GROWTH AND DEVELOPMENT OF CHILDREN

ON ARUBA IN 1974

PROEFSCHRIFT

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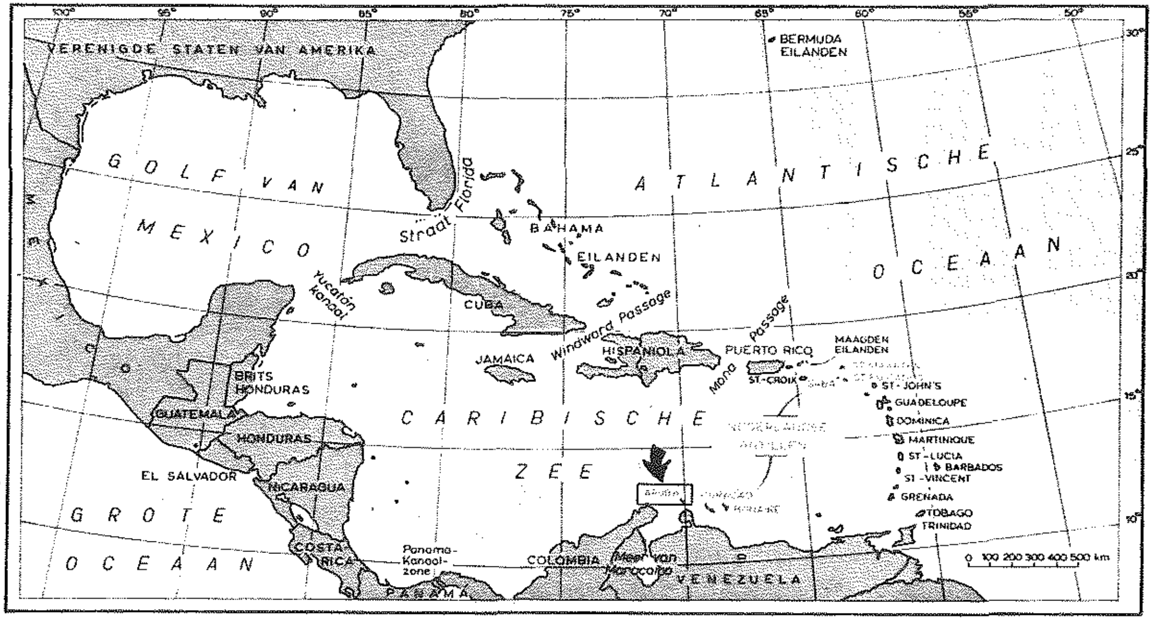
Aan de kinderen van Aruba
en aan Michiel en Heleen

CONCENTS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EL SALVADOR
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COSTA RICA
CARIBISCHE ZEE
GROTE OCEAAN
Panama-Kanaal-zone
PANAMA
COLOMBIA
Meer van Maracaibo
VENEZUELA
0 100 200 300 400 500 km

INTRODUCTION

Aruba: a handful of stones, white sand, cacti and divi-divi trees, scorching in the tropical sun, washed by a sea possessing every possible shade of blue. An island that is nowhere longer than thirty kilometres and nowhere wider than eight kilometres, situated off the Venezuelan coast, whose Paraguaná peninsula can even be seen from Aruba in fair weather.

The Leeward Islands, to which Aruba belongs, were discovered in about 1500, probably by Alonso de Ojeda. He called them "islas de los gigantes", or "islands of the giants", owing to the to him conspicuously tall stature of the Indian inhabitants. These Indians, called the Caiquetios, a tribe of the Arowaks, were still living in the Stone Age. In 1513 the islands were declared "islas inútiles", or "useless islands" because no precious metals were found on them, and the entire population was transferred to Santo Domingo, where copper mines constituted a better source of income for their rulers. However, some of these original Indians were later taken back because they were needed for the Spaniards' horse-breeding. In addition, there was some migration from the mainland coast. So when the Dutch occupied the island in 1636, they found there "a few Indians and some Spaniards". The "development plan" thereafter drawn up for Curacao by the Dutch West Indian Company included provisions for the encouragement of horse-breeding and livestock-raising on Aruba to meet the needs of the new inhabitants of Curacao. Indians were put to work for this purpose, but could never be enslaved inside the concession area of the West Indian Company. There were never any large estates, and for this reason Negro slaves were not imported and put to work on a large scale. There was a certain amount of migration, both inward and outward, for a long period thereafter. Regufees from Venezuela sought and found asylum on Aruba, whilst Arubans looking for work settled temporarily in the surrounding territories, such as Venezuela, Colombia, Cuba and Jamaica, mostly for seasonal labour.

This situation lasted until 1924, when the modern age dawned with the coming of the Lago Oil and Transport Company. The attractive force of the employment thereby offered now drew in many predominantly English-speaking Windward Islanders.

Although these snapshots from history do provide evidence of some migratory flows which will have had some effect on the formation of the contemporary Aruban population, what strikes the present-day visitor, in addition to the variety of skin colours, is the distinctness and the "Indian" features of the Arubans. The population group which has thus arisen, and in particular its children, forms the subject of this study.

The present study also follows from that carried out by F. Steenmeyer on Aruba in 1954, entitled "Food and Nutrition of Arubans". He was intrigued by the large number of prescriptions for vitamin preparations made out for the lower income groups and wanted to contribute to our knowledge of the foods existing on Aruba and the day-to-day pattern of feeding. For this purpose he visited Aruban families in order to analyse the composition of their diet by a once-for-all inquiry. He classified the foods in groups and thus compiled an Aruban food table. Family doctors and specialists provided data which showed that there was no "calorie malnutrition" but that there were possibly vitamin A, B_1, B_2 and C deficiencies; indeed, there was even an excess of calories in the diet of adults in the upper income group relative to the "recommended dietary allowances" of the National Research Council (1953). The average diet of the three income groups showed a surplus of calories and proteins and sufficient iron, but was low in retinol, carotene, riboflavine, ascorbic acid, and calcium. The higher the income, the better the qualitative composition of the food. To gain an impression of the nutritional condition of Aruban children, the height, weight and sitting height of 2470 Aruban schoolchildren aged 4-18 were then determined, although no subdivision by income was made. The data obtained were compared with similar data for children in other tropical countries (including Puerto Rico; Blanco, 1946) and in Europe (including the Netherlands: De Wijn and De Haas, 1960).

Aruban boys

The height growth curve for Aruban children up to the age of about 12 was found to lie between those for Dutch and Puerto Rican children for both boys and girls. The weight curves for Puerto Rican and Aruban children of both sexes were approximately the same, lying below the Dutch weight curves.

In the investigation described in this dissertation, the first point considered is whether the typical changes in the growth pattern of children demonstrated in many parts of the world are also evident on Aruba between 1954, when Steenmeyer carried out his survey, and 1974. Measuring and weighing are one of the ways in which it is possible to track nutritional condition and health and any changes in these. This approach also allows comparisons with other ethnic population groups, although account must be taken of any genetic differences and of ecological circumstances.
Secondly, this study presents standard values in the form of percentile curves for height, weight and sitting height, to which new information is added on head circumference, skinfold thickness, annual increase in height, weight, and sitting height, and sexual maturation. The connection between these parameters and order of birth in the family and family income is also discussed.
Thirdly, the values determined on Aruba are compared with ones for some other population groups in the Caribbean area and the position of the Aruban growth curves relative to those of the "poor"and "rich" countries is discussed.

Section I deals with the organization and conduct of the author's own investigation. Section II presents the results of the investigation, which are then discussed in Section III.
A summary in Dutch and Spanish as well as English is given at the end.

SECTION I

AUTHOR'S STUDY : ORGANIZATION AND CONDUCT

1.1. BRIEF DESCRIPTION OF SOME OF THE CONCEPTS TO BE USED.

Cross-sectional study

This is a study of a population within a relatively short time, each individual being included once in the random sample taken. The data are classified in age groups and not by individuals. This means that a study may include, for example, a group of eight-year-old children, a group of nine-year-old children, etc.

Other forms of studies are:

Longitudinal study, in which a limited group of individuals is generally examined periodically over a fairly long time. The data are classified for each individual over a certain time; in a study of this kind, a single group of children may be measured, for example, at the age of eight and at the age of nine (etc.).

Semilongitudinal study. This is a combination of the previous two types of studies, in which all individuals have been examined at least twice and in which, over the period of the study, some may be eliminated and others may be brought in at a later date.

The cross-sectional study is much simpler to organize and conduct, and is cheaper. This method is suitable for collecting data on standard values of, for instance, height, weight, sitting height, etc., expressed as mean and standard deviation, or dispersion percentiles and median. Average menarcheal age or the average age of first appearance of pubic hair growth can also be determined in a similar manner. If carried out periodically, this form of study gives a good impression of the secular growth trend of the different age groups. However, changes in growth velocity can only be indicated approximately with this method. In this connection the cross-sectional study method is most reliable if the growth velocity remains constant over a number of years - e.g., five to ten years.

Cross-sectional studies cannot be used to indicate the difference in growth velocity between individuals. This parameter must be studied longitudinally. This is because there are big differences both between individuals and between sexes in the time at which the so-called growth spurt takes place. This is the acceleration of growth which occurs at the time of puberty. This spread in the time of the period of accelerated growth as it were smoothes the growth velocity curve based on data collected by the cross-sectional method and thus gives an incorrect picture of what is actually happening in a single person. Data collected longitudinally, on the other hand, give a good impression of the mutual relationship between the parameters of growth and maturation.

Median and dispersion percentiles as compared with arithmetic mean and standard deviation

Both combinations - viz., dispersion percentiles with median, and arithmetic mean with standard deviation - are ways of expressing standard values of biometric and biochemical parameters measured at a specific instant and of indicating the degree of variation of these values within a given population.

The dispersion percentile P_x of, for example, a set of children classified by height means the height below which x percent of all observations of the population lie. Hence P_3 is the percentile below which 3% of observations still lie, and P97 is the percentile above which 3% of observations still lie. The median is P_{50}.

The arithmetic mean in a normal distributed population is the sum of all measurements divided by the number of measurements. The standard deviation (SD) indicates the extent to which a given measurement deviates from the mean.

In a normal distribution, P_{50} will coincide with the arithmetic mean. If the distribution is skew, as is, for example, usually the case with weight, this is not the case.

Dispersion percentiles and medians are easy to use with skew distributions in particular and are easy to read when used for clinical purposes or periodic investigation. The use of mean and standard deviation is more suitable for comparing data from one's own investigation with reports published elsewhere. For a survey of statistical methods used here see for example Colton (1974).

1.2. LOCATION AND ORGANIZATION

The island of Aruba is divided into six administrative districts: Oranjestad, San Nicolas, Noord, Paradera, Sta Cruz, and Savaneta. The first two of these are more urban in character and together account for about 50% of the population; the percentage of non-Antilleans is higher in them. Oranjestad has more European Dutch, while San Nicolas has more immigrants from the Windward Islands and Surinam. The other four districts are rural districts, and the percentage of Arubans is highest in them.

This study was carried out between February 1973 and April 1974 by one doctor, the writer of this dissertation, who was at the time school doctor on Aruba, and one assistant (later two assistants).
Falkner (1972) specified as the minimal desirable sample size for a cross-sectional study roughly: 13% from birth to 1 year, 5% ages 7 to 8 years and 10% around peak growth velocity. Besides the aim was to examine an approximately equal number of boys and girls in each district. In this study a random sample was taken breaking down as follows (see also Table 1)

0 - 1 year	288 children
1 - 5 years	382 children
5 - 14 years	1877 children

or about 24.0%, 6.3%, and 12.6% respectively of all children of those age groups on the island.

Table 1

Sample size by age and sex

age in years			boys		girls	
0	-	0.25	51	(3.7)	63	(4.8)
0.25	-	0.50	47	(3.4)	28	(2.1)
0.50	-	0.75	22	(1.6)	26	(2.0)
0.75	-	1.0	26	(1.9)	25	(1.9)
1	-	2	51	(3.7)	53	(4.0)
2	-	3	34	(2.5)	24	(1.8)
3	-	4	33	(2.4)	31	(2.4)
4	-	5	75	(5.5)	81	(6.2)
5	-	6	112	(8.2)	117	(8.9)
6	-	7	138	(10.1)	117	(8.9)
7	-	8	120	(8.8)	114	(8.7)
8	-	9	139	(10.2)	121	(9.2)
9	-	10	132	(9.7)	125	(9.5)
10	-	11	125	(9.2)	138	(10.5)
11	-	12	103	(7.6)	115	(8.7)
12	-	13	93	(6.8)	86	(6.5)
(13	-	14)	52	(3.8)	42	(3.2)
(14	-	15)	11	(0.8)	10	(0.8)

The percentage of the number of children of the relevant sex examined is given in parentheses.

Table 2

Sample size broken down by districts and sex

	1	2	3	4	5	6	Total
Boys	308(22.6)	301(22.1)	188(13.8)	365(26.8)	167(12.2)	35(2.6)	1364(100.0%)
Girls	261(19.8)	289(22.0)	208(15.8)	384(29.2)	145(11.0)	29(2.2)	1316(100.0%)

1 = Oranjestad　　4 = Sta Cruz
2 = Noord　　5 = Savaneta
3 = Paradera　　6 = San Nicolas

The figures in parentheses indicate the percentages of the total for that sex.

Paradera has no health centre of its own, so that there is no 0-4 age group here, this instead being included under Noord or Sta Cruz.

For the 0-4 age group, use was made of the health centres for infants and toddlers run by the White-Yellow Cross in each district, except for Paradera, which is divided between Noord and Sta Cruz. The attendance percentage for the infant centres is 90-95%. This figure is lower for the toddler centres, so that this group is more selective perhaps. The 4-13 age group was obtained via nursery and primary schools. Although schooling is not compulsory in the Netherlands Antilles, about 75% of the children go to a nursery school and some 99% undergo primary education in one form or another. At least two schools in each district were investigated.
Special primary schools were not covered by this investigation.
Since a number of ethnic groups exist on the island, the "Aruban" population to be examined was defined by the same criteria as were adopted by Steenmeyer in his 1954 study, namely:

a. Both parents and the child to be examined born on Aruba
b. Principal language spoken at home Papiamento.

The term "race" has deliberately not been used here, "ethnic group" being preferred. This is a better description of what is in fact meant, viz., populations which differ from each other in the frequency of certain specialized genes. This is not a mere substitution: the term "race" is indicative of unsound reasoning when applied to man, if only because of the incorrect associations which it evokes (Montagu, 1962).
Again, as Van Wieringen (1972) says, it seems wrong to assume that genetic differences or "racial features" can be invoked to account for, for example, differences in height between ethnic or socioeconomic groups. After all, it is still unclear whether reported differences are indeed due to variations in the frequency of the genes which regulate growth in all populations or to variations in lifestyle under widely differing conditions (Roberts, 1969).

1.3 CONDUCT OF INVESTIGATION

Data were gathered in two steps, which were the same both at health centres and at schools:
1. An interview with one parent, usually the mother
2. Measurement and weighing of the child.

1.3.1. Interview with parent

The parent was previously asked to bring the "buki di casamento" (family record book) to ensure maximum reliability of data. The following questions were answered on the basis of this book (see Table 3):

Table 3

Questionnaire:

Family data:

Name of child

Birthplace

Date of birth

Order of birth

Family size

Father:

Birthplace

Occupation

Mother:

Birthplace

Occupation

Family income per month:

I	II	III	IV
0-500 NaF*	500-1000 NaF*	1000-1500 NaF*	over 1500 NaF*

Language spoken at home: Papiamento/English/Dutch

Child : ill/healthy
what illness

Menarche: yes/no

*NaF means Netherlands Antilles guilders

a. *Birthplace of child, father and mother; language spoken at home*
As stated earlier, this information defined the target group

b. *Date of birth*
This was taken from the official papers brought by the parent and converted into decimals. This number was then subtracted from the date of measurement, also expressed in decimals, to obtain the exact age.

c. *Family size*
The question asked was the number of (still surviving) brothers and sisters. Tanner (1962) found that family size has an effect on growth velocity. Children from small families are taller than ones from large families, this difference being greater the lower the socioeconomic class. This phenomenon has also been described by others (e.g., Van Wieringen, 1972). In addition, menarcheal age is also stated to be higher in girls from larger families.

d. *Order of birth*
This means the order of birth of the child among the total number of children born to the same mother.

This has to be stated so specifically because it is not unusual on Aruba for children to be adopted in a family as its own although from another partner or from the more extended family or in some other way. These children are, of course, irrelevant to our purpose. There is a relationship between order of birth and height at a specific age. Although first-born children are significantly shorter at birth than subsequently born children (Wingerd and Schoen, 1974), from the age of five they are in all cases significantly taller than children born fourth or later, even when socioeconomic class is taken into account (Wingerd and Schoen, 1974; Goldstein, 1971).

e. *Family income*
In order to reveal any connection between income level and growth, a question was included asking in which of the four bands the family income fell: 0-500, 500-1000, 1000-1500, and over 1500 Antillean guilders per month.

(One Antillean guilder was equal to approximately $1\frac{1}{2}$ Dutch guilders). Although in general little resistance was shown to this question, it is very likely that it was not always answered truthfully. Of the exogenous factors influencing the growth pattern, the effect of socioeconomic level is by far the best studied parameter and probably also the least complicated parameter to study. Growth differences between socioeconomic groups have also been reported in central and South America (King, Foucauld, Fougere and Severinghaus, 1963; Luna-Jaspe, Macías, Rueda-Williamson, Parra and Téllez, 1970; Blanco, Acheson, Canosa and Salomon, 1974).
As a general rule, it is found that children from higher socioeconomic classes are taller than those from lower classes. This is apparently largely due to a shift in the growth pattern whereby the adolescent growth spurt takes place earlier in the group of higher socioeconomic level (Tanner, 1962).

f. *Occupation*
This question was asked in too general terms, so that when the data were processed no classifications was possible (e.g. by groups of occupations). For this reason, this parameter is henceforth disregarded.

g. *Ill/healthy*
This was used only in order to exclude from subsequent study children with known chronic diseases at the time of the investigation (e.g., chronic renal diseases or diabetes).

h. *Menarche*
The age at which the first menstruation occurs in a girl is a frequently used measure of whether puberty has early or late onset. It also has the great advantage that it is very easy to determine. This can be done in three ways: retrospectively, prospectively, or by the status quo method. In the retrospective method, adult women are asked to remember the age of first menstruation. This is unreliable, but was widely used in the past. The prospective method is based on longitudinal collection of data, the date being noted at the first periodic interview after menarche. The so-called "status quo" method is now used in cross-sectional studies. Girls between the ages of 9.0 and 17.0 are merely asked whether or not they have had their first menstruation.

After this median menarcheal age is read off from a cumulative frequency distribution graph or calculated by logit analysis (e.g., Burrell, Healy and Tanner, 1961).

The status quo method was used in this study. The upper age limit of the target group of the study was 14.0 years. Menarche is important not only as a pubertal characteristic but also by virtue of its relation to other parameters in this study. Early menarche is more frequently co-related with a greater growth spurt, greater head circumference, and greater skinfold thickness. Late menarche occurs relatively more frequently in lower income groups and larger families (Tanner, 1962). The secular change in growth observable in menarche is described in detail in Section 3.2.

1.3.2. Measuring and weighing

a. *Instruments*

The methods of investigation recommended by the International Biological Programme (Weiner and Lourie, 1969) were used. This standardized method permits comparison with studies carried out elsewhere in the world, including future studies.

To measure the height and sitting height of children up to the age of 24 months, a "Harpenden infant measuring table" was used; this consists of a flat measuring board with headrest and movable footboard. The measurement is displayed on a counter behind a window.
After 24 months, the children were measured standing (height), and sitting (sitting height) with the Harpenden anthropometer, which also had a counter of this type, from which readings are more reliable (Tanner and Whitehouse, 1957). Head length and width can be read with the aid of the anthropometer accessories.

Weighing was carried out on a balance which was calibrated in advance and checked half-way through and also after the study. This proved always to be reliable.

Infants were weighed on the same balance, to which a special tray was attached for the purpose (a correction could be made on the balance itself for this).

Heights and sitting heights were measured in millimetres, and weights in tenths of a kilogram.

A metal measuring tape was used to measure head and arm circumference. Tapes of this kind cannot stretch and hence give reliable results. Skinfold thickness was measured with the Harpenden skinfold caliper, which gives a constant pressure of 10 g/mm^2 at each opening. Its readings are accurate to within 0.1 mm (Edwards, Hammond, Healy, Tanner and Whitehouse, 1955).

b. *Methods*

First of all a few general remarks: All measurements were effected on the left-hand half of the body. Up to the age of 2, all children were naked, after which they wore pants but no vest or brassiere. The $0 - < 4$ age group was measured and weighed in the middle of the day and the 4-13 group in the morning. As already stated, all the operations described below were carried out by the author herself and by one assistant (later two assistants), also assisted by the mother where stated.
Skinfold thickness was always measured by the same person to ensure consistent results (Edwards et al., 1955; Tanner, 1962). The puberty scores were also always determined by the author herself.

Height lying down

One person (with children under 2, usually the mother) is instructed to hold the head with the crown against the fixed headrest in the Frankfurt position, where the lower margin of the orbits lies in the same now vertical plane as the meatus acusticus externus. The other person stretches the legs by pressing the knees down; the toes point straight up, and the footboard is pressed against the sole of the foot.

Height standing

The child stands on a horizontal surface with the heels together, and actively stretches as far as possible, helped by relaxing the shoulders and by the author, who exerts gentle traction via the processus mastoideus and encourages the child verbally.

The heels remain on the ground and the head in the Frankfurt position. The horizontal arm of the anthropometer is lowered on to the head. This measurement is thus also carried out by two persons, one of whom holds the child in the correct position while the other holds the anthropometer vertical and takes the reading from it.

Sitting height, lying down
The child lies on its back with the knees bent at an angle of 90°. One person holds the head in the Frankfurt position and against the headrest. The other supports the legs, applies the footboard to the buttocks and takes the reading.

Sitting height, sitting
The child sits on a table with the upper legs supported and the lower legs hanging freely over the edge. The back is actively stretched, helped by running a finger upwards along the spinal column and exerting gentle traction under the chin. The head is in the Frankfurt position. A second person operates the instrument and takes the reading.

Head circumference
A metal measuring tape is applied firmly round the head above the supraorbital margin, or the most protruding part of the forehead and over the part of the occiput that gives the maximum fronto-occipital circumference.

Head length
The maximum length in the sagittal plane is located by means of the curved accessories of the anthropometer, the glabella being the reference point.

Head width
Maximum distance between the ossae parietales.

Upper arm circumference
The arm hangs downwards relaxed. The point half-way between the acromion and the top of the olecranon is determined and the circumference measured in this position.

Skinfold thickness
The skinfold is grasped between the thumb and index finger and the caliper is applied. The measurement is taken within 1-2 seconds of application of the full pressure to the skinfold. If a longer time elapses, the result is inaccurate. Two measurements are taken of each skinfold, with a short pause between them for recovery, and are then averaged. In addition, the skinfold thickness is measured in two different positions, namely:

1. over the m. triceps
   The skinfold is grasped 1 cm above the level at which arm circumference was measured
2. over the m. subscapularis
   The skinfold is grasped below the angle of the scapula (vertical fold).

Pubertal development
For this purpose the same criteria are used as are also described in the Netherlands by, for example, Van Wieringen (1972)(taken from Tanner, 1962).

a. *Pubic hair growth*
   - PH_1 - No hair growth
   - PH_2 - The first, still only slightly pigmented and curled, pubic hairs on the labia or at the base of the penis
   - PH_3 - The first dark, clearly pigmented and curled pubic hairs, scattered sparingly over the symphysis
   - PH_4 - Type of hair growth is adult, but the area covered is smaller than in adults No spread to the medial side of the thigh.
   - PH_5 - Horizontal spread of hair growth; type and area of hair are adult. No spread in the median line along the linea alba.

b. *Breast development in girls*
   - B_1 - Pre-adolescent. Only the nipple is elevated above the surface of the breast.
   - B_2 - "Button" stage. Elevation of breast and nipple giving slight curvature. Enlargement of diameter of areola
   - B_3 - Further curvature of breast and areola without separation of their contours
   - B_4 - Elevation of areola and nipple so that these form a second, separate curve on the breast
   - B_5 - Areola falls back to breast level - adult stage.

c. *External genital development in boys*

- G_1 - Pre-adolescent. Testis, scrotum and penis have the same size and shape as in the young child.
- G_2 - Enlargement of scrotum and testis. Scrotal skin becomes redder and thinner and wrinkled. Penis still shows little to no enlargement.
- G_3 - Enlargement of penis, particularly in length, and further growth of the testis. Scrotum bulges.
- G_4 - Increasing enlargement of penis, also in width, and development of glans. Increasing pigmentation of scrotum.
- G_5 - Adult stage in size and shape.

Aruban children

SECTION II

RESULTS

2.1. GENERAL CONSIDERATIONS

The data obtained as described in Section I were examined and extreme values due the mistakes in observation, recording or encoding were corrected or, if the latter was impossible, eliminated. Elimination seldom was necessary. After this, not only distribution-free dispersion percentiles and the median were calculated but also the arithmetic mean and standard deviation. Steenmeyer presents his 1954 data in the form of arithmetic mean and standard deviation and another study cited for comparison also uses this approach. However, with a view to day-to-day use in health centres and for medical examinations in schools, for which purpose these data were also collected and processed, dispersion percentiles and median were also calculated and plotted in graphs. For a description of the method used see i.e. Herrera (1958).

In view of the number of children examined, it was possible to divide the 0-1 year-old group into sub-groups with a class width of 3 months. From 1 year upward, however, a full year had to be chosen for the class width. The points given on the curves form the class midmarks of these groups.

For example:

0.0	- $<$ 0.25 year,	class midmark 0.125	year
0.25	- $<$ 0.50 year,	class midmark 0.375	year
0.50	- $<$ 0.75 year,	class midmark 0.625	year
0.75	- $<$ 1.0 year,	class midmark 0.875	year
1.0	- $<$ 2.0 year,	class midmark 1.5	year
2.0	- $<$ 3.0 year,	class midmark 2.5	year

P_{10} and P_{90} were chosen as the dispersion percentiles instead of P_3 and P_{97} as used in many studies. The numbers examined here, do not admit of such detailed subdivision. See appendix for tables and figures referred to.

2.2. HEIGHT, WEIGHT AND SITTING HEIGHT.

2.2.1 Dispersion percentiles and median by sex (Figures 1-6 and Tables 4-9).

The 0-1 year-old group is always presented on the left-hand side of the figure. The points given are the calculated values; the line drawn is the curve which best fits them as estimated by eye. The points as such form a smoothly flowing integrated whole.

2.2.2 Comparison between boys and girls (Figures 7-9).

Here the median lines of both sexes are included in a single figure in order to bring out any differences in the growth pattern. The dispersion percentiles P_{10} and P_{90} are also included for height, but are omitted for weight and sitting height.

Height (Figure 7)
Median growth of height in boys and girls does not differ up to the age of 10.5 years, but from 11.0 years onwards girls are taller than boys. Considering also the P_{10} and P_{90} curves, it appears that the P_{90} curves for boys and girls diverge earlier and the P_{10} curves for boys and girls diverge later than at 10.5 years. These differences in the age at which the different percentiles for boys and girls diverge are also described by Van Wieringen for Dutch children (Van Wieringen, 1972). Tanner (1962) reports that between the ages of about 10.5 and 13 years girls are larger than boys in all dimensions, owing to the earlier onset of the pubertal growth spurt in girls.

The median annual increase in height and weight of boys and girls is set out again, but separately, in Figures 10 and 11 and Tables 10 and 11; the increases are calculated by subtracting the median height (or weight) at, for example, 12 years from the median height (or weight) at 13, etc.This clearly brings out the substantial annual median increase in height of more than 15 cm for the first year or so, followed by a rapid fall in the rate of increase, which is only 5-6 cm by the time the ages of 5 to 9 years are reached.

Then the increase in height appears to decline somewhat until the growth spurt begins, in girls at 10 years and in boys at 11 years. The peak here is reached in girls at 12 years; the curve is inconclusive as regards boys at this time. The annual median increase in weight is virtually the same for boys and girls, amounting to 1-3 kg per year. Here again there is a much greater increase (5-6 kg) in girls than in boys from the age of 10 years, associated with the earlier onset of the growth spurt. With regard to these last two figures in particular, it is perhaps worth repeating that they are based on cross-sectional data, which distort what is actually happening in each separate individual, especially at the time of puberty and the growth spurt. The ages given for the beginning and climax of the pubertal growth spurt are in this sense only estimates.

Weight (Figure 8; Tables 6 and 7)
The median weight of boys does not differ from that of girls up to the age of 11.0 years. From 11.0 years on, girls are heavier. If the figures (Tables 6 and 7) are plotted on a graph - which has not been done for the sake of clarity - the two P_{90} curves diverge earlier than the curves of median values.

Sitting height (Figure 9; Tables 8 and 9)
The median values of sitting heights do not differ up to the age of 11.5 years, after which girls have greater sitting height. The P_{90} curves and the P_{10} curves diverge respectively earlier and later than the median curves. To preserve clarity, these curves are not included in the figure. The figures are set out in Tables 8 and 9. The growth spurt evidently commences earlier in the legs than in the rest of the body, as the height curves diverge earlier than the sitting height curves. This sequence is also mentioned by Tanner (1962).

Sitting height/height ratio
The average sitting height/height ratio for boys and girls ages 0 to 13 is set out in Figure 12 (Table 12). The sitting height/height ratio is defined as sitting height divided by (standing) height multiplied by 100.

As is to be expected, this ratio declines sharply from 0 to 3 years, and thereafter more gradually. In other words, leg length increases relatively more than head and trunk length.

Up to the age of two, the differences between boys and girls are practically negligible. From three to about five years, boys have an appreciably larger sitting height/height ratio than girls. From the age of about five, however, the differences are again very small.

2.2.3. Secular growth trend

The 1954 data are compared with the results obtained in 1974 in Figures 13-21 and Tables 13-15. In these figures and tables, the arithmetic mean and not the median values are used for height, weight and sitting height in 1974, as explained in Section 3.1. For comparison, the mean curves for the Dutch standard values for height and weight in 1965 (Van Wieringen, 1972) and 1955 (De Wijn and De Haas, 1960) are also included. No standard values for the sitting height of Dutch boys and girls are known from that time.

A positive secular shift in growth has taken place in all three parameters compared. Its extent is such that the present (1974) values mostly lie about half-way between the 1954 curve for Aruba and the Dutch curve for 1965. In the case of both girls and boys, the secular growth differences in height between 1954 and 1974 are significant from the age of 6.5 years (Student's t test, $\alpha = 0.05$). Fig. 19 and Table 13). This means that children on Aruba are taller from that age onwards in 1974 than they were at the same age in 1954. After the age of 6.5 years, a plateau appears to form, with only a slight increase in the secular differences. For boys this remains so at least until 13.5 years, but in girls a further increase in height differences per age class between 1954 and 1974 occurs at 10.5 years, probably in consequence of the onset of puberty at that age.

The difference between 1954 and 1974 at the time of the plateau phase is 2.5 cm or more for girls and 3.5 cm or more for boys. The secular differences in weight are significant for boys from the age of 4.5 years.

(Student's t test; α = 0.05) Boys aged 4.5 years in 1974 are about 1 kg heavier than boys of that age in 1954,(Fig. 20 and Table 14). After the age of 4.5, there is a gradual increase in the differences, reaching about 4.5 kg at 13.5 years. For girls the difference is positive and significant from 5.5 years, when the difference compared with 1954 is 1.5 kg. Little change is detectable up to 10.5 years, but after this, probably owing to the onset of puberty, there is a sharp increase in the difference, reaching about 7 kg at the age of 13.5 years. Finally, sitting height (Fig. 21 and Table 15) also shows significant differences compared with the 1954 curve (Student's t test; α = 0.05). This is true of boys from the age of 5.5., when the difference is about 2.5 cm, at which level it remains up to the age of 13.5. In girls the difference compared with 1954 is also significant, from the age of 5.5., when it amounts to about 1.5 cm. Virtually no change takes place up to the age of 10.5, but from 10.5 years, again probably owing to the onset of puberty, the difference compared with the 1954 sitting height curve increases to about 3.5 cm at age 13.5

2.3. HEAD CIRCUMFERENCE; HEAD LENGTH AND HEAD WIDTH

Head circumference (Figs. 22-24 and Tables 16 and 17).

The dispersion percentiles are presented in the same way as those for height, weight and sitting height. No data on these parameters have previously been collected on Aruba. Fig. 24 shows that there is no difference in head circumference between boys and girls at the age of 14.

Head length and head width (Figs. 25 and 26 and Tables 18-21).

Arithmetic means are used here. Head lengths and widths for girls and boys on Aruba (1974) are here included in a single figure. The mean values for girls are smaller than those for boys over the whole period measured. The same was also found in Dutch measurements (Hautvast, 1971).

2.4. SKINFOLD MEASUREMENTS

These measurements were conducted on children from the age of 4 on Aruba (Figs. 27-30 and Tables 22-25). The inconvenience of the skew distribution of the skinfold thicknesses has been overcome by also plotting the measured values with a logarithmic scale distribution from the ordinate. The values converted by Edwards' transformation (Edwards et al., 1955) are set out on the right: transformed skinfold thickness = 100 log (measurement in 1/10 mm - 18).

This transforms the skew distribution into a more normal one. The percentiles P_{10}, P_{50} and P_{90} are calculated.

Triceps skinfold thickness

(Figs. 27 and 28. Tables 22 and 23).

The minimum value of this skinfold thickness for boys, 6.4 mm, (P_{50}) lies between 6.5 and 8.5 years. During these years virtually no change takes place. After 8.5 years there is a gradual increase to 8 mm (P_{50}) at the age of 11.5. In girls there is also a minimum value, of 7.8 mm (P_{50}), at 6.5 years, but there is no plateau, but instead an immediate gradual rise, which persists at least up to the age of 12.5.

Subscapular skinfold thickness

(Figs. 29 and 30. Tables 24 and 25).

Here the minimum value of 4.5 mm for boys (P_{50}) occurs between 5 and 6 years, followed by a gradual rise to 6.0 mm (P_{50}). For girls there is a minimum value of 5.6 mm (P_{50}) between 6 and 9 years, followed by a clear and persistent increase. Tables 24 and 25 show that girls have a larger skinfold thickness than boys at each age.

The arm muscle area (AMA) and the arm fat area (AFA) were also calculated, using the formulae given below:

$$AMA = \frac{(C - \pi T)^2}{4\pi}$$

in which C = arm circumference and T = triceps skinfold thickness

$$AFA = \frac{C^2}{4\pi} - AMA$$

(Frisancho, 1974; Martorell, Yarbrough, Lechtig, Delgado and Klein, 1976).

No account is taken of the diameter of the humerus in calculating the AMA, or of the compressibility of the skinfold in calculation of the AFA. These are therefore approximations. The above calculations for AMA and AFA were carried out for Aruban children between the ages of 4 and 14 and presented in percentiles and as means with standard deviation.

Arm muscle area

(Figs. 31, 32 and 35; Tables 26 and 27).

For both girls and boys there is a gradual increase with age, reminiscent of the height and weight curves when plotted graphically. Up to the age of 12 there is a slight difference between boys and girls, the former apparently having a somewhat larger arm muscle area.

Arm fat area

(Figs. 33, 34 and 36; Tables 28 and 29).

Up to the age of about 9, boys have a virtually stable fat area, followed by a rise, which is not very large for P_{10} and P_{50} in particular. Girls show little variation in fat area up to the age of about 8, after which there is a clear increase. Girls have a larger fat area than boys at all ages.

2.5. PUBERTAL DEVELOPMENT.

Maturational characteristics

For all maturational characteristics examined, ages have been subdivided into half-year classes, after which cumulative frequency distributions (Van Wieringen, Wafelbakker, Verbrugge and De Haas, 1968) of each were compiled. Two comments must be made in this connection. Firstly, the data presented here are incomplete because only a part of pubertal period was examined. However, since the pubertal development of this population has not previously been studied, these data can also form a basis for further study.

Secondly, the data were collected on a cross-sectional basis, so that the rate at which the different phases are passed through and their mutual relationship apply to the population as a whole; hence no conclusions can be drawn as to variations in these parameters within the group.

2.5.1. Boys

Pubic hair growth and genital development (Figs. 37 and 38; Table 30)

Pubic hair growth begins between the ages of 9.0 and 9.5 in the Aruban boys studied; genital development commences somewhat earlier, between 8.5 and 9.0 years. The subsequent stages (PH-3 and PH-4, and G-3 and G-4) occur in the same period between 11.5 and 12.0 years. Considering the subsequent course of the curves, this coincidence of the commencing times between stages PH-3 and PH-4 and stages G-3 and G-4 is probably due to the small numbers of individuals covered. The median for Stage 2 of pubic hair growth is attained between 12.5 and 13.0 years. The median for Stage 3 is between 13.5 and 14 years. Pubic hair growth has not commenced in all boys at the age of 14. In genital development, the median of Stage G-2 falls between 11.5 and 12.0 years, while the median of G-3 is between 13.5 and 14.0 years. Genital development had begun in 100% of the boys examined at the age of 14.

2.5.2. Girls

Pubic hair growth and breast development (Figs. 39 and 40; Table 31)

Pubic hair growth (Stage PH-2) begins in the group of girls studied between the ages of 8.0 and 8.5 years - i.e. earlier than in boys. PH-3 commences between 9.5 and 10.0 years, and PH-4 between 10.5 and 11.0 years. The medians lie between 11.0 and 11.5 years for Stage PH-2, at about 12.0 years for PH-3, and between 13.0 and 13.5 years for PH-4. These stages are thus separated by about 1 year. Pubic hair growth has commenced in all the girls studied between 13.5 and 14.0 years.

Breast development in these girls begins between ages 8.5 and 9.0 (B-2). Stage B-3 begins between 9.0 and 9.5, and B-4 between 10.0 and 10.5 years. Breast development thus begins later than pubic hair growth in girls, but at about the same age as genital development in boys. The medians of Stages B-2, B-3 and B-4 are between 10.5 - 11.0 years, 11.5 - 12.0 years, and about 13.0 years respectively. Breast development has commenced in all the girls studied between 13.0 and 13.5 years - i.e., about half a year before pubic hair growth is visible in all girls.

Menarche (Fig. 41 and Table 31)

The median value of the menarchealage is, as the figure shows, around the age of 13.25 years. The age at which menarche takes place in 50% of girls was calculated by logit analysis (see, for example, Burrell, Healy and Tanner, 1961). This age is 13.11 ± 0.13 years (measure of goodness of fit $X^2_6 = 6.87$). 70-75% of all the girls studied menstruate at the age of 14.

The relation between menarcheal age, Stage PH-2 of pubic hair growth, and breast development Stage B-2 is shown graphically once again in Fig. 42. As already stated, breast development is slightly in advance (by about half a year) of pubic hair growth. Median menarcheal age is about two years after the median age of breast development stage B-2 and about 2.5 years after the median age of pubic hair growth stage PH-2.

2.6. ORDER OF BIRTH; FAMILY SIZE; INCOME.

The possible effect of height growth, weight increase, skinfold thickness, and menarche of each of these factors was investigated separately. For this purpose order of birth, family size and income were divided into three groups, as follows:

	Order of birth of child	Family size	Income per month
Group 1	1 and 2	1 and 2 children	NaF 0- 500
Group 2	3,4 and 5	3,4 and 5 children	NaF 500-1000
Group 3	>5	>5 children	NaF >1000

The biggest problem was raised by the numbers per age group arising out of this breakdown (see Tables 32-47). The smallest numbers per age class were always encountered in Group 3. Where the number was less than ten, the relevant age class was disregarded as being too unreliable. For family size and order of birth in the family, this still yielded curves, but as regards income, Group 3 included so few children that comparisons are not readily possible.

In Figs. 43-54, Group 1 is first compared with Group 3 by order of birth for height, weight and sitting height; the same parameters are then compared by family size, also for Group 1 and Group 3. There appears to be no immediately conspicuous difference between small and large families and children born earlier and later respectively. The curves for height, weight and, in particular, triceps skinfold thickness in each figure appear to indicate that small families - i.e., with two children or less - and children born first or second are ahead in height, weight and skinfold thickness.

This impression is confirmed elsewhere (Wingerd and Schoen, 1974; Goldstein, 1971; Tanner, 1962 and 1966; De Wijn, 1976; Moyes, 1976, Antrobus, 1971). For menarche, the numbers in Group 1 were too small to be used for comparison, at least as regards family size. Table 37 suggests that children born first and second have a somewhat lower menarcheal age, but here again the numbers of children are very small.

The Student's t test ($\alpha = 0.05$), also shows the differences mentioned not to be significant for most of the age classes, either for order or birth or for family income.

Aruban family

SECTION III

REVIEW OF SOME GENERAL CONCEPTS ON THE BASIS OF THE LITERATURE AND DISCUSSION OF THE AUTHOR'S OWN RESULTS.

3.1. EFFECT OF ENDOGENOUS AND EXOGENOUS FACTORS ON GROWTH AND DEVELOPMENT.

Growth is a movement in time and a cross-sectional study yields only an instantaneous snapshot. A study of this kind thus gives only very limited information about the movement itself - whether it is fast or slow (i.e., growth velocity). It seems appropriate to review the large number of factors which can influence the growth of children and populations before embarking on a discussion of the results obtained.

Growth and development are determined by genetic and ecological factors, their interaction, and their integration by the "milieu interne" of the organism (Wolanski, 1970). A complex pattern of interactions is involved, of which only the broad outlines can at present be described, so that simplifications are inevitable. For example, there are indications that differences in growth between populations up to puberty are due primarily to differing living conditions, and that genetic differences play an important part particularly at the time of puberty. This is illustrated by the study of two groups of children carried out in Guatemala (Johnston, Wainer, Thissen and MacVean, 1976). All these children participated in a longitudinal growth study. They all attended the same school, which featured a high standard of education, nutrition and medical attention. Again, all the children originated from a high socioeconomic class. The first group of these children were Guatemalan, which meant that the four grandparents were born in Guatemala, as was the child himself, and that Spanish was spoken at home.The second group consisted of children whose parents were born in Europe or north America. They spoke no Spanish at home and were referred to as "European children".

These two groups were compared with a third group of children, who were also observed in a longitudinal growth study. These were American children from the Berkeley Growth Study in California. It was found that ABO blood group frequencies did not differ significantly between the European and American children. There was, however, a significant difference in ABO phenotype between American and European children on the one hand and Guatemalan children on the other. From this is was concluded that the American and European children were genetically identical but that these two groups differed genetically from the Guatemalan children. On the other hand, the European and Guatemalan children grew up in the same environment, in living conditions which differed from those of the American children. The growth was analysed using four parameters: height growth preceding the growth spurt, height growth during adolescence, "peak height velocity", and the age at which peak height velocity was attained. This analysis showed that the height growth of Guatemalan and European children was the same up to adolescence and significantly different from that of the American children. At the time of adolescence, however, the growth in height of the European children was just as great as that of the American children and significantly different from that of the Guatemalan children.
According to Johnston et al., this implies that growth differences between populations up to adolescence are determined more by environmental conditions, but that during adolescence genetic factors are the principal cause of these differences in growth. Habicht et al. (Habicht, Martorell, Yarbrough, Malina and Klein, 1974), who compared the height and weight growth curves of different ethnic populations, who also belonged to different socioeconomic classes, also find that the differences in growth between groups with the same ethnic background but from different socioeconomic classes are many times larger than those between different ethnic groups from the same socioeconomic classes. They consider that environment exerts a predominant influence on the pattern of growth, at least up to the age of seven.

This does not, of course, mean that genetic factors play no part in youth - on the contrary. Children within a family, for example, show greater agreement in growth pattern (height, weight, and pubertal development) than children from different families. It is true that length and birth is mainly determined by the height of the mother, but from the age of two height shows a high degree of correlation with average parental height (see, for example, Tanner, Goldstein and Whitehouse, 1970).
It is assumed that growth velocity in children in the first years after birth depends on the difference between birth length and the genetically determined length, which in turn depends on average parental height (Smith, Truog, Rogers, Greitzer, Skinner, McCann and Sedgwick Harvey, 1976). The correlation between average parental height and height between the ages of two and nine has made it possible to compile height curves allowing for average parental height. The agreement in the growth pattern is even more striking in the case of monozygotic twins. For example, Eveleth and Tanner (1976) report a decreasing breadth of variation in expected adult height in men from 25 cm in the population as a whole to 17 cm among brothers and only 1.6 cm between monozygotic male twins. Wingerd and Schoen (1974) also state that parental height is an important factor in the height differences of children. By means of an analysis of data covering about 3700 children, they calculated that at the age of five parental height was exclusively responsible for 88.6% of the differences in height. In general it is assumed that genetic factors affect primarily physical relations and the rate of development - and, in particular, changes in that rate (Tanner, 1962; Eveleth and Tanner, 1976). An example of this is the agreement in menarcheal age between mothers and daughters.
The environment (living conditions) constitutes a second group of factors which affect growth. Although this is dealt with here as a distinct group of factors, it is in fact inextricably bound up with the previous group, the genetic factors. *Nutrition* appears to run through this whole group like a continuous thread; it may be quantitatively or qualitatively deficient for all sorts of reasons, (e.g. illness, poverty, or ignorance) and may thus directly or indirectly affect the growth and development of the child.

This is a common problem especially in the "poor" countries, where it at least plays a much clearer part than in the "rich", industrialized nations. The effect of malnutrition on growth may begin even before birth. Intrauterine malnutrition, whether or not combined with intrauterine infections, gives significantly lower birth weights and shorter birth lengths (Mata, Urrutia and Lechtig, 1971; Canosa, Martins Filho, Roques, Folch and Llopis, 1975; Lubchenco, 1970; Read, Habicht, Lechtig and Klein, 1975; Stein, Susser, Saenger and Marolla, 1975). Supplementing the food of pregnant women is found to result in a clear increase in the birth weight of their children compared with a control group (Read et al., 1975). In general, however, birth weight in the poor countries is not far below that in the rich countries (Eveleth and Tanner, 1976). A lag appears only at the age of about six months (Antrobus, 1971), or possibly already at four months (Standard, Desai and Miall, 1969; Ashcroft, Bell, Nicholson and Pemberton, 1968; King, Foucauld, Fougere and Severinghaus, 1963). This age roughly corresponds with the time at which breast feeding alone becomes insufficient; this then becomes inadequate, in turn resulting in greater susceptibility to infections.
The occurrence of intestinal infections, in particular, correlates with suboptimal growth in this period (Martorell, Habicht, Yarbrough, Lechtig, Klein and Western, 1975). It is difficult to investigate whether this early malnutrition in itself has a permanent effect on the growth pattern. Experiments with rats and other animals (Widdowson and McCance, 1975) have shown that the effect of malnutrition is more serious and more lasting the longer the animal is exposed to it and the younger the age of exposure. In young children the effect is also largely dependent on treatment after the period of serious malnutrition. This is brought out very clearly by a study in Peru (Graham and Adrianzen, 1971; Baertl, Adrianzen and Graham, 1976). Fifteen children from very poor families were hospitalized because they were severely underfed. The average age on hospitalization was 10.6 months.

After a period of 6-12 months in hospital, they were returned to their original environment. The malnutrition was intensively treated during hospitalization. In the same families there were 40 children, both older and younger than the underfed children mentioned. who had never been hospitalized for malnutrition. These children were subsequently referred to as the "healthy" brothers and sisters. When the growth in height of these two groups of children was compared, it was found that the underfed children were significantly shorter at the ages of one and two years than their "healthy" brothers and sisters. From the age of three, and at least up to the age of seven, there was no difference in height growth between the two groups. Hospitalization and rehabilitation of the underfed children had evidently made it possible for them to catch up on their height growth. Later, another 18 children from the same families were placed in a sheltered environment from shortly after birth. They were fed optimally and given medical attention and every effort was made to stimulate them optimally in every way. After 18-27 months, they too were returned to their original environment. At that time their height approximated to the 25th percentile of the Boston Standard values for American children. Within a year after return to the family, average height was found to lie below the third percentile, these children then being no longer distinguishable in height from their brothers and sisters at home, from the group of "healthy" children, or from the group of children who had been hospitalized for a time with malnutrition. This applied at least up to the age of eight. The authors suggest that slower growth and lower height may be an adaptation by children in unfavourable conditions to enable them to survive.

Family size and order of birth can also affect growth, although this is most likely ultimately mediated by quality and quantity of nutrition as well. Moyes (1976) finds that it is less a matter of the total number of persons in the house than of the size of the nuclear family (i.e., mother plus all children below the age of 15).

More than four children result in a sharp increase in the frequency of suboptimal growth. Goldstein (1971) does not consider total family size, but refers in his study to order of birth, allowing for stillborn children and the number of younger brothers and sisters of the child, in comparing children at the age of seven. First-born children were found to be 2.3 cm taller than those born fourth or later (after excluding the effect of socioeconomic class, height and age of mother, and whether the mother smoked during pregnancy). Children without younger brothers and sisters are 1.1 cm taller than ones with three or more younger brothers and sisters.
Wingerd and Schoen (1974) find first-born children to be significantly shorter at birth, but taller than the average for the population to which they belong at the age of five. Antrobus (1971) finds a higher percentage of children with growth retardation, malnutrition or death among children born seventh or later on St. Vincent. Russell (1976) describes a study in rural Guatemala, in which it was found that the average height of toddlers increased the lower the number of "dependants" in the family ("dependants" being children younger than 10.5 years at the time of birth of the child under consideration). The periodic study of 8-year-olds in the Netherlands (De Wijn, 1976) showed that first-born children were significantly taller than children born fifth or later.
As regards weight, these differences were evident only in boys. There was no difference between the two groups in skinfold thickness. However, in this case only order of birth was compared, no allowance being made for whether the child concerned was the first child of a large or a small family, for example. With regard to family size, it was found that children from families with more than five children grew significantly less in height than ones from families with less than three children.

There were no significant differences in weight and skinfold thickness in this case. Once again no account was taken here of differences in age of the brothers and sisters or of whether any brothers and sisters had already left the house.

Between socioeconomic groups, there are differences in the growth pattern which also seem to bear a clear relationship to nutrition. This applies both to wealthy countries such as Great Britain (see, for example, Goldstein, 1971) and the Netherlands (Van Wieringen, 1972) and to poor countries such as Colombia (Luna-Jaspe et al., 1970) and Haiti (King et al, 1963). The parameters observed here are usually height and weight, although the same is also reported for other parameters. For example skinfold thickness is larger in the higher than in the lower socioeconomic classes of a population. This applies at least during the period of growth, and for men subsequently as well. The situation is different for adult women in rich countries, where women from the lowest socioeconomic class have a larger skinfold thickness than women from higher classes (Garn, Clark and Guire, 1975). Menarcheal age is also stated to be lower for the higher socioeconomic groups (see, for example, Eveleth and Tanner, 1976; Brundtland and Walløe, 1976).

Other subdivisions are possible within the group of environmental factors in addition to those mentioned above. For example, many workers report differences in growth as between urban and rural populations, coinciding in part with the differences already mentioned between high and low socioeconomic classes. Of course, in studying the urban population of, for example, South American towns, allowance must be made for the sometimes heavily overpopulated shanties on the periphery where "houses" consist of corrugated iron and petrol cans. Here the standard of living is at best no higher than in the country. The seasons also have an effect on growth, although it is not known precisely how.

Height growth, at least in temperate zones, is greater in spring and summer, while weight increase in these zones is larger in autumn and winter. In the tropics this correlation appears to be connected with the rainy season (where present), if food then becomes scarce and the likelihood of infections increases (Eveleth and Tanner, 1976).

One further point must be made. Although it may appear that "larger" and "better" are used as synonyms in the foregoing, this is certainly not intended. For in the rich countries, various problems arise when weight and skinfold thickness increase. The fact that greater height is not an advantage in all circumstances is also clear, for example, from a study carried out in southern Peru (Frisancho, Sanchez, Pallardel and Yanez, 1973). In very bad socioeconomic conditions, mothers with shorter body length were found to have a significantly higher "offspring survival" percentage (number of children living divided by total number of children born multiplied by 100) than mothers with greater body length. This was also found to be the case when allowance was made for the age of the mother. These better chances of survival of children of small mothers are regarded by Frisancho as a better adaptation to socioeconomic conditions.

3.2. SECULAR GROWTH TREND

The secular growth trend is the acceleration or retardation of growth and maturation, and the change in adult height and weight, in consecutive cohorts or generations of a given population (Van Wieringen, 1972). What is involved, therefore, is the occurrence within a population, during the course of time, of an increase or decrease in the age at which a given height is reached, maturational characteristics develop, and height growth stops, accompanied also by an increase or decrease in adult height. In his dissertation on the secular growth trend in the Netherlands (1972), Van Wieringen includes an extensive historical review of growth studies in the Netherlands, discussing theories of secular changes in growth.

Oppers (1963), using Dutch material, showed that a continuous change is taking place in average adult body length, which has been increasing since about the middle of the last century not only in the Netherlands but also in other European countries. An increase in average body length has also been observed outside Europe, in Asia, Australia, north America and within various ethnic populations (Meredith, 1976; Eveleth and Tanner, 1976). This is concomitant with increasingly early onset of menarche, i.e., a shift of puberty back to an earlier time of development. In most countries this increase in the height of adults amounts to 0.6 - 0.9 cm per decade (Tanner, 1966). Menarcheal age decreases by 3-4 months per decade (Tanner, 1962). Virtually no data are available on the occurrence of secular growth changes in central and south America. Ashcroft and Lovell (1965) found that boys and girls at six schools in Jamaica were taller and heavier in 1964 than in 1951, although the increase for girls below the age of ten was slight. The average difference in height at less than ten years was about 1.5 cm for boys and 0.7 cm for girls. The corresponding differences above the age of ten were 3.3 cm and 3.6 cm respectively. For St. Vincent, Ashcroft and Antrobus (1970) report that children aged 5.5 - 14.5 were taller and heavier in 1969 than in 1949. Their conclusion is based on a comparison of their own measurements with an unpublished report by Webb (1954). In most age groups heights had increased by about 4 cm and weights by some 1.5 kg. Having regard to the age group concerned (5.5 - 14.5), some of the differences between 1969 and 1949 may possibly be due to earlier onset of puberty, but no detailed breakdown of the values by age and sex is given. Eveleth, Salzano and De Lima (1974) report no secular growth trend in adult Xingu Indians in Brazil.

Many authors state that secular growth changes become evident very early on. According to Lenz and Kellner (1965), they are most pronounced in the first years of life. Van Wieringen (1972), on the other hand, finds that the change is greater in schoolchildren than in toddlers, mentioning the following differences between 1965 and the middle of the last century: increase in height for 5-year-olds of 14-15 cm, for 10-year-olds 17-18 cm, for girls of thirteen 22 cm, and for boys of fourteen 21 cm.

Tanner (1966) notes the following trend in European and north American data: since 1900 children of age 5-7 have increased in height by 1-2 cm per decade, and children of 10-14 by 2-3 cm per decade. Craig (1963) calculated the difference in height between children of different ages in Glasgow in 1955 and 1906. The difference was 5 cm for children aged five, about 8 cm for children aged nine, and nearly 10 cm for children aged eleven. All these data show that a large part of the change, expressed in centimetres, took place before the fifth year, although Tanner (1966) cites a publication by Scott (1961) on a study in London in which the biggest shift between 1954 and 1959 was concentrated between the ages of eight and fourteen years, with little difference at the ages of five, six or seven. For the Netherlands, however, about two thirds of the shift is found to occur before the fifth year. For this reason it is interesting to investigate whether there are any other factors, in addition to those mentioned in Section 3.1., which affect growth and are particularly applicable to early youth.
McCance and Widdowson (1974) postulate that growth velocity at later ages - at least in animals - seems to be determined by their rate of growth or perhaps their size during the very early critical period of development in which the regulating centres of the hypothalamus are coordinated with the growth velocity which the animal then has. Enesco and Leblond (1962) and Winick and Noble (1965), on the basis of experiments with rats, defined three growth phases in all organs, namely, growth by cell division (hyperplasia), growth by cell division and increase in the size of already existing cells hyperplasia and hypertrophy), and, finally, growth by increase in cell size alone (hypertrophy). The phase in which cell division predominates can only occur up to a certain time after conception, but may be delayed by malnutrition. If this delay prevents the full number of cells from having been formed in an organ at the end of the cell division phase, this process proves to be irreversible and the organ remains too small throughout the subsequent course of life. Growth in which increase in cell size predominates, however, can take place over a much longer period. Malnutrition during this phase reduces the size of the cells, and hence that of the organ as a whole, only for a certain time.

The eventual size of organs of fully grown animals is found to be determined not only by endogenous, genetic factors, but also by exogenous factors at the time of the cell division phase (Winick, 1975). All these experiments relate to animals. Following these animal experiments, attempts were made to establish equivalent effects in man. For instance, Winick and Rosso (1969A) and Winick, Rosso and Brasel (1972) mention anatomical and chemical investigations in a number of studies in Chile, in which it was shown that serious malnutrition during the first year of life, leading to death, results in a reduced number of cells in the brain, and a reduction in the total quantity of lipids, cholesterol and phospholipids. The reduced head circumference in these children is also stated to reflect accurately the smaller number of cells in their brains (Winick and Rosso, 1969B). In the human brain, the phase with the largest number of cell divisions per unit time occurs before birth. Theoretically, therefore, the brain is most vulnerable at that time. For this reason the consequences of intrauterine malnutrition in the "small-for-date" syndrome have also been studied. The small-for-date syndrome, also known as dysmaturity, refers to a child whose weight is smaller than the third percentile for the relevant gestation period. This does not relate to a homogeneous group. Winick (1975) describes experiments with rats in which experimental intrauterine growth retardation was obtained. Two different forms of the small-for-date syndrome could thus be demonstrated. In the first form, a reduced blood supply to the foetus was induced, resulting in an excessively small foetus. As regards the organs, the liver is small and low in glycogen, while the brain is relatively large. In the second form, growth retardation is induced by limiting protein in the diet of the mother animal. The result was again an excessively small foetus, in which the organs, and in particular also the brain, showed substantial growth retardation. If malnutrition is induced in this second form after birth too, up to the time of weaning, then there is also a greater reduction in the number of brain cells than might be expected from merely adding together the effects of prenatal and postnatal malnutrition.

Animals which were underfed prenatally are evidently more sensitive to malnutrition after birth. Winick (1975) then draws the parallel with the small-for-date syndrome in the richer countries, in which the first form, where blood supply to the foetus is reduced, occurs more frequently than malnutrition of the mother. It was found here that head circumference in young infants with the small-for-date syndrome is relatively less retarded in growth than height and weight, and that attacks of hypoglycaemia occur after birth. Van Gils (1971) also shows how 54 infants with the small-for-date syndrome were retarded in height and weight. Head circumference shows a striking ability to catch up on growth given adequate feeding after birth, but the same applies to a much lesser extent in the case of height and weight. Usher and McLean (1974) also mention uneven growth retardation. They describe small-for-dates as infants with reduced skinfold thickness, retarded bone maturation of the knee, and a small liver and thymus, while the brains are found to be relatively spared. Fancourt, Campbell, Harvey and Norman (1976) examined children aged four who had been born with the small-for-date syndrome and whose intrauterine growth had been tracked by periodic ultrasonic measurements of the distantia biparietalis. Children whose skull growth was already lagging behind before the 34th week of pregnancy were compared with children in which this was only the case after the 34th week of pregnancy. In the period up to the fourth year, it was found that the first group had a greater chance of falling below the tenth percentile in height and weight than the second group. Fitzhardinge and Steven (1972) found, in a follow-up examination at the age of four of children born with the small-for-date syndrome, that their average weight and height lay between the tenth and twenty-fifth percentiles. 35% were below the third percentile, and only 8% were above the median. The head circumference growth curve ran parallel to the height growth curve. Their brothers and sisters born with normal birth weight were in general taller, only 3% of them being below the third percentile curve and 45% being above the median.

These authors also concluded that the delayed maturation signifies that the end of the period of height growth comes later than the average to be expected in that population.

Let us now consider what these data for growth in very early youth mean in the context of the problem of the secular growth trend in populations. For example, children in the Netherlands around 1900 were smaller in height and weight than children today, owing to such factors as inferior nutrition of the mother at that time; and in addition, children around 1900 were exposed to all kinds of unfavourable exogenous influences (infections, malnutrition, etc.). Considering the studies referred to earlier, it is therefore understandable that the growth of these children was retarded, so that they were ultimately smaller than children today. The total period of growth was longer than it is now, but the genetically possible height was not reached. This suggests that the secular change in height and weight growth corresponds to the overall effect of the disappearance of growth-retarding factors, both in utero and after birth, enabling the genetically possible growth pattern to be followed. It is not very likely that all these retarding factors should cease to operate within a single generation. Small mothers who themselves grew up in conditions of want in their early years can, after all, not readily give their children an optimum start. According to Tanner (1962) and Van Wieringen (1972), this takes at least two generations, or about half a century.

3.3. DISCUSSION OF THE RESULTS OF THE AUTHOR'S OWN STUDY IN 1974

3.3.1. *Height and sitting height* (Figs. 13, 14 and 55-62).

The height curves for Aruban children are presented in Figs. 13 and 14 in a single graph together with the Dutch curves from 1965 (Van Wieringen, 1972) and 1955 (De Wijn and De Haas, 1960). It will be observed that the Aruban height curves for 1974 for girls approximate closely to the 1955 Dutch curves.

Differences are more evident for boys. Figs. 55 and 56, in which the Aruban curves are presented together with the average heights of European boys and girls measured between 1961 and 1974 (Eveleth and Tanner, 1976), show that Aruban mean height falls within the dispersion of heights of European children. This also applies to the period below the age of one year (Figs. 57 and 58). Although the Aruban children are smaller than the Dutch ones, they thus fall within the European "norms" - it should, however, be pointed out that Dutch children are among the tallest in Europe.

Sitting heights, for which no Dutch data are available, are also presented against the background of the mean values for European children (Figs.59 and 60). Up to the age of about four, Aruban children are found to have a somewhat shorter mean sitting height, but from about age 4 onwards they fall within the European amplitude of variation. Eveleth and Tanner (1976), who classify populations of Indians in south and central America among Asians, include among their comparisons those of heights of European, African and Asian populations. Comparison of regression curves of mean height and mean leg length show that the European and African curves run parallel, while the Asian curve intersects the European regression line and also has a steeper slope. This means that, for example, Chinese have relatively longer legs than Europeans at a very early age, but gradually come to have shorter leg length in relation to sitting height as the growth period progresses. Something similar may also apply to Aruban children.

The Aruban curves are presented in Figs.61 and 62 together with mean height curves for populations which are geographically somewhat closer together, compiled at about the same time. These include, first of all, data from the "West Indies" (Ashcroft and Antrobus, 1970), on the mean height of children of low socioeconomic class and a predominantly negroid population, calculated from data from Jamaica, Barbados, Guyana, St. Kitts-Nevis-Anguilla, and St. Vincent together.

In addition, there are two curves of data from Bogotá, Colombia (Luna-Jaspe, Macías, Rueda-Williamson, Parra and Téllez, 1970), viz., one for a group of high and one for a group of low socioeconomic class, and finally a curve of data from rural Guatemala (Blanco, Acheson, Canosa and Salomon, 1974). For the sake of clarity, the curve of data for the high socioeconomic class in Guatemale (Johnston, Borden and McVean, 1973) is not reproduced, but it approximates closely to the 1974 Aruba curve.

Two comments must be made concerning these curves:

- The height curves of high socioeconomic class groups in Colombia, Guatemala and Aruba 1974 are virtually identical for boys and girls, but differ very distinctly and considerably from the curves of groups of low socioeconomic class, the dispersion apparently being somewhat greater for boys than for girls.

- The aggregate "West Indian" data curve is virtually identical to the 1954 Aruba curve for boys. This is true for girls up to the age of ten, after which the Aruban curve falls below the West Indian curve. To avoid confusion, from the age of 6.5 years onwards, only the points from the 1954 Aruba curve (Steenmeyer, 1957) which do not coincide with the West Indian curve are included in Figs. 61 and 62. This means that even if the difference between the West Indian curve and the curves for the groups of high socioeconomic class does not appear to be so large, this difference is nearly identical for boys with the magnitude of the secular growth change on Aruba between 1954 and 1974.

3.3.2. *Weight and upper arm anthropometry*

(Figs. 63 - 72)

The weight of Aruban children in 1974 is compared, as was height, with data on the weight of Dutch children in 1955 and 1965 (De Wijn and De Haas, 1960, and Van Wieringen, 1972, respectively) in Figs. 63 and 64.

Only points are given for the Aruban curve, as it coincides almost entirely with the Dutch weight curve for 1955. However, Figs. 65 and 66 show that weight also falls within the amplitude of variation of European weight curves dating from after 1960 (Eveleth and Tanner, 1976).

The Aruban weight curves were then placed in a Caribbean context in Figs. 67 and 68. The weight data from Colombia (Luna-Jaspe et al., 1970), divided into high and low socioeconomic class, from Guatemala with high socioeconomic class (Johnston et al., 1973) and low socioeconomic class (Blanco et al., 1974), and pooled West Indian data (Ashcroft et al., 1970), originate from the same groups of children whose heights were compared (see Section 3.2.1). Comparison of weights clearly shows that the higher socioeconomic groups have an appreciably higher weight for age than the lower socioeconomic classes. The difference between the two Guatemalan groups is particularly striking.

The weight curve for Aruban children in 1974 is situated in the middle of the weight curves for high socioeconomic class in the Caribbean region. The 1954 curve (Steenmeyer, 1957) coincides with the "West Indian" curve, at least up to the age of ten, after which the Aruban curve increases less fast. As with the height curves, only those points on the 1954 Aruban curve (Steenmeyer, 1957) which do not coincide with the West Indian curve are included. For weight, too, then, the distance between the "West Indian" curve and the 1974 Aruban curve is equivalent to the secular growth change on Aruba between 1954 and 1974.

These height and weight measurement data and the coincidence of standard values and curves derived from a large number of measurements in a given population group give useful information on the nutritional condition and health of an individual or population group. However, there are limitations to the conclusions which may be drawn from these observations. For example, it is impossible to draw conclusions as to reciprocal relationships between height and weight unless standard values of weight for height are also compiled.

The calculation of standard values of this kind would, however, require samples with very large numbers of children. Other methods of investigation are also possible in order to answer questions on underfeeding and possible overfeeding. A method now being increasingly used for this purpose is measurement of subcutaneous skinfold thickness. What is in fact measured is the width of the layer of fat surrounding the muscle and bone in the form of a ring. This can be measured by X-ray photography as well as with a caliper (see Section 1.3.2). The correlation between these methods is high, viz., between 0.85 and 0.90 (Tanner and Whitehouse, 1962). Although there are substantial differences between the growth curves for skinfold measurements on the trunk and on the limbs, measurements as between limbs or in different positions on the trunk show a high correlation. A good general impression of skinfold thickness as a whole is thus obtained with the two most commonly used positions: over the musculus triceps and under the scapula. Mean triceps and subscapular skinfold thickness by age for Aruban children in 1974 and London children (Tanner and Whitehouse, 1975) are set out in a single figure in Figs. 69 and 70, for each sex separately. These diagrams show that triceps skinfold thickness is greater at each age than subscapular skinfold thickness. In addition, it will be seen that the difference on Aruba is smaller than in London: although the Aruban children have a smaller triceps skinfold thickness, their subscapular skinfold thickness is larger. The difference between London and Aruban triceps skinfold thickness seems to disappear towards puberty. It is not clear whether the difference in fat distribution reported here is ethnically determined. Eveleth and Tanner (1976) mention a similar difference in fat distribution between Ladinos in Guatemala and British children. Subscapular skinfold thicknesses are the same as or greater than those of London children in Asians of all socioeconomic groups. As regards triceps skinfold thickness, socioeconomic class appears to determine whether the values attained are the same as those for London.

Triceps and subscapular skinfold measurements can already give a better impression than weight/height curves of how fat a child is compared with other children or in relation to previous measurements independent of height. However, since, for example, excessive weight for a given height may mean that a child has too much fat, is muscular, or is heavy-boned, the triceps skinfold measurement is also not yet sufficiently differentiated. What is actually being measured is a skinfold (skin + fat), which in fact gives no indication of the extent of the mass of fat or muscle present on the arm. A thin skinfold on a muscular arm, which thus has a larger circumference, can in principle contain just as great a mass of fat as a thick skinfold around a less muscular arm, whose circumference is thus smaller. Such distinctions are not brought out by the skinfold measurement alone. It is useful to find a closer approximation for this, particularly as muscle and fat mass are also indirect indicators of the body's protein and calorie reserves. For this reason the concepts of arm muscle area and arm fat area have been introduced, the assumption being made that the upper arm constitutes a cylinder (see Section 2.4). The mean values for this parameter for Aruba 1974, data from the United States (Frisancho, 1974), and data from Guatemala (Martorell, Yarbrough, Lechtig, Delgado and Klein, 1976), are presented in Figs. 71 and 72. The United States data are taken from the "Ten State Nutrition Study" (low and middle socioeconomic class); the Guatemalan data are of rural origin (low socioeconomic class). It will be observed that the Guatemalan curve for arm muscle area is appreciably lower than the other two curves, and that the Arubans up to the age of about 9.5 years have virtually the same arm muscle area as the Americans.
Arm fat area (for which no American data are available) is conspicuously stable up to the age of 8.5 years for boys and 7.5 years for girls. There is no difference in arm muscle area between boys and girls up to puberty. Gurney (Gurney and Jelliffe, 1973) reports that fat area on the arm undergoes little change between 1 and 7 years.

Table 48

Arm muscle area and arm fat area at various stages of puberty

Girls Breast stage	N	minimum age	median age	maximum age	median arm muscle area	mean arm muscle area	median arm fat area	mean arm fat area
B-2	108	7.2	11.0	14.2	20.6	21.9	8.9	10.8
B-3	97	9.4	11.7	13.8	24.3	25.0	10.0	12.2
B-4	81	10.4	12.5	14.8	26.9	27.6	12.4	14.5
B-5	8	12.3	13.5	14.3	30.0	29.4	13.5	20.7
Boys Genital stage								
G-2	136	8.6	12.1	14.5	23.1	24.3	6.8	8.2
G-3	20	11.8	13.1	14.2	22.7	24.9	5.4	6.7
G-4	18	11.8	13.2	14.6	33.2	33.1	8.2	9.9
G-5	4	12.1	13.0	14.3	34.0	34.6	7.3	10.2

There may possibly be some connection with puberty. An increase in arm fat area may commence with the onset of puberty, this increase being more pronounced in girls than in boys. It is not clear from these curves whether arm muscle area also shows a greater increase or at least a change in growth pattern with the onset of puberty. Van der Werff ten Bosch (1969) correlated pubertal stages with skinfold thickness and muscle and fat area, among other parameters. For girls he chose the stages of breast development, because these usually precede the development of pubic hair growth; for boys, for the same reason, he took the change in testicular size. His study was of the cross-sectional type. He found that in boys one of the first changes at the onset of puberty was an increase in the amount of fat on the limbs together with some increase in muscle, fat loss and a considerable increase in muscle occurred only towards the end of testicular development. In girls, the fat area was found to decline somewhat at first during breast development, but this was followed by a sharp increase late in puberty. Muscle area began to increase after the attainment of Stage 2 of breast development. Aruban data from 1974 are treated in a similar manner in Tabel 48, although genital development is used instead of testicular size for boys.
There is a clear connection between arm muscle area and pubertal development.In girls muscle development increases quite uniformly as puberty proceeds. In boys there is, in particular, a sharp increase towards the end of puberty. It is striking that muscle area is approximately the same in girls and boys half-way through pubertal development (Stage B-3 in girls and Stage G-3 in boys). Arm fat area also increases uniformly in girls as their puberty advances, whereas in boys any increase in arm fat area takes place predominantly at the end of puberty.

3.3.3 *Head circumference, head length and head width*

The mean head circumference of Aruban children in 1974 is compared with data for other populations in Figs. 73 and 74. These data are obtained from an article by Meredith (1971), who discusses head circumference in different ethnic population groups and for both sexes, and refutes the conclusion in a previous report by Nellhaus (1968), to the effect that there were no significant ethnic and geographical differences in head circumference. Meredith (1971) compared head circumference at birth, at the age of one year, and during youth and puberty, grouping together a large number of investigations. Among other conclusions, he noted that the head circumference of Europeans at birth, for example, is 1.1 - 1.4 cm greater than that of neonates in India and Ceylon, and that from the ages of 4 to 18 the head circumference of, for instance, Bulgarians is 2.3 - 3.1 cm greater that that of children of the same age in India. Figs. 73 and 74 show that the values for head circumference on Aruba are comparable with those for Europeans. This is also indicated by the curve (not included in the diagram) for average Dutch head circumference (Hautvast, 1971), which closely corresponds to the Aruban curve, for both boys and girls. Head length and width of children in the Netherlands (Hautvast, 1971) and in Aruba (1974) are compared in Figs. 75 and 76. The head width of Aruban children is found to be about 0.5 cm smaller in both boys and girls. The difference in head length is even smaller. Concerning the sex difference in the head circumference growth curve, Meredith (1971) also mentions a decrease in the magnitude of the difference in head circumference between boys and girls from early youth to about the age of 13, at which age the difference is smallest. He observed this trend in all populations. The differences between boys and girls on Aruba around the age of 14 (Fig. 24 and Tables 16 and 17) are absent.

3.3.4 *Pubertal development*

Tables 49 and 50 present data on the pubertal development of Aruban boys and girls in 1974 together with data from three studies in Europe describing pubertal development:

Table 49

Ages at the attainment of various stages of male pubertal development in various studies

	G-2	G-3	G-4	G-5	PH-2	PH-3	PH-4	PH-5
Aruba, 1974 (median ages)	11.5-12.0	13.5-14.0			12.5-13.0	13.5-14.0		
Netherlands, 1965 (median ages)	11.0	13.2	14.2	15.9	11.8	13.5	14.4	16.0
Great Britain, 1969 (mean ages)	11.6	12.9	13.8	14.9	13.4	13.9	14.4	15.2
Sweden, 1976 (mean ages)	12.2	13.1	14.0	15.1	12.5	13.4	14.1	15.5

The mean ages in Great Britain were obtained by photographic examination (mixed longitudinal data). The mean ages in Sweden were obtained by clinical examination (longitudinal data). In Aruba and the Netherlands data were obtained by clinical examination in a cross-sectional study.

Table 50

Ages at the attainment of various stages of female pubertal development in various studies

	B-2	B-3	B4	B5	PH-2	PH-3	PH-4	PH-5	Menarche
Aruba, 1974 (median ages)	10.5-11.0	11.5-12.0	13.0		11.0-11.5	12.0	13.0-13.5		13.1
Netherlands, 1965 (median ages)	11.0	12.1	13.4	15.2	11.3	12.2	13.3	14.9	13.4
Great Britain, 1969 (mean ages)	11.2	12.2	13.1	15.3	11.7	12.4	13.0	14.4	13.5
Sweden, 1976 (mean ages)	11.0	11.8	13.1	15.6	11.5	12.0	12.9	15.2	13.0

The mean ages in Great Britain were obtained by photographic examination (mixed longitudinal data). The mean ages in Sweden were obtained by clinical examination (longitudinal data). In Aruba and the Netherlands data were obtained by clinical examination in a cross-sectional study.

Swedish data (Tarranger, Engström, Lichtenstein and Svennberg-Redegren, 1976) collected in a representative urban population by a cross-sectional study; British data (Marshall and Tanner, 1969 and 1970) from a semilongitudinal study in a population of high socioeconomic class; and Dutch data (Van Wieringen, 1972) collected in 1965 during a national cross-sectional study. In Britain the photographic method was used, the stage of puberty being recorded photographically at the time of each investigation and then being assessed from these photographs. In the other three studies the stage was determined solely from a clinical examination. The advantages and disadvantages of both methods have recently been clearly balanced against each other by Tarranger et al. (1976). Both the Aruban and the Dutch median ages, i.e. those at which 50% of the children showed a given maturational feature - were obtained from cumulative frequency curves. The Aruban ages are presented with a certain margin, because in some cases (see Tables 30 and 31) the numbers were on the small side and the best-fitting cumulative frequency curves drawn did not admit of greater precision in indication of the median age - not even when the logit analysis was performed on them. The absolute number of children examined in the national Dutch study were many times greater.

A striking feature of these tables is the high degree of agreement in the ages at which specific maturational characteristics appear in spite of the great difference between these populations (although the differences between girls alone are somewhat smaller than those between boys alone). On average, pubic hair growth appears to commence after the onset of genital development in boys and after the onset of breast development in girls. Menarche always occurs within Stage 4 of pubic hair growth and breast development.

The median menarcheal age of Aruban girls in 1974 (13.11 years) is somewhat lower than that in the Netherlands, where the median was 13.43 in 1965 and 13.37 years in 1971-1972 (Van Venrooy-IJsselmuiden, Smeets and Van der Werff ten Bosch, 1976). The height differences between girls of the two populations during the period of puberty are thus clearly not attributable to earlier onset of puberty, with the associated growth spurt, in the Dutch girls.

3.3.5 *Order of birth, family size, and family income*

Height, weight, skinfold thickness and menarche, as studied and compared on the basis of order of birth, family size, and family income, do not show any significant differences. The impression is, however, obtained that first and second born children, smaller families (1-2 children), and a family income exceeding 1000 NaF per month correspond with children of greater height, higher weight, greater skinfold thickness, and somewhat lower menarcheal age. It is not clear whether the small differences found are actually so small in reality or whether perhaps the wrong bases have been chosen. For example, it is conceivable that differences would have been found if a more rigid definition of family size had been adopted. For if nutrition is the ultimate limiting factor, it would probably have been better to ask how many children were still living in the house and not contributing to total family income - so that they were dependent on the income of the rest of the family (see, for example, Moyes, 1976; Russell, 1976). The parameter of family size, however, also includes children who have already left the house. "Family size" also includes those who still live in the house but have an income of their own which they may or may not contribute wholly or partially to the family. Family income admittedly includes the total income of the husband and/or wife, but it is not clear whether income of other members of the family is or is not included in this.

Another possibility is that the differences in prosperity of the group examined are simply too small to be reflected in significant differences in height, weight, skinfold thickness, or menarcheal age. For calculation shows that only 9.0% of the group examined have an income of more than 1000 NaF per month, whilst 91.0% have an income not exceeding 1000 NaF per month.

3.4. SECULAR GROWTH CHANGES : COMPARISON OF THE AUTHOR'S OWN STUDY IN 1974 WITH STEENMEYER'S 1954 INVESTIGATION

In the previous section (3.3), height, weight, and sitting height were considered against the background of Dutch curves from 1955 and 1965 (De Wijn and De Haas, 1960; Van Wieringen, 1972), European curves from 1961 (Eveleth and Tanner, 1976), and curves from the Caribbean region (Ashcroft et al., 1970; Luna-Jaspe et al., 1970; Blanco et al., 1974; and Johnston et al., 1973).

Finally, it is intriguing to compare the values found in 1974 with data for Aruba in 1954 (Steenmeyer, 1957). The secular growth change between 1954 and 1974 in cm is set out by year classes in Figures 19-21. Spearman's rank correlation test (Siegel, 1956) has been used to investigate whether the significant differences found in mean height, sitting height and weight between children on Aruba in 1954 and 1974 also increased significantly with age. This proved to be the case for all three parameters ($\alpha = 0.05$; $t_8 \geq 1.86$). For height, the secular growth change between 1954 and 1974 is significant from year class 5-6 onwards, for both boys and girls. The differences in mean height increase very gradually up to the age of 10.5 years for girls and 13.5 years for boys. In girls, perhaps partly because the onset of puberty was earlier in 1974 than in 1954, there is a conspicuous increase in the difference compared with 1954 after age 10.5. Notable is the fact that the secular growth change on Aruba between 1954 and 1974 only becomes significant from the age of about six (Fig. 13-18), an age in the middle of a period of lower annual increase in height and weight.

In general, decreasing growth velocity is found to commence earlier than this, at about six months (see, for example, Habicht et al., 1974). It is assumed that breast-feeding only then becomes plainly insufficient, while any supplementary food given contains insufficient nutrients for the growth pattern followed until then to be maintained (see Section 3.1). Living conditions on Aruba around 1954 were evidently sufficient to permit a growth velocity which during the first years of life differed little from that of Dutch children around 1955.
Consequently the height growth curve for Aruban children in 1954 ran parallel with that for Dutch children in 1955 until about the age of five. From age six for height and sitting height and from 4½ and perhaps earlier for weight, however, this growth velocity could not be maintained and a lag arose, at least in comparison with the Dutch growth curves. Weight is perhaps more sensitive in this respect than height, and it would therefore be interesting to consider once again skinfold thickness and muscle and fat area data over a period of ten years, together with possible secular growth changes in height and weight.

Are there any indications that changes have taken place in living conditions on Aruba between 1954 and 1974? First of all, the health situation is found to have improved between 1954 and 1974, the improvement being reflected, for example, in a decline in the number of recorded infectious diseases. For instance, bacillary dysentery was determined in 1355 cases in 1954 by laboratory examination for Aruba and Curacao together, this figure having fallen to only 377 in 1974. Open tuberculosis was diagnosed 13 times on Aruba in 1954, but only once in 1974. The infant mortality rate (deaths of children aged less than one year per 1000 live births) also showed a gradual decrease from 47 in 1954 to 33 in 1974. The Aruban infant mortality rate is in general lower than those of surrounding territories (see Table 51).

Table 51

Infant mortality rates* in different countries of the Caribbean area

	1938-1952	1974
Aruba	47	33
Curaçao	42	16
(Netherlands)	38	11.3
"West Indies"	1961	1972
St. Vincent	110	70
Jamaica	40	31
Barbados	60	-
Guyana	45	42
St. Kitts-Nevis-Anguilla	-	-
		1973
Colombia	-	98
Guatemala	-	81

*Infant mortality rate: number of deaths of infants under 1 year of age per 1000 corresponding live births.

One of the reasons for this fall is the appreciable extension and improvement of infant and toddler care now available from the infant and toddler health centres of the White-Yellow Cross, which were started up in 1961 and are now operating very satisfactorily. These centres also provide powdered milk and baby foods free of charge where necessary.

The same factors which affect growth probably also play a part in the fall in, for instance, infant mortality (see also Section 3.1.2). In addition family planning has got under way on Aruba since the beginning of the sixties, having been institutionalized in 1970 by the establishment of the "Fundashon pa promove paternidad responsabel". which is certainly partly responsible for the decline in the birth rate from 35.6 o/oo in 1954 to only 16.3 o/oo in 1973 (i.e., number of live births per 1000 inhabitants). (Statistical Yearbooks 1957 and 1974). This is associated with a fall in family size, insofar, at least, as this can be deduced from a fall in the percentage of pregnancies with high parity (see table below).

Table 52

Year	Parity of mother			
	1-2	3-4-5	6 or higher	unknown
1970	53.8%	31.0%	12.0%	3.0%
1974	70.8%	23.8%	8.2%	-

(De Boer and Zaandam-Verhees, 1974).

There are also indications that the level of prosperity has risen since 1954. It is true that the Lago refinery began to introduce automation after the Second World War, thus greatly reducing the number of jobs. Since the mid-fifties, however, tourism has taken on increasing importance, thus creating jobs in the service sector.

As a result, a considerable number of very large hotels have been built at a fast pace since that time, average utilization of their capacity over the year as a whole being some 80%. The figures for the number of telephone subscriber lines per 100 inhabitants (up from 2.4 in 1954 to 9.9 in 1973) and for private and commercial vehicles (up from 1 for every 10 inhabitants in 1954 to 1 for every 4.4 inhabitants in 1974) are perhaps even more telling.

When all these factors are taken into account, there are certainly indications that living conditions on Aruba in 1974 had improved compared with Aruba in 1954.
Health care has improved, as witness the fall in the number of infectious diseases and in infant mortality; and the level of prosperity has risen. There can be no doubt that this will have contributed to the occurrence of a secular growth change between 1954 and 1974.
According to Steenmeyer (1957), the decline in growth velocity from the age of about six in 1954 was attributable to a food deficiency relative to the energy needs of the body during growth. The retardation of growth velocity at this age is hardly, if at all, detectable in 1974. This is more evident in girls than in boys. However, Aruban children in 1974 still lag behind Dutch children in 1965 in height and weight. But this possible retardation of growth velocity seems to have its origin much earlier in development - perhaps in utero and during the first year of life (see Figs. 13-18). It will have to be left to future studies to show whether these differences too will also eventually disappear.

SUMMARY

This dissertation describes a study of the growth and development of Aruban children up to the age of fourteen years. The study was carried out between February 1973 and April 1974 at a number of schools and health centres equally distributed over the island of Aruba. It was conducted by the writer of this dissertation together with one assistant (later two assistants).

The study falls into three main parts, viz.:

1) Identification of any secular growth trend on Aruba between 1954 and 1974. This problem could be studied because F. Steenmeyer had carried out an investigation into food and feeding habits on Aruba in 1954, in which the height, weight and sitting height of 2470 children between the ages of four and eighteen were determined.

2) Establishment of standard values in the form of percentile curves for height, weight, sitting height, head circumference, and skinfold thickness, and determination of maturational characteristics. At the same time data were collected on factors which may have an effect on the growth and development of the child, viz., family size, order of birth, and family income.

3) Comparison of the Aruban data with those of other populations in Europe and the Caribbean region.

After the introduction, in which the above points are explained, the organization and conduct of the study are discussed in Section 1.

Section 2 presents the results of the author's own study. Dispersion percentiles and median by sex are presented graphically and discussed for the following parameters:

height, weight and sitting height (Section 2.2., Figures 1-6), head circumference (Section 2.3; Figures 22-24), triceps subscapular skinfold thicknesses (Section 2.4; Figures 27-30), arm muscle area (Section 2.4; Figures 31, 32 and 35), and arm fat area (Section 2.4; Figures 33, 34 and 36).

In addition, the annual increase in height and weight is illustrated (Section 2.2.2; Figures 10 and 11), and the sitting height/height ratio is discussed (Section 2.2.2; Fig. 12). The differences in the growth pattern of these parameters in boys and girls are also dealt with. It is found that a secular change in growth has occurred in Aruban children between 1954 and 1974. This is true for height, where the change is positive and significant ($\alpha = 0.05$) for both sexes from age 6.5. It is also true for weight, for girls from age 5.5 and for boys from age 4.5., and for sitting height, where there is a positive and significant ($\alpha = 0.05$) secular growth change from the age of 5.5 years in girls and in boys (Section 2.2.3; Figures 13-21). Finally, Section 2 contains not only data on the effect of family size, order of birth, and family income (Section 2.6; Figures 43-54) but also a classification of the development stages of puberty (Section 2.5; Figures 37-42). The classification in stages as presented by Tanner (1962) is examined with the aid of cumulative frequency curves of half-year age classes. In boys, genital development and pubic hair growth are considered, at least up to the age of fourteen. In girls, breast development, pubic hair growth, and menarche are examined, also up to age fourteen. Menarcheal age calculated by logit analysis was found to be 13.11 ± 0.13 years.

The results presented in Section 2 are reviewed in Section 3. This is preceded by a discussion of the effect of endogenous and exogenous factors on the growth and development of the child, and of the secular growth trend.

The latter is considered in the light of literature on experiments with malnutrition in animals and data on follow-up studies of children with low birth weight relative to gestation time, etc. It is established that the secular growth trend appears to be the overall effect of the disappearance of factors which impede growth - in particular, of those factors which are effective during the intrauterine period and very early youth. In the review of the author's own results for 1974, the 1974 Aruban data are compared with analogous data from the Netherlands, are then placed against the background of European curves, and finally, where possible, are compared with studies in the Caribbean region. After this, the author's own results for 1974 are compared with Steenmeyer's 1954 study.

It is found that the fall in growth velocity for height, weight and sitting height which occurred at the age of five in 1954 was no longer demonstrable at that age in 1974. Differences in height and weight between Aruban children in 1974 and Dutch children in 1965 are, however, still present, although these differences appear to originate early in development.

SAMENVATTING

In dit proefschrift wordt een onderzoek beschreven naar de groei en ontwikkeling van Arubaanse kinderen tot 14 jaar.
Het onderzoek is verricht tussen februari 1973 en april 1974, op een aantal scholen en consultatiebureaus verspreid over het eiland Aruba. De uitvoering berustte bij de schrijfster van dit proefschrift te samen met één, later twee medewersters.
Het doel van het onderzoek was drieledig, te weten:

1) Is er tussen 1954 en 1974 sprake van een seculaire groeiverschuiving op Aruba.
Het onderzoek van deze vraagstelling was mogelijk daar er in 1954 door F. Steenmeyer een onderzoek naar voedingsmiddelen en voedingsgewoonten op Aruba werd gedaan. Hierbij werd tevens van 2470 kinderen tussen vier en achttien jaar de lengte, het gewicht en de zithoogte bepaald.

2) Het vastleggen van standaardwaarden in de vorm van percentielcurven voor lengte, gewicht, zithoogte, hoofdomvang en huidplooidikte, alsmede het bepalen van rijpingskenmerken. Hierbij zijn bovendien gegevens verzameld over factoren die wellicht van invloed zijn op de groei en ontwikkeling van het kind namelijk gezinsgrootte, rangnummer bij de geboorte en gezinsinkomen.

3) Het vergelijken van de Arubaanse gegevens met die van andere populaties in Europa en het Caraïbische gebied.

Na de inleiding waarin de bovengenoemde doelstelling wordt toegelicht, komt in hoofdstuk 1 de organisatie en uitvoering van het onderzoek aan de orde.
Hoofdstuk 2 geeft de resultaten van het eigen onderzoek weer. Spreidingspercentielen en mediaan naar geslacht worden grafisch weergegeven en besproken van de volgende parameters: lengte, gewicht en zithoogte (paragraaf 2.2; Figuren 1 t/m 6), hoofdomvang (paragraaf 2.3; Figuren 22 t/m 24), triceps- en subscapulaire huidplooidikte (paragraaf 2.4; Figuren 27 t/m 30,

armspierweefseloppervlak (paragraaf 2.4; Figuren 31, 32 en 35) en armvetweefseloppervlak (paragraaf 2.4; Figuren 33, 34 en 36).
Daarnaast wordt de jaarlijkse toename in lengte en gewicht toegelicht (paragraaf 2.2.2; Figuren 10 en 11) en de zit-lengte ratio besproken (paragraaf 2.2.2; Fig. 12). Ook de verschillen in groeipatroon van deze parameters bij jongens en bij meisjes komen aan de orde. Geconstateerd wordt dat er een seculaire groeiverschuiving is opgetreden bij Arubaanse kinderen tussen 1954 en 1974. Dit geldt voor de lengte, waarbij de verschuiving positief en significant is voor beide sexen vanaf 6.5 jaar. Maar ook voor het gewicht, voor meisjes vanaf 5.5 jaar en voor jongens vanaf 4.5 jaar en tevens voor de zithoogte waar er vanaf 5.5 jaar bij meisjes en bij jongens sprake is van een positieve en significante seculaire groeiverschuiving (paragraaf 2.2.3; Figuren 13 t/m 21).
Tot slot bevat hoofdstuk 2 behalve gegevens over de invloed van gezinsgrootte, rangnummer van de geboorte en gezinsinkomen (paragraaf 2.6; Figuren 43 t/m 54) ook een overzicht van de ontwikkelingsstadia van de puberteit (paragraaf 2.5; Figuren 37 t/m 42). De indeling in stadia zoals Tanner (1962) die opgeeft, is onderzocht met behulp van cumulatieve frequentie-curven van halfjaarlijkse leeftijdsklassen. Bij jongens is de genitale ontwikkeling en pubisbeharing bekeken althans tot veertien jaar. Bij meisjes werd de mama-ontwikkeling, de pubisbeharing en de menarche onderzocht, eveneens tot veertien jaar. De menarche berekend met behulp van de logit-analyse bleek 13.11 ± 0.13 jaar.
Hoofdstuk 3 bevat een beschouwing van de resultaten die in hoofdstuk 2 werden weergegeven. Hieraan vooraf gaat een bespreking van de invloed van endogene en exogene factoren op de groei en ontwikkeling van het kind, en van de seculaire groeiverschuiving. Seculaire groeiverschuiving wordt bekeken in het licht van onder andere literatuur over experimenten met ondervoeding bij dieren en gegevens betreffende de follow-up van kinderen met laag geboorte-gewicht ten opzichte van de zwangerschapsduur.

Er wordt vastgesteld dat seculaire groeiverschuiving het totale effect lijkt te zijn van het wegvallen van factoren, die de groei remmen en met name van die factoren die van invloed zijn tijdens de intra-uteriene periode en de zeer vroege jeugd.
In de beschouwing van de eigen resultaten in 1974 worden de Arubaanse gegevens uit 1974 vergeleken met overeenkomstige gegevens uit Nederland, vervolgens geplaatst tegen de achtergrond van Europese curven en tenslotte waar mogelijk vergeleken met onderzoekingen in het Caraïbische gebied.
Hierna worden de eigen resultaten in 1974 vergeleken met het onderzoek in 1954 van Steenmeyer.
Er blijkt dat de afname van de groeisnelheid in lengte, gewicht en zithoogte zoals die in 1954 met vijf jaar optrad, in 1974 op die leeftijd niet meer aantoonbaar is. Nog wel aanwezig zijn verschillen in lengte en gewicht tussen Arubaanse kinderen in 1974 en Nederlandse kinderen in 1965. Deze verschillen lijken hun oorsprong echter vroeg in de ontwikkeling te hebben.

RESUMEN

Esta disertación describe un estudio del crecimiento y desarrollo de los niños Arubas hasta la edad de catorce años. El estudio fué llevado a cabo entre Febrero de 1973 y Abril de 1974 en un número de escuelas y centros de salud distribuídos en la isla de Aruba. Fué realizado por el autor de esta tesis junto con un asistente (posteriormente dos assistentes).
El estudio se divide en tres partes principales, a saber:

1) Indentificación de la presencia de alguna tendencia persistente en el patrón de crecimiento en Aruba, entre 1954 y 1974. Fué posible estudiar este problema ya que F. Steenmeyer había llevado a cabo una investigación del tipo de comidas y de los hábitos alimenticios de Aruba en 1954, y en sus datos figuran ta talla, peso y altura sentado de 2470 niños comprendidos entre las edades de cuatro y dieciocho años.

2) Establecimiento de valores standard, expresados como curvas índice para la talla, peso, altura sentado, circunferencia cefálica, espesor del pliegue cutáneo, y determinación de características de maduración. Simultáneamente se recolectaron datos sobre factores que pudieran haber incidido sobre el desarrollo y crecimiento del niño, a saber, tamaño del grupo familiar, orden de nacimiento, e ingreso familiar.

3) Comparación de los datos Arubianos con aquellos de otras poblaciones en Europa y en la región del Caribe.

Luego de la introducción, en la cual se exponen los puntos arriba mencionados, se discute en la Sección 1 la organización y conducción del estudio.

La sección 2 presenta los resultados originales del autor. La media y los índices de dispersión para cada sexo se presentan gráficamente en relación a los siguientes parámetros: Talla, peso y altura sentado (Sección 2.2; Figuras 1-6), circunferencia cefálica (Sección 2.3; Figuras 22-24), espesor del pliegue cutáneo a nivel del triceps y subescapular (Sección 2.4; Figuras 27-30), área de tejido muscular (Sección 2.4; Figuras 31, 32 y 35) y área de tejido adiposo (Sección 2.4; Figuras 33, 34 y 36). Además se ilustra el incremento anual en peso y talla (Sectión 2.2.2; Figuras 10 y 11) y se discute el índice altura sentado/talle (Sección 2.2.2; Fig. 12). También se exponen las diferencias en el patrón de desarrollo de esos parámetros en varones y niñas. Se demuestra la ocurrencia de una alteración persistente en el crecimiento de los niños Arubas entre 1954 y 1974. Esto es válido para la talla, cuya alteración en sentido positivo es significativa en ambos sexos, a partir de los 6.5 años. También se aplica al peso, en las niñas a partir de los 5.5 años y en los varones desde los 4.5 años; en cuanto a la altura sentado se registra asimismo una alteración persistente, significativa y de carácter positivo en el crecimiento, verificable a partir de los 5.5 años en ambos sexos (Sección 2.2.3; Figuras 13-21). Finalmente, la Sección 2 contiene no solamente datos sobre el efecto del tamaño del grupo familiar, orden de nacimiento e ingreso familiar (Sección 2.6; Figuras 43-54) sino también una clasificación de los estadios de maduración en la pubertad (Sección 2.5; Figuras 37-42). Se examina la clasificación en estadios, de acuerdo a Tanner (1962), en base a curvas cumulativas de frecuencia extraídas en clases que difieren entre sí por medio año de edad. En los varones, se consideran el desarrollo genital y el crecimoento del vello pubiano, por lo menos hasta la edad de 14 años. En las niñas se examina el desarrollo de los pechos, crecimiento del vello pubiano y menarca, también hasta la edad de 14 años. La edad de la menarca, calculade por análisis logit era 13.11 ± 0.13 años.

Los resultados presentados en la Sección 2 se revisan en la Sección 3. Esta está precedida por una discusión del efecto de factores endógenos y exógenos sobre el crecimiento y desarrollo del niño y de la tendencia persistente en el crecimiento.

Esta última se considera a la luz de la literatura experimental sobre nutrición deficiente en animales y los datos de estudios de seguimiento y control de niños nacidos con bajo peso en relación al tiempo de gestación, etc. Se establece que la tendencia persistente del crecimiento representaría el efecto global de la desaparición de factores que lo impiden, en particular aquellos cuya influencia se manifiesta durante el período intrauterino y de la temprana niñez.
En la revisión de los resultados originales del autor referidos a 1974, los datos de 1974 obtenidos para los Arubas se comparan con datos análogos provenientes de los Países Bajos, se contrastan con las curvas europeas, y finalmente, siempre que fuera posible, se los relaciona a estudios de la región del Caribe. Consecutivamente, los resultados originales del autor para 1974 se comparan con el estudio de Steenmeyer en 1954. Se llama la atención la coincidencia de períodos con una gran tendencia a alteraciones persistentes del desarrollo y períodos de alto incremento anual en el peso y la talla.

Se halla que la caída en la velocidad de crecimiento para talla, peso y altura sentado que se registraba en 1954 entre los niños de cinco años, ya no era demostrable en 1974, para esa edad. Sin embargo, aún existen diferencias entre la talla y el peso de los niños Arubas en 1974 comparados con los niños holandeses de 1965, pero esas diferencias parecerían originarse más temprano en el desarrollo.

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CURRICULUM VITAE.

Schrijfster van dit proefschrift werd in 1943 te Rotterdam geboren. Zij doorliep aldaar het Montessorilyceum waarna de studie der geneeskunde te Groningen volgde. Na het afleggen van het artsexamen in 1969 werkte zij gedurende ongeveer een jaar in de kinderkliniek van het Academisch Ziekenhuis te Groningen (Prof. Dr. J.H.P. Jonxis) onder andere onder leiding van Drs. J.A. de Vries op de afdeling Kinder-oncologie. Eind 1970 vertrok zij voor drie en een half jaar naar Aruba (Ned. Antillen) gedurende welke zij als schoolarts werkzaam was. Sinds eind 1975 is zij als wetenschappelijk medewerker verbonden aan de Stichting Nederlandse Werkgroep Leukemie bij Kinderen te Den Haag, ten behoeve van de cytologische diagnostiek.