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CHAPTER 1

General introduction

1.1 THE START

The research described in this thesis was inspired by my previous clinical observations in South Asian children. In Youth Health Care (YHC) practice, I noticed that 'thinness' seemed highly prevalent in children of South Asian descent. I also observed that many South Asian children often had a marked abdominal fat mass, even when classified as 'normal weight' based on universal norms for Body Mass Index (BMI=weight/[height in m^2]) in children. Both these observations and the developing obesity epidemic in the Netherlands prompted, in 2002, my first research project, an epidemiological inquiry into underweight, overweight and obesity in children of different ethnicities in the city of The Hague. One of most striking findings was that South Asian children seemed to grow differently from the other investigated groups.

Youth Health Care in the Netherlands – Preventive Health Assessments
All children (and their parents) and adolescents in the Netherlands are invited at fixed ages to attend (free) preventive health assessments by youth health care physicians and nurses. Between 0 and 4 years of age around 15 of these health check-ups are generally performed, and between 5 and 18 years another four. The attendance rate is generally high, up to 90-100%. The activities during these visits include, but are not limited to, health screenings, vaccinations, health education, and tailored advice. For example, at most visits length/height and weight are measured to monitor the child's health and nutritional status. The data collected during the assessments are registered in a digital health record system. Selected aggregate data are analysed periodically to monitor community health. Depending on the results of the analyses, health promotion activities are often initiated.

Previous research of the municipal health service The Hague (GGD Den Haag) had found that diabetes mellitus type 2 was highly prevalent among South Asians in the city of The Hague.[1] Therefore, one of the hypotheses I postulated was that the high prevalence of diabetes in the South Asian population might be somehow linked to growth in childhood.
By sheer accident, in the Youth Health Care archives I found health records of children born in the 1970s, many of whom were of South Asian descent. I considered this population might constitute an ideal reference population to study the normal growth of South Asian children and to establish ethnic specific BMI norms. Therefore, we secured these records for further research. The studies based on the data of this reference population and on more contemporary populations are described in different chapters of this thesis.

In the next paragraphs of this introductory chapter, I will further describe the main terminology used in this thesis, give background to growth assessments in children, and introduce the research aims that are addressed in the other chapters.

(South Asian) ethnicity

Ethnicity is generally found to be an emotionally charged concept, and refers to people that identify with each other and are connected through race, culture, language, religion, nationality, and/or physical characteristics. Usually ethnicity is being used for groups of people with common ancestry (race) and/or who share a distinctive culture. The definitions vary, from country of birth of the subject or (grand)parents to self-reported ethnicity.[2]

In this thesis the main ethnic group of interest is the South Asian population in the Netherlands, which was defined by their common ancestry. Most South Asians living in the Netherlands originate from the former Dutch colony Suriname, where their ancestors migrated to, from India, between 1873 and 1916 to work as contract labourers on the plantations.[3] Around the time of Suriname's independence from the Netherlands in 1975 a large group of Surinamese South Asians moved to the Netherlands, of whom many settled in larger cities.[4] Currently the city of The Hague has the largest population of South Asians of the European mainland and this group constitutes an estimated 8% (40,000) of the city's population.[4]

Suriname is a country with people originating from different parts of the world: South America, Africa, South Asia, Indonesia, China, and the Netherlands. Therefore, Suriname as country of birth alone is insufficient to ascertain common ancestry. Ethnicity in this thesis was defined both by the parental country of birth and a typical Surinamese South Asian family name of the child and/or the parents. For this purpose a list of common Surinamese South Asian family names was put together, with which the family names in the database were matched.

In Suriname and the Netherlands the family name was customarily inherited from the father's line. Only if the child's paternity was unknown or if the father denied paternity the family name of the mother was passed on to the child. However, in the Netherlands since 1998 parents are allowed to choose whether the child receives the father's or mother's family name.

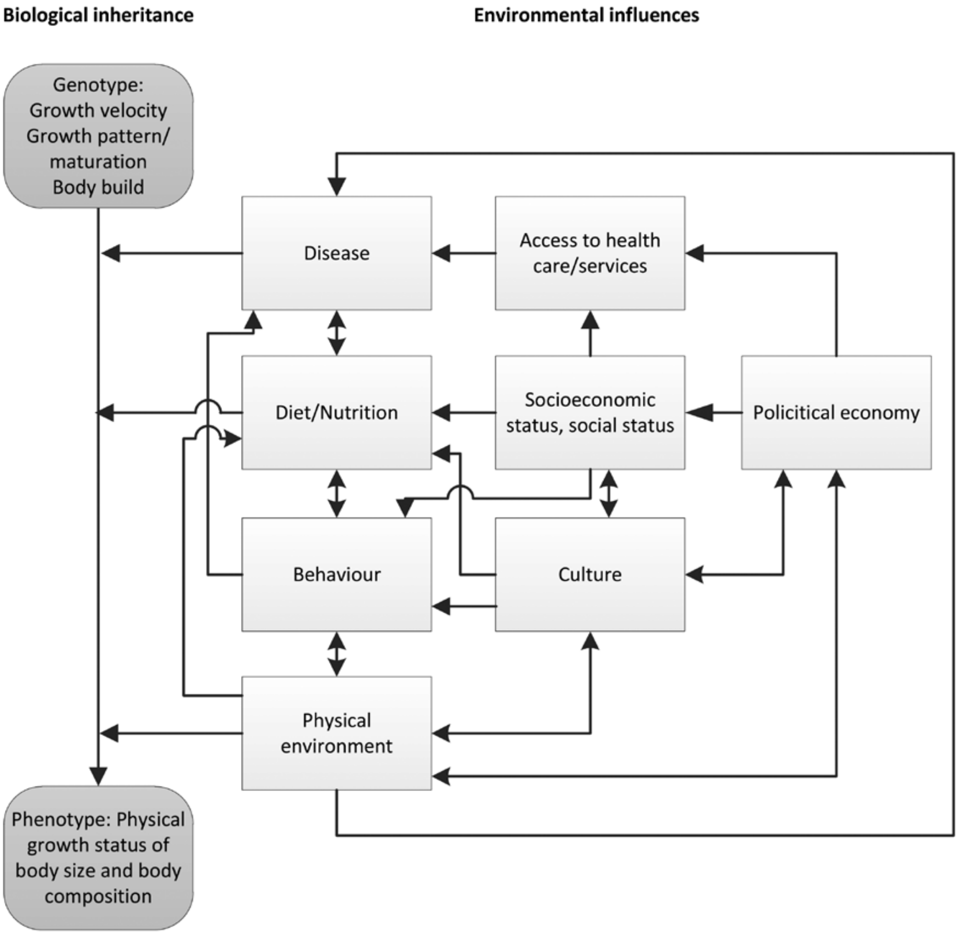
1.2 ASSESSMENT OF GROWTH: REFERENCES AND STANDARDS

An important characteristic of childhood is physical and psychological growth and development. A child's physical growth in body size and body composition is the resultant of both genetic and environmental factors.[5] In optimal environmental conditions, without constraints from socio-economic factors, physical environment, diet, disease, and access to health care (see conceptual model in figure 1),[5–7] children are expected to attain their full genetic growth potential.[7]

To assess an individual child's growth, body measurements are usually taken and compared with anthropometric* references. Such references are usually represented in reference charts (figure 2), which describe the distribution of the specific body measurement in a specific population of children, enabling health care professionals to detect deviations from the average in that population.

* *Anthropometry* comes from the Greek words anthropos (άνθρωπος = man) and metron (μέτρον = measure) and refers to the measurement of the human individual.[8]

Figure 1 *Conceptual model for influences on physical growth and development (based on various sources)*[5–7]



Often childhood growth references are based on anthropometric data from healthy affluent populations that were minimally affected by negative environmental influences, thus reflecting the optimal growth for the specific population. Such references are inherently normative and are called ‘standards’.

Based on such references, each individual measurement can be described in terms of a z-score or percentile which indicates the measurement‘s deviation from the (normative) population median; in the case of z-scores the deviation is quantified in the number of standard deviations the measurement deviates from the median.

When the specific anthropometric variable of interest is normally (symmetrically) distributed, z-scores can be calculated with the formula:

$$z = \frac{X\ (= observed\ value) - \mu\ (= median\ reference\ value)}{\sigma\ (= SD\ of\ the\ reference\ population)}$$

The nutritional status* of babies, preschool children, schoolchildren and adults is generally assessed with indirect measures of body composition or adiposity such as weight and BMI (=weight in kg / [height in m]^2). For adults single BMI cut-offs are generally used to assess the nutritional status (and the associated health risks) (Table 1)[5]. Customarily, in adults a BMI ≥25 kg/m^2 but <30 kg/m^2 is called 'overweight' and a BMI ≥30 kg/m^2 obesity.
As in children body proportions and body composition change during the physical development from birth till adulthood single BMI cut-offs are unsuitable. In babies birth weight and birth weight-for-gestational-age references are commonly used in general practice, whereas in older children weight-for-age (0-2 years), weight-for-height (2-5 years) and BMI-for-age (2-18 years) references are customarily applied.

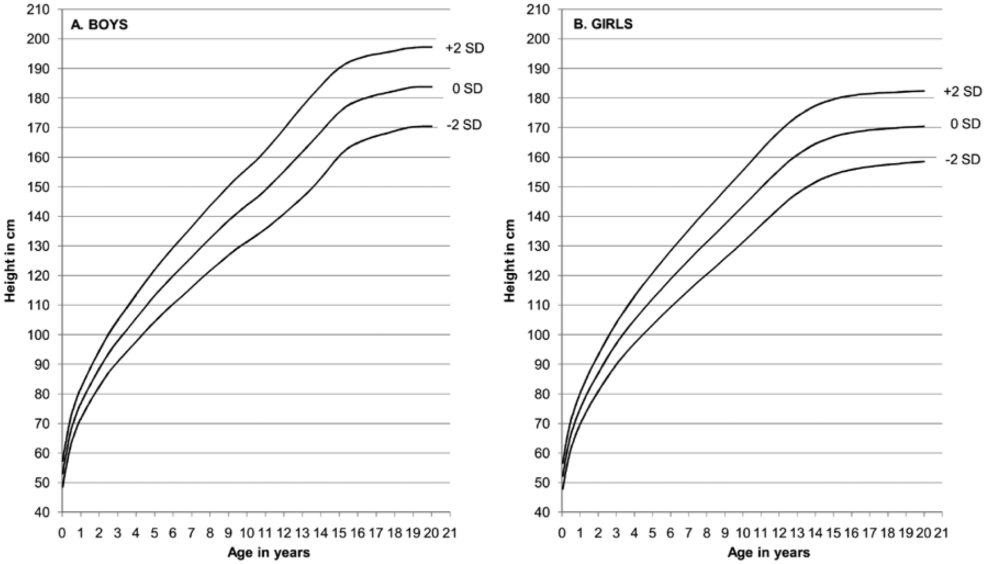
To identify children with potential health or nutritional problems, z-score or percentile cut-off values for each anthropometric reference are commonly defined above or under which the chance of such problems is high. The choice of cut-offs is mostly based on experience or empirical research in affluent populations.[5] WHO recommends the use of a z-score <-2 SD (corresponding to the 2.3rd percentile) based on either height-for-age, weight-for-age, weight-for-height, or BMI-for-age references as an indicator of an increased likelihood of health or nutritional problems. In this classification, overnutrition (overweight) is indicated by a z-score ≥+2 SD based on weight-for-height or BMI-for-age references.[10]

Table 1 *Universal BMI classification for adults (≥18 years)*[5]

BMI (kg/m^2)	BMI classification	
<16	thinness grade 3	
16.0-16.99	thinness grade 2	
17.0-18.49	thinness grade 1	
18.5-24.99	normal weight	
25.0-29.99	overweight grade 1	**Overweight**
30.0-39.99	overweight grade 2	**Obesity**
≥40	overweight grade 3	

* *Nutritional status* is defined as the extent to which nutrients are available to meet the body's metabolic needs[9]

Figure 2 *Height-for-age references 0-20 years based on a cross-sectional study of height in Dutch boys (A) and girls (B) in 2009*[11]



Since the 1980's obesity rates have reached epidemic proportions both in adults and children worldwide.[12,13] Therefore, BMI distributions of contemporary populations do not sufficiently represent a normative BMI as the corresponding distributions will be markedly skewed to the right.[14] For that reason, the current BMI standards for children were based on BMI data of healthy affluent populations that were not (or minimally) affected by the obesity epidemic. The recommended 'standards' are the WHO references,[15,16] and a standard that is known as the IOTF (International Obesity Taskforce) cut-offs 2-18 years. This latter standard was based on BMI centile or standard deviation (SD) lines that pass the recommended universal adult BMI cut-off at age 18. The corresponding cut-offs for all ages between 2 and 18 years are easily derived from these centiles.[17,18] Recently this standard has been extended to facilitate the calculation of BMI z-scores.[18] An advantage of this standard is that a continuing line from childhood into adulthood was realised. Nevertheless, even though the WHO criteria were based on SD cut-offs (-3 SD, -2 SD, -1 SD, +1 SD, and +2 SD), the corresponding cut-offs at 18 years also largely concur with the universal adult BMI cut-off points.[15,19]

1.3 ETHNIC DIFFERENCES IN BODY SIZE AND BODY COMPOSITION

Length/Height

Growth in length (supine), height (standing), and weight of children <5 years of age has been shown to be largely similar between various affluent populations of children from different ethnic backgrounds.[20,21] Also during preadolescence, growth of height shows limited variation between affluent populations from most ethnicities.[22]

Because of the similarities in growth patterns in young children during the first 5 years of life, the World Health Organization (WHO) decided to develop a universal child growth standard for all children aged 0-5 years, based on growth (height, weight and BMI) of children from six affluent contemporary populations of all continents to be representative of all ethnicities.[15] As a standard it was designed to be normative and therefore implicitly holds a value judgement, i.e. it describes 'how children should grow' in optimal environmental conditions.[23] WHO also developed complementary universal references for the assessment of height, weight and BMI in school-aged children and adolescents 5-19 years of age. These references were based on the growth data of US children from the former 1977 NCHS/WHO growth reference. Though the references derived from these data were based on growth in only one ethnic group instead of several populations of different ethnicities, the references were intended to be widely used. Together the WHO Child Growth Standard 0-5 years and the WHO Child Growth Reference 5-19 years form one single reference with a smooth transition at age 5 years.[19]

Nevertheless, Asian populations have been shown to deviate from the universal growth pattern.[24] They are generally shorter during preadolescence and have an earlier pubertal growth spurt than other ethnic groups which sets them apart from other ethnic groups. These findings raised doubts about the suitability of a single reference for all Asian subpopulations.[24]

Weight and body mass index

As with universal height references, the suitability of universal BMI references for all ethnic groups is dubious.[25,26] During the past decades evidence has emerged that the current universal references and cut-offs for the assessment of the nutritional status do not adequately reflect the body composition in all ethnic groups. Furthermore, the associations between the nutritional status indicator and associated health risks have been shown to differ between ethnic groups.[27–29] In particular, Asian populations were shown to be predisposed to a lower BMI from birth through adulthood because of a typical 'thin-fat' body composition, comprising of a smaller lean body mass percentage but a higher percentage of fat at equivalent BMI levels compared with populations of European descent.[28,30–32] Because of this typical body composition cardiometabolic risks (=risk of Diabetes Mellitus type 2 and cardiovascular disease) are increased in Asian populations at a lower BMI compared with European populations.[30,31,33–35] For that reason, WHO recommended to lower the BMI cut-off values for overweight and obesity for all Asian adults, respectively from 25 kg/m^2 to 23 kg/m^2 and from 30/kg m^2 to 27.5 kg/m^2.[27] However, within the Asian group there is also heterogeneity in body composition and health risks.[27,36,37] For example, South Asian adults have a lower lean body mass and a relatively higher fat mass than Chinese adults,[37] and consequently South Asians are more insulin resistant* at even lower BMI levels.[37,38] These findings led India to lowering the BMI cut-offs for obesity even

* *Insulin resistance* is a physiological condition in which cells, mainly skeletal muscle, fat and liver cells, show a reduced response to insulin. Insulin is a hormone with several functions of which the delivery of glucose in the cells, providing them with energy, is best known. When blood glucose levels remain high, as a compensatory mechanism insulin synthesis is increased to counteract the reduced cell response. When the pancreatic beta cells in which insulin is produced progressively fail to secrete large enough quantities of insulin, this ultimately leads to continuously elevated blood glucose levels, a condition known as type 2 diabetes mellitus.

further from 27.5 to 25 kg/m^2 as this value better reflects the associated health risks.[39]
Because of the 'thin-fat' body composition, also South Asian babies born in developed countries are shown to be generally lighter at birth than their native counterparts, and they are more often small-for-gestational-age (SGA, birth weight <10th percentile for gestational age) when based on a single population standard.[40–43] Also in the Netherlands the mean birth weight of South Asian babies was found to be considerably lower than in other ethnic groups, a difference that could not be explained by known determinants such as parental weight and height, and socioeconomic and life style factors.[44,45] Nevertheless, perinatal mortality and morbidity in South Asian babies were shown to be lower at equivalent birth weight (for gestational age) than in other ethnic groups[40,46–48] This suggests that the high rates of LBW and SGA in South Asian babies are not expressions of fetal growth restriction but are rather physiological or constitutional in origin.[29,49] Consequently, a single population standard for determining SGA in (South) Asian babies would misclassify many healthy South Asian babies as SGA. Therefore, in several countries, including the Netherlands, South Asian specific birth weight standards were developed,[29,45,50–53] some of which demonstrated a considerably higher association between SGA and adverse birth outcomes than the single population standard.
Even though South Asian children and adolescents have a body composition and cardiometabolic risk profile similar to adults,[30,33,35,54,55] the BMI cut-offs for South Asian children 2-18 years have not been adjusted. Several research groups already proposed lowered BMI cut-offs to determine overweight and obesity in South Asian children and adolescents[56–59] but none of these sets of BMI criteria have been recommended for use in general practice. The appropriateness of such adjusted BMI cut-offs specifically for South Asian children has been subject of debate. As much is unknown about the association between BMI, adiposity and cardiometabolic risks a definitive answer to the question of the desirability of ethnic specific BMI cut-offs cannot be given at this moment.[60] Nonetheless, a recent study of BMI and cardiometabolic risks in Sri Lankan children demonstrated a considerably higher sensitivity at detecting 'metabolic derangements' with ethnic specific BMI cut-offs for overweight than with the IOTF criteria, while the specificity was equally high. This indicates that South Asian specific cut-offs may be more suitable for use in general practice than the current universal standard. Normal values of weight, height, and BMI of affluent South Asian children living in a western country are currently not available. Such data may support the acceptance of ethnic specific growth references and lowered BMI cut-offs for this group, and may aid in the proper assessment of the nutritional status of South Asian children.

1.3 AIMS OF THE THESIS

The aims of this thesis are:

1. to gain more insight into the normal physical growth of South Asian children living in the Netherlands (relative to other ethnic groups), and to support the hypothesis that affluent South Asian children living in a Western country are lighter and shorter than children from other ethnic groups;

2. to develop South Asian specific height-for-age (0-21 years) and BMI-for-age (2-18 years) references and compare these with current universally used references;
3. to determine BMI cut-off values for thinness, overweight and obesity specifically for South Asian children 2-18 years with similar methods as the current universal standards, and to compare these with other sets of BMI cut-offs.

1.4 DATA COLLECTION

For this thesis several datasets of growth in children were used. Most of the data were routinely collected during preventive health assessments by youth health care physicians, youth health care nurses, and medical assistants. As not all ages between birth and 21 years were represented in those datasets, additional data were collected to establish a Surinamese South Asian growth study with representative samples of males and females 0 to 21 years. Table 2 summarizes the different datasets used, most of which were derived from the (digital) health record system of Youth health Care of the city of The Hague.

Table 2 *Study population datasets of this thesis*

Period	Type	Source	Ethnic group	Ages	Data, main measures	Thesis chapter
Cohort 1974-1976: measurements 1974-1994	Longitudinal	Routine data	Surinamese South Asian	0-18 years	Birth weight, GA, height, weight	2, 3, 6, 7
Cohort 1991-1993: measurements 1991-2008	Longitudinal	Routine data	Surinamese South Asian	Birth, 3-8 and 13-15 years	Birth weight, GA, Height, weight	2, 3
1999-2007, 2008-2011 added later	Cross-sectional and longitudinal	Routine data	Dutch, Turkish, Moroccan and Surinamese South Asian	3-4, 5-6, 7-10, and 13-16 years	Height, weight	4, 5
2006-2009	Cross-sectional and longitudinal	Routine data	Surinamese South Asian and Dutch	Birth, 0-4 years	Birth weight, GA, length/ height, weight	2, 6
2007-2009	Cross-sectional	Routine data	South Asian	5-6, 9-10, and 13-16 years	height, weight	6
2008-2009	Cross-sectional	Additionally collected data	South Asian	4-20 years	height, weight	6

GA= Gestational age

1.5 THESIS OUTLINE

This thesis is divided into two parts. The first part (chapters 2-5) covers epidemiological questions conducted to gain more insight into the normal weight and BMI development of South Asian children in the Netherlands. The second part (chapters 6-7) reports the studies in which growth references for South Asian children were created.

Chapter 2 describes the time trends in mean birth weight and LBW and SGA rates in Surinamese South Asian neonates over a period of 35 years. The aim was to gain more insight into the normal values for this group and the changes that may have occurred over the studied period. Furthermore the birth characteristics of contemporary South Asian neonates were compared to those of a cohort of Dutch neonates (of European descent) of the same period.

In **chapter 3** reports the BMI distribution in two birth cohorts. The objective was to gain more insight into the normal BMI (class) distribution in Surinamese South Asian children, living in the city of The Hague (the Netherlands), and the changes that may have occurred under the influence of a progressively obesogenic environment.

Chapter 4 and **chapter 5** both deal with the time trends from 1999 in the prevalence of overweight and obesity among children aged 3-16 years in the city of The Hague. The four largest ethnic groups of the city of The Hague (Dutch, Turkish, Moroccan and Surinamese South Asian) were included and differences between these populations were studied.

Height-for-age references 0-20 years, based on growth of contemporary Surinamese South Asian children in 2009-2010 are described in **chapter 6**. The new references were compared with references based on a historical cohort of South Asian children born 1974-1976, and with current Asian Indian, Dutch and WHO references.

Chapter 7 presents a new South Asian specific BMI reference and BMI cut-off values for thinness, overweight and obesity, based on BMI data from the reference cohort 1974-1976 of South Asian children in the Netherlands. In addition, in this chapter the newly defined BMI cut-offs are compared with universal BMI cut-offs and cut-offs based on the BMI of children in India.

Chapter 8 summarises the main findings, discusses the clinical relevance and implications, and provides recommendations for further research.

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