.1	76.5	76.7	79.5	75.9	77.7

* See footnote Table 88.

TABLE 94. Percentage contribution of foods to vegetable protein intake*.

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (g)	20	18	23	19	22	20
Observed intake (% energy)	4.2	4.0	4.3	4.2	4.3	4.3
Group V						
White bread	22.1	23.3	30.0	28.3	12.1	14.8
Meal bread	13.1	9.0	12.0	12.5	24.1	18.0
Potatoes	12.7	13.9	10.9	12.1	10.7	11.0
Breakfast biscuit	1.7	2.4	1.1	2.2	2.7	2.5
Whole meal bread	–	–	–	–	1.5	4.4
Rye bread	–	–	1.5	2.0	–	–
Currant bread	1.2	0.5	1.3	3.5	1.4	1.4
Total	50.8	49.1	56.8	60.6	52.5	52.1
Group VI						
Spinach (cooked)	2.2	2.0	–	0.5	1.5	0.9
Group I						
Choc. milk, whole	1.4	2.0	1.8	1.1	1.0	0.5
Group VII						
Peanut butter	6.8	5.8	5.8	3.8	7.7	5.9
Cake (incl. Friese koek)	2.6	2.7	0.3	0.3	0.4	0.4
Breakfast cereal	4.2	2.5	–	–	1.4	1.6
Macaroni	2.6	1.0	–	–	1.8	1.2
Total	16.2	12.0	6.1	4.1	11.3	9.1
Grand total	70.6	65.1	64.7	66.3	66.3	62.6

* See footnote Table 88.

TABLE 95. Percentage contribution of foods to dietary fibre intake*.

	Heerenveen		Roermond		Harderwijk	
	Boys	Girls	Boys	Girls	Boys	Girls
Observed intake (g)	17.8	16.1	18.9	16.7	18.6	17.2
Observed intake (g/1000 Kcal)	9.4	9.0	9.0	9.0	9.2	9.3
Group V						
Potatoes	17.8	19.4	16.3	17.6	15.8	16.0
Meal bread	9.4	6.4	9.1	9.2	18.2	13.4
White bread	8.4	8.8	12.1	11.1	4.8	5.8
Rye bread	–	–	2.6	4.5	–	–
Whole meal bread	–	–	–	–	1.6	4.8
Total	35.6	34.6	40.1	42.4	40.4	40.0
Group VI						
Apples	9.2	11.0	5.2	5.7	6.9	5.6
Oranges	6.3	6.5	5.5	7.5	4.0	6.4
Bananas	2.0	2.4	1.4	1.2	1.3	1.6
Spinach (cooked)	4.7	4.3	2.0	3.2	4.6	1.9
Green peas (cooked)	–	–	2.4	2.5	1.8	1.9
Carrots (cooked)	2.6	2.9	0.8	1.0	1.7	0.5
Endives (cooked)	1.5	1.5	0.6	–	1.7	2.2
Total	26.3	28.6	17.9	21.1	22.0	20.1
Group IV						
Chocolate flakes	1.8	1.9	2.9	2.0	1.7	2.2
Group VII						
Breakfast cereal	5.7	3.6	–	–	2.0	2.4
Peanut butter	2.5	2.2	2.2	1.5	3.0	2.3
French fried potatoes	–	0.8	2.5	2.3	1.1	1.8
Total	8.2	6.6	4.7	3.8	6.1	6.5
Grand total	71.9	71.7	65.6	69.3	70.2	68.8

* See footnote Table 88.

4. DISCUSSION

4.1. Population selection

Due to limitations in financial resources and lack of manpower only a sample of schoolchildren could be examined in each project-town. Selection of children on the basis of schools was preferred above a random sample of children in each town.

In order to fulfil the objective of the study it was felt necessary to select autochthonous children as much as possible because differences between children from the 3 towns, if present, could be blurred out if a high proportion of non-autochthonous children participated. The mobility of the population is fairly high nowadays and, consequently, the chance of a relatively high proportion of non-autochthonous children being encountered in a random sample of schoolchildren is also great. Hence, in this study the selection of schools in residential districts with predominating autochthonous people was preferred.

Screening is rather popular in this country. If a random sample of all eligible schoolchildren had been drawn, it could be expected that parents of unselected children would request examination of their children. This possibility does not exist if the selection of children is confined to schools.

The procedure of cluster sampling used could lead to questions concerning inferences beyond the data, i.e. the generalizability of the study experience. The typical objection from the statistical point of view would be that the results from studies using the design of cluster sampling cannot be interpreted in terms of the 'average' person, derived from the 'universe'. Therefore, a random sample should have been drawn preferably. The crucial point, however, is whether the study results fit within the hypotheses concerning the relationships between observations. Scientific generalization is valid if the experience gained in the study provides insight into the domain of general experience. Inferences drawn beyond the study experience, gained either by random or cluster sampling, may be validated by falsifying or verifying them in the light of experience from other studies.

4.2. Participation and refusal

The participation rate at primary schools 3 and 4 in Roermond was about 10% higher than at schools 1 and 2. This difference may be explained by the extra activities undertaken in order to get consent for participation in the survey from the parents of the children from schools 3 and 4. The average participation rate of Roermond primary schoolchildren was about 10% lower compared to Heerenveen and Harderwijk schoolchildren. An explanation for this dif-

ference is not available.

The average participation rates of the nursery schoolchildren varied from about 75 to 95%. The relatively low participation rate in Heerenveen could be due to anxiousness of the children and/or their parents for the venepuncture, according to the impression of the schoolteachers. The contacts with the parents of the nursery schoolchildren were intensified in Roermond and Harderwijk. This approach resulted in higher participation rates and reached in both Roermond and Harderwijk the rates observed in primary schoolchildren.

4.3. Demographic data

The demographic data collected were primarily used for comparison of the 3 schoolchildren populations surveyed. These data could not be compared with similar information of all schoolchildren in each town, because such information concerning parents of nursery and primary schoolchildren is not available. Unfortunately this also applies to the 1971 census data because these data do not contain selected information about parents of schoolchildren.

The 3 schoolchildren populations differed in socio-economic status of the families. The socio-economic status of the Roermond families was generally higher than that of the Heerenveen families. The socio-economic status of the Harderwijk families seemed to be the lowest. The difference in socio-economic status between the Heerenveen and Harderwijk families was generally less than the difference between Heerenveen and Roermond families. The difference in socio-economic status between the Roermond families and the families from Heerenveen and Harderwijk was very probably caused by the method of selection of schools in Roermond. All examined children were derived from schools in only two residential districts because in Roermond the primary schools consisted of boys' and girls' schools. The schools in these two districts had children from either predominately lower or higher social class families. This contrast between the districts might explain the observed over-representation of families with fathers being unskilled labourers, with fathers being small business owners and with fathers having academic or executive professions and the under-representation of the families with fathers being skilled labourers or clerks.

The full-time or part-time employment rate among Roermond mothers was about twice as high that among Heerenveen and Harderwijk mothers. The high percentage of small business owners among Roermond mothers was concurrent to the high percentage of small business owners among Roermond fathers. It is plausible to suggest that among small business owners, wives assist their husbands in the trade. Consequently, the percentage of small business owners among mothers is positively related to the percentage small business owners among fathers. The high percentage of unskilled labourers among Roermond mothers is more difficult to explain. This may be related to the high percentage of unskilled labourers among Roermond fathers of whom

in addition, a high percentage was observed to be unemployed. The most plausible explanation may be that these low social class families try to increase their income by employment by the mother.

The percentage of autochthonous parents was found to be twice as high in Roermond than in Harderwijk. This may be caused by the fact that Harderwijk is a rapidly growing town in contrast to Roermond. During the Roermond and Harderwijk projects different definitions were used for calling children autochthonous. In the Roermond project the children were called autochthonous if their parents had settled in the province of Limburg before 1960. This definition was changed for the Harderwijk project and the children were called autochthonous if their parents had settled in the North-west Veluwe from the start of their marriage. This change in definition was made because it was assumed that families who have settled in a region from the start of their marriage adopt a very similar way of life to the native families. According to the definition used during the Harderwijk project more children were called autochthonous because young children of families who had settled in Harderwijk after 1960 could also be included in the category autochthonous if their parents had lived in Harderwijk from the start of their marriage. The percentage of autochthonous children did not differ between Roermond and Harderwijk. Although the interpretation of this finding is hampered by the difference in definition used during the Roermond and Harderwijk projects this finding may be interpreted as an indication of correctness of schools selected for participation by the local school physician.

4.4. Anthropometry

The anthropometric evaluation of body dimensions revealed clear differences between the children from the 3 project-towns. The tallest children were found in Heerenveen. These children weighed more, had greater skeletal widths and a greater arm muscle. They also had lower mean values of skinfold thicknesses and also the lowest prevalence of obesity.

If boys from Roermond were compared with those from Heerenveen, a difference of 1 kg of body weight and 3 cm of standing height was noted on average. The concurrent differences in knee widths and arm muscle circumference suggested that part of the difference in body weight must be attributed to a reduced development of bone and muscle. The subcutaneous fat layer on the contrary, was thicker in the boys from Roermond, which may be inferred from the 5% higher mean values and the double prevalence of obesity, as defined, found in these boys compared to the boys from Heerenveen. The same picture arises from comparisons of findings in girls from Heerenveen and Roermond. Girls from Roermond were found to be shorter, to weigh less, to have smaller knee widths, smaller arm muscle and considerably thicker skinfolds. It is inevitable to conclude that children from Roermond are smaller, have less lean body mass and more body fat than children from Heerenveen,

and furthermore, that the difference in lean body mass is attributable to a reduced development of both skeletal and muscle mass.

Boys from Harderwijk were about 1 cm smaller and weighed approximately the same as boys from Heerenveen. Clear differences in body measurements were, however, noted. Boys from Harderwijk had reduced skeletal widths in the younger age-categories and had a smaller arm muscle than boys from Heerenveen. However, a considerably thicker subcutaneous fat layer was measured in boys from Harderwijk, and the prevalence of obesity was approximately double. In girls the same picture is noted, although the difference in subcutaneous skinfold thickness is less pronounced. This is in concordance with the finding that in all age-categories the body weights in boys from Heerenveen and Harderwijk were essentially equal, while girls from Harderwijk weighed approximately 1–1.5 kg less than girls from Heerenveen in the age-categories below 8 years. Also, the difference in prevalence of obesity between girls from Heerenveen and Harderwijk was less than that in boys.

If we compare boys from Harderwijk with those from Roermond, it is noted that boys from Harderwijk were about 2 cm taller and weighed approximately the same. Boys from Harderwijk had higher knee widths and lower arm muscle, especially in the older age-categories. At the mean level, boys from Harderwijk had considerably higher skinfold thicknesses but the prevalence of obesity in both groups was hardly different. Girls from Harderwijk were found on average to be somewhat taller and to weigh somewhat more especially in the older age-categories, than girls from Roermond. In the age-categories after the age of 8, girls from Harderwijk had higher knee widths. The arm muscle was equal in these groups and, on a mean level, girls from Harderwijk had only a slightly thicker subcutaneous fat layer than girls from Roermond.

To summarize, children from Heerenveen appeared to have the 'best' body composition, measured by these indicators of nutritional status. Children from Roermond were smaller, had less lean body mass, attributable to both a lesser skeletal and muscle mass, and had considerably more body fat which is reflected by higher levels of skinfold thicknesses and a double prevalence of obesity. Children from Harderwijk took the intermediate position with regard to standing height and body weight. Their skeletal width was comparable to children from Heerenveen, but they had even less muscle circumference than the children from Roermond. They had, at a mean level of measurement, the thickest subcutaneous fat layer but the prevalence of obesity was intermediate between Heerenveen and Roermond.

These conclusions regarding differences in body measurements were strengthened by the results from the analysis of inter-relations between body measurements. Notably high figures for total predictive power, reflected by values for the squared multiple correlation coefficient between 0.91 and 0.94 were observed in the multiple regression analysis between body weight and body measurements. This means, that less than 10% of the variation in body weight could not be explained by these measurements. This predictive force is considerably high if we take into consideration that variations in 'rest mass', i.e.

internal organs, etc. were not accounted for and errors of 2–4% were noted for most of these measurements. In addition, the results of this analysis gave an important insight into the interplay of body compartments in the prediction of body weight.

If the measured indicators do predict the actual mass of the various body compartments of these children and from all that is known from the nutritional anthropometry there seems to be little reason to question this (BROZEK, 1963), then about one-third of the variations in body weight could be accounted for by variations in standing height, one-quarter by variations in subcutaneous fat mass and one-fifth both by variations in skeletal and muscle mass. Although this reasoning seems valid for the measurements as taken, it must nevertheless be remembered that these measurements do not all represent pure, unaffected indicators of each body compartment. Arm muscle circumference, for instance, also contains a measure of skeletal mass. In the variation of skinfold thickness, a certain amount of variation in the thickness of the skin is contained. Further, it was noted that, especially in fat children, it was often difficult to measure the knee width without affecting the measurement of the subcutaneous fat layer and, finally, in the analysis of body weight by its linear regression on body measurements, two dimensions of the skeletal frame were used and almost all measurements in the regression equation were fairly highly inter-correlated. Nevertheless, it is concluded that these indicators of body composition described fairly well the situation as present and there seems to be little reason to question the validity of the previously described differences in body composition indicators between children from the 3 town-projects.

When using published prediction equations (PARIZKOVA and ROTH, 1972; DURNIN and RAMAHAN, 1967; BROOK, 1971) to convert skinfold measurements into predicted body density and, consequently, to convert body density into the percentage of body fat (KEYS and BROZEK, 1953) an assessment of median body fatness for boys and girls of 14–16% was obtained. As can be seen already from Fig. 14, this median estimate does not vary too much in boys of the various age-categories. In girls, however, a steep increase in measurements of body fatness is noted from the age of 10 onwards. Before that age, a prediction of 12–15% of body fat was found, whereas after the age of 9 years, figures of 16–18% were calculated for median percentage of body fat. It was decided to take as tentative cut-off point for *borderline* obesity the result of body skinfold measurements which predicts 20% of body fat in boys of all age-categories and in girls of the age-categories below 10 years. For the same purpose, in girls from the age of 9 onwards a cut-off point of 22% of body fat was taken. The presence of *frank* obesity was defined to be present if results of measurements of skinfold thicknesses predicted a body fat percentage of 25% of body weight and more in boys of all age-categories and in girls up to the age of 9 years. Thereafter, the cut-off point used in girls was 27% of body fat. These decisions are, of course, arbitrary and it could be argued that on the basis of insufficient knowledge of the long-term consequences of juvenile obesity on future health,

there seems no reason to define a child to be obese by whatever criterion. On the other hand, it must be remembered that a great deal of reports from epidemiological cross-sectional and short-term clinical studies have proved the association, already present in childhood, between obesity and high blood pressure (DU FLOREY et al., 1976; LAUER et al., 1975; VOORS et al., 1976), high blood levels of glucose (DU FLOREY et al., 1976; DESCHAMPS et al., 1977), triglycerides (COURT et al., 1974; FRERICHS et al., 1976a), insulin (DU FLOREY et al., 1976; DESCHAMPS et al., 1977), and possibly also total cholesterol (COURT et al., 1974) and glucagon (PAULSEN et al., 1968). Furthermore, in our society, there is no benefit from carrying around excessive amounts of body fat and children with these high levels of body fat are known to suffer frequently from affront by their age-peers. These facts give sufficient basis for the conclusion that children, found to be frankly obese by this rather conservative (GARN et al., 1975b; SELTZER and MAYER, 1965) criterion of approximately 25–27% of body fat require assistance in order to reduce this amount. Prevalences found in children from Heerenveen, Roermond and Harderwijk, i.e. 4–5% of frank obesity, indicate that this may be a formidable task from the point of view of magnitude. It should be noted here that this estimate of 4–5% is in agreement with similar estimates from the 1973/74 national survey of the nutritional status of 8 year-old schoolchildren, described by DE WIJN (1976).

Fig. 31 shows a comparison of results of skinfold measurements with recent epidemiological surveys of schoolchildren populations from Montreal (JENICEK et al., 1972), Dortmund (MAASER et al., 1972), London (TANNER and WHITEHOUSE, 1975) and a probability sample of non-institutionalized white children in the USA (JOHNSTON et al., 1972). The combined results of the median triceps and the median subscapular skinfold measurements of the boys and girls from Heerenveen, Roermond and Harderwijk served as a reference and the results of the studies just mentioned were expressed as percentages of this combination of Dutch project values.

Comparisons of this kind must be regarded with caution since results of body fatness measurements can be profoundly influenced by measurement technique, type of calipers used and mode of presentation of results. In this study, errors of measurement between observers for the triceps and subscapular skinfold of 5–7.5% were noted. This agrees with findings by others (EDWARDS et al., 1955; TANNER and WHITEHOUSE, 1975; MAASER et al., 1972; LAUER et al., 1975) but the results of replicate measurements by different observers in Cycle III of the U.S. Health Examination Survey (JOHNSTON et al., 1972) showed an average coefficient of variation between observers of 15% for both triceps and subscapular skinfold measurements. On the other hand, however, in two recent studies on observer errors in skinfold thickness measurements (WOMERSLEY et al., 1973; BURKINSHAW et al., 1973), it was concluded that 'variations in skinfold thickness due to different observers, experienced and inexperienced, (...) were not likely to influence critically results obtained'. It seems realistic from the foregoing to take a range of plus and minus 10% from the reference

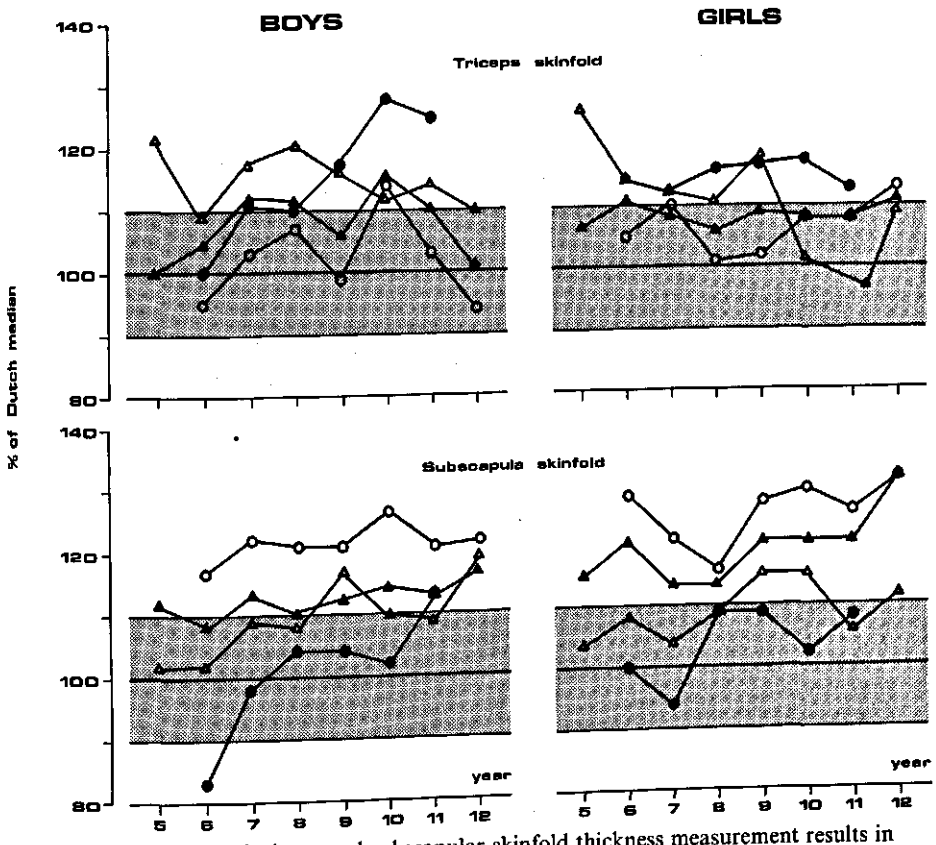

FIG. 31. Comparison of triceps and subscapular skinfold thickness measurement results in schoolchildren.
○ = Can.; ● = USA; △ = FRG; ▲ = UK. (See also Table 96).

provided by the mean results of Dutch values for the evaluation of the question whether real and consistent differences occur between the reported results.

Fig. 31 suggests that, by this criterion, German boys have higher triceps skinfold thicknesses at the median level in all age-classes. American boys above the age of 8 years also seem to exhibit higher triceps skinfold thicknesses. The results of subscapular measurements in boys reveal, however, that Canadian and British standards are definitely higher at the median level than those of Dutch boys. In girls more or less the same picture arises. In the lower age-classes the girls from Dortmund have higher median triceps values, and this applies also to all age-classes of US-girls. For the subscapular measurement, however, girls from London and Montreal showed definitely higher values at a median level. The conclusion is that when taking these results together, Dutch children have lower (combined) skinfold thicknesses at a median level than children from other industrialized countries. This conclusion is supported by the

TABLE 96. Reported 90th percentile values of skinfold distributions in several schoolchildren studies.

BOYS						GIRLS				
Montreal Canada	Dortm FRG	London UK	Sample USA	this study	age (y)	this study	Sample USA	London UK	Dortm FRG	Montreal Canada
Triceps skinfold (mm)										
–	13.5	12.0	–	11.0	5	12.5	–	14.0	15.0	–
9.5	12.0	12.0	12.0	11.0	6	12.0	14.0	14.0	14.5	12.0
10.5	12.0	12.0	12.0	10.5	7	13.0	16.0	14.5	14.5	14.0
12.0	13.5	12.0	14.0	10.5	8	14.0	18.0	16.0	16.0	14.5
11.0	15.0	13.0	17.0	11.0	9	15.5	20.0	17.5	17.5	16.0
14.0	17.0	15.0	16.0	13.0	10	16.5	20.0	19.0	17.0	18.5
14.0	17.0	17.0	19.0	14.5	11	18.5	21.0	20.0	17.5	19.0
17.0	19.0	17.5	–	15.5	12	16.5	–	20.0	16.5	16.5
Subscapular skinfold (mm)										
–	6.5	7.5	–	6.5	5	7.5	–	9.5	7.5	–
7.0	6.5	7.5	6.5	6.5	6	7.0	8.0	9.5	9.0	9.0
7.0	7.0	7.5	7.0	6.5	7	9.0	9.5	10.5	8.0	10.5
8.0	8.5	8.0	8.0	6.5	8	8.5	12.0	12.0	11.0	10.5
7.5	10.0	9.0	10.0	7.0	9	9.0	15.0	14.0	13.0	12.5
9.0	11.5	11.0	10.5	8.0	10	11.0	16.0	16.5	12.0	15.0
10.0	10.5	13.0	14.0	9.0	11	11.5	16.0	18.5	14.0	14.5
13.5	12.5	14.5	–	10.5	12	11.0	–	19.5	12.5	12.5

comparison of results reported in the same studies for the 90th percentile value of the respective skinfold distributions. This comparison is given in Table 96. Although this comparison is based on a less accurate estimate of skinfold thickness as compared to median values, it should be noted that the results obtained in the Dutch children are consistently lower than results reported from the other schoolchildren populations. Although under the uncertainties described the results for the 90th percentile in Canadian children could perhaps not be regarded as statistically different from ours, the German findings outranged the values in Dutch children at the 90th percentile by some 15%, while the British and American figures are at least 25% higher than the comparable figures in Dutch children. In conclusion, these comparisons suggest that the Dutch schoolchildren from Heerenveen, Roermond and Harderwijk compare favourably with their age-partners from other countries, who may be assumed to be comparable with respect to genetic and environmental factors. The Dutch samples of schoolchildren seem to be less fat at the mean level and seem to contain a smaller percentage of frankly obese children than among samples from London, Dortmund and the USA. This conclusion should not, however, deny the severity of the finding of a prevalence of about 4–5% of frank obesity in the Dutch children, but should merely be taken as a firm motivation for the prevention of the development of obesity in these children towards comparable levels from the other countries.

4.5. Blood chemical parameters

Results of blood haemoglobin determinations are compared in Table 97 for the 8–9 year old age-categories with results of the 1965 and 1974 orientational investigations of the nutritional status in 8 year-old schoolchildren reported by De Wijn et al. (1967; 1976).

It is clear from this comparison that the haemoglobin distributions of children from Heerenveen and Roermond were at lower levels than those of the 1965 and 1974 samples of Dutch schoolchildren. The distributions of children from Harderwijk remained at definitely higher values. In the Dutch samples of 8 year-old schoolchildren, prevalences of subclinical anaemia were reported of 2.4% and 2.7% for boys and girls in 1965, and of 1.6% and 1.0% for boys and girls in 1974, respectively. These prevalences are to be compared with values of 2.3% and 3.3% for all boys and girls of the age category 8–9 years from this investigation. These comparisons show that children from these project-towns belong to a normal, healthy schoolchildren population.

The levels of both serum total cholesterol and triglycerides were highly variable within these healthy schoolchildren populations and large numbers of children were required before subtle differences became statistically significant. Of course, care must be taken in interpreting these significances since small differences which may or may not be biologically significant will become

TABLE 97. Results of blood haemoglobin determinations (g/100 ml) in Dutch schoolchildren populations.

Age	Origin	n	Mean	s.d.	Percentiles		
					P_{10}	P_{50}	P_{90}
Boys							
8.5	1965	1039	13.5	0.65	12.6	13.5	14.3
8.5	1974	442	13.5	0.73	12.6	13.5	14.5
8-9	HVN	94	13.2	0.78	12.1	13.3	14.2
8-9	RMD	81	13.2	0.75	12.5	13.2	14.2
8-9	HWK	107	13.7	0.77	12.8	13.6	14.6
Girls							
8.5	1965	1018	13.4	0.65	12.5	13.5	14.2
8.5	1974	392	13.5	0.75	12.5	13.5	14.6
8-9	HVN	79	13.3	0.67	12.4	13.2	14.2
8-9	RMD	87	13.1	0.68	12.2	13.1	14.0
8-9	HWK	93	13.8	0.68	12.9	13.9	14.7

statistically significant with increasing group size. One may argue, on the other hand, that consistencies found in observed differences, if added to apparent statistical significance of these differences, would lead to increased belief in the biological importance of these differences. If so, the findings that children from Heerenveen consistently had the lowest mean serum total cholesterol levels and that children from Harderwijk had consistently higher levels than those from Heerenveen, gain importance. Likewise, the findings that serum total cholesterol was positively related to age-categories in both Heerenveen boys and girls and that girls had consistently higher levels of serum lipids than boys in all 3 towns, would then be biologically meaningful. Furthermore, serum triglycerides in children from Harderwijk were the lowest observed and in none of the project sex-categories was a consistent association of serum triglycerides concentrations with age-categories noted. These remarked consistencies, however, only apply to the means of concentrations found and a considerable overlap in distributions of the various parameters was evident. This would mean that the knowledge of one of these parameters in a given child would not have been sufficient to allocate him or her to one of the projects with any confidence. The observed minor differences between serum HDL-cholesterol concentrations suggest that the same holds true for this parameter.

The mean levels of serum total cholesterol found in these Dutch children generally agreed within 10 mg/100 ml with values reported for schoolchildren by several investigators in the USA (HAMES and GREENBERG, 1961; JOHNSON et al., 1965; MILLIGAN et al., 1966; STARR, 1971; GOLUBJATNIKOV et al., 1972; LAUER et al., 1975). Exceptions to this were the New York City

schoolchildren studied by BAKER et al. (1967), children from Arizona (FRIEDMAN and GOLDBERG, 1973) and the schoolchildren from the recently reported Bogalusa Heart Study (FRERICHS et al., 1976b). In these last 3 studies from the USA, lower values by more than 20 mg/100 ml were reported. Our cholesterol values are higher by more than 20 mg/100 ml compared to levels reported in Australian children (GODFREY et al., 1972) and are lower by about 10 mg/100 ml than levels reported in children from Denmark (DYERBERG and HJØRNE, 1973). Although studies of blood triglycerides in schoolchildren are limited, mean levels in these Dutch children are comparable to those reported by BAKER et al. (1967) in 10–13 year-old caucasian children from New York and those reported in Danish children (DYERBERG and HJØRNE, 1973), higher than those reported for non-fasting adolescent girls from Iowa (HODGES and KREHL, 1965), and lower than those in schoolchildren from Bogalusa (FRERICHS et al., 1976b).

Lack of standardization in protocol for sampling and laboratory techniques is a major point of consideration (SCHWARTZ and HILL, 1972; FLETCHER, 1972). Different methods of laboratory determinations used, tend to confuse the picture with regard to the evaluation of differences between population groups. It is known that profound differences in one laboratory may occur when applying two different methods for the same determination and the same may occur between laboratories even if applying the same methods. A deliberately selected example of the former possibility is shown in Fig. 32. Results in this figure show that in our laboratory determinations according to the method described by BLOOR (1916), formerly used in nutrition studies in Dutch schoolchildren (LAMBERTS, 1947; DONATH et al., 1953), yielded 13% higher values for serum total cholesterol concentrations in the same sera than the indirect ABELL method routinely used in part for this study. Similar discrepancies between these 2 methods are known to have occurred in other laboratories (SCHWARZ and HILL, 1972; KEYS et al., 1967a) and they are known to occur between other methods of determinations as well. If, in addition, the differences which may occur between laboratories (COOPER, 1975) are taken into account, it becomes clear that the comparison, as made before, between our results and those reported in the literature loose much of their value. Adjustment of results found in a laboratory, performing determinations for studies on an epidemiological basis to a common reference frame as, for example, provided by the WHO Reference Laboratories in Atlanta, USA and Prague, Czecho-Slovakia, is an absolute requirement if results of these studies are to be validly compared*.

It is important to appreciate other sources of potential error which may occur in the acquirement of a lipid profile for a given individual from a single blood collection. An attempt to evaluate effects of error attributable to biologi-

* Partly as a result of efforts during this investigation, the Laboratory of the Department of Human Nutrition passed in January 1977 for its cholesterol determination phase III and entered the continuous surveillance phase of the quality control programme offered by WHO through guidance of the Center for Disease Control, Atlanta, USA.

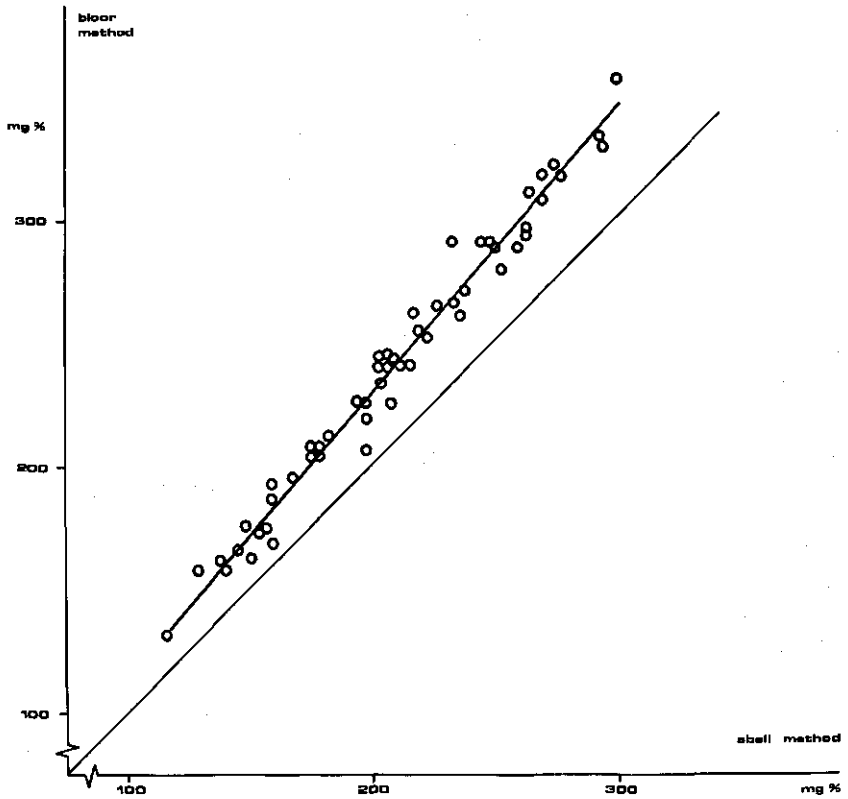

FIG. 32. Comparison of serum total cholesterol concentrations obtained by the Bloor method and the routinely used indirect Abell-Kendall method. (Conversion formula: Bloor = 1.13 × AK + 3.5; r = 0.993).

cal variability within the individual and attributable to factors inherent in sampling technique is given in the discussion on intra-individual variation (p. 31–33). All possibilities of mis-identification and error in collection and processing of samples should, in addition, be taken into account in considering how difficult it is to obtain a valid lipid profile for a given individual.

Standardized procedures, comparable to those used to derive a valid description of the lipid status in our schoolchildren populations were, to our knowledge, only reported for the Bogalusa Heart Study, for the Wairoa College Survey in New Zealand adolescents (STANHOPE et al., 1977) and for the report on serum total cholesterol values in American youths, 12–17 years (LEVY et al., 1976). Values for serum total cholesterol of 161 ± 28.7 and 164 ± 27.1 (m ± s.d.) were reported in white 5–14 year-old Bogalusa boys and girls respectively. Of all these children, 9% had values higher than 200 mg/100 ml. Clearly, the observed values for the serum total cholesterol concentration in our com-

bined samples of 175 ± 29.7 and 180 ± 30.2 in boys and girls respectively, combined with the estimate of 22% of hypercholesterolaemia using this cut-off point in all our children, make it certain that these Dutch schoolchildren had definitely higher serum total cholesterol levels than their Bogalusa counterparts. A decline in total cholesterol occurs around puberty in both boys and girls as it is clear from several reports (JOHNSON et al., 1965; MCGANDY, 1971; CHRISTENSEN, 1976). Thus, the comparison of our values with those in a sample of 'non-institutionalized' white children in the USA is, although valid from the laboratory standardization procedural point of view, somewhat hazardous. Anyway, the comparison was made using the combined results of the Dutch children for the age-category 12–13 years and the separate results for 12 and 13 year-old white boys and girls from the random USA sample respectively. Results, given in Table 98, indicate that serum total cholesterol values in boys from these samples are astonishingly equal, while the results in the American white girls samples are lower by about 4–5 mg/100 ml than those in the comparable age-categories of these Dutch children. It is not clear, however, due to lack of information, whether this comparison is confused because of differences in the degree of sexual maturation between the groups. In New Zealand non-Maori adolescents, levels of serum total cholesterol comparable to those in American youth and in our samples were reported (STANHOPE et al., 1977).

For the comparison between results of the serum triglycerides concentrations in the combined sample of Dutch children and those in the Bogalusa white children, given in Table 99, the results of Bogalusa children are combined in age-categories comparable to those used for the Dutch children. A progressive rise in serum triglycerides concentrations was noted in Bogalusa white children aged 5–14 (FRERICHS et al., 1976b), and girls had about 10% higher levels than boys in all age-classes above 5 years. In the Dutch samples no consistent age trend was visible, and mean results in both girls and boys lag, as a consequence, increasingly behind those of their counterparts from Bogalusa. Furthermore, a consistently large difference was noted in standard deviation between the

TABLE 98. Total cholesterol concentrations (mg/100 ml) in 12–13 year-old Dutch children (the 3 projects combined) and in 12 and 13 year-old American children.

Sample	Age (y)	Sex	Mean	s.d.	Percentiles		
					P_{10}	P_{50}	P_{90}
Dutch	12–13	boys	176	28.2	144	174	216
USA	12	boys	180	29.2	146	179	216
USA	13	boys	174	30.4	138	171	214
Dutch	12–13	girls	182	28.7	149	179	221
USA	12	girls	178	28.0	144	177	214
USA	13	girls	177	28.9	141	174	218

TABLE 99. Results in Dutch children (the 3 projects combined) and Bogalusa white children for triglycerides concentrations (mg/100 ml).

Age category	Bogalusa children		Dutch children	
	Boys	Girls	Boys	Girls
	mean ± s.d.	mean ± s.d.	mean ± s.d.	mean ± s.d.
6– 7	63 ± 28.8	71 ± 32.2	60 ± 22.9	68 ± 29.4
8– 9	64 ± 31.2	71 ± 30.6	61 ± 20.3	62 ± 20.8
10–11	72 ± 41.2	84 ± 52.3	63 ± 25.6	67 ± 22.2
12–13	70 ± 31.8	84 ± 33.6	64 ± 22.7	69 ± 22.6

Dutch and Bogalusa children in all sex and age-categories, which suggests a large difference between proportions of children outranging a given cut-off point for hypertriglyceridaemia. In Bogalusa, 4.3% of the white children were reported to have levels in excess of the upper 'normal' limit suggested by FREDRICKSON et al. (1967) of 140 mg/100 ml. Only 1.2% of all Dutch children exceeded this purely statistical limit of 'normality'. Reported serum triglycerides levels in non-Maori adolescents (STANHOPE et al., 1977) were more comparable to those in Bogalusa adolescents than to our observations.

In agreement with another study (MJØS et al., 1977), the present results confirm that boys and girls have equal HDL-cholesterol levels which predicted, knowing the sex-difference in beta-cholesterol, that girls had a lower HDL:beta-cholesterol ratio than boys. This difference in ratio was, however, not statistically significant. The interesting finding for this ratio was the positive association with age-categories, consistently present in the 4 project and sex-groups which were done. This suggests either an improvement of the lipid profile with increasing age for schoolchildren, or, because the observations are of a cross-sectional nature, a worse lipid profile of younger children compared to their older peers.

The correlation coefficients computed between the several blood lipid parameters were based on pairs of measurements in single samples of children. The statistical characteristics of a single-sample distribution of each of these variables depend on the distribution of means within each individual and variances among individual means. In statistical terms, the correlation coefficient between these variables is also affected by intra-individual and inter-individual variations. It can be shown that the single-sample correlation coefficient approximates a weigthed average of the correlation coefficient among individual mean values, say $\rho(\mu_1, \mu_2)$, and the average intra-individual correlation coefficient, say $E\rho_i(x_1, x_2)$ (HARRIS, 1973). The weight applied to the first of these is $(\text{Var}\ \mu_{1_i}.\ \text{Var}\ \mu_{2_i})^{1/2}$ and to the second $(E\sigma_{1_i}^2.\ E\sigma_{2_i}^2)^{1/2}$. In addition, analytical variance reduces the estimate of $E\rho_i(x_1, x_2)$, but not of $\rho(\mu_1, \mu_2)$ within the single sample correlation coefficient. So, this measure of

relationship between two variables cannot serve as an estimate of association within the average subject under study. Furthermore, separate estimates cannot be obtained when only one sample is taken from each subject.

In evaluating the correlation matrix between lipid parameters from the schoolchildren, we therefore have to accept the uncertainty that the hypothesis of $E\rho_i(x_1, x_2)$ being equal to $\rho(\mu_1, \mu_2)$ and in the same direction, cannot be tested under the conditions described for this study. Instead, it is perhaps better to rely on the matrix as a qualitative guideline. However, two points merit attention. First, correlation matrices obtained for children from Roermond and Harderwijk separately, looked surprisingly similar with respect to the magnitude and direction of their coefficients, and secondly, a basis for the observed quality and quantity of the associations can be taken from knowledge of the lipoprotein metabolism (NICHOLS, 1969). The observation of a negative association between serum triglycerides and HDL-cholesterol is also supported by similar observations in adults (NICHOLS, 1967; MILLER and MILLER, 1975) and in children (SRINIVASAN et al., 1976). Furthermore, this relationship has been experimentally proved in adults (WILSON and LEES, 1972).

After calculating the partial correlation coefficients, i.e. holding the third variables constant, predictable correlations occurred. Beta and HDL-cholesterol became uncorrelated, as well as triglycerides and LDL-cholesterol for the group, while the negative relationship between triglycerides and HDL-cholesterol remained in both groups. Despite the described problems in interpreting correlation coefficients between paired single-sample determinations, it is tempting to conclude that the knowledge of serum total cholesterol, triglycerides and HDL-cholesterol provides a valid description of independently distributed indicators of lipid metabolism in each individual. If this conclusion is correct, then the dividing of total cholesterol in beta and HDL-cholesterol may also be acceptable from a statistical point of view, and the calculated HDL:beta-cholesterol ratios provide an additional description of the individual's lipid profile.

4.6. FAMILIAL AGGRETATION OF MEASUREMENT RESULTS

The results of the analysis of resemblances in observed measurement levels between the first-degree relatives examined in the 3 project-towns, support the hypothesis of a multifactorial mode of determination for all the examined variables. The term 'multifactorial' used here includes both the concept of 'polygenic' inheritance and the extent to which the shared environment has permitted the common genes to express their potential. Certainly, all first-degree relatives we examined in the 3 project towns shared their environment as well as their genes, which makes it almost impossible to attempt to disentangle the relative contribution of both in the determination of levels observed in children.

If the several couplings which have been made with respect to the kind of

first-degree relationship are compared, varying degrees of resemblance become apparent. Between siblings from the 3 towns strong concordances of measurement levels were noted for all parameters, while the degree of aggregation was somewhat lower for the blood chemical parameters than for the anthropometric measures. Presumably, the greater intra-individual variation which is known to occur in blood lipids could be responsible for this difference. In addition, generally convincing, stepwise reciprocal changes in concordance rates were found for virtually all those parameters examined in the analyses of resemblance between children and their parents, if the latter were classified with respect to the levels observed in married couples. Although the observed number of children in each parental combination were, unfortunately, rather small, the results are extremely suggestive for the two-sided – (i.e. by both parents)–mode of determination of measurement levels observed in the children. This finding is supported by the decrease in concordance of measurement levels in children were compared to those in one parent only. If the levels found in mothers and fathers separately were compared to those found in their children, the degrees of resemblance became substantially smaller. Finally, the concordance of measurement levels observed between siblings and between married couples and their children was almost entirely absent between spouses. The described diminishing of resemblance between first-degree relatives would suggest an entirely genetic mode of determination, with no, or only slight, environmental contribution. A word of caution is, however, needed. Absence of any familial clustering rules out significant genetic effects, of course, but the presence of familial clustering, on the other hand, does not prove that only genetic mechanisms are operative since families share not only their genes but also their environment in terms of eating-patterns, exercise and psycho-social factors. Support for the claim of (at least some) environmental contribution may be derived from the apparent degree of resemblance in the level of body fatness among spouses. Furthermore, a high concordance of body fatness was found between mothers and children, and the prevalence of obesity in children was found to be associated with the level of education of the mother (Table 65). These findings, if taken together, surely suggest an environmental influence which, in this particular case, may be described perhaps by a certain socio-cultural attitude towards the acceptance of apparent obesity or the desirability of slimness, in conjunction with the mother's conception of the relationship between health and nutritional practices. It has been, for instance, a long-time practice of the nutritional education services to regard the mother as the 'gate-keeper' of the family's nutritional practices (EDEMA, 1970).

If one were interested only in a genetic control of the various measurements analysed, the hypothesis would have been that specific levels – either 'high' or 'low' – in the parents would have caused an increased proportion of their children to show exclusively concordant levels at the specified range of the distribution. For instance, if 'high' levels of serum total cholesterol were under the control of a single gene, presumably only aggregation at high levels

of cholesterol values would have been observed. Apparently, this was not consistently the case for one of the parameters under investigation, although one could object that the classification in quartiles does not represent the separation of really 'high' or 'low' values. Unfortunately, the number of observations available did not permit a finer division of values. On the other hand, the aggregation patterns, observed to be generally present at both sides of the distributions, did not support the hypothesis of a single genetic control for the population at either side of the distributions. The variable which approached this condition the closest was perhaps the blood haemoglobin concentration. The observed aggregation among siblings would suggest a dominantly genetic control at 'low' levels. However, the observed picture with respect to this variable between parents and offspring and between married couples and their children did not provide support for this assumption. The conclusion is that, on the population level, the position which a child takes in the distribution of the examined characteristics must be under polygenic control, although the amount of available data does not permit the exclusion of the possible existence of some rare cases in which defects in a single gene could have occurred.

The observed familial aggregation patterns pertain to children from the 3 towns in their school-age years. They support and possibly extend other studies in schoolchildren demonstrating familial aggregation in measurements of body dimensions (TANNER and ISRAELSOHN, 1963; MUELLER and TITCOMB, 1977; GARN et al., 1976), blood total cholesterol (DEUTSCHER et al., 1966; GODFREY et al., 1972; MJØS et al., 1977) and blood HDL-cholesterol (MJØS et al., 1977). No studies could be found to support the findings of concordance in haemoglobin and triglycerides levels. The interplay of genetics and environmental factors became apparent from studies in schoolchildren for blood pressure (DEUTSCHER et al., 1966; ZINNER et al., 1971; BIRON et al., 1975) while familial aggregation also occurred in blood glucose levels after challenge (DEUTSCHER et al., 1966).

Some of the studies mentioned made use of correlation coefficients and/or mid-parental regression analysis (JOHNSON et al., 1965; GODFREY et al., 1972; MUELLER and TITCOMB, 1977; MJØS et al., 1977; GARN, 1977). Although such statistics provide estimates of the degree to which resemblance occurs, it was decided not to use them in the present investigation because they do not permit insight into the nature of resemblances. In addition, the number of observations for the several couplings of relatives was in some instances too small to yield reasonably precise estimates for the degree of resemblance. The method of analysis used instead should be seen as a compromise with respect to the possibilities. It nevertheless yielded important clues for the possible mode of determination governing the examined parameters. Clearly, the study of familial resemblances in the indices of health in schoolchildren in The Netherlands will have to be extended in order to provide precise estimates of the degree of resemblance, in order to provide better insight into the extent of genetic control of extreme values and in order to gain insight into the relative importance of

nature and nurture in the present situation.

The repeatedly observed aggregation of risk factors for coronary heart disease, i.e. obesity, blood pressure and blood lipids, between parents and their children perhaps gives the clue to the important question of the legitimation of inferring 'risk' from certain levels of these variables even in childhood. The undesirability of high levels of body fat for reason of its frequent association with high levels of the other risk factors in childhood already, has been the subject of discussion before. The question of the justification of calling certain levels of the observed variables 'risk factors' may be proved only by the demonstration of their association with early coronary events. This relationship has been substantiated for individuals in their adulthood only, but it is, at the same time, biologically difficult to understand why this relationship should emerge exclusively and suddenly in only those people who reach the age-ranges of the subjects from these studies, while, during all that part of their lives in which they have not reached this particular age-threshold, they would not run excessive risk if showing similarly elevated levels. The repeatedly demonstrated aggregation of coronary heart disease and its risk factors may be interpreted in two ways in order to shed light on the question of legitimately calling certain elevated levels 'risk factors' in childhood. Firstly, high degrees of familial resemblance in coronary risk factors will ultimately result in a high concordance of the disease (RISSANEN and NIKKILÄ, 1977). Secondly, by inferring higher risk from elevated risk factors in parents, the stage is simultaneously set for inferring risk from the concordantly elevated levels in their children, on account of the prediction that these children will grow up into coronary-prone adults. That the observed familial aggregation of coronary risk factors is not confined to one particular phase of life only has been elegantly shown in the Tecumseh Study (DEUTSCHER et al., 1966). So if children resemble their parents in levels of certain parameters during one cross-sectional survey, as was the case in this study, there would be no solid reason to suspect why they could not exhibit the same dependence if they were examined some years later. Thus, the practical consequence of the repeatedly demonstrated familial resemblances in disease and risk factors would be the justification of inferring risk from elevated levels even in childhood and the justification of attempts to alter the risk. On the other hand, the subject of academic interest would be to estimate the extent to which children maintain their relative position in the distribution of measurements. In the mean time, this should not, in the opinion of the authors, delay the institution of preventive measures aiming at the modification of risk as early in life as possible, including that stage of life in which parents do apparently influence the levels observed in their children so profoundly as was seen, for instance, in this study.

4.7. Associations between demographic data and biological parameters

Associations between demographic data and biological parameters could be studied only by making broad categories for both parameters. Consequently, the associations found can be interpreted only as being suggestive of mutual dependency.

A statistically significant higher prevalence of obesity was observed in all 3 towns among children of mothers with a low educational level compared to children of mothers with a high educational level. Such an association did not occur between the prevalence of obesity in children and the father's education or occupation. In a national survey of the nutritional status of 8 year-old Dutch children, a generally higher prevalence of obesity was observed in children of wage-earning fathers compared to children of self-employed fathers (De Wijn, 1976). An inverse relationship between the prevalence of obesity in children and the socio-economic status of their parents was noted in several studies carried out in England and the USA (Whitelaw, 1971; Stunkard et al., 1972; Stunkard, 1975).

In this study an inverse relationship between the prevalence of obesity in children and the mother's educational level was found. In the other studies the prevalence of obesity in children was inversely related to the occupation of the father. These results suggest that in our study, in contrast to other studies, the educational level of the mother seems to be a more powerful determinant of obesity than the father's education or occupation. It may be concluded that in studies of relationships between the prevalence of obesity in children and indicators of socio-economic status of the family, information about both the mother's education and the father's education and/or occupation is needed.

Only in Roermond was obesity found to be statistically significantly more prevalent among children from autochthonous parents compared to children from non-autochthonous parents. This finding is in concordance with the results of the anthropometric survey. The prevalence of obesity was higher among Roermond children compared to Heerenveen and Harderwijk children. The observed differences suggest that the prevalence of obesity among children born and raised in Roermond may be the highest among schoolchildren from The Netherlands.

Consistent inverse relationships between the prevalence of hypercholesterolaemia in children and the educational level of the mothers and the fathers, and the socio-economic status of the family were observed in Harderwijk only. Hypercholesterolaemia was statistically significantly more prevalent in Roermond children of mothers without employment compared to children of mothers with full-time or part-time employment. In Roermond hypertriglyceridaemia was statistically significantly more prevalent among children of fathers with a low educational level compared to children of fathers with a high educational level and among children of civil servants (all grades) compared to children of fathers with another occupation. Similar inverse rela-

tionships between the prevalence of hyperlipidaemia and demographic data have not been reported, to our knowledge, in the literature.

The generally observed inverse relationships between demographic data and biological parameters seem to indicate that nowadays elevated biological parameters are more prevalent in children from the lower social classes than in the higher social classes children. The evidence supporting this view was strong concerning obesity although it should be remembered that the demographic data were not collected with the aim of studying these relationships and that, consequently, only a broad category comparison could be made. More detailed studies are needed in order to corroborate these findings and to explain the nature of the relationship. This applies also to the observed associations between the examined demographic data and the prevalence of both hypercholesterolaemia and hypertriglyceridaemia.

4.8. Dietary survey

4.8.1. *Participation and refusal*

At school 4 in Heerenveen the participation rate was about 20% lower than at the other schools. This difference may be explained by the circumstances encountered during the dietary survey at school 4. The survey was carried out in the month of June during a period of very good weather, so it frequently happened that the mothers were not found at home. Also some families were already on holiday. It seems very probable that these circumstances influenced the participation rate negatively.

The participation rate at school 3 in Roermond was about 20% higher than at the other schools. This high participation rate was found at the boys' school in the lower social class district and may be caused by the extra activities undertaken in order to enhance the expected low participation rate. However, this cannot be the only explanation because the participation rate at the girls' school in this district, school 4, was about 15% lower. There is no explanation available for the difference in participation rate between the boys' and girls' school in this district.

In the present study the average percentage of reliable records obtained varied from 77% in Heerenveen to 91% in Harderwijk. The percentage of reliable records in 5 dietary surveys, in which the present food intake was also recorded in household measures, ranged between 45 and 95% with a median of 69% (Marr, 1971). These surveys were carried out in infants, pre-schoolchildren, adolescents, students and adult patients. The percentage of reliable records in the present study is relatively high compared to the 5 surveys reviewed. However, none of the surveys, mentioned by Marr, were carried out in children of the same age-range, which detracts from the comparison between these surveys.

It can nevertheless be concluded that the percentage of reliable records in the present survey was relatively high. The refusal rate was below 10% in all 3 towns. These considerations suggest that the results of the dietary survey will not be influenced profoundly by the refusal rate.

4.8.2. *Food intake patterns*

The most striking *differences* in the foods eaten by the children from the 3 towns will be discussed and as far as possible compared to the results of earlier studies carried out in The Netherlands. The food intake pattern of 353 Dutch families was investigated in a study, carried out in 1965 (VAN SCHAIK and DRENTH, 1968). The food intake and nutritional status of initially 480 8 year-old children from a Northern and a Southern province was examined in a longitudinal study carried out in the period 1958–1968 (VAN SCHAIK, 1962; VAN SCHAIK and KENTER, 1972).

Dairy products. The percentage of Heerenveen children, who ate cheese or whole yoghurt once during the two-day survey was higher than the percentage of children in the other towns. These findings are in agreement with the results of earlier studies (VAN SCHAIK, 1962; VAN SCHAIK and DRENTH, 1968; VAN SCHAIK and KENTER, 1972). The approximately 4 times higher percentage of Harderwijk children, compared to Heerenveen and Roermond children, who drank low-fat milk may be explained largely by the fact that about half of the Harderwijk children got low-fat milk at school. In Heerenveen school milk was not provided and in Roermond about a quarter of the children got whole milk at school.

The difference in the use of school milk between the children from the 3 towns was mainly responsible for the higher animal protein intake provided by dairy products in Harderwijk compared to the other towns (Table 88).

Meat and meat products. The percentage of children who ate mean-fat pork and beef was higher in Roermond compared to Heerenveen and Harderwijk. It was found in the present study, as in other studies, that the children in Roermond got regularly soup, to which meat was added, before dinner in contrast to the children in the other towns (VAN SCHAIK, 1962; VAN SCHAIK and DRENTH, 1968; VAN SCHAIK and KENTER, 1972). This difference may have lead to the observed difference in the percentage of children who ate meat because in the encoding of the foods, the soup was split-up into its ingredients. However, the observed difference in the percentage of children who ate meat did not lead to a difference in the absolute intake of animal proteins, saturated fats and dietary cholesterol between Roermond and Heerenveen children. The Harderwijk children showed the lowest intake of these nutrients (Tables 88, 89 and 90). These results suggest that no difference in mean-fat pork and beef intake was present between the Roermond and the Heerenveen children and that the Harderwijk children tended towards the lowest meat intake.

Margarines, fats and oils. Less than 5% of the Heerenveen children used mean-PUFA low-fat margarines compared to about 35% of the Roermond and Harderwijk children. The absolute saturated fat intake was not lower in the Roermond and the Harderwijk children compared to the Heerenveen

children, in spite of the higher percentage of children in Roermond and Harderwijk who used low-fat margarines (Table 89).

Sugar, sugar-rich products and soft drinks. Sweet fruit squashes were drunk by a much higher percentage of Heerenveen children compared to the children from Roermond and Harderwijk. The oligo-saccharide intake derived from sweet fruit squashes was also higher in Heerenveen children than in the children from the other towns and amounted to about 10% of the total oligo-saccharide intake (Table 92).

Potatoes, bread and bread products. The percentage of children who ate white, or currant bread was higher in Roermond than in Heerenveen and Harderwijk. The percentage of children who ate (whole) meal bread was about twice as high in Harderwijk compared to the other towns. Similar differences in the kind of bread eaten between the provinces of Friesland and Limburg and the province of Gueldern were observed in another study (VAN SCHAIK and DRENTH, 1968).

The differences in the kind of bread intake lead to a higher intake of vegetable proteins, polysaccharides and dietary fibre in the Roermond and Harderwijk children compared to Heerenveen children (Tables 93, 94 and 95). These results suggest that the absolute bread intake in the Roermond and the Harderwijk children was higher than in the Heerenveen children. A lower bread intake in children from the province of Friesland compared to children from the province of North-Brabant, another Southern province, has also been shown in other studies (VAN SCHAIK, 1962; VAN SCHAIK and KENTER, 1972).

Miscellaneous foods. The percentage of children who used peanut butter was lower in Roermond compared to Heerenveen and Harderwijk. Cake (including Friese koek) was eaten by a much higher percentage of Heerenveen children than by children from the other towns. The percentage of children, who ate apple-sauce was more than twice as low in Heerenveen compared to the other towns. The well-known fact that people in the Southern provinces more frequently eat French fried potatoes than people in the Northern provinces could also be substantiated in the present study. Generally, these findings are in agreement with results of earlier studies (VAN SCHAIK, 1962; VAN SCHAIK and DRENTH, 1968; VAN SCHAIK and KENTER, 1972).

It may be concluded that differences in food intake patterns are still present between children from different provinces in the country. These differences lead to differences in nutrient intake. However, from the energy percentage point of view the differences in nutrient intake between the children from the different provinces are generally small (Tables 73–76).

4.8.3.1. Comparisons

In The Netherlands several dietary surveys were carried out in a large number of schoolchildren in the period 1946–1960. Such surveys were not carried out in the sixties. Interest in the collection of food intake data of Dutch schoolchildren revived at the beginning of the seventies.

In Table 100 a review of the food intake data of Dutch schoolchildren is presented. Comparisons of food intake data are hampered when different dietary survey methods are used. Comparisons concerning the energy percentage from nutrients are generally justified because different survey methods tend to give similar results if expressed as energy percentage from nutrients (see also p. 22–24).

In all dietary surveys reviewed the energy percentage from total proteins was around 12. The surveys carried out in the period 1946–1960 tended towards a predominance of vegetable over animal proteins in the children's diet. The energy percentage from total fats was around 30 in 1946 and around 35 in the fifties. The energy percentage from total carbohydrates varied around 55 at that time. Exceptions to these trends were found in the children from big cities, like Delft, Rotterdam and Amsterdam in the period 1953–1956. These children had a higher intake of animal proteins compared to vegetable proteins and the energy percentage from total fats was around 40. In the seventies the trends already observed in the big cities in 1953–1956 were even more pronounced in all the children surveyed. The intake of animal proteins nowadays amounts to 2/3 of the total protein intake. The energy percentage from total fats and total carbohydrates varies around 40 and 47% respectively. It may be inferred from these data that from 1946 to the present days, a definite increase in the intake of animal proteins and total fats has occurred. The intake of vegetable proteins and total carbohydrates showed a concomitant decrease during that period.

Table 101 presents an elaborate analysis of the diets of Heerenveen, Roermond and Harderwijk schoolchildren aged 6–10 years, of diets of a sample of the parents of the Roermond and Harderwijk schoolchildren aged 10–13 years (DE BONT, 1977), and of the food consumption figures per head of population based on the food balance sheet data of The Netherlands from 1973. The resemblance in energy percentage intake of nutrients by these population groups is very striking. Comparison between the food balance sheet data from 1936–1938 and from 1973 showed that the diet in 1973 was higher in animal proteins, saturated, mono-unsaturated and poly-unsaturated fats, dietary cholesterol and oligo-saccharides and lower in vegetable proteins, polysaccharides and dietary fibre compared to the diet in 1936–1938 (KROMHOUT, 1977). From results of the schoolchildren surveys since 1946 and from the comparison between the food balance sheet data from 1936–1938 and from 1973 it may be inferred that the current diet of the Dutch people is definitely higher in animal proteins, saturated fats and dietary cholesterol and

TABLE 100. Review of dietary surveys carried out in Dutch schoolchildren in the period 1946–1976.

Ref.	Investigators	Year(s) of investigation	Location	Dietary survey method	Children's age (y)	Sex B = boys G = girls	Number of children	Total energy (Kcal)	Percentage of energy			
									Veg. prot.	Anim. prot.	Tot. fats	Tot. carb.
1	Lamberts	1946	Rotterdam	dietary history	6–10	B and G	54	1884	7	5	29	59
2	Donath et al.	1950	Leiden	dietary history	6–10	B	56	2048	7	5	35	53
						G	55	1892	7	5	36	52
		1951	Leiden	dietary history	6–10	B	90	1979	7	6	34	54
						G	108	1760	7	6	35	53
3	Netherlands Nutrition Council	1951	10 'big' cities	cross-check dietary history	7– 9	B	575	2326	7	6	35	53
						G	549	2228	6	6	36	52
		1952	10 'big' cities		7– 9	B	682	2438	6	6	33	55
						G	716	2147	6	6	35	53
4	Kaayk	1952–53	IJsselmonde	dietary history	7– 9	B	306	2393	6	6	35	53
						G	306	2195	6	6	34	54
5	Aalbers	1953	Rural Drente	questionnaire	7– 9	B and G	120	2019	6	4	35	54
6	Winternitz	1953–54	Oss and its environment	dietary history	7– 9	B	120	2192	7	5	31	57
						G	120	1979	6	6	32	56
7	Ornee	1953–54	Delft	dietary history	7– 9	B	74	2595	6	5	39	50
						G	74	2297	5	6	38	51
			Rotterdam	dietary history	7– 9	B	104	2404	5	6	39	50
						G	103	2276	5	7	41	48
8	Neederveen-Fenenga et al.	1955–56	Amsterdam	dietary history	9	B	196	2282	5	7	41	48
						G	158	2017	5	6	39	50
9	Van Schaik	1958–60	Tilburg	cross-check dietary history	8	B	108	2329	6	4	33	57
						G	99	2214	6	5	35	55
			Leeuwarden		8	B	81	2276	6	5	33	56
						G	69	2036	6	6	34	55
10	Netherlands Nutrition Council	1973–74	'National' sample	cross-check dietary history	8	B	37	2413	4	8	40	47
						G	36	2074	4	8	40	47
11	Van der Haar and Kromhout	1974–76	Heerenveen	two-day record	6–10	B	105	1891	4	8	38	49
						G	89	1788	4	8	39	48
			Roermond	two-day record	6–10	B	94	2103	4	9	39	44
						G	68	1848	4	9	42	45
			Harderwijk	two-day record	6–10	B	120	2041	4	9	40	47
						G	99	1852	4	9	41	46
12	Hezemans et al.	1976	Nijmegen	24-hour recall	6–12	B and G	159	2061	5	8	41	47

References:

1. LAMBERTS, 1947
2. DONATH et al., 1953
3. VOEDINGSRAAD, 1958
4. KAAYK, 1955
5. AALBERS, 1956
6. WINTERNITZ, 1957
7. ORNEE, 1957
8. NEDERVEEN-FENENGA et al., 1959
9. VAN SCHAIK, 1962
10. NETHERLANDS NUTRITION COUNCIL, 1977
11. VAN DER HAAR and KROMHOUT, 1978
12. HEZEMANS, et al., 1977b

TABLE 101. Energy percentage from nutrients in schoolchildren and their parents, and in The Netherlands.

	Heerenveen	Roermond		Harderwijk		Netherlands*
	children (n = 194)	children (n = 162)	parents** (n = 119)	children (n = 219)	parents** (n = 117)	1973
Proteins						
Vegetable	4	4	4	4	4	4
Animal	8	9	10	9	10	7
Total	12	13	14	13	14	11
Fats						
Saturated	18	19	19	18	20	19
Mono-unsaturated	14	16	16	15	17	16
Poly-unsaturated	5	6	6	6	7	7
Total	39	42	42	40	44	42
Carbohydrates						
Oligo-saccharides	28	24	22	26	22	26
Polysaccharides	21	21	22	20	21	21
Total	49	45	42	46	42	47
Dietary cholesterol (mg/1000 Kcal)	130	146	157	139	154	137
Dietary fibre (g/1000 Kcal)	9.2	9.0	10.2	9.2	9.5	8.9
Total energy (Kcal)	1844	1996	2215***	1956	2263***	2978***

* Based on food balance sheet data (KROMHOUT, 1977).
** DE BONT, 1977.
*** Alcohol excluded.

TABLE 102. Review of dietary surveys carried out in children from different countries.

Ref.	Investigators	Year(s) of investigation	Country	Dietary survey method	Children's age (y)	Sex B = boys G = girls	Number of children	Total energy (Kcal)	Percentage of energy			
									Veg. prot.	Anim. prot.	Tot. fats	Tot. carb.
1	Widdowson	1935–39	England	precise	6–10	B	89	2126	4	7	36	52
				weighing		G	87	2004	4	8	38	50
				precise	11–15	B	131	2615	5	7	35	53
				weighing		G	160	2372	5	7	36	52
2	Bransby et al.	1946	England	precise	10–15	B and G	50	2660		12	32	55
		1947		weighing	12	B	32	2776		11	34	55
3	Jacoby et al.	1960–70	England	dietary record	8–15	B and G	765	2357	4	7	37	52
4	Lubbe	1962	South Africa	precise weighing	7	B and G	30	1856		12	35	53
5	Peckos and Ross	1961	United States	precise	6–10	B	443	1914	4	10	39	47
				weighing		G	481	1749	4	10	40	46
				precise	11–15	B	270	2126	5	11	38	46
				weighing		G	282	1864	4	11	41	45
6	Frank et al.	1973	United States	24-hour recall	10–14	B and G	68	2029	4	9	39	48

References:

1. WIDDOWSON, 1947
2. BRANSBY et al., 1948
3. JACOBY et al., 1975
4. LUBBE, 1968
5. PECKOS and ROSS, 1973
6. FRANK et al., 1977

lower in vegetable proteins, poly-saccharides and dietary fibre compared to the diet of the Dutch about 30 years ago.

In Table 102 the findings from dietary surveys carried out in schoolchildren from England, South Africa and the United States are presented. The age of the children in these studies was generally higher than the age of the surveyed Dutch children. However, from the energy percentage point of view the differences between 6–10 and 11–15 year old children are generally small. These data show that the predominance of animal over vegetable protein intake was already present before World War II in the investigated children from England. The energy percentage from total fats varied around 35 and the energy percentage from total carbohydrates in these children ranged between 50 and 55 in the period 1935–1947. In 1968–1970 children from England tended towards a similar food intake pattern as Dutch children, although the energy percentage from animal proteins and total fats was a little bit lower compared to those in Dutch children. The average animal protein intake amounted to about 70% of the total protein intake in dietary surveys carried out in children from the United States in 1961 and 1973. The energy percentage from total fats and carbohydrates observed in recent dietary surveys in the United States shows good agreement with the findings of the present surveys in The Netherlands.

The differences in total energy intake between boys and girls observed in the present study was also reported by other investigators (Tables 100 and 102). Dietary surveys carried out in The Netherlands in the period 1946–1974, in England and in the United States showed that in children aged 6–10 years, boys have a higher total energy intake than girls.

In this survey consistent differences in total energy intake between obese and lean children were not observed. These findings are in agreement with the results from several other studies (STEFANIK et al., 1959; CAHN, 1968; WILKINSON et al., 1977). A plausible explanation for these findings may be that the physical activity level of obese children is low compared to their energy intake. Consequently, even on an average energy intake level, obese children would overeat.

4.8.3.2. Relationships with serum total cholesterol

Statistically significant relationships between Φ values and serum total cholesterol were not observed in Heerenveen, Roermond and Harderwijk schoolchildren. A plausible explanation for these zero correlations is the homogeneity of the diets of these children and the small range in serum total cholesterol level between them. It is also attractive to examine these relationships in Dutch children from a historical perspective, because dietary surveys and serum total cholesterol analyses were also carried out in Dutch children in 1946 and 1951 (Table 103). The total energy intake of these children was on the same level as the total energy intake of Heerenveen, Roermond and Harderwijk children examined in 1974, 1975 and 1976 respectively. However, the energy percentage from animal proteins and total fats was considerably lower and the energy percentage from vegetable proteins and total carbohydrates

TABLE 103. Serum total cholesterol and total energy and nutrient intake in Dutch schoolchildren aged 6–10 years since 1946.

Investigators	Year of investigation	Number of children	Serum total cholesterol* (mg/100 ml)	Total energy (Kcal)	Percentage of energy			
					vegetable proteins	animal proteins	total fats	total carbohydrates
Lamberts	1946	43	149	1867	7	5	28	59
Donath et al.	1951	194	146	1862	7	6	34	53
Van der Haar and Kromhout	1974 Heerenveen	185	172	1833	4	8	39	49
	1975 Roermond	156	178	1987	4	9	42	45
	1976 Harderwijk	207	182	1947	4	9	40	46

* In the studies of LAMBERTS and of DONATH et al., serum total cholesterol was determined according to the BLOOR method. These values have been re-calculated to ABELL-KENDALL values according to the formula AK = (B−3.5)/1.13 (see also Fig. 32).

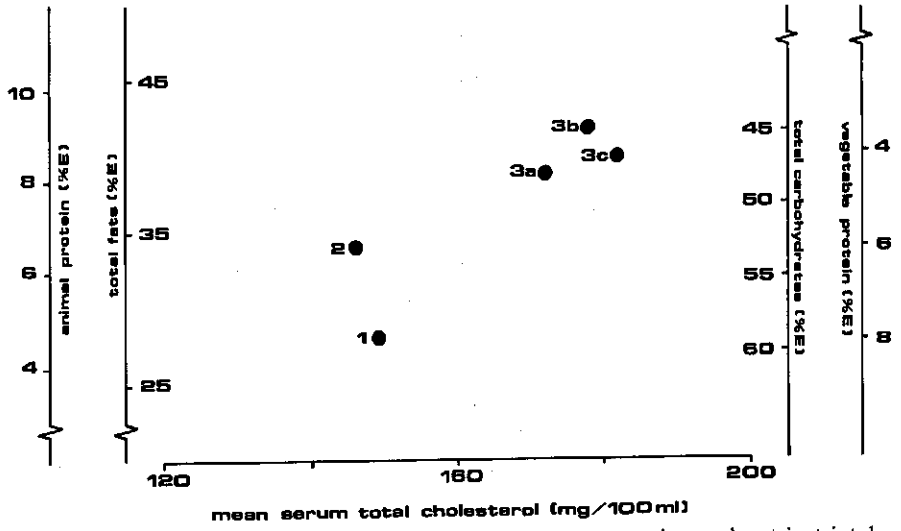

FIG. 33. Relationships between serum total cholesterol concentration and nutrient intake data in Dutch schoolchildren, aged 6–10 year. (See also Tab. 103).
1 = Lamberts; 2 = Donath et al.; 3a = HVN; 3b = RMD; 3c = HWK.

was considerably higher in the Dutch children examined in 1946 and 1951. These changes were parallelled by an average difference in serum total cholesterol of about 30 mg/100 ml. In Fig. 33 the relationships between serum total cholesterol and the energy percentage from these nutrients are shown. These findings demonstrate that significant correlations between serum total cholesterol level and nutrient intake data reappear when larger ranges in these parameters are present.

It may be concluded that a positive relationship between serum total cholesterol and the energy percentage from animal proteins and total fats can already be found in children. The increase in energy percentage from total fats in the period 1946–1951 to 1974–1976 is parallelled by a similar increase in the energy percentage from saturated fats (KROMHOUT, 1977). It may be inferred from this that a positive relationship between serum total cholesterol and the percentage of energy from saturated fats already exists in childhood. This epidemiological finding does not prove a causal relationship between serum total cholesterol and saturated fats but is at least consistent with the saturated fat – serum cholesterol hypothesis.

4.8.3.3. Is the current diet a desirable one?

The present study showed that hypercholesterolaemia and, although to a lesser extent, also obesity was prevalent in a considerable percentage of school-

children (see also p. 114–118 and p. 106–108). Hypercholesterolaemia and obesity are important risk factors for coronary heart disease. It has been shown that risk factors measured in male students of 20 years of age have predictive power with respect to CHD death in the future (PAFFENBARGER et al., 1966a; PAFFENBARGER et al., 1966b). The predictive power of risk factors with respect to CHD death in the future is inversely related to age (KANNEL, 1976). From these data it may be inferred that the effectiveness and efficiency of preventive measures increase if these measures are started in childhood.

CHD risk factors (e.g. cigarette smoking) or their determinants (e.g. diet-induced hypercholesterolaemia) are characteristics of the affluent Western way of life. Hence, preventive measures should be based on changes in this way of life e.g. eating and living habits. If the current diet has to be changed it is necessary to formulate recommendations about a desirable diet. An attempt will be made to formulate such recommendations based on evidence of international comparative studies and on intervention trials. Thereafter recommendations will be made, based on the results of the present study, concerning the realization of a desirable diet in everyday practice.

International comparative studies showed that the saturated fat or total fat intake is generally high in countries with high serum total cholesterol levels and high CHD death rates, and low in countries with low serum total cholesterol levels and low CHD death rates (GUZMAN and SCRIMSHAW, 1968; KEYS, 1970). In intervention trials, a reduction in saturated fat intake by replacement with poly-unsaturated fats leads to a reduction in serum total cholesterol level and to a decrease in CHD mortality and generally also to a decrease in total mortality (DAYTON et al., 1969; MIETTINEN et al., 1972). These findings suggest that a diet high in saturated fats promotes CHD death and a diet low in saturated fats prevents CHD death.

Dietary cholesterol also elevates serum total cholesterol although to a lesser extent than saturated fats (KEYS et al., 1965). The animal protein content of the current diet is high compared to 30–40 years ago. The increase in animal protein intake is concordant with the increase in saturated fat and dietary cholesterol intake because foods rich in animal protein are generally also rich in saturated fats and dietary cholesterol.

Oligo-saccharides in the current diet contribute to about one quarter of the total energy intake. From a nutritional point of view the intake of oligo-saccharides should be as low as possible because a large part is derived from so-called 'empty energy' foods like crystal sugar, soft drinks and sweet fruit squashes.

The current diet is low in poly-saccharides, vegetable proteins and dietary fibre compared to 30–40 years ago, mainly caused by a reduced intake of bread and potatoes.

From these data it may be inferred that a desirable or prudent diet compared to the current diet should be lower in saturated fats, dietary cholesterol, animal proteins and oligo-saccharides and higher in polysaccharides, vegetable proteins and dietary fibre (Fig. 34). Similar recommendations have been made for

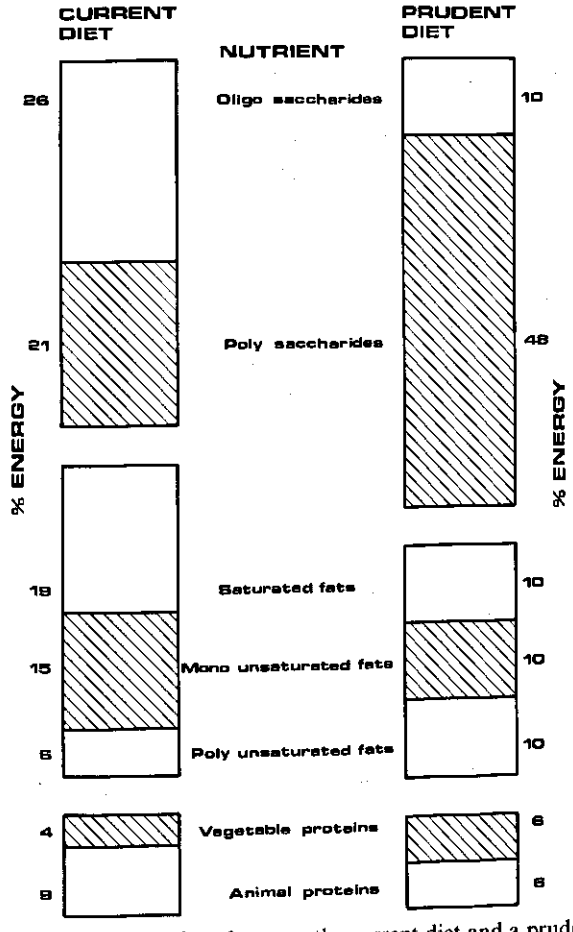

FIG. 34. Comparison between the current diet and a prudent diet.

several countries. Such recommendations have recently been presented for the United States and for The Netherlands (DIETARY GOALS FOR THE UNITED STATES, 1977; KROMHOUT, 1977).

4.8.3.4. Realization of the prudent diet

An attempt will be made to realize the prudent diet on the basis of changes in the intake of the 38 foods dominating the food pattern observed in the children in the present study (Table 72). It may be expected that the greatest chance of realization of the prudent diet in everyday practice can be achieved by rather small modifications of the current diet.

The high intake of animal proteins, saturated fats and dietary cholesterol can be reduced by a lower intake of dairy products and/or meat. This means a lower intake of whole milk, cheese, eggs, whole custard, whole yoghurt, whole

chocolate milk, mean-fat pork, beef and luncheon meat. Another possibility for the reduction in saturated fat content of the diet may be the use of low-fat varieties of milk, cheese, pork or beef instead of saturated fat-rich varieties. The low-PUFA margarines and cooking fats are an other important determinant of the saturated fat intake. Reduction of the intake of low-PUFA margarines and cooking fats or replacement of low-PUFA margarines by low-fat margarines or high-PUFA margarines also provides an important contribution to a lower saturated fat intake.

A large part of the high oligo-saccharide intake is derived from the so-called 'empty energy' foods like crystal sugar, soft drinks and sweet fruit squashes. The intake of these foods should be as low as possible.

The intake of polysaccharides, vegetable proteins and dietary fibre is low in the current diet. The intake of these nutrients can be increased by a higher consumption of bread, potatoes, fruits and vegetables.

The general conclusion may be drawn that a prudent diet can be realized by an increased intake of foods from groups V and VI and a reduced intake of foods from the other groups (Table 71). A prudent diet, low in saturated fats, dietary cholesterol, animal proteins and oligo-saccharides and high in polysaccharides, vegetable proteins and dietary fibre, compared to the current diet is not only desirable with respect to the prevention of CHD but is also recommended for the prevention of cancer (Wynder, 1976). It may be concluded that a prudent diet recommended to the *whole* population is an important tool in the prevention of chronic diseases. If preventive measures are initiated in childhood, they can be expected to be effective and efficient in the repression of the burden of premature death from chronic diseases in Western societies. To prove this hypothesis by means of intervention trials is one of the major challenges in preventive health of the present time.

5. SUMMARY AND CONCLUSIONS

The major health problems in populations of economically developed countries at the present time are of a chronic nature with, as their main clinical characteristic, the frequently occurring premature coronary heart disease. When food intake data are to be evaluated, it would be incorrect in this situation to devote attention chiefly to the intake of essential nutrients. Instead, investigations into the food intake in these countries should currently be concerned in the first place with observed nutrient properties suspected of causing the development of elevated blood lipid levels in the majority of the individuals under study. This consideration was the most important point at issue during the performance, and presentation in this thesis, of a regional comparative study into the food intake and nutritional health status of 3 selected Dutch schoolchildren populations.

The introduction starts with a short description of some recently conducted *in vitro* experiments investigating the role of lipoproteins in atherogenesis. Next, reviews are presented which cover fields of research related to the evaluation of associations between certain features of the life style and the incidence or mortality of atherosclerotic complications. One of these reviews was concerned with the socio-economic status, a very widely used index of life style, and its association with CHD death and CHD risk factors. It was concluded that the observed differences in CHD death and the relationship demonstrated to exist between socio-economic status, CHD death and CHD risk factors, strongly suggest environmental influences in the etiology of atherosclerosis. Diet, of course, is also one of the features of life style. The habitual diet of populations and, particularly, of individuals is difficult to characterize. The various dietary survey methods were the subject of an extensive review in an effort to assess the value of results to be expected from applying them in the collection of food intake data. It was concluded that, with due attention to survey period and number of participants, most dietary measurement techniques can be applied accurately enough to characterize the average diet of groups. If it is essential to assess accurately the individual's habitual diet, carefully conducted long lasting surveys will be needed. This conclusion was shown to have severe impact upon the objective of correlating nutrient composition of the individual's habitual diet to observed serum total cholesterol levels. The other argument used to demonstrate that zero correlation is the inevitable consequence of relating diet to serum total cholesterol within a population, has to do with the inaccuracy of characterizing individuals with respect to their serum total cholesterol level on the basis of single determinations. The variation in observed serum total cholesterol level was the subject of a further review. It was concluded that a single determination is insufficient to provide an accurate description of the individual's position in the observed distribution

of serum total cholesterol determinations.

Results from inter-population studies and from intervention trials were shown to be consistent with the saturated fat – serum cholesterol – CHD hypothesis. The conclusions reached in the foregoing reviews were reconciled with this hypothesis which may be shortly formulated as follows: a confluence of socio-economic and socio-cultural factors in industrialized countries, often indicated briefly with affluency, has led to the fact that the majority of the population now consumes an abundant diet. This diet, excessive in energy in relation to expenditure and rich in animal protein, saturated fat, cholesterol, sugar and salt, leads to a high prevalence of obesity and hyperlipidaemia in the population. Sustained hypercholesterolaemia markedly increases the probability of premature atherosclerotic disease in the population. In addition, a high prevalence of obesity often has the concomitant consequence of hypertension, hypertriglyceridaemia, etc. Thus, diet is related to the CHD epidemic through at least two identifiable changes of etio-pathological events. This justifies the designation of the current habitual diet as the decisive factor in the pathogenesis of the epidemic appearance of premature atherosclerotic disease.

Of course, it is not the intention in this hypothesis to ignore the genetic contribution. It was formulated in the last review of the introduction that inheritance clearly primarily determines the question of whether or not a certain physiological status might be obtained, but that the environment moderates the extent to which the genetic make-up can express its potential. Although the simultaneous investigation of parents and children does not permit the disentangling of hereditary and environmental contributions, the practical consequences of observed familial resemblance in coronary risk factors would be the prediction of increased risk from elevated risk factor levels even in childhood and, at the same time, the justification of efforts aimed at reducing this risk. It has also been recognized that since the education towards the modern, affluent life style occurs during childhood, it is justified to include children into public recommendations intended to reduce the generally elevated risk factor levels in industrialized countries through modification of the diet in the whole community.

The objective of the present study was to investigate whether differences in food intake data would lead to differences in nutritional health status, as measured by anthropometry and by blood lipids. Three comparative epidemiological surveys were carried out in the period 1974–1976 in schoolchildren between the ages of 3.5–13.5 from towns in different provinces of The Netherlands. Based on demographic data from the 1971 census the towns Heerenveen, Roermond and Harderwijk were chosen. In each town, schools with predominantly authochthonous children were selected by mutual arrangement with the local schoolphysician.

Anthropometric measures and blood lipids were assessed in the participating schoolchildren and in parents from a sub-sample of these children. Food intake

data were obtained from Grades 1-3 primary schoolchildren. Relationships between nutrient intake data and body fatness and between nutrient intake data and serum total cholesterol could be studied in these children. In another sub-sample, parent-child relationships concerning anthropometric data and blood lipids could be analysed.

About 95% of the primary schoolchildren in Heerenveen and Harderwijk participated in the survey. The participation rate was about 10% lower in Roermond. The participation rates in the nursery schools ranged between about 75 and 95%. The participation rate among Heerenveen nursery schoolchildren was relatively low. The contacts with the parents of the nursery schoolchildren were intensified during the Roermond and Harderwijk survey, resulting in higher participation rates among nursery schoolchildren in these towns.

Demographic data about the education and occupation of the parents, socio-economic status of the family and birth-places of parents and children was obtained by a general questionnaire filled in by the parents. The socio-economic status of the families tended to be highest in Roermond, intermediate in Heerenveen and lowest in Harderwijk. However, the difference between Roermond and Heerenveen families seemed to be larger than the difference between Heerenveen and Harderwijk families. The difference between Roermond and the other towns may be explained by differences in the method of selection of schools. About 15% of the Heerenveen and Harderwijk mothers were fully or part-time employed. In Roermond this percentage was twice as high. In Roermond about 2/3 of the parents was authochthonous compared to about 1/3 in Harderwijk. In both Roermond and Harderwijk about 2/3 of the examined children had been born and raised in the province of Limburg and the region of the North-west Veluwe respectively. During the Heerenveen survey information about the birth-places of parents and children was not obtained.

The anthropometry included measuring of each child's body weight, standing height, knee widths, mid-arm muscle circumference and skinfold thicknesses at 4 sites – biceps, triceps, subscapular and suprailiac. Results of the measurements were adjusted to a joint level on the basis of comparison experiments, by correcting the mean level of measurements obtained in Heerenveen and Harderwijk children to the level of measurements observed for the regular Roermond investigator. Children from Heerenveen compared favourably to their age-peers from Roermond and Harderwijk with respect to the anthropometric measurements. Frank obesity, tentatively defined to be present if estimates of body fatness based on skinfold thickness measurements exceeded 25–27%, was observed in 3.2% of the Heerenveen children. Compared to these Heerenveen children, children from Roermond were found to be smaller and to have less skeletal and muscle mass, but considerably more body fat. This was reflected by higher mean skinfold thicknesses and a higher prevalence of frank obesity, amounting to 6.0% of all Roermond children. Children from Harder-

wijk took the intermediate position with respect to body weight and standing height. Skeletal mass in children from Harderwijk was found to be roughly comparable to that in children from Heerenveen, but Harderwijk children were found to have even less muscle mass than children from Roermond. At the mean level, children from Harderwijk had the thickest subcutaneous fat layer but the prevalence of frank obesity found, 4.6%, was intermediate between that observed in children from Heerenveen and Roermond. A high dependence of the observed body weights in the children upon the examined anthropometric measures was demonstrated by multiple regression analysis. This finding was interpreted as a substantiation for the above-described comparisons. Comparison of the findings for the thickness of the subcutaneous fat layer in these Dutch children with figures reported for schoolchildren populations from other economically developed countries, reveals that these Dutch children generally exhibited lower skinfold thicknesses than their age-peers from the USA, Canada, England and West-Germany.

The determinations in venous blood, obtained by a Vacutainer system while participants were in the fasting state, comprised the assessment of the concentrations of blood haemoglobin, serum total cholesterol and serum triglycerides. The determination of the serum HDL-cholesterol concentration was added to these during the execution of the Roermond and Harderwijk projects. Results of serum total cholesterol and triglycerides determinations from the 3 project towns were adjusted to the level of measurement observed in a subsample of the collected sera by the Johns Hopkins University LRC Laboratory, which performed the determinations according to regulations of the international WHO Lipid Standardization Program under surveillance of the CDC Standardization Laboratory at Atlanta, Georgia. Results of the haemoglobin determinations in both boys and girls from all three towns were consistent with the well-known increase in haemoglobin concentration with age in schoolchildren. Girls were found to have a somewhat higher haemoglobin concentration than boys. The prevalence of clinical plus subclinical anaemia (haemoglobin < 12.0 g/100 ml) was highest in children from Roermond and lowest in children from Harderwijk. Only a very small number of children had clinical anaemia (Haemoglobin < 11.0 g/100 ml) and it has consequently been concluded that the results of blood haemoglobin determinations have confirmed the assumption that the participating children belonged to the normal, healthy schoolchildren population from The Netherlands.

Observed mean serum total cholesterol concentrations in boys and girls from the 3 towns varied between 160 and 190 mg/100 ml. Consistently lower values were observed in children from Heerenveen, compared to those from Roermond and Harderwijk. Only in the Heerenveen children was the mean serum total cholesterol concentration positively related to age-categories. Girls had approximately 5 mg/100 ml higher mean concentrations than boys in all 3 towns. The overall prevalence of borderline plus frank cholesterolaemia (cholesterol $\geqslant 200$ mg/100 ml) was found to be 19.5% in boys and 24.8% in girls.

Frank hypercholesterolaemia (cholesterol $\geqslant$ 220 mg/100 ml) was present in 7.2% of all boys and in 9.8% of all girls. By both criteria, children from Heerenveen showed the lowest, and children from Harderwijk the highest prevalence. However, the differences observed in prevalence of hypercholesterolaemia did not consistently reach statistical significance. Comparisons of the findings in these Dutch children with reported serum total cholesterol concentrations in children from other Western countries generally revealed that the levels in these Dutch children were among the highest reported. In addition, almost identical figures have been reported in adolescents from New Zealand and the USA.

The observed mean triglycerides concentrations in boys and girls from the 3 towns varied between 55 and 75 mg/100 ml. Mean triglycerides concentrations in children from Harderwijk were about 10% lower than those in Roermond children. Heerenveen children were found to have only slightly lower mean concentrations than children from Roermond. Girls had approximately 4 mg/100 ml higher mean serum triglycerides concentrations than boys in all 3 towns. No consistent relationship with age-category was observed. The prevalence of frank hypertriglyceridaemia, tentatively evaluated by the cut-off point of 100 mg/100 ml, was found to be 7.5% in all boys and 7.1% in all girls. Comparison of serum triglycerides concentrations with values reported in schoolchildren populations from other countries seems to indicate that the values found in these Dutch children were relatively low.

The mean serum HDL-cholesterol concentrations in children from Roermond and Harderwijk were found to vary between 50 and 60 mg/100 ml. Only minor differences were observed in mean serum HDL-cholesterol concentrations between children from Roermond and Harderwijk. In these schoolchildren about 1/3 of the serum total cholesterol was contained in the HDL. Although this percentage was highly variable between individual children, a positive association was found with age-categories in the 4 project-sex combinations.

The examination of parents from a sub-sample of the participating children offered the possibility of comparing the level of measurements in fathers and mothers, both separately and by the combination of spouse pairs, to the levels observed in children. The same analysis was done for the measurements obtained among married couples and among siblings. Strong concordances in measurement levels for standing height, body fatness and blood chemical parameters were observed between married couples and their children. The same concordance was noted for all anthropometric and blood chemical parameters in the analysis of resemblance between siblings. If levels observed in parents were compared to those of their children for fathers and mothers separately and, moreover, for daughters and sons separately, the degree of resemblance became substantially smaller. The concordance of measurement levels between spouses seemed to be virtually absent. It was concluded from these observations that the position which the child takes in the distribution of examined characteristics must be on the polygenic control, and that the degree and nature of

resemblance was in agreement with the concept of determination by both parents. In addition, it has been argued that the same environment shared by the first degree relatives must have contributed to the degree in which inheritance could have expressed its potential. It has been recognized that the repeatedly demonstrated familial resemblance in disease and the risk factors justified the inference of risk from elevated levels even in childhood and, at the same time, the justification for attempts to alter these risks in childhood.

In all 3 towns statistically significant inverse associations were observed between the prevalence of obesity in the children and the educational level of the mother. Consistent inverse relationships between hypercholesterolaemia in children and the educational level of the father or mother and the socio-economic status of the family were observed in Harderwijk only. These data seem to indicate that nowadays elevated biological parameters are more prevalent in children from the lower social classes compared to children from the higher social classes. However, these associations could only be studied by making broad categories. More detailed studies are needed in order to corroborate these findings.

Information about the food intake of the children was obtained by a two-day record filled in by the mother. This record was checked for completeness after the recording period, during an interview between the mother and one of the investigators. The percentage of children in which reliable dietary records were obtained ranged from 77% in Heerenveen to 91% in Harderwijk. Co-operation was refused by the mothers of 8% of the Heerenveen children, 9% of the Roermond children and 3% of the Harderwijk children. It was concluded that the results of the dietary surveys were not profoundly influenced by the refusal rate.

As suggested by previous studies, differences in food intake patterns between the children from the different towns could be observed. The percentage of children who ate cheese, yoghurt, sweet fruit squashes or breakfast cake (including 'Friese koek') was higher in Heerenveen compared to the other towns. The percentage of children who ate apple sauce or mean-PUFA low-fat margarines was lower in Heerenveen compared to the other towns. The percentage of children who ate mean-fat pork or French fried potatoes was higher and the percentage of children who ate peanut butter was lower in Roermond compared to the other towns. The percentage of children who drank low-fat milk or ate (whole) meal bread was higher, and the percentage of children who ate white bread was lower in Harderwijk compared to the children in the other towns. These differences in food intake patterns led to some differences in nutrient intake data. However, from the energy percentage point of view these differences were very small.

The energy intake of boys aged 6–10 was higher compared to that of girls of the same age. Consistent differences in energy intake between obese and lean children were not observed. These findings confirmed the results of other studies.

Statistically significant relationships between nutrient intake data and serum total cholesterol level could not be found in the present study. Significant relationships between nutrient intake data and serum total cholesterol could be shown when the results of studies carried out in schoolchildren in the period 1946–1951 were included. These findings demonstrated that the relationship between nutrient intake data and serum total cholesterol was concealed when the range in these parameters was relatively small. When this range was increased, significant relationships reappear.

Compared to the results of previous studies, the current diet of Dutch children is high in animal proteins, saturated fats, dietary cholesterol and oligosaccharides and low in polysaccharides, vegetable proteins and dietary fibre. Such a diet is known for its atherogenic properties and the results of the present study showed that hypercholesterolaemia, and to a lesser extent obesity, was present in a considerable percentage of children. It is known from prospective studies that the predictive power of CHD risk factors is inversely related to age. From these data it can be inferred that the effectiveness and efficiency of preventive measures could be increased if they are started in childhood.

A prudent diet, low in animal proteins, saturated fats, dietary cholesterol and oligo-saccharides and high in polysaccharides, vegetable proteins and dietary fibre, compared to the current diet is recommended for the whole population in the prevention of CHD. Some investigators have also recommended such a diet in the prevention of cancer. It may be expected that if such a diet was used by the whole population, *including children*, the burden of premature death from chronic diseases could be reduced. To prove this hypothesis by means of intervention trials is one of the major challenges in preventive health of the present time.

6. APPENDIX

SUMMARY OF MEASUREMENT RESULTS BY PROJECT-TOWN, AGE AND SEX

6.1. ANTHROPOMETRIC MEASURES

6.1.1. *Heerenveen boys*

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Body weight (kg)	4– 5	35	19.6	2.18	0.37	17.2	19.4	22.3
	6– 7	96	23.9	2.78	0.28	19.9	23.8	27.5
	8– 9	95	27.8	4.07	0.42	22.5	27.6	34.4
	10–11	104	34.3	6.53	0.64	27.0	33.2	42.4
	12–13	57	40.9	5.94	0.79	34.1	40.0	49.3
Standing height (cm)	4– 5	35	112.9	4.17	0.70	108.4	112.5	118.4
	6– 7	94	124.9	5.26	0.54	118.0	125.4	130.9
	8– 9	95	134.2	7.19	0.74	125.6	133.3	144.4
	10–11	104	144.7	7.89	0.77	134.1	144.1	154.9
	12–13	57	153.8	6.58	0.87	146.4	153.6	161.6
Sum of knee widths (cm)	4– 5	35	13.9	0.68	0.12	13.1	13.9	15.0
	6– 7	96	14.8	0.75	0.08	13.8	14.8	15.8
	8– 9	96	15.5	0.90	0.09	14.3	15.6	16.8
	10–11	104	16.6	1.13	0.11	15.2	16.6	17.9
	12–13	57	17.5	1.09	0.14	16.1	17.5	18.8
Mid-arm muscle circumference (cm)	4– 5	35	15.1	0.96	0.17	13.9	15.0	16.2
	6– 7	96	16.0	1.10	0.11	14.6	15.9	17.5
	8– 9	96	16.9	1.37	0.14	15.4	16.8	19.0
	10–11	104	18.0	1.39	0.14	16.2	17.9	20.0
	12–13	57	19.3	1.34	0.18	17.3	19.4	21.0
Biceps skin-fold (mm)	4– 5	35	4.6	1.27	0.21	2.9	4.3	6.8
	6– 7	96	3.6	1.37	0.14	2.4	3.2	5.6
	8– 9	96	3.3	1.57	0.16	2.0	2.9	5.3
	10–11	104	4.0	2.50	0.24	2.1	3.3	7.3
	12–13	57	4.2	2.11	0.28	2.1	3.6	7.3
Triceps skin-fold (mm)	4– 5	35	9.2	1.69	0.29	6.8	9.1	11.0
	6– 7	96	7.7	1.93	0.20	5.5	7.5	10.5
	8– 9	96	7.5	2.50	0.26	5.0	7.0	10.2
	10–11	104	8.7	4.14	0.41	5.2	7.6	14.3
	12–13	57	9.2	3.00	0.40	5.7	9.1	14.3

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Subscapular skinfold (mm)	4– 5	35	5.2	1.26	0.21	4.3	4.7	7.8
	6– 7	96	4.7	1.06	0.11	3.6	4.5	6.1
	8– 9	96	4.6	1.39	0.14	3.5	4.5	6.0
	10–11	104	5.6	3.48	0.34	3.8	4.7	7.4
	12–13	57	5.9	2.72	0.36	3.9	5.3	8.6
Suprailiac skinfold (mm)	4– 5	35	6.6	2.72	0.46	4.6	6.0	9.2
	6– 7	96	6.2	2.91	0.30	4.0	5.6	9.1
	8– 9	96	7.2	4.24	0.43	4.1	6.0	12.1
	10–11	104	8.5	5.47	0.54	4.6	6.5	14.9
	12–13	57	10.3	5.35	0.71	5.3	8.3	19.3
Skinfold sum (mm)	4– 5	35	25.6	5.71	0.97	20.0	24.5	33.0
	6– 7	96	22.1	6.44	0.66	16.4	20.4	31.1
	8– 9	96	22.7	9.09	0.93	15.2	20.4	33.0
	10–11	104	26.8	14.74	1.45	16.7	21.6	43.9
	12–13	57	29.6	12.04	1.59	17.9	24.4	48.5
6.1.2. *Heerenveen girls*								
Body weight (kg)	4– 5	40	19.8	2.10	0.33	16.9	19.6	22.5
	6– 7	77	22.6	3.22	0.37	19.2	21.9	27.9
	8– 9	80	27.7	3.80	0.43	23.7	26.8	33.2
	10–11	75	35.1	6.63	0.77	27.7	34.6	45.4
	12–13	62	42.7	7.54	0.96	33.9	41.7	54.5
Standing height (cm)	4– 5	39	115.1	5.10	0.82	109.8	114.4	123.3
	6– 7	77	122.7	5.71	0.65	114.9	122.8	130.5
	8– 9	80	133.2	6.02	0.67	126.6	133.1	141.1
	10–11	74	146.1	7.43	0.86	136.2	145.7	157.2
	12–13	62	156.3	7.33	0.93	148.1	156.1	163.9
Sum of knee widths (cm)	4– 5	40	13.4	0.72	0.11	12.4	13.4	14.2
	6– 7	77	14.1	0.80	0.09	13.1	13.9	15.1
	8– 9	80	14.9	0.88	0.10	13.9	14.8	16.3
	10–11	75	16.1	1.02	0.12	14.9	16.1	17.4
	12–13	62	16.9	1.09	0.14	15.7	16.7	18.5
Mid-arm muscle circumference (cm)	4– 5	40	15.0	1.05	0.17	13.4	15.1	16.3
	6– 7	77	15.6	1.18	0.13	14.1	15.6	17.4
	8– 9	80	16.5	1.16	0.13	15.1	16.2	18.2
	10–11	75	17.8	1.40	0.16	16.2	17.8	19.7
	12–13	62	19.3	1.70	0.22	17.2	19.5	21.8
Biceps skinfold (mm)	4– 5	40	4.6	1.54	0.24	3.0	4.0	6.7
	6– 7	77	4.5	1.89	0.21	2.8	4.3	6.5
	8– 9	80	4.6	1.99	0.22	2.8	4.2	7.0
	10–11	75	5.6	3.07	0.35	2.9	4.7	10.1
	12–13	62	5.7	2.29	0.29	2.8	5.3	9.0

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Triceps skinfold (mm)	4– 5	40	9.5	2.41	0.38	6.7	8.9	12.8
	6– 7	77	9.2	2.87	0.33	6.2	8.4	14.3
	8– 9	80	9.9	3.33	0.37	6.5	9.1	14.2
	10–11	75	11.3	4.68	0.54	6.7	10.3	17.0
	12–13	62	11.0	3.10	0.39	7.8	10.5	15.2
Subscapular skinfold (mm)	4– 5	40	5.2	1.19	0.19	3.6	5.0	6.5
	6– 7	77	5.4	2.06	0.23	3.8	4.9	7.7
	8– 9	80	5.6	1.78	0.20	4.0	5.1	7.5
	10–11	75	6.8	4.20	0.48	4.2	5.6	9.7
	12–13	62	6.8	1.82	0.23	4.8	6.6	9.3
Suprailiac skinfold (mm)	4– 5	40	7.1	3.14	0.50	4.1	6.2	10.8
	6– 7	77	7.7	3.79	0.43	4.4	6.6	13.5
	8– 9	80	8.5	3.89	0.43	4.9	7.6	13.3
	10–11	75	10.8	6.58	0.76	5.1	9.3	17.4
	12–13	62	12.5	5.74	0.73	6.6	11.2	19.9
Skinfold sum (mm)	4– 5	40	26.3	7.26	1.15	17.9	25.1	39.0
	6– 7	77	26.9	9.61	1.09	17.6	23.8	41.7
	8– 9	80	28.7	10.02	1.12	19.8	25.9	43.6
	10–11	75	34.6	17.54	2.03	19.6	29.5	53.6
	12–13	62	35.9	11.78	1.50	24.1	34.5	53.5
6.1.3. *Roermond boys*								
Body weight (kg)	4– 5	41	18.8	2.29	0.36	14.9	18.8	21.6
	6– 7	82	22.5	3.24	0.36	18.8	22.2	26.6
	8– 9	85	27.6	4.41	0.48	22.2	27.2	34.0
	10–11	114	34.3	6.19	0.58	27.1	33.6	43.6
	12–13	90	38.8	7.19	0.76	31.1	37.1	51.0
Standing height (cm)	4– 5	41	110.7	5.68	0.89	101.5	111.7	117.6
	6– 7	82	121.3	6.26	0.69	113.8	121.5	129.4
	8– 9	85	132.1	6.63	0.72	123.8	132.5	140.7
	10–11	114	142.4	6.65	0.62	133.9	142.7	151.5
	12–13	90	149.2	6.62	0.70	140.8	149.5	158.0
Sum of knee widths (cm)	4– 5	41	13.8	0.77	0.12	12.7	13.9	14.7
	6– 7	82	14.6	0.81	0.09	13.6	14.5	15.7
	8– 9	85	15.1	0.82	0.09	14.1	15.1	16.1
	10–11	114	15.9	0.92	0.09	14.7	16.0	17.2
	12–13	90	16.5	0.92	0.10	15.5	16.3	17.8
Mid-arm muscle circumference (cm)	4– 5	40	14.0	1.09	0.17	12.5	14.2	15.4
	6– 7	81	14.9	1.19	0.13	13.7	14.7	16.5
	8– 9	85	16.3	1.53	0.17	14.4	16.2	18.4
	10–11	114	17.6	1.63	0.15	15.9	17.4	19.6
	12–13	90	18.3	1.74	0.18	16.2	18.0	21.0

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Biceps skinfold (mm)	4– 5	41	4.7	1.14	0.18	3.3	4.5	6.4
	6– 7	82	4.1	1.14	0.13	3.0	3.9	5.5
	8– 9	85	4.1	1.46	0.16	2.8	3.6	6.2
	10–11	114	4.6	1.95	0.18	2.9	4.0	6.9
	12–13	90	4.7	2.28	0.24	3.0	3.9	8.7
Triceps skinfold (mm)	4– 5	41	8.6	1.84	0.29	6.7	8.5	11.6
	6– 7	82	8.1	2.02	0.22	5.9	7.8	11.0
	8– 9	85	8.1	2.38	0.26	5.9	7.5	11.6
	10–11	114	9.5	3.45	0.32	6.0	8.6	14.2
	12–13	90	9.5	3.90	0.41	6.0	8.7	16.1
Subscapular skinfold (mm)	4– 5	41	5.0	1.17	0.18	3.8	4.7	6.6
	6– 7	82	4.9	1.40	0.15	3.8	4.5	6.6
	8– 9	85	5.2	1.55	0.17	3.8	4.8	7.7
	10–11	114	5.9	2.47	0.23	4.2	5.5	8.3
	12–13	90	6.3	3.34	0.35	4.3	5.0	10.7
Suprailiac skinfold (mm)	4– 5	41	6.7	2.74	0.43	4.2	5.7	10.4
	6– 7	82	6.7	3.85	0.43	3.7	5.6	10.8
	8– 9	85	7.5	4.88	0.53	3.6	5.7	14.1
	10–11	114	9.6	6.34	0.59	4.3	7.3	18.5
	12–13	90	10.5	7.71	0.81	4.6	7.3	23.1
Skinfold sum (mm)	4– 5	41	24.9	6.07	0.95	17.9	23.1	33.8
	6– 7	82	23.7	7.69	0.85	17.1	21.7	32.7
	8– 9	85	24.9	9.70	1.05	17.0	22.1	38.1
	10–11	114	29.4	13.50	1.26	18.6	25.1	47.4
	12–13	90	31.1	16.22	1.74	19.0	24.5	59.1
6.1.4. *Roermond girls*								
Body weight (kg)	4– 5	46	18.8	2.16	0.32	16.0	18.6	22.1
	6– 7	51	21.6	3.60	0.50	18.0	20.9	26.3
	8– 9	88	27.9	5.18	0.55	22.7	27.5	35.6
	10–11	104	34.3	6.18	0.61	27.7	33.2	43.7
	12–13	66	40.9	7.23	0.89	31.0	40.5	50.9
Standing height (cm)	4– 5	46	110.7	4.99	0.74	104.4	111.4	116.0
	6– 7	51	119.3	5.27	0.74	112.4	119.3	126.5
	8– 9	88	131.9	6.65	0.71	123.8	132.6	140.5
	10–11	104	142.9	7.47	0.73	133.4	141.7	153.8
	12–13	66	152.2	7.58	0.91	141.1	151.8	161.4
Sum of knee widths (cm)	4– 5	46	13.4	0.70	0.10	12.7	13.4	14.5
	6– 7	51	13.7	0.70	0.10	12.9	13.6	14.9
	8– 9	88	14.5	0.83	0.09	13.5	14.5	15.6
	10–11	104	15.3	0.90	0.09	14.2	15.3	16.4
	12–13	66	16.1	0.89	0.11	15.0	16.2	17.3

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Mid-arm muscle circumference (cm)	4– 5	46	13.8	1.01	0.15	12.2	13.9	14.9
	6– 7	51	14.6	1.25	0.18	13.1	14.5	16.1
	8– 9	88	16.0	1.46	0.16	14.4	16.0	18.2
	10–11	103	17.2	1.33	0.13	15.4	17.0	19.1
	12–13	64	18.2	1.38	0.17	16.4	18.1	20.0
Biceps skinfold (mm)	4– 5	46	5.0	1.09	0.16	3.5	4.9	6.5
	6– 7	51	5.0	1.59	0.22	3.3	4.4	7.2
	8– 9	88	5.3	1.88	0.20	3.4	5.0	7.7
	10–11	104	6.1	2.48	0.24	4.0	5.5	8.9
	12–13	66	6.2	2.32	0.29	3.9	5.8	10.0
Triceps skinfold (mm)	4– 5	46	9.8	1.75	0.26	7.6	9.6	12.0
	6– 7	51	9.7	2.55	0.36	6.7	9.4	13.6
	8– 9	88	10.3	3.30	0.35	7.0	9.7	15.3
	10–11	104	11.2	3.65	0.36	7.1	10.4	16.1
	12–13	66	11.3	3.56	0.44	7.5	10.5	17.4
Subscapular skinfold (mm)	4– 5	46	5.5	1.19	0.18	4.3	5.2	7.6
	6– 7	51	5.8	2.08	0.29	4.0	5.2	7.8
	8– 9	88	6.6	3.00	0.32	4.3	5.6	9.7
	10–11	104	7.2	3.93	0.39	4.7	6.1	10.5
	12–13	66	7.6	3.00	0.37	5.1	6.7	11.3
Suprailiac skinfold (mm)	4– 5	46	7.4	2.95	0.43	4.3	6.8	11.7
	6– 7	51	8.1	4.99	0.70	4.1	6.9	14.5
	8– 9	88	10.7	6.45	0.69	5.0	8.7	20.8
	10–11	104	12.4	7.30	0.72	5.5	10.2	23.3
	12–13	66	13.4	6.51	0.80	6.7	11.8	22.4
Skinfold sum (mm)	4– 5	46	27.7	5.97	0.88	21.3	27.4	36.2
	6– 7	51	28.6	10.26	1.44	19.1	25.7	42.9
	8– 9	88	32.9	13.80	1.47	20.7	29.4	50.7
	10–11	104	36.9	16.27	1.60	22.5	32.5	61.0
	12–13	66	38.5	14.21	1.75	25.5	33.7	57.1
6.1.5. *Harderwijk boys*								
Body weight (kg)	4– 5	70	18.4	2.17	0.26	16.1	18.0	21.2
	6– 7	107	23.5	2.89	0.28	20.2	23.2	27.4
	8– 9	112	28.2	4.59	0.43	23.4	27.9	34.1
	10–11	110	34.0	5.64	0.54	27.9	33.1	42.1
	12–13	71	41.7	8.36	0.99	33.7	40.7	50.3
Standing height (cm)	4– 5	70	109.7	4.81	0.58	102.8	109.4	115.4
	6– 7	107	123.3	4.92	0.59	115.7	123.0	131.1
	8– 9	112	133.6	4.76	0.60	125.6	133.7	142.9
	10–11	111	143.7	6.41	0.61	136.0	143.4	152.3
	12–13	71	153.7	7.73	0.92	143.4	153.1	164.3

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Sum of knee widths (cm)	4– 5	70	13.5	0.73	0.09	12.6	13.4	14.6
	6– 7	107	14.6	0.78	0.08	13.6	14.6	15.7
	8– 9	112	15.6	0.97	0.09	14.5	15.4	16.8
	10–11	111	16.5	0.98	0.09	15.2	16.6	17.8
	12–13	71	17.6	1.21	0.14	16.1	17.5	19.0
Mid-arm muscle circumference (cm)	4– 5	70	14.1	0.86	0.10	13.2	14.0	15.3
	6– 7	107	15.1	0.94	0.09	14.1	15.1	16.5
	8– 9	112	15.9	1.29	0.12	14.4	15.6	17.5
	10–11	111	17.0	1.35	0.13	15.5	16.9	18.9
	12–13	71	18.1	1.50	0.18	16.4	17.8	19.9
Biceps skinfold (mm)	4– 5	70	4.7	0.94	0.12	3.5	4.7	6.3
	6– 7	107	4.5	1.21	0.12	3.1	4.3	6.1
	8– 9	112	4.6	1.92	0.18	3.1	4.0	6.8
	10–11	111	4.8	2.07	0.20	3.0	4.3	7.8
	12–13	71	5.4	2.28	0.27	3.3	4.9	8.9
Triceps skinfold (mm)	4– 5	70	8.7	1.88	0.22	6.3	8.9	10.8
	6– 7	107	8.1	2.29	0.22	5.5	7.8	11.1
	8– 9	112	8.6	3.23	0.31	5.3	7.9	12.3
	10–11	111	8.7	3.71	0.35	5.2	7.4	14.9
	12–13	71	10.2	4.29	0.51	5.8	9.2	15.8
Subscapular skinfold (mm)	4– 5	70	5.3	1.08	0.13	3.9	5.1	6.8
	6– 7	107	5.2	1.23	0.12	4.1	4.8	6.8
	8– 9	112	5.4	2.29	0.22	4.0	4.9	7.2
	10–11	111	5.8	2.73	0.26	4.0	5.0	8.8
	12–13	71	6.9	3.18	0.38	4.1	5.9	11.2
Suprailiac skinfold (mm)	4– 5	70	8.0	1.61	0.19	6.2	7.8	10.1
	6– 7	107	8.5	2.64	0.25	6.5	7.7	11.6
	8– 9	112	9.4	4.45	0.42	6.4	8.1	13.7
	10–11	111	10.3	5.48	0.52	6.4	8.4	17.7
	12–13	71	12.2	6.27	0.74	7.4	10.3	21.8
Skinfold sum (mm)	4– 5	70	26.8	4.63	0.55	21.2	26.6	32.6
	6– 7	107	26.1	6.78	0.66	19.6	24.3	34.1
	8– 9	112	28.0	11.20	1.06	18.9	25.8	38.2
	10–11	111	29.7	13.30	1.26	19.0	25.3	45.8
	12–13	71	34.7	15.45	1.83	20.8	29.4	60.2
6.1.6. *Harderwijk girls*								
Body weight (kg)	4– 5	71	18.3	2.36	0.28	15.5	17.9	21.3
	6– 7	95	21.5	3.16	0.32	17.8	21.1	26.0
	8– 9	95	28.0	4.67	0.48	23.2	27.5	34.2
	10–11	98	35.3	7.12	0.72	27.0	34.9	44.5
	12–13	55	42.9	9.06	1.22	33.7	42.2	55.5

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Standing height (cm)	4– 5	71	109.8	5.20	0.62	103.0	110.4	117.5
	6– 7	95	120.0	6.61	0.68	112.7	119.6	129.4
	8– 9	95	132.6	6.53	0.67	124.3	132.6	141.4
	10–11	98	143.7	7.90	0.80	132.4	144.3	154.2
	12–13	55	154.3	7.47	1.01	143.6	154.1	164.5
Sum of knee widths (cm)	4– 5	71	13.0	0.73	0.09	12.3	13.1	13.9
	6– 7	95	13.7	0.86	0.09	12.5	13.7	14.8
	8– 9	95	14.9	0.95	0.10	13.7	14.9	16.1
	10–11	99	16.1	1.15	0.12	14.7	15.9	17.6
	12–13	55	16.8	1.08	0.15	15.4	16.8	18.4
Mid-arm muscle circumference (cm)	4– 5	71	13.9	0.97	0.12	12.8	13.7	15.2
	6– 7	94	14.7	1.15	0.12	13.4	14.6	16.2
	8– 9	95	15.7	1.16	0.12	14.2	15.6	17.5
	10–11	99	17.1	1.31	0.13	15.3	17.0	18.8
	12–13	55	18.3	1.59	0.21	16.6	18.0	20.7
Biceps skinfold (mm)	4– 5	71	5.4	1.31	0.16	4.0	5.1	7.1
	6– 7	95	4.7	1.19	0.12	3.7	4.5	6.0
	8– 9	95	5.5	1.88	0.19	3.8	5.1	7.7
	10–11	99	6.6	2.82	0.28	3.5	5.9	10.3
	12–13	55	6.5	2.45	0.33	4.0	6.0	10.1
Triceps skinfold (mm)	4– 5	71	9.9	2.01	0.24	7.4	9.8	12.7
	6– 7	95	8.7	2.33	0.24	6.3	8.3	11.3
	8– 9	95	10.6	3.48	0.36	7.0	10.1	15.4
	10–11	99	11.9	4.64	0.47	6.6	10.8	19.1
	12–13	55	11.8	4.52	0.61	7.6	10.7	18.4
Subscapular skinfold (mm)	4– 5	71	5.6	1.35	0.16	4.3	5.4	7.7
	6– 7	95	5.4	1.30	0.13	4.2	5.2	7.0
	8– 9	95	6.3	2.40	0.25	4.3	5.5	9.4
	10–11	99	7.8	3.68	0.37	4.8	6.6	13.8
	12–13	55	8.1	3.74	0.50	5.4	6.7	14.4
Suprailiac skinfold (mm)	4– 5	71	8.6	2.13	0.25	6.6	8.1	11.2
	6– 7	95	8.7	2.33	0.24	6.4	8.3	11.8
	8– 9	95	10.2	4.11	0.42	6.9	9.1	16.0
	10–11	99	12.4	5.64	0.57	7.3	10.1	21.6
	12–13	55	12.9	5.01	0.68	8.0	11.2	22.1
Skinfold sum (mm)	4– 5	71	29.6	6.01	0.72	23.0	28.4	39.2
	6– 7	95	27.6	6.57	0.67	21.2	26.2	35.4
	8– 9	95	32.6	11.24	1.15	22.1	29.2	48.0
	10–11	99	38.7	15.68	1.58	23.1	33.9	62.5
	12–13	55	39.3	14.72	1.99	25.9	34.7	61.4

6.2. Blood chemical parameters

6.2.1. *Heerenveen boys*

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Haemoglobin (g/100 ml)	4– 5	35	12.9	0.74	0.13	12.0	12.9	13.9
	6– 7	94	13.3	0.89	0.09	12.1	13.3	14.4
	8– 9	94	13.2	0.78	0.08	12.1	13.3	14.2
	10–11	103	13.5	0.77	0.08	12.6	13.6	14.5
	12–13	56	13.9	0.90	0.12	12.9	13.9	15.3
Total cholesterol (mg/100 ml)	4– 5	33	158	25.0	4.4	128	158	194
	6– 7	93	168	26.8	2.8	132	166	202
	8– 9	94	172	23.5	2.4	146	172	205
	10–11	103	173	25.9	2.6	143	171	208
	12–13	55	173	28.1	3.8	142	171	214
Triglycerides (mg/100 ml)	4– 5	33	63	24.6	4.3	42	55	105
	6– 7	93	63	21.0	2.2	44	58	89
	8– 9	94	60	19.9	2.1	38	55	80
	10–11	103	64	25.7	2.5	40	58	92
	12–13	55	71	21.7	2.9	47	65	102

6.2.2. *Heerenveen girls*

Haemoglobin (g/100 ml)	4– 5	40	13.2	0.80	0.13	12.3	13.1	14.4
	6– 7	71	13.0	0.78	0.09	12.1	13.0	14.0
	8– 9	79	13.3	0.67	0.08	12.4	13.2	14.2
	10–11	73	13.8	0.83	0.10	13.0	13.6	14.8
	12–13	49	13.7	1.01	0.14	12.3	13.9	15.2
Total cholesterol (mg/100 ml)	4– 5	37	169	24.9	4.1	138	167	212
	6– 7	72	167	29.1	3.4	134	170	213
	8– 9	77	179	27.5	3.1	149	173	219
	10–11	75	179	28.1	3.2	148	176	217
	12–13	61	181	28.6	3.7	143	178	224
Triglycerides (mg/100 ml)	4– 5	37	69	25.2	4.1	40	63	114
	6– 7	70	74	26.9	3.2	47	65	113
	8– 9	76	61	18.2	2.1	32	56	88
	10–11	74	66	18.9	2.2	45	64	88
	12–13	61	69	19.9	2.5	44	67	98

6.2.3. *Roermond boys*

Haemoglobin (g/100 ml)	4– 5	39	12.7	0.65	0.10	11.8	12.6	13.6
	6– 7	80	13.0	0.69	0.08	12.3	12.9	13.9
	8– 9	81	13.2	0.75	0.08	12.5	13.2	14.2
	10–11	113	13.4	0.68	0.06	12.6	13.4	14.3
	12–13	87	13.3	0.75	0.08	12.3	13.4	14.3

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
Total cholesterol (mg/100 ml)	4– 5	39	177	39.6	6.4	125	179	230
	6– 7	80	170	27.1	3.0	139	169	207
	8– 9	82	176	24.3	2.7	147	176	205
	10–11	112	182	29.3	2.8	148	177	224
	12–13	88	176	29.9	3.2	140	175	219
Triglycerides (mg/100 ml)	4– 5	37	65	31.1	5.1	35	55	134
	6– 7	80	62	25.0	2.8	41	62	101
	8– 9	82	62	20.3	2.2	37	58	88
	10–11	112	69	31.4	3.0	37	61	107
	12–13	88	67	26.0	2.8	41	61	108
HDL-cholesterol (mg/100 ml)	4– 5	35	52	13.1	2.2	35	52	71
	6– 7	77	56	12.9	1.5	42	55	71
	8– 9	76	62	11.4	1.3	49	60	75
	10–11	109	58	12.1	1.2	42	56	76
	12–13	86	55	13.0	1.4	38	54	73
Beta-cholesterol (mg/100 ml)	4– 5	35	123	37.0	6.3	74	117	172
	6– 7	77	114	25.3	2.9	79	115	141
	8– 9	76	115	24.8	2.9	78	114	149
	10–11	109	124	29.9	2.9	94	119	165
	12–13	86	121	27.2	2.9	88	118	164
HDL: beta-cholesterol ratio (%)	4– 5	35	45	15.6	2.6	22	48	60
	6– 7	77	52	19.9	2.3	32	47	77
	8– 9	76	57	20.4	2.3	36	53	93
	10–11	109	50	18.6	1.8	27	47	75
	12–13	86	48	16.0	1.7	30	46	73
6.2.4. *Roermond girls*								
Haemoglobin (g/100 ml)	4– 5	45	12.5	0.63	0.09	11.8	12.5	13.5
	6– 7	48	13.0	0.71	0.10	12.1	12.8	13.9
	8– 9	87	13.1	0.68	0.07	12.2	13.1	14.0
	10–11	103	13.3	0.63	0.06	12.6	13.3	14.3
	12–13	63	13.4	0.62	0.08	12.7	13.3	14.3
Total cholesterol (mg/100 ml)	4– 5	44	169	26.0	3.9	137	170	202
	6– 7	48	182	40.1	5.8	151	172	230
	8– 9	87	190	27.9	3.0	158	187	235
	10–11	103	189	31.3	3.1	152	189	222
	12–13	62	179	26.1	3.3	151	174	218
Triglycerides (mg/100 ml)	4– 5	43	62	21.1	3.2	37	61	92
	6– 7	48	73	33.8	4.9	42	66	113
	8– 9	86	65	25.7	2.8	40	59	99
	10–11	103	71	23.6	2.3	46	67	100
	12–13	62	72	26.5	3.4	44	71	93

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
HDL-cholesterol (mg/100 ml)	4– 5	43	51	11.0	1.7	37	52	61
	6– 7	46	57	15.5	2.3	39	56	78
	8– 9	84	60	20.6	1.4	45	60	76
	10–11	103	62	13.0	1.3	46	62	78
	12–13	61	58	12.9	1.7	45	57	74
Beta-cholesterol (mg/100 ml)	4– 5	43	118	24.4	3.7	88	114	153
	6– 7	46	125	43.0	6.3	90	117	172
	8– 9	84	130	30.5	3.3	88	130	171
	10–11	102	127	25.2	3.2	95	123	165
	12–13	61	120	27.1	3.5	88	119	155
HDL: beta-cholesterol ratio (%)	4– 5	43	45	12.1	1.9	25	43	61
	6– 7	46	51	24.1	3.6	25	48	79
	8– 9	84	50	20.7	2.3	29	46	76
	10–11	102	54	30.3	3.0	31	49	84
	12–13	61	52	18.6	2.4	31	49	79
6.2.5. *Harderwijk boys*								
Haemoglobin (g/100 ml)	4– 5	66	12.9	0.82	0.10	11.9	13.0	14.0
	6– 7	103	13.3	0.82	0.08	12.4	13.3	14.4
	8– 9	107	13.7	0.77	0.07	12.8	13.6	14.7
	10–11	108	14.0	0.91	0.09	13.0	13.9	14.8
	12–13	69	13.9	1.04	0.13	12.5	13.9	14.8
Total cholesterol (mg/100 ml)	4– 5	65	179	31.0	3.9	142	172	229
	6– 7	103	181	26.6	2.6	152	181	211
	8– 9	106	179	28.8	2.8	146	177	217
	10–11	107	189	36.9	3.6	147	187	238
	12–13	68	178	26.3	3.2	150	176	215
Triglycerides (mg/100 ml)	4– 5	64	65	27.6	3.5	39	54	98
	6– 7	99	56	22.3	2.2	37	50	78
	8– 9	105	57	20.5	2.0	38	52	82
	10–11	108	57	17.3	1.7	39	52	85
	12–13	69	56	18.9	2.3	36	50	84
HDL-cholesterol (mg/100 ml)	4– 5	63	52	13.0	1.6	39	51	69
	6– 7	94	56	13.2	1.4	41	56	76
	8– 9	99	59	13.5	1.4	43	58	77
	10–11	108	61	12.8	1.2	45	61	79
	12–13	68	59	10.2	1.2	45	58	72
Beta-cholesterol (mg/100 ml)	4– 5	63	127	28.1	3.5	94	124	167
	6– 7	94	124	26.6	2.8	93	124	154
	8– 9	99	119	26.6	2.7	87	119	156
	10–11	107	128	27.3	3.4	90	124	172
	12–13	67	119	27.4	3.4	88	118	152

Measurement	Age, years	n	Mean	s.d.	s.e.	Percentiles		
						10th	50th	90th
HDL: beta-cholesterol ratio (%)	4– 5	63	43	13.5	1.7	28	43	62
	6– 7	94	48	15.2	1.6	29	46	66
	8– 9	99	53	21.0	2.1	32	49	81
	10–11	107	51	35.5	1.8	32	48	77
	12–13	67	53	19.1	2.3	35	48	81
6.2.6. *Harderwijk girls*								
Haemoglobin (g/100 ml)	4– 5	63	13.0	0.87	0.11	12.0	12.9	14.0
	6– 7	90	13.4	1.02	0.11	12.2	13.4	14.4
	8– 9	93	13.8	0.68	0.07	12.9	13.9	14.7
	10–11	95	14.0	0.82	0.08	13.0	14.0	15.2
	12–13	54	13.9	0.68	0.09	13.0	14.0	14.9
Total cholesterol (mg/100 ml)	4– 5	60	186	27.9	3.6	152	185	222
	6– 7	87	181	26.8	2.9	149	179	215
	8– 9	89	185	27.2	2.9	154	185	222
	10–11	92	188	34.4	3.6	149	184	240
	12–13	54	187	30.6	4.2	155	183	227
Triglycerides (mg/100 ml)	4– 5	60	68	22.6	2.9	41	62	99
	6– 7	86	61	16.3	1.8	41	57	85
	8– 9	91	60	17.3	1.8	42	56	90
	10–11	92	64	23.6	2.5	40	58	98
	12–13	54	64	20.7	2.8	41	59	94
HDL-cholesterol (mg/100 ml)	4– 5	58	51	11.8	1.6	39	49	69
	6– 7	80	54	11.6	1.3	41	53	70
	8– 9	85	56	10.9	1.2	44	54	70
	10–11	90	60	12.7	1.3	46	60	78
	12–13	53	60	12.8	1.8	46	59	73
Beta-cholesterol (mg/100 ml)	4– 5	58	135	28.8	3.8	99	137	177
	6– 7	80	128	23.8	2.7	97	126	157
	8– 9	83	128	25.8	2.8	98	123	162
	10–11	90	127	31.5	3.3	92	123	162
	12–13	53	128	28.9	4.0	101	121	164
HDL: beta-cholesterol ratio (%)	4– 5	58	40	14.5	1.9	26	38	63
	6– 7	80	44	13.8	1.5	30	42	60
	8– 9	83	46	14.4	1.6	30	44	63
	10–11	90	50	15.8	1.7	34	48	77
	12–13	53	49	15.7	2.2	29	48	70

7. SAMENVATTING EN CONCLUSIES

Op het ogenblik vormen de zogenaamde chronische ziekten zoals hart- en vaatziekten en kanker de belangrijkste volksgezondheidsproblemen. Het huidige voedselconsumptie patroon dient dan ook tegen deze achtergrond geevalueerd te worden. Hierdoor verschuift het accent in het voedselconsumptie onderzoek van het onderzoek naar voedingsdeficiënties t.g.v. tekorten aan essentiële nutriënten naar onderzoek gericht op nutriënten die de determinanten vormen van de risicofactoren voor chronische ziekten. Deze risicofactoren leveren een belangrijke bijdrage aan de verklaring van de premature sterfte aan chronische ziekten. Deze overwegingen vormden de belangrijkste uitgangspunten voor het uitvoeren van het in dit proefschrift beschreven vergelijkende epidemiologische onderzoek naar de voedings- en gezondheidstoestand van 3 geselecteerde schoolkinderen populaties.

De introductie begint met een korte beschrijving van recent uitgevoerde experimentele onderzoekingen naar de rol die de verschillende lipoproteïnenfracties spelen in het atherosclerotische proces. Het daarop volgende gedeelte van het literatuuronderzoek heeft betrekking op de zogenaamde verzadigd vet-serum cholesterol-coronaire hartziekten hypothese. In internationaal vergelijkende onderzoekingen werd een duidelijk verband aangetoond tussen de hoeveelheid verzadigd vet in de voeding, het serum totaal cholesterolgehalte en de sterfte aan coronaire hartziekten. Deze relaties worden niet gevonden binnen Westerse populaties. Om deze tegenstelling naar waarde te kunnen schatten is er een uitgebreide literatuurstudie verricht naar de betekenis van

- voedselopname gegevens, verzameld m.b.v. verschillende methodieken;
- variatie in voedselopname van een individu;
- variatie in het serum totaal cholesterolgehalte van een individu.

Er werd geconcludeerd dat alle gangbare methodieken voor bepaling van de voedselopname, uitgezonderd de short-cut methode, geschikt zijn voor een beschrijving van de gemiddelde voedselopname van een populatie. Een nauwkeurige schatting van de voedselopname van een individu vereist echter langdurig en zorgvuldig uitgevoerd onderzoek. Een nauwkeurige schatting van het serum totaal cholesterolgehalte van een individu kan niet verkregen worden op grond van een eenmalig uitgevoerde bepaling. Deze conclusies maken duidelijk dat binnen populaties significante correlaties tussen nutriënten, verkregen uit kortdurend onderzoek naar de voedselopname en een eenmalig bepaald serum totaal cholesterolgehalte niet verwacht mogen worden, tengevolge van de grote intra-individuele variaties in deze parameters. De resultaten van onderzoekingen waarbij de invloed van de intra-individuele variatie werd geëlimineerd zoals in vergelijkende bevolkingsonderzoekingen en in interventie studies, zijn consistent met de verzadigd vet- serum cholesterol-coronaire hartziekten hypothese. In deze hypothese wordt ervan uitgegaan dat het overgrote gedeelte van de bevolking van Westerse landen een voeding gebruikt die overdadig is aan

energie in verhouding tot de energiebesteding en die rijk is aan verzadigd vet, dierlijk eiwit, voedingscholesterol, suiker en zout. Zo'n voeding heeft een hoge prevalentie van hypercholesterolemie en obesitas tot gevolg. Als hypercholesterolemie bij een groot gedeelte van de populatie voorkomt, neemt de kans op premature sterfte aan coronaire hartziekten sterk toe. Obesitas gaat vaak samen met hypertensie, hypertriglyceridemie, etc. Op grond van deze gegevens kan geconcludeerd worden, dat de rol van de voeding in de etiologie van coronaire hartziekten verloopt via de risicofactoren hypercholesterolemie en obesitas. Daarom lijkt het gerechtvaardigd om aan het huidige voedingspatroon een beslissende rol in de pathogenese van de epidemie van premature coronaire hartziekten toe te kennen.

Tenslotte werd de betekenis van genetische- en milieufactoren in relatie tot de atherogenese besproken. Er werd geconcludeerd, dat de milieufactoren bepalen in hoeverre de genetische eigenschappen hun potentieel aanwezige mogelijkheden kunnen realiseren. Onderzoek naar de overeenkomst tussen ouders en kinderen betreffende risicofactoren geeft geen uitsluitsel over de betekenis van genetische- en milieufactoren afzonderlijk, maar indien familiale overeenkomst in risicofactoren wordt gevonden, kan de inferentie worden gemaakt dat aan een hoog risico bij kinderen waarschijnlijk dezelfde betekenis moet worden toegekend als aan een hoog risico bij volwassenen. Daarom lijkt het gerechtvaardigd om bij adviezen voor verandering van de voeding in het kader van preventie van chronische ziekten niet alleen volwassenen maar ook kinderen te betrekken.

De doelstelling van het in dit proefschrift beschreven onderzoek was na te gaan of verschillen in voedselopname zouden leiden tot verschillen in voedings- en gezondheidstoestand, bepaald aan de hand van anthropometrische maten en bloedchemische parameters. Deze doelstelling werd getoetst door het uitvoeren van 3 vergelijkende epidemiologische onderzoekingen bij kinderen van kleuter- en basisscholen uit plaatsen in verschillende provincies. Op grond van gegevens van de volkstelling van 1971 werden de steden Heerenveen, Roermond en Harderwijk gekozen. In iedere stad werden in overleg met de plaatselijke schoolarts scholen geselecteerd waar voornamelijk autochtone kinderen op zaten.

Anthropometrische gegevens en bloedchemische waarden werden bij alle aan het onderzoek deelnemende kinderen, en bij de ouders van een steekproef van deze kinderen verzameld. Informatie over de voedselopname werd verkregen van de kinderen in de eerste t/m de derde klas van de basisscholen. Bij deze kinderen was het mogelijk relaties tussen de nutriëntenopname en de hoeveelheid lichaamsvet en tussen de nutriëntenopname en het serum totaal cholesterolgehalte te bestuderen. In een andere steekproef kon de overeenkomst tussen ouders en kinderen betreffende anthropometrische gegevens en bloedchemische waarden onderzocht worden.

Ongeveer 95% van de basisschoolkinderen in Heerenveen en Harderwijk nam aan het onderzoek deel. Het deelnemingspercentage in Roermond lag ongeveer 10% lager. De deelnemingspercentages op de kleuterscholen va-

rieerden tussen ongeveer 75 en 95%. Het percentage deelnemende kinderen was relatief laag bij de Heerenveense kleuterschoolkinderen. Derhalve werden de contacten met de ouders van de kleuterschoolkinderen in Roermond en Harderwijk geïntensiveerd, wat leidde tot hogere deelnemingspercentages van deze kinderen.

Demografische gegevens betreffende beroep en opleiding van de ouders, sociaal-economische status van het gezin en autochtoniteit van de ouders en de kinderen werden verkregen d.m.v. een algemene enquête, die door de ouders werd ingevuld. De sociaal-economische status van de gezinnen van de deelnemende kinderen bleek het hoogst in Roermond, intermediair in Heerenveen en het laagst in Harderwijk te zijn. Het verschil tussen de Roermondse en Heerenveense gezinnen bleek echter groter dan dat tussen Heerenveense en Harderwijkse gezinnen. Het verschil tussen Roermond en de andere steden kan waarschijnlijk verklaard worden door verschillen in de wijze waarop de scholen geselecteerd werden. Ongeveer 15% van de Heerenveense- en Harderwijkse moeders had een full-time of part-time baan. In Roermond was dit percentage twee keer zo hoog. In Roermond was ongeveer 2/3 van de ouders van de onderzochte kinderen autochtoon tegenover 1/3 in Harderwijk. In zowel Roermond als Harderwijk was ongeveer 2/3 van de kinderen geboren en getogen in resp. de provincie Limburg of de regio Noord-west Veluwe. Tijdens het Heerenveense onderzoek werd geen informatie over de autochtoniteit van de ouders en kinderen verzameld.

De volgende anthropometrische maten werden gemeten: gewicht, lichaamslengte, kniebreedte, armspieromtrek en vier huidplooidikten, t.w. biceps, triceps, subscapula en suprailiaca. Op grond van vergelijkende onderzoekingen werden de resultaten van de metingen op één niveau gebracht door het gemiddelde niveau van de metingen in Heerenveen en Harderwijk te corrigeren naar het niveau van de metingen van de onderzoeker die in Roermond de anthropometrische metingen uitvoerde. De lichaamssamenstelling van de Heerenveense kinderen was het gunstigst. Uitgesproken obesitas, gedefinieerd als meer dan 25–27% lichaamsvet, werd waargenomen bij 3,2% van de Heerenveense kinderen. De Roermondse kinderen waren kleiner en hadden een geringere skelet- en spiermassa en een aanzienlijk grotere vetmassa dan de Heerenveense kinderen. Dit laatste kwam duidelijk naar voren in de hogere gemiddelde huidplooidikten en de hogere prevalentie van uitgesproken obesitas (6,0%) bij Roermondse schoolkinderen. De skeletmassa van de Harderwijkse kinderen was ongeveer gelijk aan die van de Heerenveense kinderen maar de spiermassa van de Harderwijkse kinderen was zelfs minder dan die van de Roermondse kinderen. De gemiddelde dikte van het onderhuidse vetweefsel was het hoogst bij de Harderwijkse kinderen, maar de prevalentie van uitgesproken obesitas (4,6%) lag tussen die van de kinderen uit Heerenveen en Roermond in. Multiple regressie analyse toonde aan dat er bij de onderzochte kinderen een sterke mate van afhankelijkheid bestond tussen het waargenomen lichaamsgewicht en de gemeten anthropometrische indices. Dit resultaat werd geïnterpreteerd als een bevestiging van de hierboven beschreven vergelijkingen. De onderhuidse vet-

laag van de onderzochte Nederlandse kinderen bleek over het algemeen minder dik te zijn dan die van hun leeftijdsgenootjes uit de Verenigde Staten, Canada, Engeland en West Duitsland.

Alle kinderen waren nuchter toen veneus bloed werd afgenomen d.m.v. een Vacutainer systeem. In het bloed werd het hemoglobinegehalte en in het serum werd het totaal cholesterol- en triglyceridengehalte bepaald. In Roermond en in Harderwijk werd eveneens het serum HDL cholesterolgehalte bepaald. De resultaten van de serum totaal cholesterol- en triglyceridenbepalingen van de 3 projecten werden op het niveau gebracht van de resultaten die door de Johns Hopkins University LRC Laboratory, Baltimore werden gevonden in een steekproef uit de sera van alle 3 projecten. De Johns Hopkins University LRC Laboratory voerde de bepalingen uit volgens het voorschrift van het WHO Lipid Standardization Program van het CDC Standardization Laboratory, Atlanta.

De resultaten van de hemoglobinebepalingen vertoonden de bij kinderen bekende toename van het hemoglobinegehalte met de leeftijd. Het gemiddelde hemoglobinegehalte was bij meisjes iets hoger dan bij jongens. De prevalentie van clinische en subclinische anemie was het hoogst bij Roermondse kinderen en het laagst bij Harderwijkse kinderen. Clinische anemie kwam slechts bij een zeer gering aantal kinderen voor. Op grond van de resultaten van de hemoglobine bepalingen werd geconcludeerd dat deze resultaten de vooronderstelling bevestigden dat de aan het onderzoek deelnemende kinderen behoorden tot de gezonde Nederlandse schoolkinderen populatie.

Het gemiddelde serum totaal cholesterolgehalte van de jongens en de meisjes uit de 3 steden varieerde tussen 160 en 190 mg/100 ml. De waarden van de Heerenveense kinderen waren consistent lager dan de waarden van de kinderen uit de andere steden. Alleen bij de Heerenveense kinderen bleek het serum totaal cholesterolgehalte positief gecorreleerd te zijn met de leeftijd. In alle 3 steden bleken de meisjes ongeveer 5 mg/100 ml hogere gemiddelde cholesterolgehaltes te hebben dan de jongens. De prevalentie van hoog-normale cholesterolwaarden inclusief uitgesproken hypercholesterolemie ($\geqslant$ 200 mg/100 ml) bleek 19,5% bij de jongens en 24,8% bij de meisjes te zijn. Uitgesproken hypercholesterolemie ($\geqslant$ 220 mg/100 ml) bleek bij 7,2% van de jongens en 9,8% van de meisjes voor te komen. Op grond van beide criteria werd de laagste prevalentie bij Heerenveense kinderen en de hoogste prevalentie bij Harderwijkse kinderen gevonden. De waargenomen verschillen in de prevalentie van hypercholesterolemie waren echter niet statistisch significant. Uit vergelijking van de in dit onderzoek gevonden waarden met de resultaten die bij leeftijdsgenootjes in andere Westerse landen gevonden werden bleek dat de niveau's, waargenomen bij Nederlandse schoolkinderen, behoren tot de hoogste die gepubliceerd zijn. Een vergelijkbaar niveau werd gevonden bij adolescenten in Nieuw Zeeland en de Verenigde Staten.

De gemiddelde serum triglyceridenwaarden van jongens en meisjes varieerden tussen 55 en 75 mg/100 ml. Het gemiddelde triglyceridengehalte van Harderwijkse kinderen was ongeveer 10% lager dan dat van Roermondse kinderen.

Er werd slechts een gering verschil geconstateerd tussen de waarden van de Heerenveense- en Roermondse kinderen. In alle 3 steden bleken de meisjes ongeveer 4 mg/100 ml hogere triglyceridengehaltes te hebben dan de jongens. Er werd geen consistente relatie gevonden tussen het serum triglyceridengehalte en de leeftijd. De prevalentie van uitgesproken hypertriglyceridemie ($\geqslant$ 100 mg/100 ml) was 7,5% bij de jongens en 7,1% bij de meisjes. Vergelijking met de triglyceridenwaarden van andere onderzoekingen toonde aan, dat de in dit onderzoek gevonden waarden relatief laag waren.

Het gemiddelde serum HDL cholesterolgehalte bij Roermondse en Harderwijkse kinderen varieerde tussen 50 en 60 mg/100 ml. Er werden slechts kleine verschillen gevonden tussen Roermondse en Harderwijkse kinderen in het gemiddelde serum HDL cholesterolgehalte. Bij deze kinderen bleek ongeveer 1/3 van het serum totaal cholesterolgehalte afkomstig te zijn van de HDL lipoproteïnenfractie. Hoewel dit percentage sterk varieerde tussen de individuele kinderen, werd in beide projecten een positieve relatie met de leeftijd geconstateerd.

Doordat bij een steekproef van de deelnemende kinderen ook de ouders werden onderzocht, was het mogelijk om de overeenkomst in waarden tussen ouders en kinderen te bestuderen. Eveneens werd de overeenkomst tussen vaders en moeders en tussen broertjes en zusjes onderzocht. Een sterke mate van overeenkomst in anthropometrische en bloedchemische parameters werd waargenomen tussen ouderparen en hun kinderen. Een soortgelijke mate van overeenkomst in anthropometrische- en bloedchemische parameters werd gevonden tussen broertjes en zusjes. De mate van overeenkomst was beduidend geringer wanneer de niveau's van de onderzochte parameters van de afzonderlijke ouders met die van hun kinderen vergeleken werden. De mate van overeenkomst was bijna volledig afwezig wanneer de resultaten tussen ouderparen vergeleken werden. Op grond van deze bevindingen werd geconcludeerd dat de positie die een kind in de verdeling van de onderzochte parameters inneemt onder polygene controle moet staan en dat de mate van overeenkomst in overeenstemming was met de genetische determinatie door beide ouders. Bovendien werd geconcludeerd dat het delen van dezelfde milieuomstandigheden door eerstegraads verwanten moet bijdragen tot de mate waarin de erfelijke eigenschappen tot ontplooiing kunnen komen. De herhaaldelijk aangetoonde familiale overeenkomst in risicofactoren en ziekten lijkt beïnvloeding van verhoogde niveau's van risicofactoren reeds tijdens de jeugd te rechtvaardigen.

In alle 3 steden werden statistisch significante inverse relaties waargenomen tussen de prevalentie van obesitas bij kinderen en het opleidingsniveau van de moeder. Consistente inverse relaties tussen hypercholesterolemie bij kinderen en het opleidingsniveau van de vader of moeder en de sociaal-economische status van het gezin werden alleen in Harderwijk gevonden. Deze gegevens lijken erop te wijzen dat tegenwoordig een verhoogd niveau van biologische parameters meer voorkomt bij kinderen uit de lagere sociale klassen dan bij kinderen uit de hogere sociale klassen. Deze relaties konden echter slechts

worden bestudeerd door een indeling in grove categorieën te maken. Daarom zijn uitgebreidere studies nodig om deze resultaten te verifiëren.

Informatie over de voedselopname werd bij deze kinderen verzameld d.m.v. de 2-daagse opschrijfmethode. De moeder van het kind vulde gedurende twee dagen een voedingsboekje in dat na afloop van de opschrijfperiode op volledigheid gecontroleerd werd tijdens een gesprek tussen de moeder en één van de onderzoekers. Het percentage kinderen waarvan betrouwbare voedingsboekjes werden verkregen varieerde van 77% in Heerenveen tot 91% in Harderwijk. Deelname aan het voedingsonderzoek werd geweigerd door 8% van de Heerenveense moeders, 9% van de Roermondse moeders en 3% van de Harderwijkse moeders. Op grond van deze lage weigeringspercentages werd geconcludeerd dat de resultaten van het voedingsonderzoek hierdoor niet diepgaand beïnvloed kunnen zijn.

Er werden, evenals in vroegere studies, verschillen gevonden in voedselopname patroon tussen de kinderen uit de verschillende steden. Het percentage kinderen dat kaas, yoghurt, limonadesiroop of ontbijtkoek (inclusief Friese koek) gebruikte was hoger in Heerenveen vergeleken met de andere steden. Het percentage kinderen dat appelmoes of halvarines met een gemiddeld gehalte aan meervoudig onverzadigde vetzuren gebruikte was lager in Heerenveen vergeleken met de andere steden. Het percentage kinderen dat varkensvlees met een gemiddeld percentage vet en patates frites at, was hoger en het percentage kinderen dat pindakaas gebruikte was lager in Roermond t.o.v. de andere steden. Het percentage kinderen dat halfvolle melk dronk was, evenals het percentage kinderen dat bruin- of volkorenbrood at, hoger en het percentage kinderen dat witbrood at was lager in Harderwijk vergeleken met de kinderen uit andere steden. Deze verschillen in voedselopname patroon weerspiegelden zich tevens in verschillen in nutriëntenopname. Uitgedrukt in energiepercentages waren deze verschillen in nutriëntenopname echter zeer klein.

De energieopname van de 6–10 jarige jongens was hoger dan die van de meisjes in deze leeftijdscategorie. Consistente verschillen in energieopname tussen vetzuchtige en slanke kinderen werden niet waargenomen. Deze resultaten bevestigen de waarnemingen van andere onderzoekingen.

Statistisch significante correlaties tussen de nutriëntenopname en het serum totaal cholesterolgehalte konden binnen dit onderzoek niet worden waargenomen. Significante relaties tussen de nutriëntenopname en het serum totaal cholesterolgehalte konden worden aangetoond toen de resultaten van onderzoekingen uitgevoerd in de periode 1946–1951 bij de resultaten van het huidige onderzoek werden betrokken. Deze resultaten maakten duidelijk dat een significante samenhang tussen de nutriëntenopname en het serum totaal cholesterolgehalte verborgen bleef zolang de spreiding van deze parameters betrekkelijk gering was.

Vergeleken met de resultaten van vroegere onderzoekingen, uitgevoerd bij Nederlandse schoolkinderen, wordt de huidige voeding gekenmerkt door een hoge opname van dierlijk eiwit, verzadigd vet, voedingscholesterol en oligosacchariden en een lage opname van polysacchariden, plantaardig eiwit en

voedingsvezel. Zo'n voeding is bekend vanwege zijn atherogene eigenschappen en de resultaten van dit onderzoek tonen aan dat hypercholesterolemie en in mindere mate obesitas voorkwamen bij een aanzienlijk percentage kinderen. Uit prospectieve epidemiologische onderzoekingen is bekend dat de voorspellende waarde van de risicofactoren m.b.t. het ontstaan van coronaire hartziekten afneemt bij toenemende leeftijd. Op grond hiervan mag verwacht worden dat de effectiviteit en efficiency van preventieve maatregelen toeneemt als er al in de jeugd mee wordt begonnen.

Een sobere voeding, gekenmerkt door een lage opname van dierlijk eiwit, verzadigd vet, voedingscholesterol en oligosacchariden en door een hoge opname van polysacchariden, plantaardig eiwit en voedingsvezel t.o.v. onze huidige voeding werd aanbevolen voor de gehele bevolking in het kader van preventie van coronaire hartziekten. Door sommige onderzoekers werd een soortgelijke voeding aanbevolen in het kader van de preventie van kanker. Er mag worden verwacht dat wanneer zo'n voeding gebruikt zou worden door de gehele bevolking, *inclusief kinderen*, de hoge premature sterfte aan chronische ziekten zou afnemen. Het bewijzen van deze hypothese d.m.v. interventie onderzoekingen is één van de grootste uitdagingen op het terrein van de gezondheidkunde van de tegenwoordige tijd.

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Gedurende de kandidaatsstudie viel hun keuze op de toenmalige nieuwe studierichting Humane Voeding. In januari 1974 behaalden zij als één der eersten het ingenieursdiploma van deze studierichting met als hoofdvak Humane Voedingsleer (verzwaard) en Gezondheidsleer en Toxicologie als bijvakken. Na een overgangsaanstelling vanwege het GVO-project, Katholieke Universiteit Nijmegen, werden zij vanaf september 1974 als promotie-assistent van de vakgroep Voeding en Voedselbereiding van de Landbouwhogeschool aangesteld om het in dit proefschrift beschreven onderzoek uit te voeren.