DOES ONE SIZE FIT ALL?

The case for ethnic specific standards to assess growth in South Asian children

JEROEN DE WILDE

Does one size fit all?

The case for ethnic specific standards to assess growth in South Asian children

Jeroen de Wilde

ISBN 978 94 6259 524 8

Layout and cover design by: José Noé & Jeroen de Wilde
Printed by: Ipskamp drukkers
Photos by: Jeroen de Wilde

Does one size fit all?

The case for ethnic specific standards to assess growth in South Asian children

Proefschrift

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van Rector Magnificus prof.mr. C.J.J.M. Stolker,
volgens besluit van het College voor Promoties
te verdedigen op woensdag 18 februari 2015
klokke 15:00 uur

door

Jeroen Alexander de Wilde

geboren te Wageningen
in 1970

Promotiecommissie

Promotores
Prof. Dr. B.J.C. Middelkoop
Prof. Dr. S. van Buuren (Universiteit Utrecht)

Overige leden
Prof. Dr. H. Raat (ErasmusMC, Rotterdam)
Prof. Dr. J.M. Wit
Dr. P.H. Verkerk (TNO, Leiden)
Prof. Dr. R.A. Hirasing (VUmc, Amsterdam)
Prof. Dr. R. Reis
Prof. Dr. S.E. Buitendijk

Financial support by the Dutch Heart Foundation and the department of Youth Health Care of the Community Health Service (GGD) Haaglanden for the publication of this thesis is gratefully acknowledged.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

BMI	Body Mass Index
CI	Confidence Interval
GA	Gestational Age
IOTF	International Obesity Taskforce
LBW	Low Birth Weight
NA	Not available
NCHS	National Center for Health Statistics
OR	Odds Ratio
SD	Standard deviation
SDS	Standard Deviation Score
SES	Socioeconomic Status
SGA	Small-For-Gestational-Age
SPSS	Statistical Package for Social Sciences
WHO	World Health Organization

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.

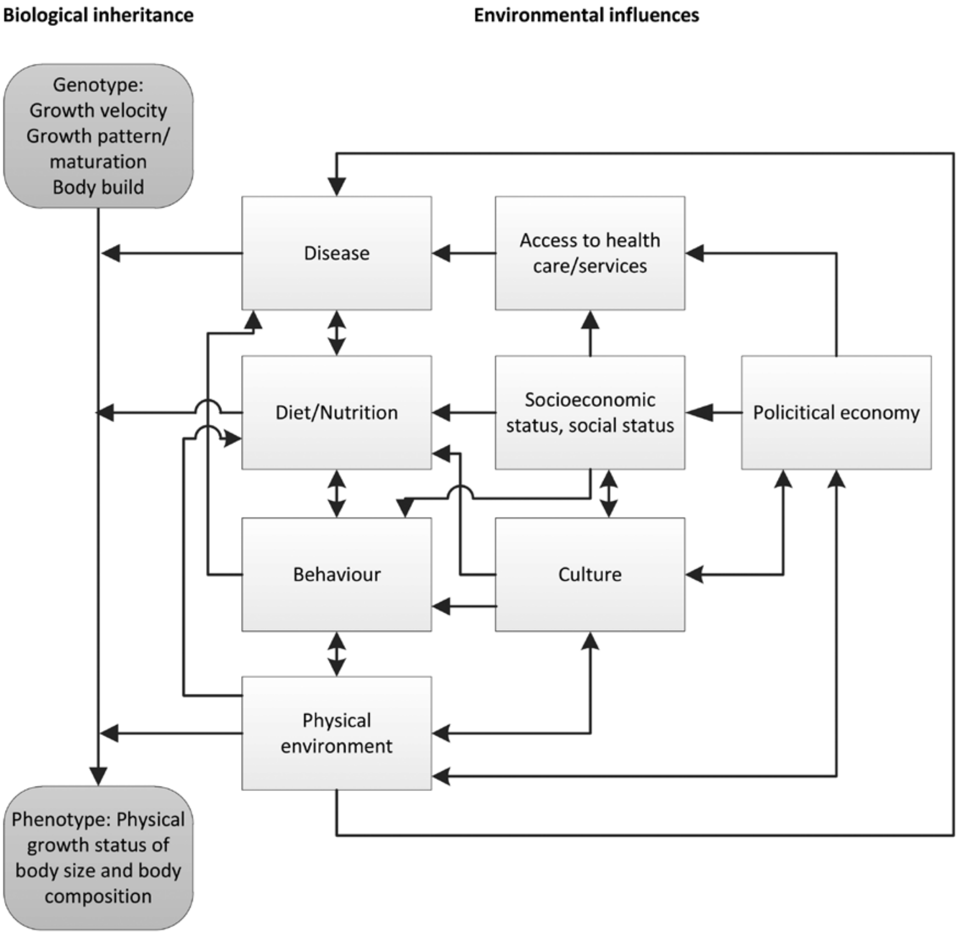
1.2 ASSESSMENT OF GROWTH: REFERENCES AND STANDARDS

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.

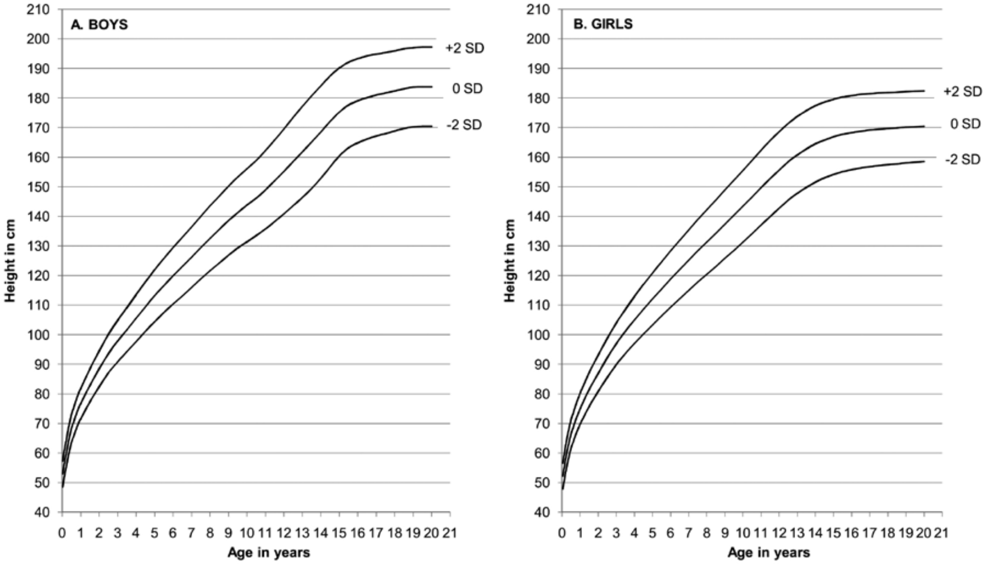
To identify children with potential health or nutritional problems, z-score or percentile cut-off values for each anthropometric reference are commonly defined above or under which the chance of such problems is high. The choice of cut-offs is mostly based on experience or empirical research in affluent 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.

REFERENCES

1. Middelkoop BJ, Kesarlal-Sadhoeram SM, Ramsaransing GN, Struben HW. Diabetes mellitus among South Asian inhabitants of The Hague: high prevalence and an age-specific socioeconomic gradient. *Int J Epidemiol* 1999; 28(6):1119-1123.
2. Stronks K, Kulu-Glasgow I, Agyemang C. The utility of 'country of birth' for the classification of ethnic groups in health research: the Dutch experience. *Ethn Health* 2009; 14(3):255-269.
3. De Klerk CJM. De immigratie der Hindostanen in Suriname.1ste druk. Amsterdam: Urbi et Orbi, 1953.
4. Oudhof, K., Harmsen, C., Loozen, S., and Choenn, C.: Omvang en spreiding van Surinaamse bevolkingsgroepen in Nederland. Rijswijk: CBS (Statistics Netherlands); 2011. Available from: http://www.cbs.nl/NR/rdonlyres/E77E4C63-775E-4708-B347-1D1DA392B119/0/2011k2b15p97art.pdf.

5. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; 854):1-452.
6. Frongillo EA, Jr., Hanson KM. Determinants of variability among nations in child growth. *Ann Hum Biol* 1995; 22(5):395-411.
7. Ulijaszek SJ. The international growth standard for children and adolescents project: environmental influences on preadolescent and adolescent growth in weight and height. *Food Nutr Bull* 2006; 27(4 Suppl Growth Standard):S279-S294.
8. Anthropometry. Wikipedia, the free encyclopedia; 2013. Available from: http://en.wikipedia.org/wiki/Anthropometry.
9. Nursing outcomes classification (NOC). Moorhead S, Johnson M, Maas ML, Swanson E (editors). 5th edition. St. Louis: Elsevier Mosby, 2013.
10. de Onis M, Lobstein T. Defining obesity risk status in the general childhood population: which cut-offs should we use? *Int J Pediatr Obes* 2010; 5(6):458-460.
11. Schonbeck Y, Talma H, van DP *et al.* The world's tallest nation has stopped growing taller: the height of Dutch children from 1955 to 2009. *Pediatr Res* 2013; 73(3):371-377.
12. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002; 360(9331):473-482.
13. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006; 1(1):11-25.
14. de Onis M. The use of anthropometry in the prevention of childhood overweight and obesity. *Int J Obes Relat Metab Disord* 2004; 28 Suppl 3):S81-S85.
15. WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: WHO, 2006.
16. de Onis M. Growth curves for school age children and adolescents. *Indian Pediatr* 2009; 46(6):463-465.
17. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* 2007; 335(7612):194.
18. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes* 2012; 7(4):284-294.
19. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007; 85(9):660-667.
20. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Paediatr Suppl* 2006; 450):56-65.
21. Habicht JP, Martorell R, Yarbrough C, Malina RM, Klein RE. Height and weight standards for preschool children. How relevant are ethnic differences in growth potential? *Lancet* 1974; 1(7858):611-614.
22. Haas JD, Campirano F. Interpopulation variation in height among children 7 to 18 years of age. *Food Nutr Bull* 2006; 27(4 Suppl Growth Standard):S212-S223.
23. Enrolment and baseline characteristics in the WHO Multicentre Growth Reference Study. *Acta Paediatr Suppl* 2006; 450):7-15.
24. Ulijaszek SJ. Secular trends in growth: the narrowing of ethnic differences in growth. *Nutrion Bulletin* 2001; 26):43-51.
25. van Buuren S, van Wouwe JP. WHO Child Growth Standards in action. *Arch Dis Child* 2008; 93(7):549-551.
26. Wickramasinghe VP, Arambepola C, Bandara DM *et al.* Validity of newly-developed BMI and waist cut-off values for Sri Lankan children. *Ann Hum Biol* 2013;)
27. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004; 363(9403):157-163.
28. Duncan JS, Duncan EK, Schofield G. Accuracy of body mass index (BMI) thresholds for predicting excess body fat in girls from five ethnicities. *Asia Pac J Clin Nutr* 2009; 18(3):404-411.
29. Kierans WJ, Joseph KS, Luo ZC, Platt R, Wilkins R, Kramer MS. Does one size fit all? The case for ethnic-specific standards of fetal growth. *BMC Pregnancy Childbirth* 2008; 8(1):1.

30. Yajnik CS, Lubree HG, Rege SS *et al*. Adiposity and hyperinsulinemia in Indians are present at birth. *J Clin Endocrinol Metab* 2002; 87(12):5575-5580.
31. Deurenberg-Yap M, Chew SK, Deurenberg P. Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. *Obes Rev* 2002; 3(3):209-215.
32. Wickramasinghe VP. Hattori chart based evaluation of body composition and its relation to body mass index in a group of Sri Lankan children. *Indian J Pediatr* 2012; 79(5):632-639.
33. Ehtisham S, Crabtree N, Clark P, Shaw N, Barrett T. Ethnic differences in insulin resistance and body composition in United Kingdom adolescents. *J Clin Endocrinol Metab* 2005; 90(7):3963-3969.
34. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. *Int J Obes (Lond)* 2011; 35(2):167-187.
35. Whincup PH, Gilg JA, Papacosta O *et al*. Early evidence of ethnic differences in cardiovascular risk: cross sectional comparison of British South Asian and white children. *BMJ* 2002; 324(7338):635.
36. Low S, Chin MC, Ma S, Heng D, Deurenberg-Yap M. Rationale for redefining obesity in Asians. *Ann Acad Med Singapore* 2009; 38(1):66-69.
37. Lear SA, Kohli S, Bondy GP, Tchernof A, Sniderman AD. Ethnic variation in fat and lean body mass and the association with insulin resistance. *J Clin Endocrinol Metab* 2009; 94(12):4696-4702.
38. Gray LJ, Yates T, Davies MJ *et al*. Defining obesity cut-off points for migrant South Asians. *PLoS One* 2011; 6(10):e26464.
39. Misra A, Chowbey P, Makkar BM *et al*. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. *J Assoc Physicians India* 2009; 57):163-170.
40. Alexander GR, Wingate MS, Mor J, Boulet S. Birth outcomes of Asian-Indian-Americans. *Int J Gynaecol Obstet* 2007; 97(3):215-220.
41. Leon DA, Moser KA. Low birth weight persists in South Asian babies born in England and Wales regardless of maternal country of birth. Slow pace of acculturation, physiological constraint or both? Analysis of routine data. *J Epidemiol Community Health* 2012; 66(6):544-551.
42. van Steijn L., Karamali NS, Kanhai HH *et al*. Neonatal anthropometry: thin-fat phenotype in fourth to fifth generation South Asian neonates in Surinam. *Int J Obes (Lond)* 2009; 33(11):1326-1329.
43. Yajnik CS, Fall CH, Coyaji KJ *et al*. Neonatal anthropometry: the thin-fat Indian baby. The Pune Maternal Nutrition Study. *Int J Obes Relat Metab Disord* 2003; 27(2):173-180.
44. Troe EJ, Raat H, Jaddoe VW *et al*. Explaining differences in birthweight between ethnic populations. The Generation R Study. *BJOG* 2007; 114(12):1557-1565.
45. Visser GH, Eilers PH, Elferink-Stinkens PM, Merkus HM, Wit JM. New Dutch reference curves for birthweight by gestational age. *Early Hum Dev* 2009; 85(12):737-744.
46. Balchin I, Whittaker JC, Patel RR, Lamont RF, Steer PJ. Racial variation in the association between gestational age and perinatal mortality: prospective study. *BMJ* 2007; 334(7598):833.
47. Bhargava SK, Sachdev HP, Iyer PU, Ramji S. Current status of infant growth measurements in the perinatal period in India. *Acta Paediatr Scand Suppl* 1985; 319):103-110.
48. Campbell-Brown M, Willmott M. Perinatal deaths in immigrant Indian women. *J Obstet Gynaecol* 1983; 4(2):6.
49. Gardosi J. Ethnic differences in fetal growth. *Ultrasound Obstet Gynecol* 1995; 6(2):73-74.
50. Ray JG, Sgro M, Mamdani MM *et al*. Birth weight curves tailored to maternal world region. *J Obstet Gynaecol Can* 2012; 34(2):159-171.
51. Seaton SE, Yadav KD, Field DJ, Khunti K, Manktelow BN. Birthweight centile charts for South Asian infants born in the UK. *Neonatology* 2011; 100(4):398-403.
52. Hanley GE, Janssen PA. Ethnicity-specific growth distributions for prediction of newborn morbidity. *J Obstet Gynaecol Can* 2012; 34(9):826-829.

53. Vangen S, Stoltenberg C, Skjaerven R, Magnus P, Harris JR, Stray-Pedersen B. The heavier the better? Birthweight and perinatal mortality in different ethnic groups. *Int J Epidemiol* 2002; 31(3):654-660.
54. Jafar TH, Islam M, Poulter N *et al*. Children in South Asia have higher body mass-adjusted blood pressure levels than white children in the United States: a comparative study. *Circulation* 2005; 111(10):1291-1297.
55. Wickramasinghe VP, Arambepola C, Bandara P *et al*. Distribution of obesity-related metabolic markers among 5-15 year old children from an urban area of Sri Lanka. *Ann Hum Biol* 2013;)
56. Duncan JS, Duncan EK, Schofield G. Ethnic-specific body mass index cut-off points for overweight and obesity in girls. *N Z Med J* 2010; 123(1311):22-29.
57. Khadilkar VV, Khadilkar AV, Borade AB, Chiplonkar SA. Body Mass Index Cut-offs for Screening for Childhood Overweight and Obesity in Indian Children. *Indian Pediatr* 2012; 49(1):29-34.
58. Wickramasinghe VP, Lamabadusuriya SP, Cleghorn GJ, Davies PS. Defining anthropometric cut-off levels related to metabolic risk in a group of Sri Lankan children. *Ann Hum Biol* 2011; 38(5):537-543.
59. Pandey RM, Madhavan M, Misra A, Kalaivani M, Vikram NK, Dhingra V. Centiles of anthropometric measures of adiposity for 14- to 18-year-old urban Asian Indian adolescents. *Metab Syndr Relat Disord* 2009; 7(2):133-141.
60. Viner RM, Cole TJ, Fry T *et al*. Insufficient evidence to support separate BMI definitions for obesity in children and adolescents from south Asian ethnic groups in the UK. *Int J Obes (Lond)* 2010; 34(4):656-658.

PART 1

Epidemiology

CHAPTER 2

Trends in birth weight and the prevalence of low birth weight and small-for-gestational-age in Surinamese South Asian babies since 1974: cross-sectional study of three birth cohorts

Jeroen A de Wilde
Stef van Buuren
Barend JC Middelkoop

BMC Public Health, 2013;13:931

ABSTRACT

Background: South Asian babies born in developed countries are generally lighter than babies from other ethnic groups born in the same country. While the mean birth weight of Caucasian babies in the Netherlands has increased in the past decades, it is unknown if the mean birth weight of South Asian babies born in the Netherlands has increased and if the prevalence of low birth weight (LBW) or small-for-gestational-age (SGA) has decreased.
The aims of this study are: 1. to investigate secular changes in mean birth weight and the prevalence of LBW and SGA in Surinamese South Asian babies, and 2. to assess differences between Surinamese South Asian and Dutch Caucasian neonates born 2006-2009.
Methods: A population based study for which neonatal characteristics of 2014 Surinamese South Asian babies, born between 1974 and 2009 in the Netherlands, and 3104 Dutch Caucasian babies born 2006-2009 were obtained from well-baby clinic records. LBW was defined as a birth weight <2500g. SGA was based on a universal population standard (the Netherlands) and three ethnic specific standards (the Netherlands, UK, Canada).
Results: In Surinamese South Asian babies from 1974 to 2009 no secular trend in mean birth weight and prevalence of LBW was found, whereas SGA prevalence decreased significantly.
Surinamese South Asian babies born in 2006-2009 (2993g; 95%CI 2959-3029g) were 450g lighter than Dutch Caucasian babies (3448g; 95%CI 3429-3468g), while LBW and SGA prevalences, based on universal standards, were three times higher. Application of ethnic specific standards from the Netherlands and the UK yielded SGA rates in Surinamese South Asian babies that were similar to Dutch. There were considerable differences between the standards used.
Conclusion: Since 1974, although the mean birth weight of Surinamese South Asian babies remained unchanged, they actually gained weight when assessed by gestational age.

BACKGROUND

Birth weight is generally used as an indicator of a newborn's wellbeing, and as an indirect measure of the intrauterine environment and the nutritional status of the mother during pregnancy. In developing regions with lower socioeconomic status and poorer nutrition, babies are lighter and more frequently have adverse birth outcomes compared to developed regions.[1] South Asia has the highest incidence of low birth weight (LBW, <2500g) in the world (21-28%)[2] and one of the highest perinatal mortality rates.[1] Despite higher socioeconomic status and better nutrition, immigrant South Asian babies born in developed countries also tend to be lighter, shorter, and leaner at birth, and have a higher prevalence of LBW than their native counterparts.[3–5] However, there is increasing evidence that the lower birth weight and high rates of LBW and small-for-gestational-age (SGA, birth weight <10th percentile for gestational age) in these populations are not expressions of fetal growth restriction, but are rather physiological or constitutional in origin.[6–8] Consequently, using a single population standard for determining SGA in South Asian babies is likely to cause misclassification of many healthy South Asian babies as SGA. For that reason, in several countries South Asian specific birth weight standards were developed, which demonstrated a much higher association between SGA and adverse birth outcomes than the single population standard.[7,9,10]

In the Netherlands, perinatal mortality generally declined between 2000 and 2006,[11] but the rates in South Asian babies have remained considerably higher than in Dutch Caucasian babies.[12] It is unknown if this discrepancy is related to differences in birth weight or SGA prevalence. While the mean birth weight of neonates born in the Netherlands increased from 3372 grams in 1989 to 3466 grams in the years 2008-2010,[13] it is unknown if the mean birth weight of South Asian babies born in the Netherlands has increased, or if the prevalence of LBW or SGA has decreased.

The objectives of our study were firstly to determine if there are secular trends in birth weight and prevalence of LBW and SGA (based on universal and ethnic specific standards) in Surinamese South Asian babies born in the Netherlands, and secondly, to assess the differences in neonatal characteristics between Surinamese South Asian and Dutch babies born in 2006-2009, particularly the distributions of birth weight in both populations.

METHODS

Data source

In the Netherlands, the health of all infants is periodically assessed by physicians and nurses of Youth Health Care at well-baby clinics. The results of these check-ups are registered in health records which are kept at least 10 years after the child's 19th birthday.

The records of all Surinamese South Asian children born in the periods 1974-1976 and 1991-1993 were analysed in a previous study.[14] For the current study all records of Dutch and Surinamese South Asian children born 2006-2009 were added. The following data were extracted from the records: the child's family name, date of birth, sex, gestational age, birth

weight, country of birth of the mother and father.
As this study encompassed routinely collected data from medical records, under Dutch law approval by an ethical review committee was not needed.[15] Approval of the study protocol and permission to use the data for this study were obtained from the head of the department of Youth Health Care and from the head of the department of Epidemiology of the Municipal Health Service of the city of The Hague.

Population
Most South Asian people in the Netherlands are descendants of Asian Indians who migrated from 1873 to 1916 to the former Dutch colony Suriname. At around the time of Suriname's independence in 1975 many Surinamese South Asians moved to the Netherlands, to the city of The Hague in particular.[16] As Suriname is a multi-ethnic society, with people originating from the Netherlands, India, West-Africa, Java and China, the country of birth is insufficient to determine ethnicity. Therefore, the child's ethnicity was defined by country of birth of both the father and mother, together with their respective family names.
Surinamese South Asian ethnicity was then determined by a typical Surinamese South Asian family name of both parents (by matching the names with a list of common Surinamese South Asian family names), and Suriname or the Netherlands as country of birth for respectively first generation and second generation parents in the Netherlands. Parents with a typical Dutch family name who were also born in the Netherlands were considered Dutch Caucasian. Only children of whom both parents were Surinamese South Asian or Dutch Caucasian were included in the study. In cases with one or both parental family names missing (4.3%), ethnicity was determined by the child's family name and the available parental family name, together with the parent's country of birth.
Based on these selection criteria, 2858 records of Surinamese South Asian children born in 1974-1976, 1991-1993 or 2006-2009, and 3256 records of Dutch children born 2006-2009 were retrieved. For the final selection, children born outside the Netherlands (n=635) were excluded, as in these cases gestational age and birth weight were self-reported and therefore considered less reliable. Additionally, children of multiple birth (n=92), or with a missing record of birth weight (n=174) or gestational age (n=95) were excluded. A total of 2014 records of Surinamese South Asian children and 3104 records of Dutch children remained for the analyses.

Measurements and fetal growth standards
In all time periods a midwife or an obstetrician calculated the gestational age based on the first day of the last menstrual period. In cases with unknown or dubious last menstrual period, gestational age was determined from an ultrasound dating scan. The gestational age, together with other details regarding pregnancy and birth, were added to the child's health record after a home visit by a Youth Health Care nurse in the second week postpartum. In 92% of cases of cohort 1974-1976 gestational age was recorded in completed weeks, and in the remainder in weeks and days. In 1991-1993 and 2006-2009 gestational age was registered in weeks and

days. A gestational age of <37 weeks was considered a preterm birth. LBW was defined as a birth weight <2500g. To estimate the prevalence of SGA in Dutch Caucasian and Surinamese South Asian babies, the most recent universal Dutch standard for birth weight by gestational age (gestational ages ≥25 and ≤42 weeks, sex and parity dependent)[17] was applied. Secondly, we determined SGA rates based on separate standards for babies of South Asian descent and for babies of European descent, from the Netherlands,[17,18] the United Kingdom,[19] and Canada.[20] A birth weight below the 10th percentile for gestational age was defined as SGA. Children of unknown parity were classified as primiparous.

Statistical analyses

As this study had two objectives, the data were analysed accordingly. Firstly, the data of Surinamese South Asian babies were analysed to assess the differences between the time periods, and secondly, differences between Dutch and Surinamese South Asian babies born in 2006-2009 were analysed.

Furthermore, we used a stepwise approach. In the first step we compared neonatal and maternal characteristics using Pearson's Chi-square tests (categorical variables) and analysis of variance (mean gestational age). In the second step, birth weight characteristics were examined. To test for differences between birth weights, a general linear model (GLM) was used with birth weight as the dependent variable and sex, parity, and gestational age as adjusting factors. Differences in the prevalence of LBW (LBW vs. not LBW) and SGA (SGA vs. not SGA) were assessed with logistic regression analyses, firstly with time period as the independent variable to test for differences between Surinamese South Asian time periods and secondly with ethnic group as the independent variable to test for differences between Surinamese South Asian and Dutch babies born in 2006-2009. Analyses of LBW were adjusted for sex, parity, and gestational age. Analyses of SGA based on the South Asian standard from the Netherlands were adjusted for sex and parity, as this standard is not sex or parity specific. Analyses based on the sex-specific Canadian and British standard were adjusted for parity.

All analyses were conducted using IBM SPSS Statistics 20.

RESULTS

We found differences in neonatal and maternal characteristics between Surinamese South Asian cohorts, and between the Dutch and Surinamese South Asian population (Table 1). Within the Surinamese South Asian population, Surinam as the maternal birth country of birth declined from 100% in 1974-1976 to 67.3% in 2006-2009. The mean gestational age decreased significantly from 39.4 weeks in 1974-1976 to 39.0 weeks in 2006-2009. The distribution of gestational ages generally shifted to the left while the standard deviation increased. The mean gestational age was significantly shorter in the Surinamese South Asian cohort 2006-2009 than in Dutch Caucasian neonates, while preterm rates were twice as high.

Table 1 *Child and maternal characteristics of Surinamese South Asian and Dutch population*

		Surinamese South Asian			Dutch
		1974-1976	1991-1993	2006-2009	2006-2009
Number of births		337	830	847	3104
% Maternal country of birth[a]	Suriname	100	99.3	67.3	0
	The Netherlands	0	0.7	32.7	100
% Parity[c]	1	46.9	44.1	46.6	56.8
	>1	51.0	55.7	49.5	39.8
	unknown	2.1	0.2	3.9	3.5
% Sex	boy	49.6	50.2	51.6	50.8
	girl	50.4	49.8	48.4	49.2
Gestational age, mean in weeks (SD)[b]		39.4 (1.7)	39.2 (1.9)	39.0 (2.0)	39.7 (1.7)
Gestational age categories[b]	<31	0.3	0.6	0.9	0.5
	31-32	0.6	0.6	1.2	0.4
	33-34	0.3	1.6	2.2	0.8
	35-36	4.7	4.9	6.1	3.8
	37-38	21.1	25.5	31.3	20.7
	39-40	57.3	51.1	45.3	50.7
	41-43	15.7	15.7	12.9	23.1
% Preterm, <37 weeks[b]		5.9	7.7	10.5	5.4

[a]significantly different 1. between Surinamese South Asian time periods, P<0.05 and 2. between Dutch and Surinamese South Asian babies born 2006-2009, P<0.001
[b]significantly different 1. between Surinamese South Asian time periods, P<0.01 and 2. between Dutch and Surinamese South Asian babies born 2006-2009, P<0.001
[c]Analysed without 'unknown'category; Dutch significantly different from Surinamese South Asian 2006-2009, P<0.001

We found no secular changes in mean birth weight of Surinamese South Asian neonates (Table 2). LBW prevalence in Surinamese South Asian newborns showed a non-significant increasing trend since 1974-1976. Concurrently, the prevalence of SGA significantly decreased when both the Dutch universal standard, and the ethnic specific Dutch and British standards were applied. The British standard resulted in the lowest prevalence of SGA, whereas the universal Dutch and the Canadian standard yielded the highest prevalence (Figure 2).
Surinamese South Asian neonates born in 2006-2009 differed from Dutch babies in almost all birth weight characteristics (Table 1). The mean birth weight was around 450g lower than in Dutch babies.

While the shape and spread of both distributions were similar (Figure 1), the Surinamese South Asian curve (mean±SD: 2993±521) was shifted to the left relative to the Dutch curve (mean±SD: 3448±552). As a result, the proportion of LBW <2500g neonates was over three times higher in SGA prevalence, based on the universal Dutch standard, was also more than three times higher in Surinamese South Asian babies (Figure 2).
The application of the ethnic specific Dutch and British standards resulted in similar rates of SGA in Dutch and Surinamese South Asian babies. However, using the Canadian standard resulted in SGA rates that were higher than expected, both in Dutch and Surinamese South Asian babies.

Table 2 *Birth weight characteristics with 95% Confidence Intervals (CI) of Surinamese South Asian and Dutch population*

	Surinamese South Asian						Dutch	
	1974-1976		1991-1993		2006-2009		2006-2009	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Birth Weight in g								
unadjusted	2995	2941-3049	3038	3002-3074	2993	2958-3029	3448*[b]	3429-3468
Adjusted[a]	2983	2878-3087	3067	2953-3181	3032	2982-3083	3461*[b]	3432-3489
Birth Weight ≥37 wk in g								
Unadjusted	3048	2998-3098	3113	3080-3145	3090	3060-3120	3505*[b]	3488-3523
Adjusted[a]	3106	2988-3223	3144	3031-3258	3126	3070-3183	3517*[b]	3488-3547
% LBW								
<2500 g	11.3	7.9-14.7	12.7	9.3-16.1	14.8	11.4-18.2	4.4*[b]	3.7-5.1

* P<0.001

[a] adjusted for sex, parity, and gestational age

[b] Dutch significantly different from Surinamese South Asian 2006-2009

Figure 1 *Birth weight distribution of Surinamese South Asian and Dutch newborns, born 2006-2009*

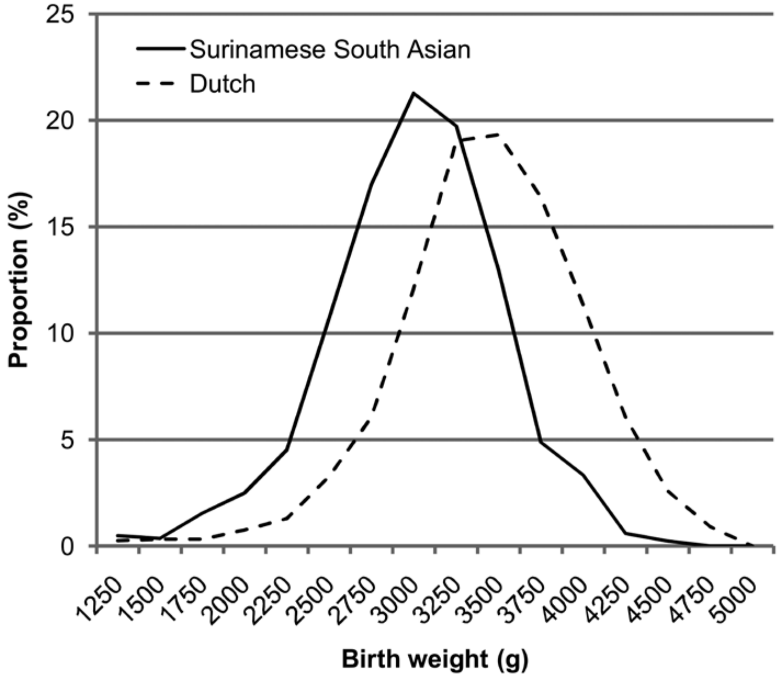
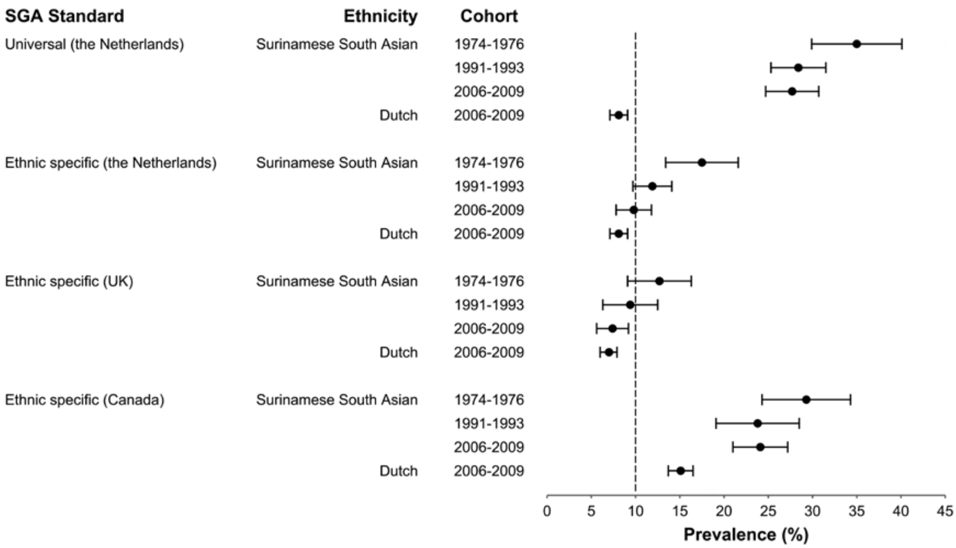


Figure 2 *Prevalence of SGA with 95% confidence interval, by SGA standard in Surinamese South Asian and Dutch neonates. The dashed vertical line at the 10 percent mark represents the reference value of the SGA standards*



DISCUSSION

This study shows that the mean birth weight of Surinamese South Asian neonates did not significantly change over a period of 35 years. As the mean birth weight of Dutch babies was previously shown to have increased by almost 100 grams since the late 1980's,[13] this finding implies that the difference in mean birth weight between Surinamese South Asian and Dutch neonates has become greater.
However, mean birth weight alone does not tell the whole story. The decrease in SGA rates in our population showed that Surinamese South Asian neonates have actually gained weight, but this effect was not reflected in higher mean birth weights, most likely due to a considerable increase in the prevalence of preterm delivered babies. Contrary to reports from other countries which found increasing trends in the proportion of preterm delivered babies,[21] preterm rates in the Netherlands have decreased in the past decade.[22] The cause of preterm rates in the Surinamese South Asian population in the Netherlands increasing strongly since 1974 is unclear. It could be explained by a generally higher prevalence of pathology during pregnancy in South Asian women, such as pre-eclampsia and gestational diabetes,[23] leading to earlier complications during pregnancy and thus subsequently a relatively higher proportion of induced labour. For our study, information on the proportion of such iatrogenic preterm deliveries was not available.

The strengths of this study are the large sample size, and the availability of some important confounding factors. However, not all known confounders such as maternal age, socio-economic status, maternal height and pre-pregnancy weight, and information on smoking during pregnancy were available to enable adjustment. Another limitation is that a change in pregnancy dating methods, from menstrual dating in the early years to menstrual and ultrasound dating in the more recent years, could have influenced the temporal trends among the Surinamese South Asian infants. Lastly, children with congenital or chromosomal anomalies could not be excluded, as this information was unavailable. Nevertheless, as most of these children receive specialised care and do not usually attend the standard check-ups at well-baby clinics, it is expected that only a small proportion of these children were included in our study.

Compared with the birth weights of South Asian babies in other countries, the mean birth weight of Surinamese South Asian babies born in 2006-2009 (3032g) was lower than the birth weights of South Asian babies in the United States (3170g),[3] Canada (3221g),[24] Norway (3244g),[10], and the UK (3072-3129g).[4] This difference may be the result of our stricter selection criterion for ethnicity. In our study both the country of birth and the family name of both parents were required, whereas in many other studies only the background data of the mother were used, which may have led to a less homogeneous group.
In addition, there may also be differences between the populations of South Asians in these countries. For example, the Norwegian study[10] only included babies with a Pakistani ethnicity. In Britain, Pakistani (3129g) babies were also shown to be heavier than babies of Bangladeshi (3072g) or Asian Indian (3087g) parents.[4] Therefore, the term 'South Asian' does not entail

homogeneity. This is also reflected in differences between the birth weight standards from these countries, with the Canadian standard yielding considerably higher SGA rates than the ethnic specific Dutch and the British standard.

While the large left shift of the birth weight distribution of Surinamese South Asian babies compared with that of Dutch Caucasian babies was remarkable, similar differences in birth weight between South Asian and Caucasian neonates have been observed in other developed countries.[3,6,7] The differences have been attributed to physiological variations in body composition, which in South Asian babies have been described as a smaller muscle mass but similar fat stores compared with Caucasian babies.[25] To account for such ethnic variation and other physiological factors in the assessment of the nutritional status of neonates, ethnic specific or customised fetal growth standards are recommended for use in clinical practice. The application of such standards generally improves the prediction of adverse birth outcomes.[7,9,10,26]

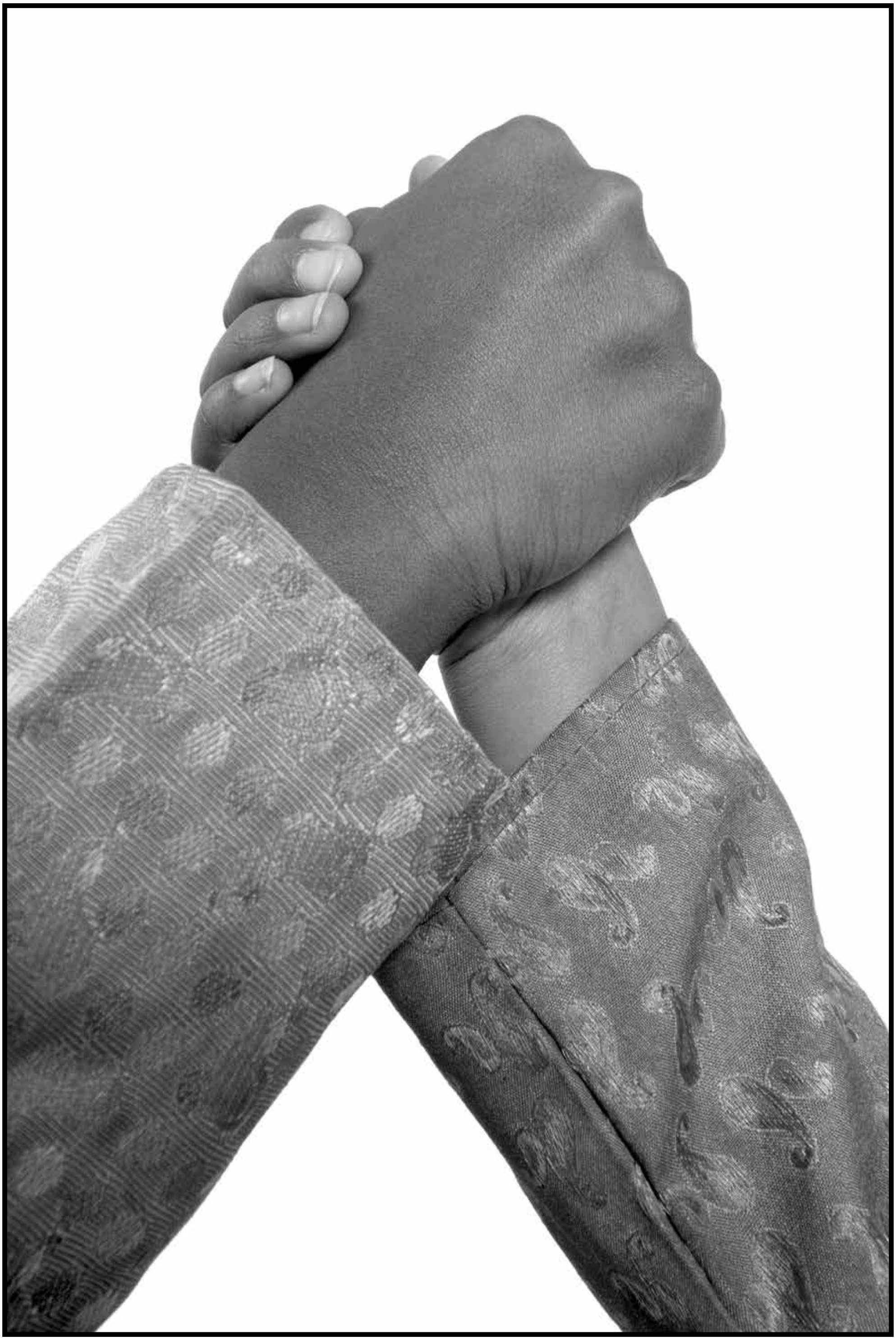
CONCLUSION

In conclusion, this study found no secular changes in mean birth weight and LBW prevalence in Surinamese South Asian babies since 1974. While not expressed in the mean birth weight, SGA prevalence decreased significantly, indicating that Surinamese South Asian babies have actually gained a healthier weight for their gestational age. Surinamese South Asian babies were approximately 450 grams lighter than Dutch Caucasian neonates, and LBW and SGA was highly prevalent when based on a single standard. When applying ethnic specific criteria to determine SGA, the rates were concordant with those found in Dutch Caucasian babies.

REFERENCES

1. Perinatal and neonatal mortality. Country, regional and global estimates. Geneva: World Health Organization; 2006. Available from: http://whqlibdoc.who.int/publicatitons/2006/9241563206_eng.pdf.
2. 2. 6th Report on the World Nutrition Situation. Geneva: United Nations Standing Committee on Nutrition; 2009. Available from: www.unscn.org/files/Publications/RWNS6/report/SCN report.pdf.
3. Alexander GR, Wingate MS, Mor J, Boulet S. Birth outcomes of Asian-Indian-Americans *Int J Gynaecol Obstet* 2007; 97(3):215-220.
4. Leon DA, Moser KA. Low birth weight persists in South Asian babies born in England and Wales regardless of maternal country of birth. Slow pace of acculturation, physiological con straint or both? Analysis of routine data. *J Epidemiol Community Health* 2012; 66(6):544- 551.
5. Troe EJ, Raat H, Jaddoe VW et al. Explaining differences in birthweight between ethnic populations. The Generation R Study. *BJOG* 2007; 114(12):1557-1565.
6. Gardosi J. Ethnic differences in fetal growth. *Ultrasound Obstet Gynecol* 1995; 6(2):73-74.
7. Kierans WJ, Joseph KS, Luo ZC, Platt R, Wilkins R, Kramer MS. Does one size fit all? The case for ethnic-specific standards of fetal growth. *BMC Pregnancy Childbirth* 2008; 8(1):1.
8. Resnik R. One size does not fit all. *Am J Obstet Gynecol* 2007; 197(3):221-222.
9. Hanley GE, Janssen PA. Ethnicity-specific growth distributions for prediction of newborn morbidity. *J Obstet Gynaecol Can* 2012; 34(9):826-829.

10. Vangen S, Stoltenberg C, Skjaerven R, Magnus P, Harris JR, Stray-Pedersen B. The heavier the better? Birthweight and perinatal mortality in different ethnic groups. *Int J Epidemiol* 2002; 31(3):654-660.
11. Ravelli AC, Tromp M, van Huis M et al. Decreasing perinatal mortality in The Netherlands, 2000-2006: a record linkage study. *J Epidemiol Community Health* 2009; 63(9):761-765.
12. Ravelli AC, Tromp M, Eskes M et al. Ethnic differences in stillbirth and early neonatal mortality in The Netherlands. *J Epidemiol Community Health* 2011; 65(8):696-701.
13. Birth, height and weight at birth and breastfeeding [in Dutch]. CBS (Statistics Netherlands); 2012. Available from: http://statline.cbs.nl/StatWeb/publication/?DM=SLN-L&PA=37302&D1=23-44&D2=a&VW=T.
14. De Wilde JA, Zandbergen-Harlaar S, van Buuren S, Middelkoop BJ. Trends in body mass index distribution and prevalence of thinness, overweight and obesity in two cohorts of Surinamese South Asian children in The Netherlands. *Arch Dis Child* 2013; 98(4):280-285.
15. Step-by-step plan RC review. The Hague: Central Committee on Research Involving Human Subjects (CCMO); 2012. Available from: http://www.ccmo-online.nl/main.as- p?pid=10&sid=30&ssid=51.
16. Hindoestanen. Wikipedia; 2012. Available from: http://nl.wikipedia.org/wiki/Hindoestanen.
17. Visser GH, Eilers PH, Elferink-Stinkens PM, Merkus HM, Wit JM. New Dutch reference curves for birthweight by gestational age. *Early Hum Dev* 2009; 85(12):737-744.
18. PRN Reference curve Hindi. Utrecht: The Netherlands Perinatal Registry (PRN); 2009. Available from: http://www.perinatreg.nl/uploads/167/84/PRNreferentiecurve_Hindi.pdf.
19. Seaton SE, Yadav KD, Field DJ, Khunti K, Manktelow BN. Birthweight centile charts for South Asian infants born in the UK. *Neonatology* 2011; 100(4):398-403.
20. Ray JG, Sgro M, Mamdani MM et al. Birth weight curves tailored to maternal world region. *J Obstet Gynaecol Can* 2012; 34(2):159-171.
21. Slattery MM, Morrison JJ. Preterm delivery. *Lancet* 2002; 360(9344):1489-1497.
22. Schaaf JM, Mol BW, Abu-Hanna A, Ravelli AC. Trends in preterm birth: singleton and multiple pregnancies in the Netherlands, 2000-2007. *BJOG* 2011; 118(10):1196-1204.
23. Khalil A, Rezende J, Akolekar R, Syngelaki A, Nicolaides KH. Maternal racial origin and adverse pregnancy outcomes: a cohort study. *Ultrasound Obstet Gynecol* 2013; 41(3):278-285.
24. Ray JG, Jiang D, Sgro M, Shah R, Singh G, Mamdani MM. Thresholds for small for gestational age among newborns of East Asian and South Asian ancestry. *J Obstet Gynaecol Can* 2009; 31(4):322-330.
25. Yajnik CS, Fall CH, Coyaji KJ et al. Neonatal anthropometry: the thin-fat Indian baby. The Pune Maternal Nutrition Study. *Int J Obes Relat Metab Disord* 2003; 27(2):173-180.
26. Gardosi J, Francis A. Adverse pregnancy outcome and association with small for gestational age birthweight by customized and population-based percentiles. *Am J Obstet Gynecol* 2009; 201(1):28.



CHAPTER 3

Trends in Body Mass Index distribution and prevalence of thinness, overweight, and obesity in two cohorts of Surinamese South Asian children in the Netherlands

Jeroen A. de Wilde
Silvia Zandbergen-Harlaar
Stef van Buuren
Barend J.C. Middelkoop

Archives of Disease in Childhood, 2013;98:280

ABSTRACT

Objectives: Asians have a smaller muscle mass and a larger fat mass at the same BMI than most other ethnic groups. Due to a resulting higher cardiometabolic risk, the BMI cut-offs for overweight and obesity were lowered for adults. For Asian children universal criteria still apply. The objectives of this study were to determine the normal BMI distribution and assess the BMI class distribution in a reference cohort of affluent South Asian children born before the obesity epidemic and to assess the influence of the obesity epidemic on the distributions.
Methods: Historical cohort study with 4350 measurements of height and weight of two cohorts (born 1974-1976 and 1991-1993) of Surinamese South Asian children living in the Netherlands, analysed with WHO Child Growth References and IOTF BMI cut-offs.
Results: The reference cohort 1974-1976 was significantly lighter (BMI Z-score=-0.63; 95% CI -0.69, -0.58) and more variable (SD=1.19) than the WHO reference. Total thinness prevalence was exceptionally high, both in cohort 1974-1976 (WHO 38.3%; IOTF 36.4%) and 1991-1993 (WHO 23.6%; IOTF 23.9%). Overweight and obesity prevalences were low in the reference cohort (WHO 6.0% and 2.1%; IOTF 5.3%, 0.9%, respectively), but much higher in cohort 1991-1993 (WHO 13.6%, 9.1%; IOTF 11.7%, 6.0%).
Conclusion: The low mean BMI Z-score and high prevalence of thinness is likely the expression of the characteristic body composition of South Asians. Universal BMI cut-offs should be applied carefully in South Asian populations as thinness prevalence is likely to be overestimated and obesity underestimated. The development of ethnic specific cut- offs is recommended.

What is already known on this topic

- South Asian children and adults have a higher percentage of body fat for the same body mass index (BMI) level than most other ethnic groups.
- BMI cut-offs to determine overweight and obesity have been lowered for adult Asian populations to 23 and 27.5 respectively.
- Underweight prevalence in India is the highest in the world.

What this study adds

- The mean BMI Z-score of a cohort of Surinamese South Asian children, born before the obesity epidemic, was much lower than of the WHO reference.
- Thinness prevalence in a reference cohort of Surinamese South Asian children was very high and overweight and obesity prevalence very low.
- The obesity epidemic had a strong influence on the BMI class distribution in Surinamese South Asian children but the thinness prevalence remained very high.

INTRODUCTION

The worldwide prevalence of childhood overweight and obesity has increased dramatically during the past decades, both in developing and developed countries.[1] Up to the 1980's South Asian countries were among the countries with the lowest rates[1] but since then overweight and obesity prevalences have gradually increased in preschool children (< 5 years) in South Asian countries.[2] For children 5-18 years in this region national prevalence data on overweight and obesity are currently unavailable, but in urban areas an increasing trend has also been found[3,4] with current figures ranging up to 19.6%-27%[3] approximating those of developed countries.
At the same time, India still has the highest prevalence of childhood underweight and low birth weight (<2500g) in the world.[5]

The nutritional status of children and adults is generally assessed with the body mass index (BMI) as an indirect measure of body fat. To assess health risks associated with low or high percentages of body fat, universal BMI cut-off values, suitable for all ethnic groups, were recommended by the World Health Organization (WHO).[6,7] During the past decades increasing evidence has shown that South Asian populations are predisposed to a lower BMI because of a typical 'thin-fat' body composition, comprising of a smaller lean body mass but larger fat stores at equivalent BMI levels compared with other ethnic groups.[8–10] In differing degrees most Asian subpopulations display this body composition and consequently cardiometabolic risks for these groups are higher at lower BMI levels.[9,11] For that reason WHO has recommended lowering 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.[12]
Even though South Asian children and adolescents have a similar body composition to adults, with comparable increased cardiometabolic risks,[8,13–15] BMI cut-offs for South Asian children have not been lowered. Considering the differences in body composition between ethnic groups, the BMI distribution in a healthy population of South Asian children, unaffected by the obesity epidemic, is expected to be shifted to the left, relative to the BMI distribution of a universal reference population. However, knowledge about the normal BMI and BMI class distribution in such a population is currently lacking, but may support the decision to establish BMI criteria specific for South Asian children.

The first objective of our study was to determine the normal BMI distribution of a reference cohort of South Asian children living in a developed country and born before the obesity epidemic began. In addition, the BMI class distribution (prevalence of severe thinness, thinness, overweight and obesity) in this cohort was assessed with two sets of universal BMI cut-offs. Lastly, we compared the BMI and BMI class distribution in the reference cohort with those in a similar cohort of South Asian children born during the obesity epidemic.

Chapter 3

METHODS

Subjects and data collection

The city of The Hague in the Netherlands comprises many ethnic groups. South Asian people are one of the largest ethnic minority groups, estimated at 8% of the city's population.[16] Most South Asians in the Netherlands are descendants of Asian Indians that migrated to the former Dutch colony of Suriname between 1873 and 1916. After Suriname's independence in 1975 a large group of Surinamese South Asians migrated to the Netherlands. [17]

For this study we used routinely collected growth and background data from the medical records of Youth Health Care in the city of The Hague. Ethical approval for this study was not required as under Dutch law scientific research based on data from patient records does not need a medical ethics review.[18] The records of two birth cohorts of Surinamese South Asian children, one born 1974-1976 and the second 1991-1993, were selected on the basis of a Surinamese South Asian ethnicity of the child that was defined by two criteria: 1. Suriname as country of birth of the parents and 2. a typical Surinamese South Asian surname of the child and both parents. Other socio-demographic and personal data such as sex, date of birth, gestational age, and singleton/multiple birth, as well as height and weight measurements from routine health check-ups at ages 3-5, 6-8 and 13-15 years were also extracted from paper and digital health records.

Most children of cohort 1974-1976 had more than one measurement in each age group registered, whereas children from cohort 1991-1993 had only one measurement. This difference can be attributed to a change in the scheme of standard health examinations of Youth Health Care since the late 1980's in the Netherlands. When a child from cohort 1974-1976 had more than one registered measurement per age group, the measurement at an age closest to the group mean of the age groups of cohort 1991-1993 was selected to establish similar group compositions.

Inclusion criteria

All available medical records were checked for the presence of any disorder or medicine use that could have affected growth, such as thyroid disease, diabetes, celiac disease, cerebral palsy, scoliosis, congenital heart disease, prolonged use (> one year) of oral corticosteroids, and treatment for short stature. If present, these records were excluded from the analyses. Furthermore, only singleton children with a gestational age of ≥37 weeks were included in the study as multiple birth and preterm birth may have a long-lasting influence on childhood growth.[19–21]

Anthropometric measurements

Trained Youth Health Care professionals (physicians, nurses and health care assistants) routinely measured the children's height and weight, with a stadiometer/measuring tape and a calibrated mechanical flat scale, respectively. All children were measured without shoes wearing light (under)clothing. Body mass index was calculated with the formula [weight]/[height]^2(kg/m^2).

The WHO child growth standard (for ages 0-4 years)[22] and reference (5-19 years),[7] further referred to as WHO, were applied to calculate BMI Z-scores of each measurement. A Z-score of

-2, -1, 0, +1, and +2 Standard Deviations (SD) at 18 years of age correspond respectively to a BMI of 17.3, 19.2, 21.7, 24.9 and 29.2 kg/m^2 in boys and 16.4, 18.6, 21.3, 24.8 and 29,5 kg/m^2 in girls. As cut-offs to determine the BMI class we used a value of <-2 SD for severe thinness, ≥-2 SD and <-1 SD for thinness, ≥+1 SD and <+2 SD for overweight and ≥+2 SD for obesity.
BMI class was also determined by using a second set of sex and age specific BMI cut-off values for ages 2-18 years, that were constructed to pass the adult BMI cut-offs at age 18 for severe thinness (<17 kg/m^2), thinness (≥17 kg/m^2 and <18,5 kg/m^2), overweight (≥25 kg/m^2 and <30 kg/m^2) and obesity (≥30 kg/m^2).[23,24] The cut-offs for overweight and obesity were adopted by the International Obesity Task Force (IOTF) and are often named IOTF cut-offs. In this paper we will use the term IOTF to designate the whole set of BMI criteria.

Statistical analyses

Continuous variables are reported as means with 95% confidence intervals (CI), and categorical variables as percentages and number of observations. Differences in the distribution of the study characteristics between the two cohorts were tested with either the independent-samples t-test for continuous variables or the chi-square test for categorical variables. Unequal variance and equal variance t-tests were used to examine differences in BMI Z-scores between cohort 1974-1976 and cohort 1991-1993. Differences in prevalence of severe thinness, thinness, overweight and obesity between both cohorts were analysed in strata according to age group (3-5 years, 6-8 years and 13-15 years). For analyses of differences in prevalence of BMI classes between groups, BMI classes were dichotomised into severe thinness and not severe thinness, thinness and not thinness, overweight and not overweight, and obesity and not obesity. The resulting variables were analysed with logistic regression analyses with cohort as independent variable. As age groups were unequally distributed between the cohorts and as age shows an almost linear relationship with the outcome variable, age was added to the model as continuous variable. Other confounding factors, such as country of birth (Surinam, Netherlands, other and unknown) and sex were also included in the adjusted model as categorical variables.
A P-value <0.05 (two-sided) was considered statistically significant. All statistical analyses were conducted with IBM SPSS Statistics, version 20.

RESULTS

A total of 2015 children with 4350 height and weight measurements were included in the study (Figure 1). The main difference between the two cohorts was that most children of cohort 1991-1993 were born in the Netherlands (90.5%), compared with just 35.7% of cohort 1974-1976 (Table 1). Furthermore, cohort 1991-1993 had more measurements at ages 3-5 years and 13-15 years. Compared with the normal distribution of WHO, cohort 1974-1976 had a lower mean BMI Z-score (mean=-0.63; 95% CI -0.69 to -0.58), was more variable (SD=1.19) and was slightly positively skewed (Figure 2). The mean BMI Z-score of cohort 1991-1993 was similar to that of the WHO distribution (mean=0.01; 95% CI -0.05 to 0.06), but the variability was even larger (SD=1.37) than in cohort 1974-1976 and the distribution was more positively skewed. As the left side of the cohort 1991-1993 curve was still shifted to the left, relative to WHO, it indicates there were more children with a lower BMI. In addition, the large tail to the right indicates a large proportion of children with a higher than average BMI.

The calculated BMI class prevalences based on both sets of BMI cut-offs confirmed these findings (Tables 2 and 3). Although there were some discrepancies between the prevalences calculated with WHO and IOTF the distributional patterns were largely similar.
Cohort 1974-1976 generally showed a high overall prevalence of severe thinness and thinness with combined prevalence rates of 38.3% (WHO) and 36.4% (IOTF). Especially in the youngest age group 3-5 years total thinness (including severe thinness) rates were high (WHO 39.6%; IOTF 45.7%) while overweight and obesity rates were very low. Cohort 1991-1993 had a similarly high total thinness prevalence at ages 3-5 years, but the rates decreased rapidly with age, while overweight and obesity prevalence increased at the same time. The overall combined overweight and obesity prevalence in cohort 1991-1993 was with 22.7% (WHO) and 17.7 % (IOTF) more than twice that of cohort 1974-1976. Where overweight rates had doubled compared with cohort 1974-1976, obesity rates had increased 4-6 fold.

Figure 1 *Selection procedure of cohort 1974-1976 and cohort 1991-1993*

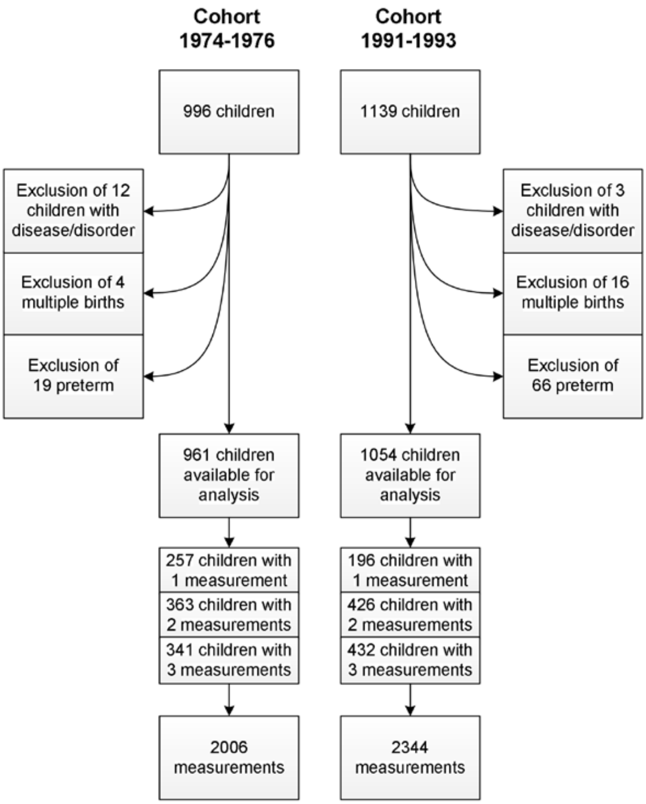


Table 1 *Population characteristics of cohort 1974-1976 and cohort 1991-1993*

		Cohort 1974-1976	Cohort 1991-1993
N		961	1054
Sex % (n)	Boy	52.0 (500)	49.7 (524)
	Girl	48.0 (461)	50.3 (530)
Age groups % (n)[a]	3-5 years	34.6 (694)	34.4 (806)
	6-8 years	38.0 (762)	32.6 (763)
	13-15 years	27.4 (550)	33.1 (775)
Place of birth % (n)[a]	Suriname	63.4 (609)	9.2 (97)
	The Netherlands	35.7 (343)	90.5 (954)
	Other	0 (0)	0.3 (3)
	Unknown	0.9 (9)	0 (0)

[a] P<0.001

Figure 2 *BMI Z-Score distribution of ages 3-15 years of cohort 1974-1976 and cohort 1991-1993, compared with the distribution of the WHO Child Growth Standard and Reference*

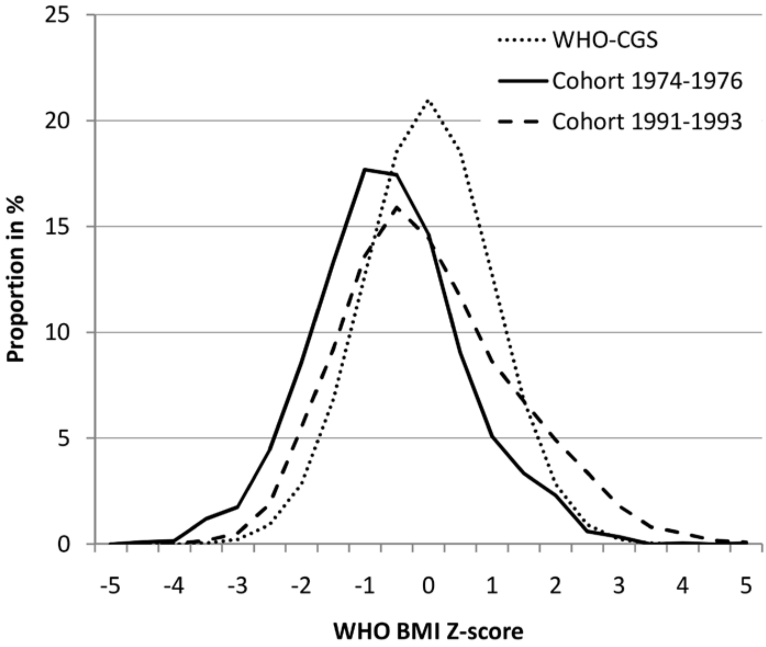


Table 2 *BMI class prevalences (%) based on BMI cut-offs of WHO per age group of cohort 1974-1976 and cohort 1991-1993, with unadjusted and adjusted (for sex, age and child's country of birth) odds ratio (OR) and 95% confidence interval (CI)*

	Prevalence		Odds Ratio, between cohort effect	
	Cohort 1974-1976	Cohort 1991-1993	Unadjusted	Adjusted
	% (n)	% (n)	OR [95% CI]	OR [95% CI]
Severe thinness				
3-5 years	10.5 (73)	7.0 (56)	0.64 [0.44, 0.91][a]	0.91 [0.57, 1.45]
6-8 years	14.5 (110)	4.2 (32)	0.26 [0.17, 0.39][c]	0.37 [0.23, 0.60][c]
13-15 years	9.1 (50)	3.6 (28)	0.38 [0.23, 0.60][c]	0.37 [0.22, 0.63][c]
Total	11.6 (233)	5.0 (116)	0.40 [0.31, 0.50][c]	0.49 [0.37, 0.65][c]
Thinness (excl. severe)				
3-5 years	29.1 (202)	25.4 (204)	0.83 [0.66, 1.05]	0.90 [0.68, 1.19]
6-8 years	27.8 (211)	16.0 (122)	0.50 [0.39, 0.65][c]	0.55 [0.40, 0.74][c]
13-15 years	22.2 (122)	13.9 (108)	0.57 [0.43, 0.76][c]	0.61 [0.44, 0.86][b]
Total	26.7 (535)	18.6 (434)	0.63 [0.55, 0.73][c]	0.68 [0.57, 0.81][c]
Overweight (excl. obesity)				
3-5 years	4.0 (28)	8.2 (66)	2.02 [1.28, 3.19][b]	2.15 [1.19, 3.86][a]
6-8 years	5.5 (42)	17.3 (132)	3.52 [2.45, 5.07][c]	3.22 [2.03, 5.09][c]
13-15 years	12.6 (69)	15.6 (121)	1.29 [0.93, 1.77]	1.15 [0.79, 1.67]
Total	6.9 (139)	13.6 (319)	2.08 [1.69, 2.56][c]	1.94 [1.50, 2.50][c]
Obesity				
3-5 years	0.7(5)	4.1 (33)	2.58 [2.28, 15.15][c]	3.33 [1.23, 9.06][a]
6-8 years	2.5 (19)	13.7 (104)	6.17 [3.74, 10.18][c]	5.27 [2.89, 9.63][c]
13-15 years	3.5 (19)	9.9 (77)	3.08 [1.54, 5.16][c]	3.66 [1.98, 6.75][c]
Total	2.1 (43)	9.1 (214)	4.59 [3.29, 6.40][c]	4.42 [2.99, 6.56][c]

[a] P<0.05; [b] P<0.01; [c] P<0.001

Table 3 *BMI class prevalences (%) based on BMI cut-offs of IOTF per age group of cohort 1974-1976 and cohort 1991-1993, with unadjusted and adjusted (for sex, age anD child's country of birth) odds ratio (OR, between cohort effect) and 95% confidence interval (CI).*

	Prevalence		Odds Ratio, between cohort effect	
	Cohort 1974-1976	Cohort 1991-1993	Unadjusted	Adjusted
	% (n)	% (n)	OR [95% CI]	OR [95% CI]
Severe thinness				
3-5 years	17.9 (124)	16.3 (131)	0.89 [0.68, 1.17]	1.05 [0.78, 1.45]
6-8 years	14.0 (107)	4.2 (32)	0.27 [0.18, 0.40][c]	0.37 [0.23, 0.60][c]
13-15 years	7.3 (40)	2.6 (20)	0.34 [0.20, 0.58][c]	0.31 [0.16, 0.59][c]
Total	13.5 (271)	7.8 (183)	0.54 [0.45, 0.66][c]	0.64 [0.50, 0.81][c]
Thinness (excl. severe)				
3-5 years	27.8 (193)	24.3 (196)	0.83 [0.66, 1.05]	0.88 [0.66, 1.17]
6-8 years	23.5 (179)	13.6 (104)	0.51 [0.39, 0.67][c]	0.59 [0.42, 0.82][b]
13-15 years	15.8 (87)	10.1 (78)	0.60 [0.43, 0.83][b]	0.68 [0.45, 1.02]
Total	22.9 (459)	16.1 (378)	0.65 [0.56, 0.75][c]	0.74 [0.61, 0.89][b]
Overweight (excl. obesity)				
3-5 years	1.4 (10)	6.0 (48)	4.33 [2.17, 8.63][c]	3.95 [1.69, 9.22][b]
6-8 years	5.2 (40)	14.7 (112)	3.11 [2.13, 4.52][c]	3.24 [1.97, 5.32][c]
13-15 years	10.2 (56)	14.8 (115)	1.54 [1.09, 2.16][a]	1.48 [0.97, 2.26]
Total	5.3 (106)	11.7 (275)	2.38 [1.89, 3.01][c]	2.38 [1.77, 3.20][c]
Obesity				
3-5 years	0.4 (3)	2.5 (20)	5.86 [1.73, 19.81][b]	3.48 [0.89, 13.61]
6-8 years	0.5 (4)	9.4 (72)	19.75 [7.18, 54.33][c]	13.65 [4.44, 41.97][c]
13-15 years	2.0 (11)	6.2 (48)	3.24 [1.66, 6.29][b]	3.49 [1.57, 7.77][b]
Total	0.9 (18)	6.0 (140)	7.02 [4.28, 11.50][c]	5.94 [3.33, 10.57][c]

[a] P<0.05; [b] P<0.01; [c] P<0.001

DISCUSSION

This is the first study to investigate BMI and BMI class distributions in a reference cohort of healthy and affluent South Asian children, that were largely unaffected by the obesity epidemic. Our study is also the first to investigate thinness rates based on universal BMI cut-offs in South Asian children living in a developed country. We found an unusually, in fact implausibly high prevalence of (severe) thinness for a developed country as the Netherlands and a very low prevalence of obesity. Although severe thinness and thinness rates in cohort 1991-1993 were still very high, especially at ages 3-5 years, these declined with increasing age while simultaneously overweight and obesity prevalence increased, findings that are suggestive of the effect of the obesity epidemic.

In India the prevalence of thinness/undernutrition is still the highest in the world,[5] despite generally better socio-economic circumstances and lower poverty levels than in many other developing countries, a situation that has been called the 'South Asian enigma'.[25] A recent Indian study found a total thinness prevalence, based on the IOTF criteria, of around 70% in rural Indian schoolchildren 5-12 years of age.[26] Caucasian children in the Netherlands aged 2-18 years had in 1980 a prevalence of severe thinness and thinness of 1.5-2.9% and 11.4-12.1%, respectively, figures that had only slightly changed in 1997[27] and that are much lower than in both cohorts. On the other hand, the doubling of the overweight prevalence in Dutch Caucasian children between 1980 and 1997[28] parallels the increase seen in our study between cohort 1974-1976 and cohort 1991-1993, whereas the increases in obesity were much larger in Surinamese South Asian children. Rates of overweight and obesity in contemporary 14-17 year old children living in affluent urban areas in India are with 16.0% and 5.0% similar to those found in 13-15 year old Surinamese South Asian children of cohort 1991-1993.[3] Recent studies of Indian adolescents in the UK generally found higher rates of overweight and obesity than in cohort 1991-1993 of our study.[29,30]

Implications for clinical practice

The high prevalence of (severe) thinness and the low prevalence of overweight and obesity in our reference cohort is likely the expression of the typical 'thin-fat' body composition of South Asian children.[8–10] A recent Sri Lankan body composition study demonstrated that many children classified as 'thin' (based on the IOTF cut-offs) had a normal or even high fat mass percentage whereas children with a normal BMI had on average very high fat mass percentages with values over 35%.[10] Consequently, universal BMI criteria are expected to underestimate the prevalence of overweight and obesity,[29,31] and overestimate the prevalence of thinness in South Asian children.

Therefore, without ethnic specific cut-off values for the determination of thinness, overweight and obesity in South Asian children, a proper nutritional assessment will remain difficult. Several recent studies have proposed lowered BMI cut-offs to determine overweight and obesity in South Asian children,[32–34] but consensus has not been reached over which set of BMI cut-offs is most suitable, perhaps because of the different designs and limitations of the studies.

Although we encourage the development of ethnic specific BMI cut-offs for thinness, overweight, and obesity for South Asian children aged 2-18 years, we would recommend these to be developed with the state-of-the-art methods that were used to establish the WHO reference and IOTF cut-offs.[7,23] Even though these BMI criteria are purely statistically defined, and therefore more or less arbitrary, there are presently few available alternatives. A set of South Asian specific cut-offs derived in this manner would complement the existing sets of BMI criteria of WHO and IOTF and make them more comparable. Nevertheless, strong evidence based research relating the defined BMI cut-offs with actual health outcomes during childhood (or even adulthood) remains highly needed.

Strengths and limitations

Strengths of this study were the availability of personal, socio-demographic, obstetric, and medical information, and of high quality follow-up data on height and weight of two almost complete birth cohorts.

A limitation of our data is that the beginning of the obesity epidemic in the Netherlands may have influenced the BMI class distribution of our reference cohort, as the 13-15 years age group was measured around the late 1980's, at which time the obesity epidemic had already begun. Nevertheless, we expect the effect of the beginning of the obesity epidemic to have been marginal as the obesogenic changes in Dutch society occurred gradually and the effects on older age groups are likely to have been smaller than on younger children.

CONCLUSIONS

Our study is the first to investigate the BMI and BMI class distribution in a cohort of affluent South Asian children born before the obesity epidemic. In this cohort we found a disproportionately high prevalence of thinness and a low prevalence of overweight and obesity when based on universal BMI cut-offs. The obesity epidemic had a strong influence on rates of (severe) thinness, overweight and obesity prevalence in Surinamese South Asian children, but thinness rates generally remained implausibly high. Based on these findings and current knowledge on body composition of South Asians, we challenge the use of universal BMI cut-offs whereby thinness prevalence will consistently be overestimated and overweight and obesity prevalence underestimated. Therefore, we recommend the development of a single set of ethnic-specific BMI criteria for South Asian children.

REFERENCES

1. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006; 1(1):11-25.
2. de Onis M, Blossner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. *Am J Clin Nutr* 2010; 92(5):1257-1264.
3. Khadilkar VV, Khadilkar AV, Cole TJ, Chiplonkar SA, Pandit D. Overweight and obesity prevalence and body mass index trends in Indian children. *Int J Pediatr Obes* 2011; 6(2-2):e216-e224.
4. Jafar TH, Qadri Z, Islam M, Hatcher J, Bhutta ZA, Chaturvedi N. Rise in childhood obesity with persistently high rates of undernutrition among urban school-aged Indo-Asian children. *Arch Dis Child* 2008; 93(5):373-378.
5. 6th report on the world nutrition situation. Geneva: United Nations Standing Committee on Nutrition, 2009. www.unscn.org/files/Publications/RWNS6/report/SCN_report.pdf
6. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; 854):1-452.
7. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007; 85(9):660-667.
8. Yajnik CS, Lubree HG, Rege SS *et al*. Adiposity and hyperinsulinemia in Indians are present at birth. *J Clin Endocrinol Metab* 2002; 87(12):5575-5580.
9. Deurenberg-Yap M, Chew SK, Deurenberg P. Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. *Obes Rev* 2002; 3(3):209-215.
10. Wickramasinghe VP. Hattori chart based evaluation of body composition and its relation to body mass index in a group of Sri Lankan children. *Indian J Pediatr* 2012; 79(5):632-639.
11. Lear SA, Kohli S, Bondy GP, Tchernof A, Sniderman AD. Ethnic variation in fat and lean body mass and the association with insulin resistance. *J Clin Endocrinol Metab* 2009; 94(12):4696-4702.
12. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004; 363(9403):157-163.
13. Ehtisham S, Crabtree N, Clark P, Shaw N, Barrett T. Ethnic differences in insulin resistance and body composition in United Kingdom adolescents. *J Clin Endocrinol Metab* 2005; 90(7):3963-3969.
14. Jafar TH, Islam M, Poulter N *et al*. Children in South Asia have higher body mass-adjusted blood pressure levels than white children in the United States: a comparative study. *Circulation* 2005; 111(10):1291-1297.
15. Whincup PH, Gilg JA, Papacosta O *et al*. Early evidence of ethnic differences in cardiovascular risk: cross sectional comparison of British South Asian and white children. *BMJ* 2002;324(7338):635.
16 . Den Haag in cijfers - Bevolkingsgegevens gemeente Den Haag. Municipality of The Hague; 2012. Available from: http://denhaag.buurtmonitor.nl/quickstep/QsPrintPresentation.aspx?sel_code=add919ed-e2a1-4aa4-a79a-b1ba8a59e64a.
17. Hindoestanen. Wikipedia; 2012. Available from: http://nl.wikipedia.org/wiki/Hindoestanen.
18. Step-by-step plan RC review. The Hague: Central Committee on Research Involving Human Subjects (CCMO); 2012. Available from: http://www.ccmo-online.nl/main.asp?pid=10&sid=30&ssid=51.
19. Euser AM, de Wit CC, Finken MJ, Rijken M, Wit JM. Growth of preterm born children. *Horm Res* 2008; 70(6):319-328.
20. Luke B, Leurgans S, Keith L, Keith D. The childhood growth of twin children. *Acta Genet Med Gemellol (Roma)* 1995; 44(3-4):169-178.
21. van Dommelen P, de Gunst M, van der Vaart A, van Buuren S, Boomsma D. Growth references for height, weight and body mass index of twins aged 0-2.5 years. *Acta Paediatr* 2008; 97(8):1099-1104.

22. WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl* 2006; 450):76-85.
23. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; 320(7244):1240-1243.
24. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* 2007; 335(7612):194.
25. Nube M. The Asian enigma: predisposition for low adult BMI among people of South Asian descent. *Public Health Nutr* 2009; 12(4):507-516.
26. Mondal N, Sen J. Thinness is a major underlying problem among Indian children. *J Trop Pediatr* 2010; 56(6):456-458.
27. van Buuren S. [Body-mass index cut-off values for underweight in Dutch children]. *Ned Tijdschr Geneeskd* 2004; 148(40):1967-1972.
28. Hirasing RA, Fredriks AM, van BS, Verloove-Vanhorick SP, Wit JM. [Increased prevalence of overweight and obesity in Dutch children, and the detection of overweight and obesity using international criteria and new reference diagrams]. *Ned Tijdschr Geneeskd* 2001; 145(27):1303-1308.
29. Saxena S, Ambler G, Cole TJ, Majeed A. Ethnic group differences in overweight and obese children and young people in England: cross sectional survey. *Arch Dis Child* 2004; 89(1):30-36.
30. Taylor SJ, Viner R, Booy R *et al*. Ethnicity, socio-economic status, overweight and underweight in East London adolescents. *Ethn Health* 2005; 10(2):113-128.
31. Shaw NJ, Crabtree NJ, Kibirige MS, Fordham JN. Ethnic and gender differences in body fat in British schoolchildren as measured by DXA. *Arch Dis Child* 2007; 92(10):872-875.
32. Duncan JS, Duncan EK, Schofield G. Ethnic-specific body mass index cut-off points for overweight and obesity in girls. *N Z Med J* 2010; 123(1311):22-29.
33. Khadilkar VV, Khadilkar AV, Borade AB, Chiplonkar SA. Body Mass Index Cut-offs for Screening for Childhood Overweight and Obesity in Indian Children. *Indian Pediatr* 2012; 49(1):29-34.
34. Wickramasinghe VP, Lamabadusuriya SP, Cleghorn GJ, Davies PS. Defining anthropometric cut-off levels related to metabolic risk in a group of Sri Lankan children. *Ann Hum Biol* 2011; 38(5):537-543.

CHAPTER 4

Trends in overweight and obesity prevalence in Dutch, Turkish, Moroccan and Surinamese South Asian children in the Netherlands

Jeroen A. de Wilde
Paula van Dommelen
Barend J.C. Middelkoop
Paul H. Verkerk

Archives of Disease in Childhood, 2009;95:795

ABSTRACT

Objective: To determine trends in the prevalence of overweight and obesity in children in the city of The Hague (the Netherlands) from 1999 through 2007.
Design: Population-based study of a series of cross -sectional assessments of height and weight from electronic health records.
Setting: Child Health Care of Municipal Health Service The Hague.
Participants: 50 961 children, aged 3-16 years, with Dutch (59%), Turkish (17%), Moroccan (13%) or Surinamese South Asian (11%) ethnicity, representative of the four major ethnic groups in The Hague, with 85 234 weight and height measurements recorded in the period 1999-2007.
Main outcome measures: (Trends in) prevalence of overweight (excluding obesity) and obesity as defined by the International Obesity Taskforce (IOTF) cut-off points, using logistic regression with year as independent variable.
Results: From 1999 through 2007 there was a decrease in the prevalence of overweight in Dutch girls from 12.6% to 10.9% (odds ratio [OR]=0.96; 95% Confidence Interval [CI]= 0.95-0.98) and an increase in Turkish boys from 14.6% to 21.4% (OR=1,08; 95%CI:1.04-1.11). Obesity prevalence rose significantly in Turkish boys from 7.9% to 13.1% (OR=1.04; 95%CI:1.01-1.06) and in Turkish girls from 8.0% to 10.7% (OR=1.04; 95%CI:1.01-1.08). Dutch boys, and Moroccan and Surinamese South Asian boys and girls showed no significant trends.
Conclusions: The declining prevalence of overweight in Dutch girls may indicate a turning point in the trend from past decades in the Netherlands. However, in Turkish children prevalence of overweight as well as obesity is high and increasing. Further public health actions remain necessary, especially for Turkish children.

What is already known on this topic

- Overweight and obesity prevalence in children in the Netherlands is still rising and at a faster rate than between 1980 and 1997.
- Overweight and obesity in the Netherlands are more prevalent in Turkish and Moroccan children.

What this study adds

- In Dutch girls overweight prevalence has declined since 1999.
- In Turkish children overweight and obesity prevalence has risen strongly since 1999.

INTRODUCTION

Worldwide, the prevalence of obesity in children has steadily increased since the 1980's.[1,2]
The fourth Dutch growth study of 1997 in the Netherlands also showed a two to fourfold increase in overweight and obesity prevalence in Dutch children compared to 1980 with a total overweight (including obesity) prevalence of 13%.[3] In this study, for the first time, the second and third largest ethnic groups in the Netherlands, Turkish and Moroccan, were studied separately. These groups showed a two to four times higher prevalence of both overweight and obesity compared to Dutch children.[4] The prevalence of overweight and obesity in Turkish children in the Netherlands is however comparable to that found in Germany.[5] In Turkey itself, prevalence of overweight and obesity in children is lower and approximates the current level of overweight and obesity of Dutch children in the Netherlands.[6–8]
Compared to many other Western European countries, prevalence of overweight and obesity in Caucasian children in the Netherlands is relatively low. In 1997 around 12% of children aged 7-17 years were overweight or obese while in the United Kingdom rates in Caucasian children were almost twice as high as in the Netherlands. [9] However, the prevalence of overweight and obesity in the Netherlands may be changing. A recent study showed a faster rate of increase of overweight and obesity in the Netherlands since 1997 than between 1980 and 1997.[10]
Since in that study no separate analyses of overweight and obesity in relation to ethnicity were performed, it is not known whether prevalence of overweight or obesity has increased in all ethnic groups at the same rate.
The aim of our study was to determine time trends in prevalence of overweight (excluding obesity) and obesity among children in the largest ethnic groups in the Netherlands between the ages of 3 and 16 years, using data routinely collected in the city of The Hague between 1999 and 2007.

METHODS

Data collection

Child Health Care in the Netherlands records growth data as part of a routine health surveillance programme in all children. Height and weight are measured at specific ages: 3-4, 5-6, 7-10, and 13-16 year olds. In general all children in these age groups are invited for a standard preventive health examination by a school physician or school nurse. Examinations of 3-6 year olds are performed by a school physician and 7-10 year olds are examined by a school nurse. Until 2004 13-16 year olds were examined by school physicians, but numbers of examined adolescents were, because of understaffing, never optimal. From 2004 examinations of 13-16 year olds were prioritized and more school nurses were employed to perform the examinations instead of the school physicians. The year 2004 can be regarded as a transition year in which more 13-16 year olds and slightly less 7-10 year olds had a health assessment.
In the city of The Hague, with a population of around 470 000, all findings from preventive health assessments by Child Health Care have been documented in an electronic patient record

system since September 1998. For the current study we used all height and weight data that had been collected between January 1st 1999 and December 31st 2007. Only children with Dutch, Turkish, Moroccan or Surinamese South-Asian ethnicity were included in the study.
Main personal data such as name, date of birth, sex, address, postal code, land of birth of both child and parents, and nationality were acquired from the Municipal Database (Personal Files) to keep the electronic patient record system up to date.

Anthropometric methods and definitions of overweight

Heights and weights were measured by trained public health care professionals (school physicians and school nurses). At ages 3 through 6 body weight was measured with a standard mechanical or electronic step scale in underclothes. From the age of 7 body weight was measured in light clothing without shoes. Height was measured with a stadiometer or microtoise and rounded to the nearest 0.1-0.5 cm and weight rounded to the nearest 0.1-0.5 kg, depending respectively on the type of stadiometer / microtoise or scale. Body Mass Index (BMI) was calculated with the formula *weight (in kg)/[height(in m)]*^{2}.
To determine weight status we used the internationally agreed standard for overweight (excluding obesity) and obesity of the International Obesity Taskforce (IOTF) using BMI cut-off points for age and sex that correspond to the adult cut-offs of 25 for overweight and 30 for obesity.[11]
In this study we will define overweight as overweight but not obese, and total overweight as overweight including obesity.

Ethnicity and Socioeconomic status

Ethnic origin of children was first based on the mother's country of birth. If however the mother was born in the Netherlands and the father was born outside the Netherlands the father's birth country prevailed. If parental country of birth was not recorded in the municipal database, nationality was used as a proxy for ethnicity. Surinamese South Asian children could not be selected on parental birth country alone, because Surinam is a multi-ethnic society with people originating from China, Indonesia, India, the Netherlands and Africa. To select Surinamese South Asian children we matched the family names with a list of 2236 typical Surinamese South Asian family names.
As a proxy of socioeconomic status (SES) we used municipal area deprivation scores (ADS) that have been attributed to each residential district of The Hague since 1995. ADS is a continuous variable, that is based on unemployment rates, average income, housing subsidy rates in the particular area, and percentage immigrants. It ranges from -25 to 25. The ADS was added to each recorded height and weight based on the postal code during the time of measurement.

Method of analysis

Dutch, Turkish and Moroccan growth reference values from the fourth Dutch growth study [3,4] were added to the individual records. As no growth reference for Surinamese South Asian children exist the Dutch reference was added to these records. Extreme values of height, weight, BMI, height-SDS, weight-SDS and BMI-SDS were checked and either corrected where possible or excluded from the analyses. Time trends in prevalence rates of overweight and obesity over the nine year period (1999-2007) were calculated with logistic regression analyses with year of examination as a continuous independent variable for each sex, ethnic group and age group separately. In these analyses, all records of children in the database that did not belong to the analysed group were used as a reference group, i.e. all non-obese (including overweight) were analysed versus obese and all non-overweight (including obese) versus overweight. Age and SES, both measured on a continuous scale, were introduced into the model as adjusting variables. P-values (two-sided) less than 0.05 were considered statistically significant.

RESULTS

A total of 85 234 measurements of both weight and height in 50 961 children, measured between 1999 and 2007, were used in the analyses. Less than 0.1% of all measurements were excluded from the analyses. Table 1 shows the details of the studied population. Ethnic groups are represented equally over the years and together form a representative sample of the population of The Hague.

Participation in the health surveillance programme was high (83.0%) after non-respondents were sent a second invitation to attend. Participation did not change markedly during the studied period and between ethnic groups the participation rate was similar (Dutch: 83.5%, Turkish 82.0%, Moroccan 81.6%, Surinamese South Asians 83.0%). Reasons for non-participation are not known.

Over the 9-year time period Turkish children had the highest mean prevalence of total overweight (including obesity) of 28%, followed respectively by Moroccan (23%), Surinamese South Asian (15%) and Dutch children (13%). In Turkish boys (Figure 1) and girls (Figure 2) total overweight prevalence has respectively increased from 22.4% to 34.5% ($P<0.0001$) and from 27.4% to 33.8% ($P=0.003$). Total overweight in Dutch girls has decreased significantly from 16.3% in 1999 to 14.2% in 2007 ($P<0.0001$). Dutch boys, and Moroccan and Surinamese South-Asian boys and girls show no significant trend after adjustment for age and SES.

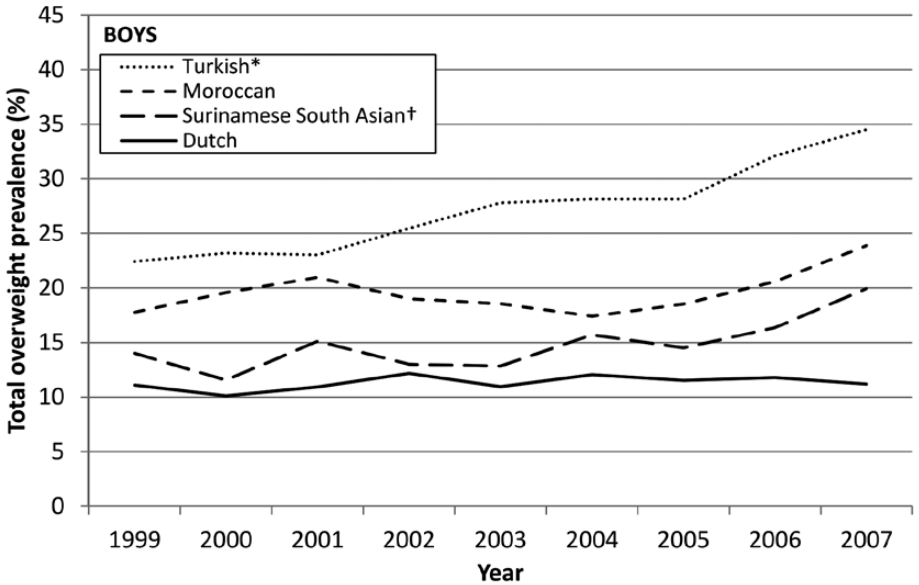
In Tables 2 and 3 prevalence of overweight and obesity is shown by ethnic group, sex and age group. The odds ratios are adjusted for SES (for the different age groups) or age and SES (total per sex). The analyses show a decline in the prevalence of overweight in Dutch 3-6 year old boys and girls, however, overweight prevalence in 7-10 year old Dutch boys showed a significant increase and therefore prevalence in the group of Dutch boys as a whole does seem to be stable.

In Turkish boys overweight prevalence has increased from 14.5% in 1999 to 21.4% in 2007 ($P=0.005$), which can be attributed to a significant increase in overweight in 7-10 year olds boys. Obesity prevalence has however increased in all age groups and the total prevalence rose from 7.9% to 13.1% in 2007 ($P<0.0001$). In Turkish girls overweight increased significantly in 3-6 year olds and obesity in 7-10 year olds. Whilst at a group level no significant trends for overweight and obesity could be found in Moroccan and Surinamese South Asian children, overweight prevalence has significantly increased in 7-10 year old Surinamese South Asian boys and 13-16 year old Moroccan boys. In Moroccan 13-16 year old boys also obesity rates have risen.

Table 1 *Study population characteristics (numerator between brackets)*

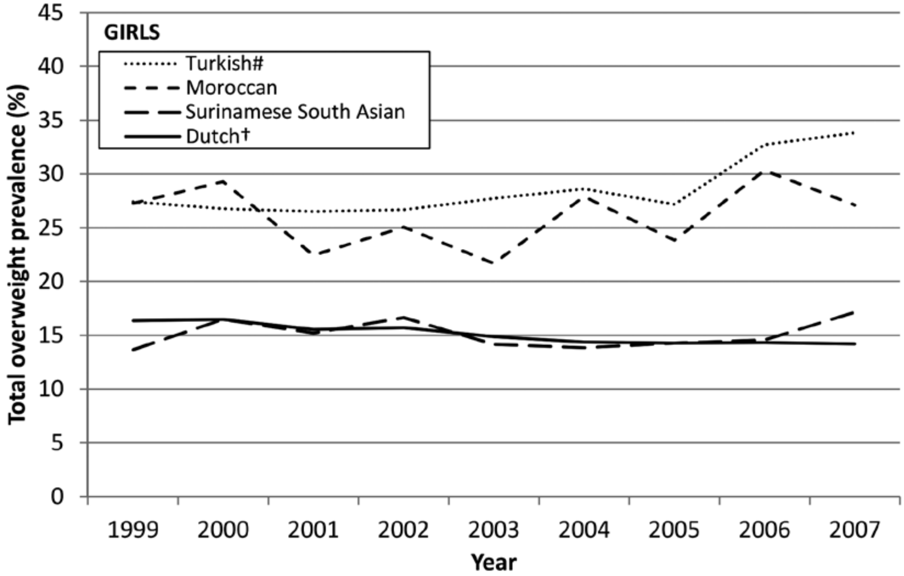
	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
N	8749	8112	9541	8574	8524	9407	9919	12100	10308	85234
Sex (%)										
Boy	50.8 (4444)	51.0 (4140)	51.3 (4891)	50.6 (4337)	51.1 (4358)	50.8 (4776)	50.4 (5003)	51.2 (6193)	50.7 (5224)	50.9 (43366)
Girl	49.2 (4305)	49.0 (3972)	48.7 (4650)	49.4 (4237)	48.9 (4166)	49.2 (4631)	49.6 (4916)	48.8 (5907)	49.3 (5084)	49.1 (41868)
Ethnicity (%)										
Dutch	61.1 (5349)	57.1 (4636)	57.2 (5458)	60.0 (5147)	60.3 (5141)	57.7 (5424)	61.4 (6086)	60.8 (7359)	56.2 (5793)	59.1 (50393)
Turkish	14.4 (1260)	17.5 (1416)	17.5 (1672)	16.5 (1413)	16.1 (1372)	16.8 (1583)	16.0 (1591)	16.3 (1975)	18.3 (1889)	16.6 (14171)
Moroccan	12.1 (1063)	13.4 (1086)	13.9 (1322)	12.0 (1032)	12.4 (1054)	13.8 (1298)	12.0 (1193)	12.1 (1469)	14.4 (1480)	12.9 (10997)
Surinamese South Asian	12.3 (1077)	12.0 (974)	11.4 (1089)	11.5 (982)	11.2 (957)	11.7 (1102)	10.6 (1049)	10.7 (1297)	11.1 (1146)	11.3 (9673)
Age Group (%)										
3-6 year	64.0 (5596)	68.9 (5586)	66.8 (6374)	70.6 (6055)	79.6 (6784)	77.1 (7252)	69.2 (6865)	57.6 (6965)	48.1 (4959)	64.0 (5596)
7-10 years	30.6 (2681)	24.4 (1982)	27.0 (2576)	25.9 (2218)	17.3 (1474)	9.1 (858)	16.5 (1639)	21.9 (2646)	31.8 (3283)	22.7 (19357)
13-16 years	5.4 (472)	6.7 (544)	6.2 (591)	3.5 (301)	3.1 (266)	13.8 (1297)	14.3 (1415)	20.6 (2489)	20.0 (2066)	11.1 (9441)
Response (%)	82.3	78.7	84.8	84.5	83.2	83.2	84.5	85.6	79.9	83.0

Figure 1 *Total overweight (including obesity) prevalence in boys per ethnic group from 1999 through 2007*



*Significant increase, also after adjustment for age and SES (OR=1.061; 95%CI =1.039-1.083), †significant increase, but not after adjustment for age and SES.

Figure 2 *Total overweight (including obesity) prevalence in girls per ethnic group from 1999 through 2007*



*Significant increase, also after adjustment for age and SES (OR=1.032; 95%CI =1.010-1.053), †Significant decrease, also after adjustment for age and SES (OR=0.964; 95%CI=0.951-0.978).

Table 2 *Overweight (excluding obesity) rates (%) per ethnic group, sex and age group in 1999 and 2007 and for the whole period 1999-2007; Unadjusted and adjusted odds ratio (OR) and 95% Confidence Interval (CI) for 1999 through 2007 with year of examination as independent variable, adjusted for SES (age group) or SES and age (totals per sex per ethnic group)*

			1999	2007	1999 - 2007		
			% (n)	% (n)	% (n)	OR; 95%CI, unadjusted	OR; 95%CI, adjusted
Dutch	Boys	3-6 years	7.6 (1683)	5.2 (1474)	7.2 (1241)	0.972; 0.949-0.995*	0.975; 0.952-0.998*
		7-10 years	10.8 (916)	13.1 (793)	11.9 (675)	1.031; 1.002-1.060*	1.040; 1.011-1.070**
		13-16 years	11.5 (113)	12.2 (637)	14.4 (374)	0.849; 0.757-0.952**	0.981; 0.933-1.031
		Total	8.8 (2712)	8.9 (2904)	8.9 (229)	1.010; 0.994-1.027	0.983; 0.967-1.000
	Girls	3-6 years	10.8 (1689)	8.4 (1447)	9.9 (1643)	0.970; 0.950-0.990**	0.971; 0.951-0.991**
		7-10 years	16.2 (819)	14.1 (834)	15.7 (872)	0.976; 0.951-1.001	0.984; 0.959-1.010
		13-16 years	13.2 (129)	12.7 (608)	14.7 (382)	0.888; 0.791-0.996*	0.972; 0.927-1.018
		Total	12.6 (2637)	10.9 (2889)	11.7 (2897)	0.979; 0.965-0.994**	0.963; 0.948-0.978***
Turkish	Boys	3-6 years	12.0 (459)	15.9 (441)	13.9 (657)	1.027; 0.994-1.062	1.028; 0.994-1.063
		7-10 years	21.3 (150)	28.1 (392)	24.0 (428)	1.074; 1.033-1.117***	1.076; 1.035-1.119***
		13-16 years	18.4 (38)	20.6 (175)	25.4 (210)	0.858; 0.762-1.016	1.047; 0.983-1.116
		Total	14.5 (647)	21.4 (1008)	17.6 (1295)	1.035; 1.011-1.060**	1.037; 1.012-1.062**
	Girls	3-6 years	17.0 (406)	18.7 (406)	17.3 (776)	1.035; 1.003-1.068*	1.035; 1.003-1.069*
		7-10 years	28.0 (161)	28.3 (339)	26.7 (419)	1.002; 0.963-1.042	1.003; 0.964-1.044
		13-16 years	10.9 (46)	23.5 (136)	23.2 (179)	0.949; 0.785-1.147	1.056; 0.987-1.129
		Total	19.4 (613)	23.2 (881)	20.1 (1374)	1.019; 0.995-1.043	1.020; 0.996-1.044
Moroccan	Boys	3-6 years	12.8 (374)	11.8 (357)	11.9 (432)	0.984; 0.945-1.024	0.984; 0.945-1.024
		7-10 years	10.7 (140)	20.8 (231)	17.5 (214)	1.050; 0.997-1.106	1.050; 0.996-1.106
		13-16 years	9.5 (21)	22.7 (132)	16.2 (99)	1.202; 0.962-1.502	1.118; 1.014-1.233*
		Total	12.1 (535)	16.7 (720)	13.7 (745)	1.023; 0.993-1.054	1.011; 0.981-1.042
	Girls	3-6 years	20.3 (325)	18.0 (333)	17.4 (616)	1.024; 0.989-1.061	1.023; 0.988-1.060
		7-10 years	20.3 (138)	24.8 (286)	22.0 (283)	1.032; 0.986-1.080	1.032; 0.986-1.080
		13-16 years	18.5 (65)	17.7 (141)	23.5 (167)	0.916; 0.758-1.107	0.986; 0.925-1.052
		Total	20.1 (528)	20.5 (760)	19.2 (1066)	1.026; 1.000-1.053	1.015; 0.989-1.042
Surinamese South Asian	Boys	3-6 years	6.7 (343)	7.3 (261)	5.6 (179)	1.032; 0.971-1.096	1.030; 0.969-1.095
		7-10 years	12.3 (179)	22.7 (220)	16.6 (192)	1.107; 1.048-1.169***	1.108; 1.049-1.170***
		13-16 years	14.3 (28)	15.3 (111)	16.8 (108)	0.880; 0.707-1.096	0.995; 0.912-1.086
		Total	8.9 (550)	14.5 (592)	9.6 (479)	1.083; 1.044-1.124***	1.034; 0.996-1.074
	Girls	3-6 years	5.0 (317)	6.7 (240)	7.5 (216)	0.967; 0.917-1.024	0.976; 0.923-1.032
		7-10 years	15.7 (178)	20.7 (188)	19.2 (220)	1.044; 0.991-1.100	1.048; 0.994-1.104
		13-16 years	15.6 (32)	11.9 (126)	13.8 (95)	0.863; 0.682-1.091	0.987; 0.904-1.078
		Total	9.3 (527)	12.6 (554)	11.3 (531)	1.009; 0.975-1.044	0.984; 0.950-1.020

* P <0.05; ** P<0.01; *** P<0.001

DISCUSSION

The main finding of this study is that in recent years overweight and obesity prevalence in children in the city of The Hague (the Netherlands) has been rising, and in particular in Turkish children. Prevalence of total overweight in Turkish boys rose from 22.4% in 1999 to 34.5% in 2007, which is an increase of 54% since 1999. In Turkish girls a 23% increase in total overweight since 1999 was found, from 27.4% to 33.8%. We also found an unexpected decline in prevalence of overweight (excluding obesity) in Dutch girls from 12.6% in 1999 to 10.9% in 2007,

Table 3 *Obesity rates (%) per ethnic group, sex and age group in 1999 and 2007 and for the whole period 1999-2007; Unadjusted and adjusted odds ratio (OR) and 95% confidence interval (CI) for 1999 through 2007 with year of examination as independent variable, adjusted for SES (age group) or SES and age (totals per sex per ethnic group)*

			1999	2007	1999 - 2007		
			% (n)	% (n)	% (n)	OR; 95%CI, unadjusted	OR; 95%CI, adjusted
Dutch	Boys	3-6 years	1.8 (1683)	1.2 (1474)	1.8 (17343)	0.975; 0.933-1.020	0.992; 0.949-1.038
		7-10 years	3.3 (916)	4.2 (793)	3.6 (5652)	1.016; 0.967-1.067	1.045; 0.994-1.099
		13-16 years	0.9 (113)	2.5 (637)	3.7 (2593)	0.792; 0.645-0.972*	1.039; 0.940-1.148
		Total	2.2 (2712)	2.3 (2904)	2.4 (25588)	1.010; 0.979-1.041	0.997; 0.965-1.029
	Girls	3-6 years	3.4 (1689)	3.5 (1447)	3.0 (16666)	0.992; 0.958-1.029	1.005; 0.970-1.042
		7-10 years	4.5 (819)	3.6 (834)	4.3 (5541)	0.946; 0.903-0.991*	0.972; 0.927-1.019
		13-16 years	3.1 (129)	2.3 (608)	3.7 (2598)	0.803; 0.643-1.003	0.940; 0.864-1.023
		Total	3.7 (2637)	3.3 (2889)	3.4 (24805)	0.973; 0.947-0.999*	0.978; 0.951-1.005
Turkish	Boys	3-6 years	8.3 (459)	11.1 (441)	9.5 (4741)	1.071; 1.030-1.114**	1.071; 1.029-1.114**
		7-10 years	8.7 (150)	14.0 (392)	11.6 (1782)	1.054; 1.000-1.100	1.056; 1.004-1.113*
		13-16 year	0 (38)	16.0 (175)	9.3 (827)	1.182; 0.922-1.515	1.100; 1.037-1.167**
		Total	7.9 (647)	13.1 (1008)	10.0 (7350)	1.075; 1.043-1.107***	1.188; 1.063-1.329**
	Girls	3-6 years	7.6 (406)	8.4 (406)	8.1 (4478)	1.020; 0.977-1.066	1.022; 0.978-1.068
		7-10 years	7.5 (161)	14. 2 (339)	10.8 (1572)	1.082; 1.021-1.146**	1.085; 1.025-1.150**
		13-16 years	13. 0 (46)	8.8 (136)	8.3 (771)	1.181; 0.872-1.600	1.022; 0.924-1.131
		Total*	8.0 (613)	10.7 (881)	8.8 (6821)	1.042; 1.008-1.076*	1.041; 1.007-1.077*
Moroccan	Boys	3-6 years	5.1 (374)	5.9 (357)	5.5 (3619)	0.988; 0.934-1.046	0.968; 0.931-1.044
		7-10 years	7.9 (140)	8.7 (231)	7.3 (1222)	1.025; 0.950-1.107	1.025; 0.950-1.107
		13-16 years	0 (21)	8.3 (132)	6.9 (611)	1.065; 0783-1.448	1.164; 1.002-1.353*
		Total	5.6 (535)	7.2 (720)	6.1 (5452)	1.019; 0.976-1.064	1.011; 0.968-1.056
	Girls	3-6 years	7.7 (325)	6.3 (333)	6.6 (3546)	0.968; 0.918-1.022	0.968; 0.918-1.022
		7-10 years	5.8 (138)	6.6 (286)	8.6 (1287)	0.961; 0.898-1.028	0.960; 0.897-1.027
		13-16 years	7.7 (65)	7.1 (141)	6.3 (712)	1.240; 0.877-1754	1.040; 0.926-1.168
		Total	7.2 (528)	6.6 (760)	7.0 (5545)	0.973; 0.936-1.012	0.970; 0.933-1.010
Surinamese South Asian	Boys	3-6 years	2.3 (343)	3.4 (261)	3.3 (3177)	0.975; 0.901-1.054	0.980; 0.906-1.060
		7-10 years	10. 1 (179)	7.7 (220)	9.4 (1157)	0.997; 0.931-1.067	0.997; 0.931-1.067
		13-16 years	7.1 (28)	5.4 (111)	7.9 (642)	0.924; 0.675-1.266	0.965; 0.860-1.084
		Total	5.1 (550)	5.4 (592)	5.3 (4976)	0.994; 0.948-1.042	0.962; 0.916-1.010
	Girls	3-6 years	2.8 (317)	2.9 (240)	2.5 (2866)	1.014; 0.924-1.113	1.017; 0.926-1.117
		7-10 years	7.3 (178)	6.9 (188)	6.3 (1144)	0.985; 0.906-1.072	0.994; 0.913-1.083
		13-16 years	3.1 (32)	4.0 (126)	4.9 (687)	0.992; 0.670-1.470	0.965; 0.842-1.105
		Total	4.4 (527)	4.5 (554)	3.8 (4697)	0.995; 0.940-1.053	0.975; 0.919-1.034

* P <0.05; ** P<0.01; *** P<0.001

a 14% decrease since 1999. These findings differ from a previous study that showed an increase in overweight and obesity prevalence among children in the general Dutch population.[10] However, in that study ethnic differences were not investigated. Thus, ethnic specific figures in that study may have been similar to those in our study. Alternatively, differences between the studies may be a result of the population of children in The Hague perhaps differing from other regions in the Netherlands or public health campaigns potentially having been more successful in The Hague. More national growth studies are needed to confirm if our findings are representative of the whole of the Netherlands.

The use of growth data from standard health assessments is ideal for monitoring overweight, and the increasing use of electronic patient records systems makes it much easier to acquire growth data for analyses. A strength of this study is the large study population, high response rate and availability of measured (rather than reported) data on weight and height. Furthermore, the reliability of the collected data is high. The electronic patient record system in which the growth data are recorded also plots growth charts which are shown to parents and children during the health examination. Errors in registration are therefore easily recognized and will be corrected by the examiner. Another strong point of our study is that data on SES (based on area deprivation scores) were available. A limitation of using area deprivation scores as a proxy for SES is that they are partly based on percentage immigrants in the particular area. When used as an adjusting factor it could lead to overcompensation for ethnicity. In the present study SES was only used as adjusting variable in analyses within the different ethnic groups and therefore did not affect the outcome.

Although response rates were generally high, for 13-16 year olds the whole target population was not invited every year for a health assessment, due to understaffing until 2003. This would only have affected the results if a specific group had been invited to attend the health assessments. Since this had not been the case, the examined children were most likely a random sample of the target population.

The decrease in the proportion of overweight (excluding obese) Dutch girls and no overall increase in overweight and obesity prevalence in Dutch boys may suggest that in Dutch children a plateau in overweight and obesity prevalence has been reached . Similarly, in Sweden a decrease of overweight in 10 year old girls[12], and in France a stabilization of overweight (including obesity) in 4 to 15 year old children has recently been found.[13]

It is unclear why in our study the prevalence of overweight and obesity is increasing in Turkish children and overweight has decreased in Dutch 3-6 year old boys and girls. Perhaps public health campaigns of the past decade have been better directed to and adopted by Dutch parents and children than by Turkish. A low parental educational level, a known risk factor for childhood overweight and obesity [3], may be an important influential factor since Turkish people in the Netherlands belong to the lowest educated ethnic groups [14].

Many social and behavioural factors such as parenting skills, self-regulation of food intake and the parents' own eating behaviour influence the development of overweight and obesity.[15] The decrease of overweight (excluding obesity) in the youngest age group of Dutch children could mean that parents of young children are becoming more aware of the importance of physical activity and healthy nutrition, and have changed some of these behaviours. However, the concurrent rise in overweight prevalence in 7-10 year old Dutch boys shows that explaining these trends may be more complex with many factors influencing the weight status of a population. In conclusion, prevalence of overweight and obesity in the Netherlands may have reached a plateau in most ethnic groups. However, in Turkish children overweight as well as obesity is still increasing at an alarming rate. In addition, since prevalence in all ethnic groups is continuing to be much higher than in 1980, public health interventions are still needed, especially interventions tailored to Turkish children and their parents.

REFERENCES

1. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002; 360(9331):473-482.
2. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006; 1(1):11-25.
3. Fredriks AM, van Buuren S, Wit JM, Verloove-Vanhorick SP. Body index measurements in 1996-7 compared with 1980. *Arch Dis Child* 2000; 82(2):107-112.
4. Fredriks AM, van Buuren S, Sing RA, Wit JM, Verloove-Vanhorick SP. Alarming prevalences of overweight and obesity for children of Turkish, Moroccan and Dutch origin in The Netherlands according to international standards. *Acta Paediatr* 2005; 94(4):496-498.
5. Kuepper-Nybelen J, Lamerz A, Bruning N, Hebebrand J, Herpertz-Dahlmann B, Brenner H. Major differences in prevalence of overweight according to nationality in preschool children living in Germany: determinants and public health implications. *Arch Dis Child* 2005; 90(4):359-363.
6. Bundak R, Furman A, Gunoz H, Darendeliler F, Bas F, Neyzi O. Body mass index references for Turkish children. *Acta Paediatr* 2006; 95(2):194-198.
7. Oner N, Vatansever U, Sari A *et al*. Prevalence of underweight, overweight and obesity in Turkish adolescents. *Swiss Med Wkly* 2004; 134(35-36):529-533.
8. Simsek E, Akpinar S, Bahcebasi T, Senses DA, Kocabay K. The prevalence of overweight and obese children aged 6-17 years in the West Black Sea region of Turkey. *Int J Clin Pract* 2007;)
9. Lobstein T, Frelut ML. Prevalence of overweight among children in Europe. *Obes Rev* 2003; 4(4):195-200.
10. van den Hurk K., van Dommelen P., Van Buuren S., Verkerk PH, Hirasing RA. Prevalence of overweight and obesity in the Netherlands in 2003 compared to 1980 and 1997. *Arch Dis Child* 2007; 92(11):992-995.
11. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* 2007; 335(7612):194.
12. Sjoberg A, Lissner L, bertsson-Wikland K, Marild S. Recent anthropometric trends among Swedish school children: evidence for decreasing prevalence of overweight in girls. *Acta Paediatr* 2008; 97(1):118-123.
13. Peneau S, Salanave B, Maillard-Teyssier L *et al*. Prevalence of overweight in 6- to 15-year-old children in central/western France from 1996 to 2006: trends toward stabilization. *Int J Obes (Lond)* 2009; 33(4):401-407.
14. Merens,A., Hermans,B. Emancipatiemonitor 2008. Den Haag: Sociaal Cultureel Planbureau, 2009.
15. Birch LL, Davison KK. Family environmental factors influencing the developing behavioral controls of food intake and childhood overweight.
Pediatr Clin North Am 2001; 48(4):893-907.

CHAPTER 5

Declining and stabilising trends in prevalence of overweight and obesity in Dutch, Turkish, Moroccan and South Asian children 3-16 years of age between 1999 and 2011 in the Netherlands

JA de Wilde
PH Verkerk
BJC Middelkoop

Archives of Disease in Childhood, 2014;99:46

ABSTRACT

Objective: In many developed countries overweight and obesity prevalence seems to stabilise. The aim of this study was to determine trends between 1999 and 2011 in overweight and obesity prevalence, and mean BMI z-score in Dutch, Turkish, Moroccan, and Surinamese South Asian children in the Netherlands.

Design: A cross-sectional population based study with 136 080 measurements of height and weight of 73 290 children aged 3-16 years. BMI class and BMI z-score were determined with the latest IOTF criteria, with overweight defined as an adult BMI-equivalent ≥25, and obesity ≥30. Time trends per year were analysed using logistic and linear regression analyses.

Results: The prevalence of overweight in Dutch children declined from 13% to 11% (Odds Ratio 0.960; 95% Confidence Interval 0.954 to 0.965), but increased in Turkish children from 25% to 32% (OR 1.028; 95% CI 1.020 to 1.036). In Moroccan and Surinamese South Asian children overweight rates were stable, but obesity prevalence decreased (OR 0.973; 95% CI 0.957 to 0.989, OR 0.964; 95% CI 0.943 to 0.985 respectively) as well as the mean BMI z-score (B=-0.010; 95% CI -0.014 to -0.006, B=-0.010; 95% CI -0.016 to -0.004). In Turkish children, trends limited to the period 2007-2011 showed no statistically significant relationship for all outcome measures.

Conclusion: The decrease in obesity prevalence in Dutch, Moroccan and Surinamese South Asian children suggests that overweight children became less adipose. The stabilising trend in overweight and obesity prevalence in Turkish children since 2007 may signify a levelling off for this ethnic group.

What is already known on this topic

- Overweight (excluding obesity) and obesity prevalence has been shown to stabilise in many developed countries.
- In Dutch, Moroccan, and Surinamese South Asian children in the Netherlands over weight (excluding obesity) and obesity prevalence was stable from 1999 throug 2007.
- In Turkish children overweight (excluding obesity) and obesity prevalence increased strongly from 1999 through 2007.

What this study adds

- Overweight (including obesity) prevalence declined in Dutch boys and girls from 13% in 1999 to 11% in 2011, obesity prevalence from 3.0% to 1.8%.
- Although in Moroccan and Surinamese South Asian children overweight (including obesity) prevalence was stable since 1999, obesity prevalence and mean BMI z-score declined significantly.
- In Turkish children a stabilising trend in overweight (including obesity) and obesity rates was found since 2007.

INTRODUCTION

In many developed countries overweight and obesity prevalence has been shown to level off since the late 1990's.[1,2] In a previous study we showed that between 1999 and 2007 in the city of The Hague (the Netherlands) overweight and obesity prevalence had stabilised in most ethnic groups, however, there were marked differences between the ethnic groups studied. Dutch children of Western European descent had in 2007 a prevalence of overweight (including obesity) of around 13-14% whereas children of Turkish descent had a much higher rate, of around 34%.[3] Also, time trends differed between the groups. While overweight prevalence in Dutch girls had decreased since 1999, in Turkish children both overweight and obesity had increased sharply. A recent nationwide Dutch study also found that in the four largest cities of the Netherlands (including the city of The Hague) the prevalence of overweight and obesity had levelled off in children of European descent, although at the national level overweight and obesity in this group had increased.[4] Until 1997 the prevalence of overweight and obesity in these cities was appreciably higher than in other parts of the country, leading to national and local governments deciding to provide extra funds for the development and implementation of prevention programs and interventions in these cities. While the extra provisions in the large cities might be responsible for the improvements in certain groups of children, a direct effect has not been measured.[4] Currently, trends in overweight and obesity prevalence in minority groups in the Netherlands are unknown.

The aim of this study is to firstly, estimate the current level of overweight and obesity in four of the major ethnic groups living in the Netherlands, including Dutch of European descent, Turkish, Moroccan, and Surinamese South Asian children, and secondly, to determine trends over time for the period 1999-2011 in prevalence of overweight and obesity, and in mean BMI z-score for each ethnic group.

METHODS

Population

The health of all children in the Netherlands is periodically assessed by physicians, nurses and physician assistants of Youth Health Care. In general, up until the age of four years around 15 health assessments are performed, and thereafter another three occur, usually at ages 5-6, 9-10 and 13-16 years.[5] The attendence rates to the assessments are generally high, ranging from 90-95% in children up until the age of four, and 80-90% in children older than four years of age.[3] The current study used all the height and weight data routinely collected between January 1st 1999 and December 31st 2011 during the standard health examinations at ages 3 through 16 years in the city of The Hague. Important personal and demographic variables such as family name, sex, date of birth, area code, country of birth of child and parents, and nationality were extracted from the digital health records according to the method described in our previous report.[3] Ethical consent for this study was not required as under Dutch law (Medical Research Involving Human Subjects Act) the use of routine medical information for scientific research is allowed without the need for an evaluation by a medical ethical committee, provided that privacy is protected.[6] All personal data, such as names and dates of birth were removed from the database after some essential variables for the analyses were derived from these data, such as ethnic group and age at measurement. The anonymised dataset was used for the analyses.

As in our previous trend analysis,[3] only children belonging to the largest ethnic groups in the city of The Hague were included: Dutch (of European descent), Turkish, Moroccan and Surinamese South Asian. Because an increasing number of parents are second generation migrants in the Netherlands, i.e. born in the Netherlands themselves, ethnicity of all children measured in the years 2008 through 2011 was based on the country of birth of parents and the family name of the child. In the case of mixed origin of the parents, the country of birth of the mother determined ethnicity. However, if the mother was born in the Netherlands but the father in Turkey, Morocco or Suriname, and the child had respectively a typical Turkish, Moroccan or Surinamese South Asian family name, ethnicity was determined by father's country of birth and the child's family name.

BMI criteria

Body Mass Index [BMI=weight/(height)^2] is generally used as a proxy for body fat.[7] In adults a BMI-value of ≥25 kg/m^2 but <30 kg/m^2 is generally defined as overweight and a BMI-value of ≥30 kg/m^2 as obese. As body composition and proportions change during physical development of children these BMI criteria are unsuitable for children. Therefore, BMI cut-offs for age and sex were developed to correspond to adult BMI cut-offs of 25 and 30 kg/m^2 at 18-years[8]. This set of BMI criteria is often referred to as the IOTF (International Obesity Taskforce) cut-offs and can be applied universally, irrespective of ethnic group. Recently this set has been updated to accommodate the calculation of BMI z-scores.[9] For this study we used the new IOTF reference for all ethnic groups and we defined overweight (including obesity) as corresponding to an adult BMI-equivalent ≥25 kg/m^2 and obesity as a BMI ≥30 kg/m^2.

Area deprivation score

The socioeconomic status of a child is customarily determined by educational level of parents or the household income. As this information was unavailable for this study we used the deprivation score of the residential area of the child as a proxy for socioeconomic status of the child. These area deprivation scores are determined by the municipality of the city of The Hague and are based on the percentage of non-western migrants, the percentage of people unemployed for more than three years, the mean household income, the mean value of immovable properties (houses), and the percentage of people who relocated in the past three years. The score ranges from -25 to 25, whereby a higher score indicates a higher deprivation.

Statistical analyses

The differences in population characteristics between the years were determined using chi-square tests. To determine trends over time in the prevalence of overweight (including obesity) and obesity, logistic regression analyses were conducted with overweight (versus no overweight)

and obesity (versus no obesity) as the dependent variables, and year of measurement as the independent variable. Analyses per ethnic group were adjusted for age, deprivation score and sex; analyses per ethnicity and sex were adjusted for age and deprivation score.
Trends over time in mean BMI z-score per ethnic group were tested using a linear regression model with BMI z-score as the dependent variable and year of measurement, sex, age, and area deprivation score as the independent variables.
In all the analyses a p-value (two-sided) <0.05 was considered statistically significant.
IBM SPSS statistics software (Version 20) was used for all analyses.

RESULTS

A total of 73 290 children with 136 080 measurements of height and weight from 1999 through 2011 were included in the analyses. The population characteristics for the period 1999-2011 are shown in table 1. The ethnic group and age group distributions were significantly different between years. In the early years fewer adolescents (13-16 years) received a preventive health assessment. In later years the differences between the distributions were relatively small.

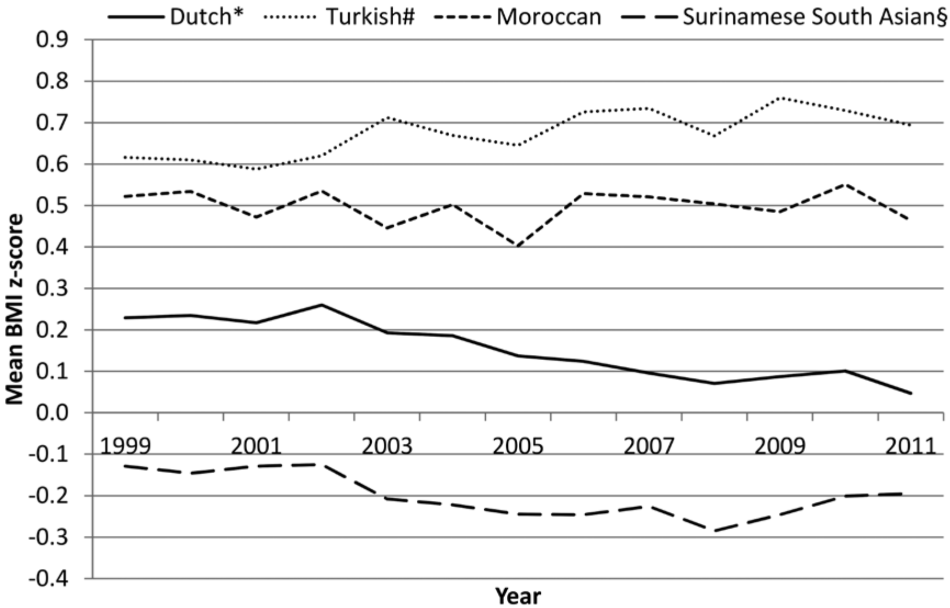
Table 1 *Study population characteristics, 1999-2011. As 1999 through 2007 were published previously, only 1999 and 2007 are shown*[3]

	Year						
	1999	2007	2008	2009	2010	2011	Total 1999-2011
N	8 749	10 308	13 429	11 946	13 574	11 897	136 080
Sex (%)							
Boys	50.8	51.0	50.3	50.5	50.2	50.0	50.7
Girls	49.2	49.0	49.7	49.5	49.8	50.0	49.3
Ethnicity (%)[a]							
Dutch	61.1	56.2	61.3	61.5	58.6	59.8	59.6
Turkish	14.4	18.3	15.6	15.8	17.6	16.7	16.5
Moroccan	12.1	14.4	12.8	12.8	13.9	13.5	13.0
Surinamese South Asian	12.3	11.1	10.3	9.9	9.9	10.0	10.9
Age group (%)[a]							
3-6 years	64.0	48.1	55.4	54.2	55.7	52.2	61.8
7-10 years	30.6	31.8	22.8	25.3	25.2	25.3	23.4
13-16 years	5.4	20.0	21.8	20.5	19.2	22.5	14.8

[a]significantly different from 1999 through 2011, P <0.001

Turkish children had the highest mean BMI z-score, followed by Moroccan, Dutch and Surinamese South Asian children (figure 1). In Surinamese South Asian children the mean BMI z-score in each year was below 0, indicating that on average Surinamese South Asian children had lower BMI's compared to the IOTF reference population. The mean BMI z-score declined statistically significantly in Dutch children between 1999 and 2011, but increased in Turkish and Surinamese South Asian children. However, in Surinamese South Asian children, after adjusting for sex, age and deprivation score, the mean BMI z-score declined significantly.

Figure 1 *Mean BMI z-score by ethnic group, adjusted for age, sex, and area deprivation score, 1999-2011.*



*significant decrease (B=-0.017; 95% CI -0.019 to -0.015), #significant increase (B=0.011; 95% CI 0.007 to -0.015), §significant decrease (B=-0.009; 95% CI -0.015 to -0.003)

We found considerable differences between ethnic groups in overweight (including obesity) and obesity prevalence in 2011 (table 2 and 3). Turkish children had the highest rates, followed by Moroccan, Surinamese South Asian, and Dutch children. Overweight and obesity prevalence declined significantly in Dutch children between 1999 and 2011. In Moroccan and Surinamese South Asian children overweight (including obesity) rates remained stable during the 13-year period, whereas obesity prevalence decreased in both ethnic groups. In Turkish children overweight (including obesity) and obesity increased. However, as the data in table 2 suggest that the prevalence may have levelled off in Turkish children since 2007, we also calculated the trends between 2007 and 2011 (data not shown). These analyses confirmed that in Turkish children there was no statistically significant trend in overweight (including obesity) prevalence (OR 0.997; 95% CI 0.968 to 1.027), nor after adjustment for sex, age and area deprivation score (OR 1.003; 95% CI 0.974 to 1.034). For obesity, a similar trend was found (OR 0.975; 95% CI 0.933 to 1.019; after adjusting for confounding factors OR 0.977; 95% CI 0.934 to 1.021). To test if in Turkish children the trends between the periods 1999-2007 and 2007-2011 were different (increase versus flattening), we performed a logistic regression analysis for the three calendar years 1999 (coded as 1) , 2007 (=9), and 2011 (=13), with the quadratic term $[\text{calendar year}]^2$ added as independent factor (data not shown). This analysis confirmed that the trends were different between the two periods as the quadratic term was statistically significantly associated to the dependent factor *overweight (including obesity)* (P=0.032) and *obesity* (P=0.003) while adjusting for sex, age, and area deprivation score.

The trends between 1999 and 2011 in the mean BMI z-score in overweight (including obese) children showed a statistically significant decline in Dutch, Moroccan, and Surinamese South Asian children (figure 2). This suggests that overweight children of these ethnic groups became less adipose. In overweight (including obese) Turkish children we found no significant trend in mean BMI z-score.

Table 2 *Overweight (including obesity) rates by sex and ethnic group in 1999, 2007, 2011 (other years not shown), and time trends from 1999 through 2011 per calendar year.*

	Overweight (incl. obesity)			Time trends 1999-2011, per calendar year	
	1999	2007	2011	OR (95% CI), unadjusted	OR (95% CI), adjusted
Dutch					
Boys	11.3	11.3	10.6	0.995 (0.987 to 1.003)	0.966 (0.958 to 0.975)[c]
Girls	16.0	14.3	12.3	0.974 (0.967 to 0.982)[c]	0.954 (0.947 to 0.962)[c]
Total	13.6	12.8	11.4	0.984 (0,979 to 0.989)[c]	0.960 (0.954 to 0.965)[c]
Turkish					
Boys	22.7	34.8	32.3	1.049 (1.038 to 1.061)[c]	1.033 (1.021 to 1.045)[c]
Girls	27.1	33.8	32.6	1.034 (1.022 to 1.045)[c]	1.023 (1.011 to 1.035)[c]
Total	24.8	34.4	32.4	1.042 (1.034 to 1.050)[c]	1.028 (1.020 to 1.036)[c]
Moroccan					
Boys	18.1	23.9	23.2	1.020 (1.006 to 1.035)[b]	1.014 (1.000 to 1.028)
Girls	26.1	27.5	22.5	1.003 (0.990 to 1.016)	0.994 (0.981 to 1.007)
Total	22.1	25.7	22.8	1.011 (1.001 to 1.020)[a]	1.003 (0.994 to 1.013)
Surinamese South Asian					
Boys	14.2	19.9	17.4	1.036 (1.019 to 1.053)[c]	1.000 (0.982 to 1.017)
Girls	13.5	17.1	17.3	1.013 (0.996 to 1.030)	0.987 (0.970 to 1.005)
Total	13.8	18.6	17.3	1.024 (1.012 to 1.037)[c]	0.994 (0.981 to 1.006)

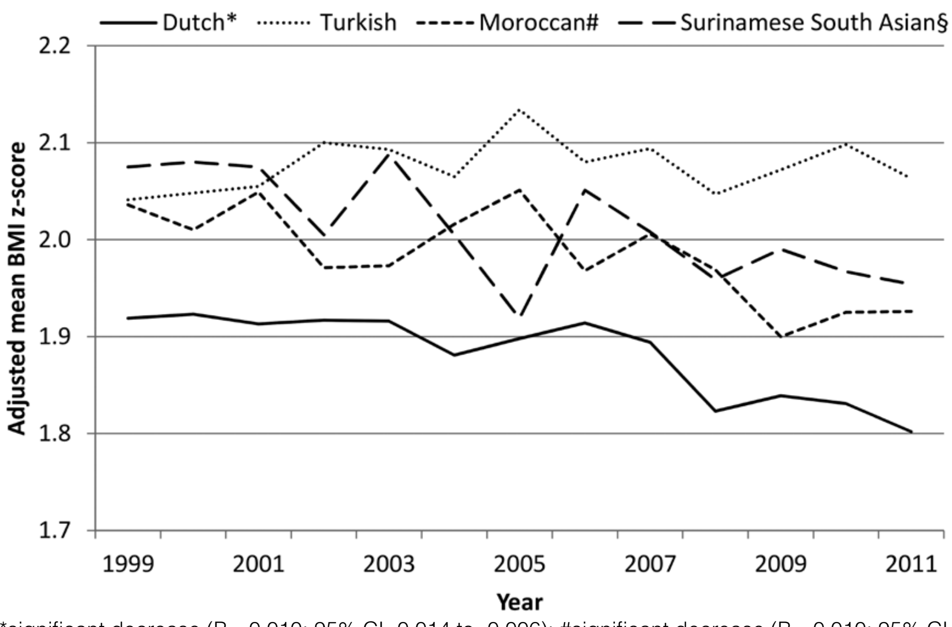
[a]P<0.05; [b]P<0.01; [c]P<0.001; OR=Odds Ratio; CI=Confidence Interval

Table 3 *Obesity rates by sex and ethnic group in 1999, 2007, 2011 (other years not shown), and time trends from 1999 through 2011 per calendar year.*

	Obesity			Time trends 1999-2011, per calendar year	
	1999	2007	2011	OR (95% CI), unadjusted	OR (95% CI), adjusted
Dutch					
Boys	2.2	2.3	1.6	0.976 (0.959 to 0.994)[b]	0.943 (0.925 to 0.961)[c]
Girls	3.9	3.4	1.9	0.951 (0.936 to 0.965)[c]	0.932 (0.917 to 0.947)[c]
Total	3.0	2.8	1.8	0.962 (0.951 to 0.973)[c]	0.937 (0.925 to 0.949)[c]
Turkish					
Boys	8.0	13.1	11.0	1.035 (1.018 to 1.053)[c]	1.030 (1.013 to 1.048)[c]
Girls	8.0	11.5	8.9	1.028 (1.011 to 1.047)[b]	1.025 (1.007 to 1.044)[b]
Total	8.0	12.3	10.0	1.032 (1.020 to 1.044)[c]	1.028 (1.016 to 1.041)[c]
Moroccan					
Boys	6.0	7.1	5.3	0.981 (0.958 to 1.005)	0.973 (0.949 to 0.997)[a]
Girls	7.6	7.2	5.5	0.975 (0.954 to 0.996)[a]	0.972 (0.951 to 0.995)[a]
Total	6.8	7.2	5.4	0.977 (0.962 to 0.993)[b]	0.973 (0.957 to 0.989)[b]
Surinamese South Asian					
Boys	5.1	5.4	5.2	0.987 (0.961 to 1.015)	0.959 (0.932 to 0.987)[b]
Girls	4.6	4.7	3.0	0.989 (0.957 to 1.021)	0.969 (0.937 to 1.002)
Total	4.8	5.1	4.1	0.988 (0.967 to 1.009)	0.964 (0.943 to 0.985)[b]

[a]P<0.05; [b]P<0.01; [c]P<0.001; OR=Odds Ratio; CI=Confidence Interval

Figure 2 *Mean BMI z-score, adjusted for sex, age and area deprivation score, in the subgroup of overweight (including obese) children by ethnic group, 1999-2011.*



*significant decrease (B=-0.010; 95% CI -0.014 to -0.006); #significant decrease (B=-0.010; 95% CI -0.014 to -0.006); §significant decrease (B=-0.010; 95% CI -0.016 to -0.004)

DISCUSSION

In this study for the period 1999-2011 we found more pronounced trends than in our previous report for the period 1999-2007.[3] Obesity declined significantly in Dutch, Moroccan, and Surinamese South Asian children between 1999 and 2011, whereas overweight (including obesity) only declined in Dutch children. While in Moroccan and Surinamese South Asian children overweight rates were stable during the 13-year period, the declining trend in obesity prevalence suggests that Moroccan and Surinamese South Asian overweight children became less adipose. This was also confirmed by a significant decrease in the mean BMI z-score in overweight children of these ethnic groups. In Turkish children overweight and obesity increased significantly between 1999 and 2011, but as there was no trend in the mean BMI z-score in overweight Turkish children over time, this group did not become more adipose. Also, from 2007, overweight (including obesity) and obesity prevalence remained stable in Turkish children, which may indicate that levels have plateaued.

The large representative sample, including four of the major ethnic groups in the Netherlands, and the adjustment for age and area deprivation score in the analyses are unique in our study. Previous studies were of smaller size and compared just two periods, whereas our study included data per calendar year. In addition, height and weight were measured (instead of self-reported) and plotted on digital growth charts that were shown to parents and children during the routine health assessment. This practice allows for the detection of erroneous measurements and the consecutive correction, leading to more precise and reliable data. A limitation of our study is that our results may not be representative of Dutch children (of European descent) in the Netherlands in general, as overweight (including obesity) prevalence in the Dutch population of our study (11%) was somewhat lower than the estimates of a recent national prevalence study (14%).[4] The reasons for this discrepancy are currently unclear. For the minority groups studied, the results from our study are expected to be representative of the whole of the Netherlands, as most Turkish, Moroccan and Surinamese South Asian children reside in larger cities, and our previously determined prevalence rates in Turkish and Moroccan children in 1999 were similar to results from the national study of 1997.[10]

Despite the improvements detected in our study, considerable differences in childhood overweight and obesity prevalence remain between ethnic groups in the Netherlands with overweight (including obesity) in Turkish children (32%) being three times more prevalent than in Dutch children (11%). The differences have even become more pronounced as, contrary to the other ethnic groups, in Dutch children both overweight (including obesity) and obesity have declined. Also, while the prevalence of overweight (including obesity) and obesity in 1999 were still similar for Turkish and Moroccan children, in 2011 the prevalence of overweight (including obesity) in Turkish children was almost 10 percent points higher.

In our previous study, we showed that differences between the ethnic groups in overweight and obesity prevalence were already present in the youngest age groups.[3] Another Dutch study also found considerably higher overweight (including obesity) rates in Turkish and Moroccan children at 2 years of age compared with other ethnic groups,[11] which was attributed to the mother's pre-pregnancy BMI and a more rapid weight gain in the first 6 months. The reason that Turkish and Moroccan children gain more weight during infancy is unknown. Even though infant feeding practices differed between the ethnic groups studied, this was not directly associated with the excess weight gain.[12] Such single factors may not sufficiently explain the ethnic disparities in childhood overweight and obesity. More likely, the found differences are the result of a combination of biological, cultural, socio-economic, and environmental factors, and the interactions between them.[13]

Among the minority groups Surinamese South Asian children are different from Turkish and Moroccan children. In the current study, the mean BMI z-score of Surinamese South Asian children was even the lowest of all ethnic groups, and overweight (including obesity) prevalence was at 17% only slightly higher than in Dutch children. Nonetheless, the prevalence rates in Surinamese South Asian children may not represent the true prevalence in this group, as we recently showed that current universal cut-offs to determine overweight and obesity are likely to be too high for South Asian children.[14] Consequently, the current overweight and obesity rates in South Asian children expectedly underestimate the true prevalence in this group. Therefore, similarly to South Asian adults[15], BMI cut-offs to determine overweight and obesity may have to be lowered for South Asian children.

Although we cannot relate our data to the effectiveness of preventive programs, the declining prevalence of obesity in most ethnic groups of our study, and the stabilisation in the prevalence of overweight (including obesity) and obesity in Turkish children since 2007, might be a result of such programs in the city of The Hague. While studies of individual preventive interventions for overweight have either not shown an effect, or at most a small effect on BMI,[16] the combination of interventions and health promotional activities at different levels (policy, environmental, individual, school, and community) for a prolonged period of time may have had a synergetic effect to lower the overweight and obesity prevalence in several ethnic groups in the city of The Hague. Nevertheless, despite the evidence of a plateau in the prevalence of overweight and obesity in Turkish children, the differences between Dutch children and children from other ethnic groups have increased. This may be due to health promotional messages and lifestyle interventions insufficiently targeted to adequately reach migrant groups, but information on the varying effectiveness of strategies on different ethnic groups is not available. In conclusion, more research is necessary to investigate why the observed trends differ between the migrant groups studied, and why overweight (including obesity) and obesity rates remain considerably higher in Turkish children than in other ethnic groups.

REFERENCES

1. Olds T, Maher C, Zumin S *et al*. Evidence that the prevalence of childhood overweight is plateauing: data from nine countries. *Int J Pediatr Obes* 2011; 6(5-6):342-360.
2. Rokholm B, Baker JL, Sorensen TI. The levelling off of the obesity epidemic since the year 1999--a review of evidence and perspectives. *Obes Rev* 2010; 11(12):835-846.
3. De Wilde JA, van Dommelen P, Middelkoop BJ, Verkerk PH. Trends in overweight and obesity prevalence in Dutch, Turkish, Moroccan and Surinamese South Asian children in the Netherlands. *Arch Dis Child* 2009; 94(10):795-800.
4. Schonbeck Y, Talma H, van Dommelen P *et al*. Increase in prevalence of overweight in Dutch children and adolescents: a comparison of nationwide growth studies in 1980, 1997 and 2009. *PLoS One* 2011; 6(11):e27608.
5. Wieske RC, Nijnuis MG, Carmiggelt BC, Wagenaar-Fischer MM, Boere-Boonekamp MM. Preventive youth health care in 11 European countries: an exploratory analysis. *Int J Public Health* 2012; 57(3):637-641.
6. Step-by-step plan RC review. The Hague: Central Committee on Research Involving Human Subjects (CCMO); 2012. Available from: http://www.ccmo-online.nl/main.asp?pid=10&sid=30&ssid=51.
7. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; 854):1-452.
8. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; 320(7244):1240-1243.
9. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes* 2012; 7(4):284-294.
10. Fredriks AM, van Buuren S, Sing RA, Wit JM, Verloove-Vanhorick SP. Alarming prevalences of overweight and obesity for children of Turkish, Moroccan and Dutch origin in The Netherlands according to international standards. *Acta Paediatr* 2005; 94(4):496-498.
11. de Hoog ML, van Eijsden M., Stronks K, Gemke RJ, Vrijkotte TG. Overweight at age two years in a multi-ethnic cohort (ABCD study): the role of prenatal factors, birth outcomes and postnatal factors. *BMC Public Health* 2011; 11):611.
12. de Hoog MLA, van Eijsden M, Stronks K, Gemke RJB, Vrijkotte TGM. The role of infant feeding practices in the explanation for ethnic differences in infant growth: the Amsterdam Born Children and their Development study. *British Journal of Nutrition* 2011; 106(10):1592-1601.
13. Caprio S, Daniels SR, Drewnowski A *et al*. Influence of race, ethnicity, and culture on childhood obesity: implications for prevention and treatment: a consensus statement of Shaping America's Health and the Obesity Society. *Diabetes Care* 2008; 31(11):2211-2221.
14. De Wilde JA, Zandbergen-Harlaar S, van Buuren S, Middelkoop BJ. Trends in body mass index distribution and prevalence of thinness, overweight and obesity in two cohorts of Surinamese South Asian children in The Netherlands. *Arch Dis Child* 2013; 98(4):280-285.
15. Misra A, Chowbey P, Makkar BM *et al*. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. *J Assoc Physicians India* 2009; 57):163-170.
16. Waters E, de Silva-Sanigorski A, Hall BJ *et al*. Interventions for preventing obesity in children. *Cochrane Database Syst Rev* 2011;(12):CD001871.

Chapter 5

PART 2

Growth references

CHAPTER 6

Height of South Asian children in the Netherlands aged 0-20 years: secular trends and comparisons with current Asian Indian, Dutch and WHO references

Jeroen A de Wilde
Paula van Dommelen
Stef van Buuren
Barend JC Middelkoop

Annals of Human Biology, 2014, early online;
DOI: 10.3109/03014460.2014.926988

ABSTRACT

Background: People from Asian populations are generally shorter than other ethnic groups. It is unknown if current universal height references are suitable for affluent South Asian children in the Netherlands.

Aims: To develop height-for-age charts for contemporary South Asian children aged 0-20 y living in the Netherlands, to evaluate secular trends, and to compare the charts with current Asian Indian, Dutch and WHO references.

Subjects and methods: A population-based study measured 3315 South Asian children aged 0-20 y between 2006 -2009. Among this cohort, 6876 measurements were taken. 7388 measurements were taken of a historical cohort of 1078 children born between 1974-1976 (aged 0-18y).

Results: An upward trend in height was observed for South Asian children living in the Netherlands between 1992 and 2009. The height-for-age charts of the South Asian historical cohort were similar to current Asian Indian charts. South Asian children in the Netherlands were shorter than their Dutch contemporaries at every age; and these differences increased further during adolescence. Compared to the WHO height-for-age references, there were considerable discrepancies in height, with curves intersecting twice.

Conclusion: The discrepancies between the South Asian and Dutch and WHO height-for-age references indicate differences in growth patterns between the source populations.

INTRODUCTION

Height and body weight are important indicators of a child's physical and psychological well-being[1]. In optimal environmental and nutritional conditions it is assumed that children can attain their full genetic growth potential. Therefore, the assessment of growth has been widely used as a (screening) tool for detecting health problems and assessing nutritional status.[1]
The height of a child is usually evaluated by comparing his or her current height to a reference that represents the average height in the child's population. Ideally, the reference is derived from data of a population sample in which there are no constraints due to socio-economic factors, diet, disease and/or access to health services.[2,3] Thus, in developing countries, the reference is usually determined from a more affluent portion of the population in which negative factors impacting growth are limited. However, in many countries such optimal references are not available for the local population.
As the distribution of height was shown to be fairly similar in most ethnic groups up to the age of 5 years, the World Health Organization (WHO) developed a universal child growth standard for children aged 0-5 years, based on data from six affluent populations from all continents. As it represents all major ethnic groups,[4] it was designed as a universally applicable standard, describing 'how children should grow'. As the WHO Child Growth Standard (subsequently referred to as WHO) is ethnic-independent, it assumes all ethnic groups have the same genetic potential. A complementary height-for-age reference for school-aged children and adolescents aged between 5 and 19 years was added later, based on growth in a single population of US children in the late 1970s.[5] As this reference was based on a single population of Caucasian US children, it is unlikely to represent all ethnic groups. Large differences between school-aged children from affluent populations of other countries and this reference population have been reported previously.[6] For example, Dutch children aged 7-18 years were shown to be taller at most ages, whereas Asian children were generally shorter. Moreover, at age 17 adolescents from Northern European countries were found to be considerably taller than 17 year olds in the south of Europe, despite equivalent levels of prosperity. Therefore, the WHO reference may not be suitable for all ethnic groups.[7]
The physical growth of South Asian children in the Netherlands is monitored with growth charts developed for Dutch children.[8] But since Dutch children are the tallest in the world[8] and Asian children are generally among the shortest ethnic groups,[9] the Dutch references may not adequately reflect the height of South Asian children living in The Netherlands. Recently, in India, height-for-age charts have been developed that were based on measurements of affluent children,[10] but it is unknown if these charts will reflect the growth of South Asian children living in the Netherlands.

The objectives of this study were to: firstly, construct height-for-age charts for South Asian children in the Netherlands aged 0-20 years, secondly, evaluate the secular trend in height in this group, and thirdly, determine if the height of contemporary South Asian children in the Netherlands differs from Asian Indian,[10] Dutch,[8] and WHO[4,5] reference populations.

METHODS

Population

The population of South Asians in the Netherlands is estimated at 180 000.[11] The city of The Hague has the largest population of around 40 000, most of whom are descendants of Asian Indians who migrated to the former Dutch colony of Suriname in the 19th century. Around the time of Suriname's independence in 1975, many South Asians migrated to the Netherlands.
For this study, growth data were collected from South Asian children and adolescents living mostly in The Hague area.

Data collection

Youth Health Care services in the Netherlands periodically assess the health of all children at fixed ages.[12] Approximately 15 routine check-ups are generally performed between 0 and 4 years of age, with another three checks at ages 5-6, 9-10 and 13-15 years. The length or height is measured at each visit by trained physicians, nurses or physician's assistants. Customarily, the length of children up to 1.5-2.0 y is measured to the nearest 0.1 cm using a measuring board in a supine position with legs fully extended and heels touching a vertical backboard. From the age of 2 y standing height is measured with a measuring tape (microtoise) or (portable) stadiometer to the nearest 0.1 cm.

To construct growth charts of contemporary South Asian children 0-20 years, all available length/height data, measured between 2006 and 2009, were extracted from the digital Youth Health Care record system of the city of The Hague. As not all ages were represented in these records, additional measurements were taken in 2008 and 2009 from South Asian children and adolescents aged outside the range of the standard check-ups (6-8, 11-12, and 15-20 years). Supplementary data, such as date of birth, sex, the highest level of education achieved by both parents, parental country of birth, the family name of the child and parents, date of menarche, medicine use, and the presence of diagnosed growth disorders were either acquired from the digital record system or from a questionnaire (additionally measured children). In the digital health records date of menarche was not uniformly registered and therefore omitted.
The educational level of parents was subdivided in three categories low, middle, and high.[13]
This part of the current study will be further referred to as 'the 2009 study'.

A second growth study, based on the growth data of a birth cohort born 1974-1976, was performed to investigate the secular trend of height. Measurements of this cohort, taken between 1974 and 1994, were extracted from paper Youth Health Care records alongside the supplementary data. In these records, date of menarche and parental educational level were not available. Contrary to current practice, where children from the age of 4 years are measured only three times, up until the early 1990s children aged between 4 and 18 years were measured every two years. In many records, length/height measurements were missing, as many children lived only a part of their childhood in the city, and because during most health assessments between birth and two years of age, only weight and not length was measured. We will refer to this part of the study as the 'the 1976 study'.

The 2009 study was approved by the Ethical Board of Leiden University Medical Center as part of the 5th National Growth Study. Written consent was obtained from the parents of children under 16 years and verbal consent from the child as well from 12 years. For the 1976 study ethical approval was not needed, as under Dutch law the use of routinely collected medical data from health records is allowed without consent, provided that privacy is protected.[14]

All data were anonymised before analysis.

Inclusion and exclusion criteria

South Asian origin was determined by the country of birth of both parents (born in a South Asian country). Surinamese South Asian ethnicity was determined by two criteria: Suriname (first generation parents) or the Netherlands (second generation) as country of birth of both parents, and the presence of a typical (Surinamese) South Asian family name in both parents. Parents of children who were measured additionally were asked for their ethnicity, alongside the country of birth of parents and grandparents. Only children of whom both parents were of (Surinamese) South Asian descent were included in the study.

Prematurely born children (<37 weeks of gestation) and children with a birth weight <2500g were included, similarly to the 5th Dutch growth study of 2009.[8] Children with a diagnosed growth disorder or using medicine known to affect growth were excluded.

Statistical methods

The LMS method[15] was used to construct growth charts. This method, which transforms data into a normal distribution, is summarized by three age-dependent curves, for skewness (L), median (M) and coefficient of variation (S), which are smoothed against age using natural splines. The amount of smoothing depends on the degrees of freedom of each curve, and was determined by assessing worm plots with 16 age groups.[16]

Age was transformed with a cube root to obtain a better fit during periods of rapid growth. This transformation stretches periods of greater height velocity, for instance during infancy, and compresses periods of slower growth such as the period between the age of four and the beginning of puberty. After an optimal fit was established, the distribution was scaled back to the original age. To enable the height distributions of the 2009 study to be compared with other references, all height data from the 2009 study were converted into z-scores using recent Asian Indian,[10] Dutch,[8] and WHO[4,5] references, as well as the references created in the 1976 study. Z-scores indicate the measurement's deviation from the mean in the reference population.

To determine if the mean z-scores per age differed significantly from the mean of the specific reference, indicated by a value of 0 SD, "estimated marginal means" and 95% confidence intervals were calculated using a linear mixed-effects model. This model takes the correlation between repeated measurements on each subject into account as well as unbalanced designs, for example in studies with unequal numbers of repeated measurements between subjects.

The estimated marginal means are calculated from the fitted model and adjusted for any

of the other variables defined in the model. For the current study, z-score was the dependent variable, and age category and parental educational level were independent variables.
The height reference values (LMS parameters) were calculated with R statistical software v3.0.2 and the GAMLSS package v4.2-6,[17] whereas the other data analyses were performed with IBM SPSS Statistics 20.

RESULTS

2009 Growth charts

The 2009 study included 1644 boys and 1671 girls with 4520 length/height measurements at ages 0-4 years and 2356 at ages 5-20 years. Most children (99%) were of Surinamese South Asian ethnicity. The remainder were of Indian, Pakistani, or Sri Lankan descent.
Of the measurements 18.9%, 51.5% and 29.6% were of children with low, middle and high educated parents respectively.
The height data were normally distributed. Therefore L, the measure of skewness, had a fixed value of 1 at every age. After an optimal fit of the curve was established, the mean (M) and Standard Deviation (SD) were calculated (Table 1). In boys, the final height was reached at age 20 years (Table 1); in girls at 16.5 years of age. The mean age of menarche, based on the reported date of menarche, was 11.4 years (N=381; SD=1.3).

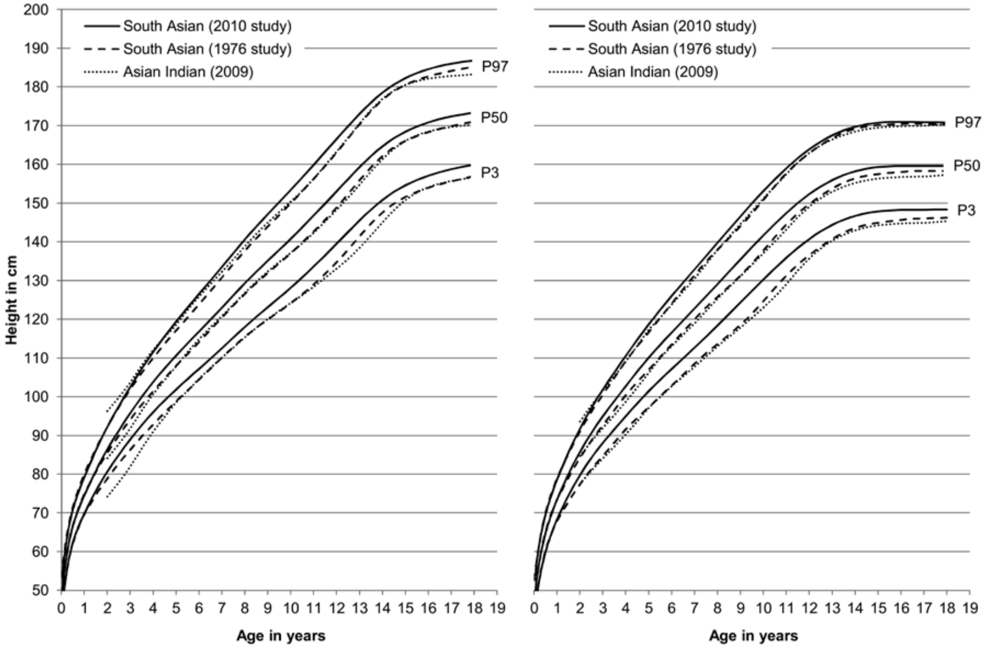
Secular trend in height

In the 1976 study 551 boys and 527 girls were included with 3781 measurements of length/height at ages 0-4 years and 3596 at ages 5-18 years. Similar to the 2009 study the values of height were normally distributed. Table I shows the determined mean and SD values for height.
Secular trends by age and sex were evaluated by comparing the mean values of the 2009 study with the values determined in the 1976 study, finding that in the first month after birth boys of the 2009 study were on average 1.1 cm and girls 0.8 cm shorter than the 1976 cohort (Table 1). This difference gradually decreased during infancy. From the first birthday, the height of both sexes in the 2009 study trended upward compared with the 1976 study until the age of 18.
A maximum positive height difference of 4.2 cm was reached at age 11.5 years in boys, and at 9.0 years in girls. At 18 years of age, boys of the 2009 study were 2.3 cm taller and girls 1.3 cm.

Comparison with Asian Indian, Dutch and WHO references

The height-for-age charts of South Asian children in the Netherlands and of affluent children in India were very similar in shape (Figure 1). The Asian Indian reference and the reference of the historical cohort even coincided at most ages. Children of the 2009 study were significantly taller at all ages 2-18 years ($P<0.001$). The mean z-score based on the Asian Indian reference was 0.5 (Standard Deviation 0.9) both in boys and girls (Figure 2).

Figure 1 *Boys (A) and girls (B) height-for-age charts 0-18 years (P3, P50 and P97), combined South Asian 2009 study, South Asian 1976 study, and Asian Indian 2009 charts.*



Compared with Dutch children, contemporary South Asian children in the Netherlands were shorter at every age between birth and 20 years of age (all P-values <0.001). Four weeks after birth the mean z-score was -0.8 in boys and -1.0 SD in girls. However, these z-scores quickly rose in the first months to -0.5 in boys and -0.6 in girls, after which the values remained fairly stable up till the age of 12 years in boys and 10 years in girls. From that age, the difference in height between South Asian and Dutch children grew. At 20 years of age, the South Asian boys studied were 10.1 cm shorter, and girls 11.1 cm shorter than their Dutch counterparts.

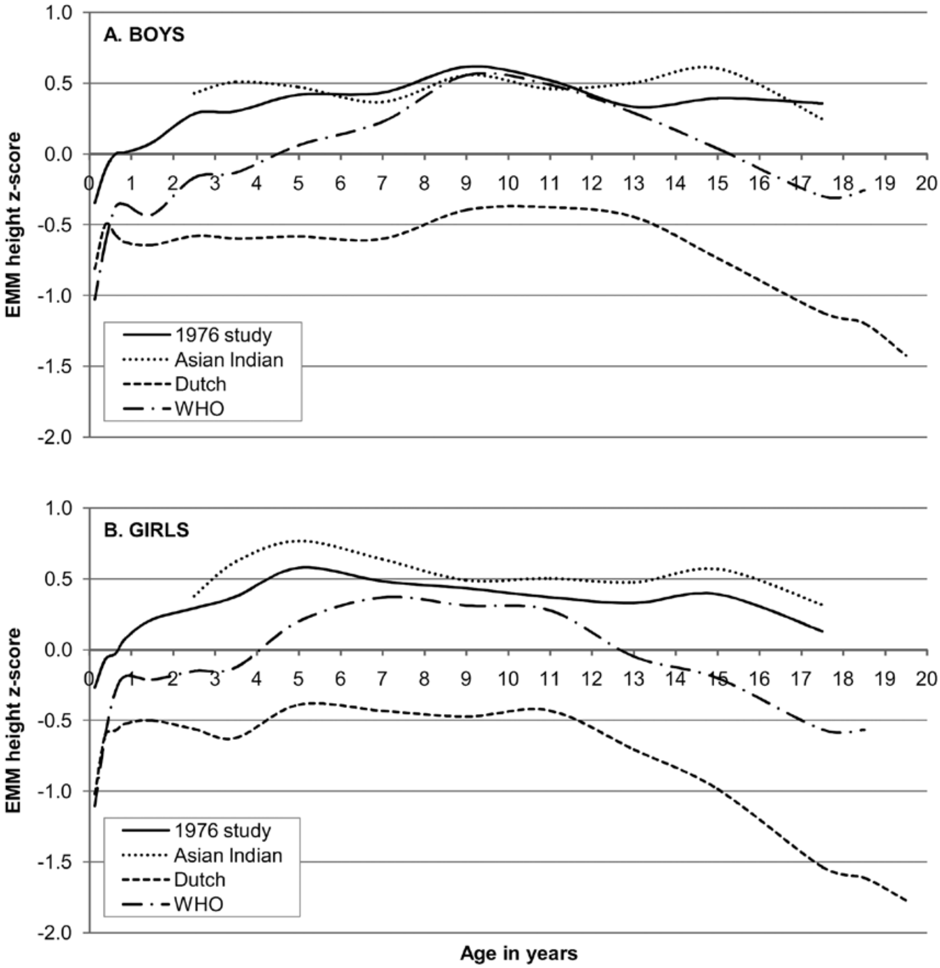
When applying the WHO reference to South Asian children of the 2009 study, a different growth pattern was found (Figure 2). Similar to the Dutch reference, in the first month after birth the mean z-scores were low, -1.1 in boys and -1.0 in girls, values that rapidly increased up to the age of 6 months. However, the mean z-scores became significantly greater than 0 between the age of 5 and 14 years in South Asian boys, with a maximum positive difference of 0.6 SD (P<0.001) at 9 years of age, and in South Asian girls between 5 and 12 years, with the largest difference of 0.4 (P=0.004) at 7 years of age. This indicates that South Asian children in the Netherlands were taller at these ages than the WHO population (US children). Mean height z-scores became again significantly smaller than 0 from the age of 16 years in boys (P<0.001) and from the age of 14 in girls (P<0.001).

Table 1 *Height/Length reference data for boys and girls aged 0-20 years of the Surinamese South Asian 2009 study and the Surinamese South Asian 1976 study*

	Boys				Girls			
	2009		1976		2009		1976	
Age	mean	SD	mean	SD	mean	SD	mean	SD
birth	NA	NA	49.2	2.3	NA	NA	48.4	2.3
0.0417	NA	NA	51.1	2.3	NA	NA	50.4	2.3
0.0833	52.4	2.2	53.5	2.3	51.3	2.3	52.1	2.3
0.1667	56.4	2.2	57.3	2.4	55.1	2.4	55.4	2.4
0.2500	59.8	2.2	60.3	2.4	58.1	2.5	58.4	2.4
0.5000	66.7	2.3	66.9	2.5	64.8	2.6	65.3	2.6
0.7500	71.1	2.4	71.4	2.6	69.6	2.6	69.8	2.8
1.0000	74.6	2.5	75.0	2.8	73.5	2.7	73.5	2.9
1.2500	77.9	2.6	77.9	3.0	76.9	2.8	76.5	3.1
1.5000	80.9	2.8	80.6	3.2	80.1	3.0	79.1	3.3
2.0000	86.5	3.1	85.6	3.5	85.8	3.2	84.2	3.6
3.0000	95.8	3.6	94.1	4.1	95.0	3.7	92.7	4.2
4.0000	103.9	4.1	101.4	4.6	102.8	4.1	100.5	4.7
5.0000	110.7	4.7	108.0	4.9	110.1	4.6	107.0	5.2
6.0000	116.9	5.1	114.2	5.2	116.7	5.0	113.5	5.6
7.0000	123.1	5.6	120.5	5.5	122.9	5.4	120.0	6.1
8.0000	129.4	6.0	126.6	5.9	129.1	5.7	125.9	6.5
9.0000	135.2	6.4	132.0	6.4	135.5	5.9	131.3	6.8
10.0000	140.8	6.7	137.1	6.9	141.7	6.1	137.8	7.0
11.0000	146.8	7.0	142.7	7.3	147.5	6.1	144.5	7.0
12.0000	153.1	7.2	148.9	7.5	152.4	6.2	149.8	7.0
13.0000	159.3	7.3	156.0	7.7	156.0	6.2	153.8	6.9
14.0000	164.7	7.4	162.2	7.7	158.2	6.1	156.4	6.8
15.0000	168.5	7.4	166.1	7.7	159.3	6.1	157.5	6.7
16.0000	170.9	7.3	168.4	7.6	159.6	6.1	158.1	6.6
17.0000	172.4	7.2	169.9	7.6	159.6	6.0	158.3	6.5
18.0000	173.4	7.2	171.1	7.5	159.6	6.0	158.3	6.4
19.0000	174.0	7.1	NA	NA	159.6	5.9	NA	NA
20.0000	174.3	7.0	NA	NA	159.6	5.9	NA	NA

SD=Standard Deviation; NA=Not Available

Figure 2 *South Asian (2009) boys (A) and girls (B) estimated marginal mean (EMM) height z-score by age, based on the 1976 study, Asian Indian, Dutch and WHO references.*



DISCUSSION

With the two separate South Asian specific height-for-age references created in this study, an upward trend in height over the studied period was shown at most ages, except during infancy. In 2009, the final height at 18 years of age was 2.3 cm taller in boys and 1.3 cm in girls than in the 1976 cohort.

While the height-for-age reference charts of the 1976 study coincided to a large extent with current Asian Indian height-for-age charts, the average height of contemporary South Asian children in the Netherlands of the 2009 study was significantly greater at every age than in the population of affluent Asian Indian children upon which the Asian Indian reference was based. Furthermore, we found that South Asian children were shorter at every age than Dutch children, with the largest differences observed during infancy and adolescence. Compared with the WHO reference populations even larger discrepancies in growth patterns over the whole age range were observed.

Strengths and Limitations

A major strength of this study is that it's the first study in which South Asian specific height-for-age charts were developed based on heights of affluent South Asian children living in a developed country. Other strengths are the relatively large sample sizes, the presence of historical data and the availability of important selection criteria, such as demographic data and information on medicine use and diseases/disorders that could have affected growth.

Although the numbers of children were not evenly distributed (larger numbers under the age of 4 years and between 9 and 16 years), so as to establish a good fit of the curves at the age periods of increased growth, the samples were generally large enough to determine statistically significant differences over the whole age range for most references used. However, statistical power was likely not large enough in certain age bands to determine if z-scores statistically significantly differed from a value of 0, especially at the ages with z-scores near the 0 SD-line (WHO reference). Therefore, the exact ages at which the mean height of South Asian children deflects from the WHO reference (population) could not be precisely pinpointed. Nevertheless, the discrepancies in growth pattern between the South Asian and WHO population remain clear.

Another limitation of this study may be the generalisability of the results. It is currently unknown if South Asian children in the Netherlands differ genetically from South Asian populations in other countries, as mixed marriages with other ethnic groups may have occurred in Suriname or the Netherlands. Nonetheless, as most South Asians originating from Suriname have been shown to predominantly marry within their own ethnic group,[18,19] differences are likely to be minimal. In addition, as the growth charts of South Asian children in the Netherlands were almost identical to growth charts of contemporary Asian Indian children, a large concordance in growth is expected. However, further research is needed to verify that the growth charts created in this study are suitable for monitoring height in other populations originating from the Indian subcontinent.

Differences in height between populations: environment or genes?

Similar to the South Asian population in the Netherlands, also in the largest minority populations, the height of Turkish and Moroccan children is still increasing[20]. This secular increase in height of Turkish and Moroccan children is likely the result of improvements in socio-economic factors, as Turkish and Moroccan adults in the Netherlands move from a generally low level of education toward a higher education.[21] Compared with Turkish and Moroccan children, the adult height of South Asian children is on average 3 cm shorter. But this difference is unlikely to be explained by differences in socioeconomic factors as the educational level of South Asian adults, used as proxy for socio-economic status, was already similar in the 1970s to that of Dutch adults.[22] Also in the present study the level of parental education was highly comparable.[23]

Nevertheless, although socioeconomic circumstances in the Netherlands generally improved between 1974 and 2006,[24] the secular trend of increasing height in children of Dutch origin was recently shown to have halted.[8] Additionally, in South Asian children of the current study the increase in final height since 1974 was relatively small, especially when compared with the secular trend found in Turkish and Moroccan children whose final heights increased 2-3 cm in a time frame of only 13 years.[20] Also in India the upward trend in height of affluent children was relatively small in 2007 compared with height in a similar group measured in 1989.[10]
Considering that the socioeconomic status of Dutch and South Asian populations in the Netherlands has been similar at least since the 1970s, environmental factors known to influence growth, such as disease, nutrition, physical environment, and access to (child) health care[2] are less likely to have played a role in the observed height differences. On the other hand, cultural differences between the Dutch and South Asians may affect nutrition, (health) behaviour, and the social and physical environment, but the influence of such factors on growth are probably smaller than socioeconomic factors.
The similarity in growth trajectories of South Asian children in the Netherlands and children in India suggests that genetic factors may be more important than environmental factors in explaining differences in height between ethnic groups in the Netherlands. In general, the heritability of height has been estimated to be very high at 0.8-0.9, indicating that 80 to 90% of the variation in height between people may be explained by genetic differences.[25–27] Also, the onset of pubertal development was shown to be controlled by genes to a large extent.[28] In the present study no clinical assessment of sexual maturation (Tanner staging) was performed to allow pubertal development to be taken into account. However, menarcheal age indicating completion of female puberty, was available, which showed a 1.7 years earlier menarche (at 11.4 years) of South Asian girls compared with Dutch girls.[29] As earlier menarche is associated with shorter adult stature[30] this may explain the large difference in final height between South Asian and Dutch children. A similar mean menarcheal age was found in urban Asian Indian girls (11.4 years)[31] and in adopted Asian Indian girls in Sweden (11.6 years).[32]

Are universal height-for-age references suitable for South Asian children?

Because most Asian subpopulations generally have an earlier onset of pubertal development than most other ethnic groups, and consequently a pubertal growth spurt at a younger age, doubts were raised about the suitability of a single universal reference for the assessment of pubertal growth in Asian adolescents.[9] As the WHO reference 5-19 years was based on the heights of US children,[5] the difference in growth pattern between the South Asian and this US population likely reflects maturational differences between South Asian children and children of European descent. On the other hand, the WHO growth standard for ages 0-5 years, based on growth in six populations of all continents, did not adequately correspond to the growth of South Asian children 0-5 years either. To some extent, the large difference in length at 4 weeks after birth compared with the WHO standard may be the result of a difference in the inclusion criteria of the studies. Contrary to our study, WHO only included full-term and exclusively breast-fed babies. However, this is unlikely to entirely explain the discrepancy. A US study found that also term babies (>37 weeks of gestation) of Asian Indian descent were 0.8-1.1 cm shorter at birth than babies of European descent,[33] which corresponds to a difference of 0.4-0.6 SD with the WHO reference. Nonetheless, the slightly shorter length of infants of the 2009 study compared with the 1976 study may be due to a two times higher prevalence of preterm birth, which was shown in a previous study.[34]

CONCLUSION

In conclusion, an upward trend in height of South Asian children in the Netherlands was found at most ages. Also, South Asian children in the Netherlands are currently taller than contemporary affluent Asian Indian children. Compared with other minority groups in the Netherlands, South Asian children are shorter, despite a higher socio-economic status. WHO height-for-age references, both for ages 0-5 and 5-19 years, do not properly reflect the growth pattern) of South Asian children and adolescents which makes it more difficult to assess growth with these references. As the observed growth patterns of South Asian children living in the Netherlands and children living in India were similar, the South Asian specific height-for-age charts from our study may be more appropriate for monitoring growth of children originating from the Indian subcontinent than the WHO references, although further research is needed to confirm its suitability.

REFERENCES

1. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; 854):1-452.
2. Frongillo EA, Jr., Hanson KM. Determinants of variability among nations in child growth. *Ann Hum Biol* 1995; 22(5):395-411.
3. Ulijaszek SJ. The international growth standard for children and adolescents project: environmental influences on preadolescent and adolescent growth in weight and height. *Food Nutr Bull* 2006; 27(4 Suppl Growth Standard):S279-S294.
4. WHO multicentre growth reference study group. WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl* 2006; 450):76-85.
5. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007; 85(9):660-667.
6. Haas JD, Campirano F. Interpopulation variation in height among children 7 to 18 years of age. *Food Nutr Bull* 2006; 27(4 Suppl Growth Standard):S212-S223.
7. van Buuren S, van Wouwe JP. WHO Child Growth Standards in action. *Arch Dis Child* 2008; 93(7):549-551.
8. Schonbeck Y, Talma H, van DP *et al*. The world's tallest nation has stopped growing taller: the height of Dutch children from 1955 to 2009. *Pediatr Res* 2013; 73(3):371-377.
9. Ulijaszek SJ. Secular trends in growth: the narrowing of ethnic differences in growth. *Nutrion Bulletin* 2001; 26):43-51.
10. Khadilkar VV, Khadilkar AV, Cole TJ, Sayyad MG. Crosssectional growth curves for height, weight and body mass index for affluent Indian children, 2007. *Indian Pediatr* 2009; 46(6):477-489.
11. Oudhof, K., Harmsen, C., Loozen, S., and Choenn, C.: [Size and spread of Surinamese populations in the Netherlands]. Rijswijk: CBS (Statistics Netherlands); 2011. Available from: http://www.cbs.nl/NR/rdonlyres/E77E4C63-775E-4708-B347-1D1DA392B119/0/2011k2b15p97art.pdf.

12. Wieske RC, Nijnuis MG, Carmiggelt BC, Wagenaar-Fischer MM, Boere-Boonekamp MM. Preventive youth health care in 11 European countries: an exploratory analysis. *Int J Public Health* 2012; 57(3):637-641.
13. Verweij, A.: [Training and education: classification of level of education]. Bilthoven: RIVM; 2008. Available from: http://www.nationaalkompas.nl/bevolking/scholing-en-opleiding/indeling-opleidingsniveau/.
14. Central Committee on Research Involving Human Subjects: Step-by-step plan RC review. The Hague: CCMO; 2012. Available from: http://www.ccmo-online.nl/main.asp?pid=10&sid=30&ssid=51.
15. Cole TJ, Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. *Stat Med* 1992; 11(10):1305-1319.
16. van Buuren S, Fredriks M. Worm plot: a simple diagnostic device for modelling growth reference curves. *Stat Med* 2001; 20(8):1259-1277.
17. Stasinopoulos DM, Rigby RA. Generalized additive models for location scale and shape (GAMLSS) in R. *J Stat Softw* 2007; 23(7):1-46.
18. Mungra G. [Hindustani families in the Netherlands] [Leiden: Centrum voor Onderzoek van Maatschappelijke Tegenstellingen, Rijksuniversiteit Leiden; 1990.
19. Oudhof, K. and Harmsen, C.: [The social situation of Surinamese populations in the Netherlands]. CBS (Statistics Netherlands); 2011. Available from: http://www.cbs.nl/NR/rdonlyres/F240F5ED-EE42-4DD4-8FE5-902E6EE5BC30/0/2011k4p46b15art.pdf.
20. Schonbeck,Y., van Buuren S. [Factsheet Results 5th national growth study]. Leiden: TNO, 2010. http://www.tno.nl/downloads/20100608%20Factsheet%20Resultaten%20Vijfde%20Landelijke%20Groeistudie1.pdf
21. Dagevos,J., Gijsberts,M. [Year report integration 2007]. Den Haag: Sociaal en Cultureel Planbureau, 2007. http://www.scp.nl/dsresource?objectid=19608&type=org
22. Ganzeboom, H. B. G. and Sno, T. E.: [Social mobility and achieved status of Surinamese in Suriname en Surinamese in the Netherlands]. Amsterdam: Vrije Universiteit, faculty of Social Sciences; 2012. Available from: http://home.fsw.vu.nl/hbg.ganzeboom////Pdf/2012-ganzeboom-sno-surimob93.pdf.
23. Centraal Bureau voor de Statistiek: [Labour force; reached educational level by ethnicity, sex and age]. CBS (Statistics Netherlands); 2012. Available from: http://www.cbs.nl/nl-NL/menu/themas/dossiers/allochtonen/cijfers/onderwijs/opleidingsniveau-sl.htm.
24. Boelhouwer,J. Wellbeing in the Netherlands: the scp life situation index since 1974. The Hague: Sociaal en Cultureel Planbureau, 2010. http://www.scp.nl/english/Publications/Publications_by_year/Publications_2010/Wellbeing_in_the_Netherlands
25. Perola M, Sammalisto S, Hiekkalinna T *et al*. Combined genome scans for body stature in 6,602 European twins: evidence for common Caucasian loci. *PLoS Genet* 2007; 3(6):e97.
26. Silventoinen K, Sammalisto S, Perola M *et al*. Heritability of adult body height: a comparative study of twin cohorts in eight countries. *Twin Res* 2003; 6(5):399-408.
27. Visscher PM, Medland SE, Ferreira MA *et al*. Assumption-free estimation of heritability from genome-wide identity-by-descent sharing between full siblings. *PLoS Genet* 2006; 2(3):e41.
28. Choi JH, Yoo HW. Control of puberty: genetics, endocrinology, and environment. *Curr Opin Endocrinol Diabetes Obes* 2013; 20(1):62-68.
29. Talma H, Schonbeck Y, van DP, Bakker B, van BS, Hirasing RA. Trends in menarcheal age between 1955 and 2009 in the Netherlands. *PLoS One* 2013; 8(4):e60056.
30. McIntyre MH, Kacerosky PM. Age and size at maturity in women: a norm of reaction? *Am J Hum Biol* 2011; 23(3):305-312.
31. Ray S, Mishra SK, Roy AG, Das BM. Menstrual characteristics: a study of the adolescents of rural and urban West Bengal, India. *Ann Hum Biol* 2010; 37(5):668-681.
32. Proos LA. Growth & development of Indian children adopted in Sweden. *Indian J Med Res* 2009; 130(5):646-650.
33. Madan A, Holland S, Humbert JE, Benitz WE. Racial differences in birth weight of term infants in a northern California population. *J Perinatol* 2002; 22(3):230-235.
34. De Wilde JA, van BS, Middelkoop BJ. Trends in birth weight and the prevalence of low birth weight and small-for-gestational-age in Surinamese South Asian babies since 1974: cross-sectional study of three birth cohorts. *BMC Public Health* 2013; 13):931.

Chapter 6

CHAPTER 7

Appropriate body mass index cut-offs to determine thinness, overweight and obesity in South Asian children in the Netherlands

Jeroen A de Wilde
Paula van Dommelen
Barend JC Middelkoop

PLoS One, 2013;8: e82822

ABSTRACT

Background: Asian populations have an increased risk of developing cardiometabolic disorders at a lower body mass index (BMI) than other ethnic groups. Therefore, lower adult BMI cut-offs to determine overweight and obesity are recommended to assess the associated health risks for Asian (23 and 27.5 kg/m^2 respectively) and Asian Indian (23, 25 kg/m^2) populations.

The objective of this study was to develop BMI cut-offs for thinness, overweight, and obesity for South Asian children in the Netherlands, and to compare the BMI cut-offs and distribution with an Asian Indian reference, the WHO Child Growth Reference, and universal BMI cut-offs.

Methods: A reference cohort of 546 Surinamese South Asian boys and 521 girls, born between 1974-1976 (during the pre-obesity era) with 3408 and 3267 BMI measurements respectively, was retrospectively analysed. BMI-for-age charts were created with the LMS method. BMI centile curves passing through the cut-off points of 15 (thinness), 23 (overweight), 25 and 27.5 kg/m^2 (obesity) at 18y were drawn as cut-off levels.

Results: The BMI of Surinamese South Asian children had a similar distribution to the Asian Indian reference, apart from a lower mean and less variation. The BMI distribution differed considerably from the WHO reference and universal BMI criteria. The calculated BMI cut-offs corresponding to a BMI of 15, 23, 25, and 27.5 kg/m^2 at 18y were at the 7.1, 81.1, 89.8, and 95.5 percentile respectively in boys, and at the 2.7, 79.5, 89.2, and 95.2 percentile in girls.

Conclusions: This is the first study proposing BMI cut-offs for South Asian children based on measurements from a prosperous population unaffected by the obesity epidemic.

We recommend the use of these cut-offs in South Asian children in the Netherlands as these better reflect the health risks associated with thinness, overweight and obesity, and therefore may prevent the development of cardiometabolic disorders.

INTRODUCTION

The body mass index (BMI) is generally used as a proxy for estimating the body fat percentage and associated health risks. For many years, one set of BMI cut-offs has been used in clinical practice for all ethnic groups.[1] However, over the past decade evidence has emerged that Asian populations are at an increased risk of cardiometabolic disorders at lower BMI levels than other ethnic groups, which has been attributed to a considerably higher body fat percentage.[2] For that reason, in 2004 the World Health Organization (WHO) recommended lowering the BMI cut-offs for Asian adults, for overweight from 25 to 23 kg/m^2 and for obesity from 30 to 27.5 kg/m^2 in anticipation of the increased health risks.[3] However, there is evidence that these cut-offs are still too high for South Asian populations which have an increased risk of cardiovascular and metabolic disease risks at an even lower BMI.[4–7] This led to India adopting the lower BMI cut-off points of 23 kg/m^2 for overweight and 25 kg/m^2 for obesity as clinical markers requiring further intervention.[8]

Although cardiometabolic risks in South Asian children and adolescents are also higher at a lower BMI than in children of European descent,[9–11] BMI cut-offs have not yet been adjusted for this population. In several studies lowered BMI cut-offs to determine overweight and obesity in South Asian children and adolescents have been proposed,[12–15] but none of these BMI criteria have been adopted by WHO. For all ethnic groups the universal BMI-cut-offs for ages 2-18 years,[16,17] or the WHO Child Growth Standard 0-5 years[18] and the WHO Growth Reference 5-19 years[19] are still recommended.

The universal cut-offs and the WHO Growth Reference 5-19 years were based on BMI data from studies conducted in healthy, affluent populations before the obesity epidemic began. As the rates of undernutrition and overnutrition were generally low in these populations, the corresponding BMI distributions were presumed to delineate the desirable norm.[20] The universal cut-off values were created to correspond to the centiles passing the recommended adult BMI cut-offs for thinness (16, 17, and 18.5 kg/m^2), overweight (25 kg/m^2) and obesity (30 kg/m^2) at 18 years of age. The WHO cut-offs were based on standard deviation (SD) criteria (-2 SD: thinness; +1 SD: overweight; +2 SD: obesity), but these cut-offs also correspond to the universal adult BMI cut-points at 18 years of age, and thus create a continuous scale from childhood to adulthood. Although the lowering of BMI cut-offs for overweight and obesity in South Asians is supported by evidence,[21] little is known about the other end of the spectrum, thinness. Presently, no expert guidelines for thinness exist, and the current cut-offs classifying thinness are merely based on supposition.[22] The varying rates of thinness between countries,[23] are generally ascribed to differences in socioeconomic factors, with the exception of South Asia. Despite favourable socioeconomic conditions,[21] South Asia has the highest underweight rates in the world (based on universal criteria). However, the under-five mortality is almost half that of Sub-Saharian Africa.[24] Furthermore, in affluent Surinamese South Asian children living in the Netherlands, a disproportionately high prevalence of thinness was found.[25] This is likely to be a consequence of the high body fat percentage at low BMI, resulting in many ‘underweight' children being misclassified.

The possibility that children are being wrongly determined as underweight is supported by a recent Sri Lankan study which found that most children who were classified as underweight had a normal, or even high body fat percentage.[14]

The first objective of this study was to develop South Asian specific cut-offs for the determination of thinness, overweight and obesity in children 2-18 years, based on a reference population of South Asian children who lived in a developed country during a pre-obesogenic era. The second objective was to compare the BMI distribution and cut-offs with 1) recently established Asian Indian BMI references and cut-offs for children 5-18 years,[13,26] 2) the WHO Child Growth Reference,[18,27] and 3) current universal BMI cut-offs for thinness, overweight and obesity.[16,17]

METHODS

Subjects and data collection

The city of The Hague holds the largest community of South Asians in Continental Europe, most of whom are descendents of Asian Indians who migrated between 1873 and the 1916 from the Indian states, Uttar Pradesh and Bihar, to Suriname, a former Dutch colony.[28]

As part of the Dutch health surveillance programme from birth to 19y, Youth Health Care in the Netherlands routinely performs standardized health assessments that are registered in health records. Up until the early 1990's more frequent assessments were performed: between 0 and 4y of age around 15 and from the age of 4 up to 18y at least every second year. During infancy, weight was measured at every visit, but length was less frequently measured. From the age of 1 year, length/height and weight were measured during most health assessments. For this study all length/height and weight data of a reference cohort of Surinamese South Asian children born between 1974 and 1976 were extracted from the health records of Youth Health Care, together with personal data (to determine ethnicity) and information about medical conditions or medicine use. All measurements were taken by trained Youth Health Care professionals (physicians, nurses, physician assistants). Up to the age of 1.0-2.0 years, length was measured to the nearest 0.5 cm using a measuring board in supine position with legs fully extended and heels pressed against a vertical footrest, and weight was measured to the nearest 0.01 kg with a paediatric balance beam scale. From the age of 1.5-2.0 years, height was measured on bare feet with a stadiometer or height measuring tape (microtoise) to the nearest 0.1 cm or 0.5 cm, respectively, and weight in underwear was measured with a calibrated balance beam or mechanical step scale to the nearest 0.1 kg or 0.5 kg, respectively.

Inclusion criteria

Only records of children with a Surinamese South Asian ethnicity, as determined by parental country of birth (Suriname) and a typical Surinamese South Asian surname of the parents, were selected from the Youth Health Care archives. 12 children with a disorder or medicine use known to affect growth were excluded: diabetes (n=2), thyroid disease (n=2), celiac disease (n=1), cerebral palsy (n=2), scoliosis (n=1), prolonged use of corticosteroids (n=1), or treated for short stature (n=3). In addition, all measurements below the age of 2 years from preterm children were excluded from the analyses (n=94). Preterm birth was defined as a gestational age below 36 weeks instead of 37 weeks, as South Asian babies mature one week earlier in utero than babies of Western European decent and therefore, the lowering of the criteria for preterm birth of South Asian babies has been suggested.[29–31]

Ethical approval

Under Dutch law (Medical Research Involving Human Subjects Act) ethical approval for this study was not required, as this study encompassed historical routinely collected data from medical records.[32] The legal guardians of all children participating in the Youth Health Care health surveillance program gave oral consent for the health surveillance data to be stored in a medical record, and the legal guardians were also informed that anonymised data could be used in future scientific research. The dataset of this study was anonymised after the initial inclusion and coding of the required variables, by removing personal data such as (family) names, country of birth and date of birth. All data analyses were performed on this dataset. The head of the department of Youth Health Care of the Municipal Health Service of the city of the Hague and other medical staff approved the study protocol and gave permission to use the data required for this study.

Statistical analyses

To determine the BMI cut-offs for the Surinamese South Asian population, the same methodology was applied as was used to establish the universal BMI cut-offs.[33] Separate BMI-for-age charts for males and females were determined with the LMS method,[34] using R statistical software (v2.14.0) and the GAMLSS package (v4.1-0). This method transforms data into a normal distribution resulting in three smoothed age-dependent curves for skewness (L), median (M) and coefficient of variation (S), that accurately describe the characteristics of the distribution, when combined. The more L deviates from a value of 1, which signifies a symmetric distribution, the stronger the distribution is skewed. The number of degrees of freedom determines the smoothness of the curves and how well they fit the data. By assessing worm plots the appropriate amount of smoothing was applied.[35] To obtain a better fit in age periods where the LMS parameters have steeper slopes, age was log-transformed. After an optimal fit was achieved, age was transformed back to the original distribution and the LMS parameters per sex and age were calculated.

As a BMI of 23 and 27.5 was proposed to define overweight and obesity in Asian populations[3] in general, and a BMI of 23 and 25 for overweight and obesity in Asian Indians [9], the standard deviation scores or Z-scores (Z) that pass a BMI of 23, 25 and 27.5 at 18 years for males and females separately were calculated with the formula:

$$Z = \frac{(\frac{BMI}{M})^{L} - 1}{LS} ,$$

where BMI has a value of 23, 25 or 27.5 and L, M and S are the calculated values at age 18 of the population of interest. Similarly to the WHO criteria, a Z-score of -2 was initially chosen as the thinness criterion.
Based on the found Z-scores for each BMI class, the corresponding cut-offs for sex and age are calculated with the formula:

$$BMI = M\,(ZLS + 1)^{\frac{1}{L}},$$

where Z is the value determined in the former step and L, M, and S the values for the specific age and sex.
To measure the agreement between the BMI classes (normal weight, overweight and obesity) determined by the BMI cut-offs of this study and by the previously determined Asian Indian cut-offs,[13] Cohen's kappa was calculated with IBM SPSS Statistics v20. To compare the agreement for each BMI category separately, the BMI categories were dichotomised into three variables: normal weight versus no normal weight, overweight versus no overweight, and obesity versus no obesity.

RESULTS

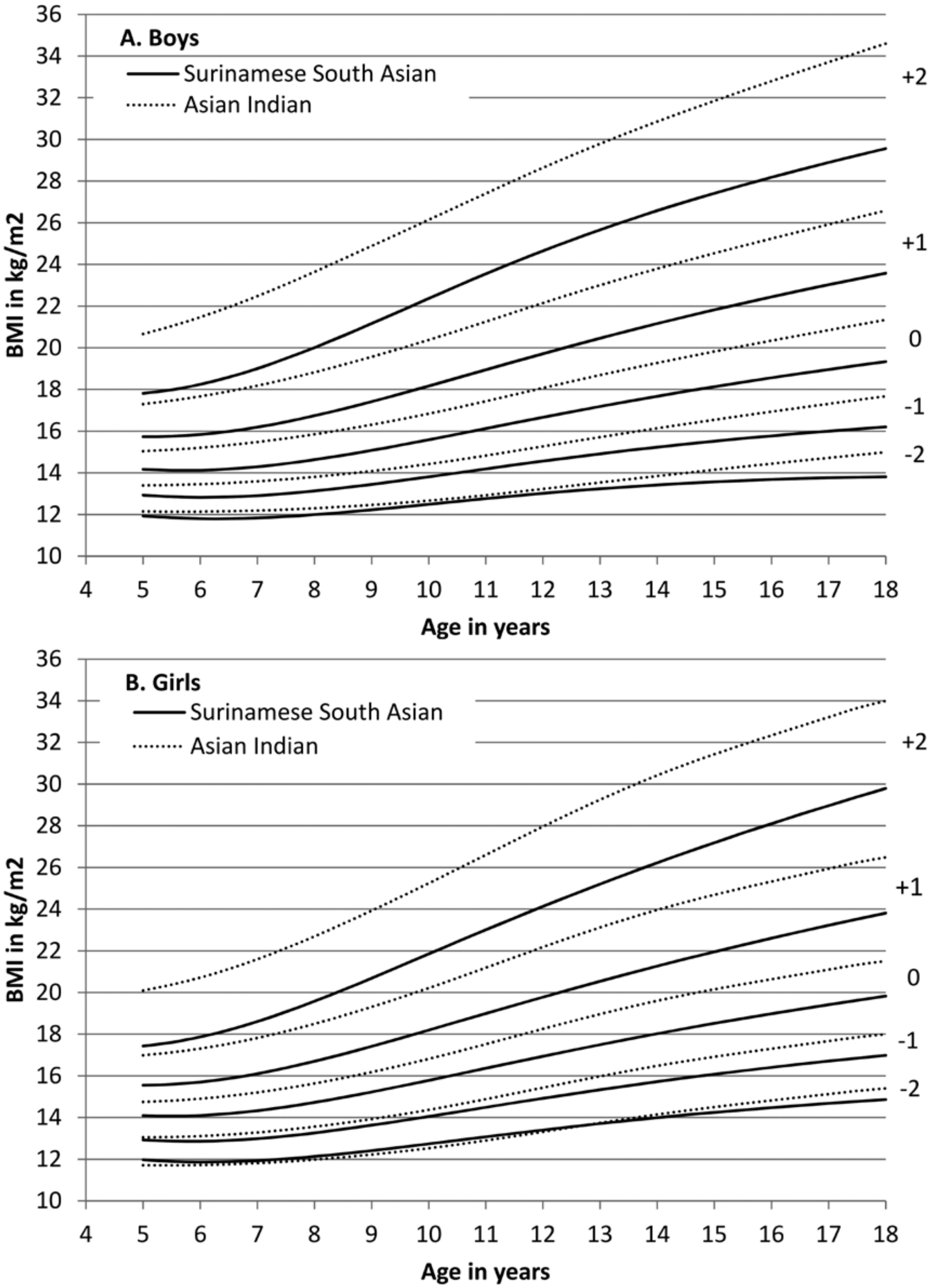
A total of 546 boys with 3408 BMI measurements, and 521 girls with 3267 measurements were included in this study. 2746 measurements were of children aged 0-3 years and 3929 of children 4-18 years. The LMS values of the distributions are shown in Table 1. At all ages the L-values were lower than 1 which indicates skewedness to the right. The coefficient of variation S was relatively low up to the age of five but progressively increased with age, signifying that the range of BMI's was increasing.
The BMI distribution was consistent with a recent Asian Indian reference 5-18 years (Figure 1), showing a similar skewedness, and therefore a similar distributional pattern of BMI. Also, the lower end of the distribution coincided with that of Asian Indian children, reflecting similar thinness rates in the Indian population. However, in the Surinamese South Asian population at every age the median and coefficient of variation was smaller.

Surinamese South Asian specific BMI cut-off points for overweight and obesity were calculated to correspond to the proposed BMI cut-offs for Asian populations of 23 and 27.5 at age 18 (Tables 2 and 3), and additionally to the BMI equivalent of 25 at age 18 (for obesity in Asian Indian populations).
Despite the sample only consisting of children born before the obesity epidemic, the overweight and obesity rates based on these cut-off values were relatively high, as indicated by the percentiles. The combined prevalence of overweight and obesity was then 18.9% in boys and 20.5% in girls.

Table 1 *L (skewness), M (median), and S (coefficient of variation) values for BMI (kg/m^2) by age and sex of Surinamese South Asian reference cohort 1974-1976*

Age in years		Boys			Girls		
		L	M	S	L	M	S
0.0383	(2 weeks)	-0.0519	12.24	0.0919	-2.3969	12.08	0.0636
0.0833	(1 month)	0.1012	13.46	0.0942	-0.9712	13.19	0.0726
0.1667	(2 months)	0.3242	14.69	0.0944	0.0421	14.31	0.0807
0.3333	(4 months)	0.6674	15.91	0.0924	0.6035	15.50	0.0857
0.5	(6 months)	0.8338	16.47	0.0904	0.6810	16.05	0.0864
0.6667	(8 months)	0.8635	16.72	0.0887	0.6407	16.23	0.0859
0.8333	(10 months)	0.7995	16.75	0.0874	0.5453	16.23	0.0849
1		0.6865	16.65	0.0864	0.4296	16.14	0.0838
1.5		0.2852	16.11	0.0847	0.0700	15.68	0.0812
2		-0.0875	15.54	0.0843	-0.2353	15.21	0.0801
2.5		-0.4192	15.10	0.0849	-0.4932	14.88	0.0802
3		-0.7068	14.78	0.0864	-0.7255	14.64	0.0813
3.5		-0.9497	14.56	0.0886	-0.9359	14.46	0.0831
4		-1.1512	14.39	0.0912	-1.1225	14.30	0.0855
4.5		-1.3174	14.26	0.0942	-1.2791	14.17	0.0885
5		-1.4538	14.17	0.0974	-1.4026	14.09	0.0918
5.5		-1.5641	14.12	0.1008	-1.4942	14.07	0.0953
6		-1.6513	14.12	0.1044	-1.5587	14.10	0.0990
6.5		-1.7183	14.18	0.1082	-1.6014	14.19	0.1027
7		-1.7657	14.29	0.1119	-1.6266	14.33	0.1065
7.5		-1.7945	14.45	0.1158	-1.6380	14.51	0.1102
8		-1.8059	14.63	0.1196	-1.6385	14.72	0.1139
8.5		-1.8016	14.84	0.1234	-1.6303	14.96	0.1174
9		-1.7831	15.08	0.1272	-1.6148	15.22	0.1209
9.5		-1.7519	15.33	0.1310	-1.5929	15.50	0.1242
10		-1.7099	15.59	0.1347	-1.5655	15.78	0.1274
10.5		-1.6586	15.86	0.1384	-1.5338	16.07	0.1305
11		-1.5995	16.13	0.1420	-1.4988	16.37	0.1334
11.5		-1.5342	16.40	0.1455	-1.4615	16.65	0.1362
12		-1.4640	16.67	0.1490	-1.4229	16.94	0.1390
12.5		-1.3904	16.93	0.1524	-1.3839	17.22	0.1416
13		-1.3150	17.19	0.1558	-1.3450	17.50	0.1442
13.5		-1.2392	17.43	0.1591	-1.3065	17.76	0.1467
14		-1.1638	17.68	0.1624	-1.2686	18.02	0.1492
14.5		-1.0894	17.91	0.1656	-1.2316	18.28	0.1516
15		-1.0162	18.13	0.1687	-1.1957	18.52	0.1539
15.5		-0.9445	18.35	0.1718	-1.1608	18.75	0.1563
16		-0.8745	18.56	0.1749	-1.1270	18.98	0.1585
16.5		-0.8064	18.76	0.1779	-1.0941	19.20	0.1608
17		-0.7402	18.96	0.1809	-1.0623	19.42	0.1629
17.5		-0.6758	19.15	0.1839	-1.0315	19.62	0.1651
18		-0.6133	19.34	0.1868	-1.0013	19.83	0.1672

Figure 1 *BMI distribution for ages 0-18 years of Asian Indian reference[22] and Surinamese South Asian cohort 1974-1976, boys (A) and girls (B)*



Thinness based on a Z-score of -2 resulted in a very low BMI at age 18 of 13.8 kg/m^2 in boys. In girls, the BMI value was higher at 14.9, but still more than 2 BMI points lower than the universally used cut-off of 17. As the recommended BMI cut-offs to determine overweight and obesity in Asian adults are respectively 2.0 and 2.5 BMI points lower than universal BMI criteria, a single adult BMI equivalent of 15 kg/m^2 was chosen as cut-off to determine thinness, which corresponds to the 7.1th percentile in boys and the 2.7th percentile in girls.

The cut-off values for overweight were similar to the recently published Asian Indian cut-offs (Tables 2 and 3).[13] Up to the age of 10 years the Surinamese South Asian cut-offs for overweight were 0.1-0.4 BMI points lower than the Asian Indian values, but from that point the values were almost identical. For obesity, a similar pattern was observed in boys, however, as the Asian Indian cut-offs correspond to a BMI of 28 at 18y, instead of 27.5, it was to be expected that the cut-offs would be lower. The BMI classes normal weight (κ=0.96), overweight (κ=0.88), and obesity (κ=0.82) determined by the Surinamese South Asian BMI cut-offs and the Asian Indian cut-offs were highly comparable.
The centiles of the BMI distribution of the universal BMI cut-offs and of WHO differed from the Surinamese South Asian distributions (Figure 2). In particular, the smaller variability of the Surinamese South Asian distribution at a young age, and the greater dispersion with increasing age, were notable. This resulted in the Surinamese South Asian obesity curve corresponding with a BMI of 27.5 at 18y being positioned below the overweight curve of the universal criteria up to the age of seven. Therefore, Surinamese South Asian children with a BMI at the higher end of the 'normal' range based on the universal criteria, would already be classified as obese based on ethnic specific criteria. When applying the BMI 25 criterion for obesity in South Asian children, this discrepancy became even more pronounced, as the South Asian curve stayed well below the universal overweight curve up to 18y.

DISCUSSION

The present universal BMI cut-offs for children insufficiently reflect the body fat percentage in South Asian children.[14,36] Also, in this population cardiometabolic risks are higher at lower BMI thresholds compared to children of Western European decent.[9,10] As a consequence, the assessment of the nutritional status with universal BMI criteria is inappropriate. Thus, we have developed BMI cut-offs for 2-18 year old South Asian children in the Netherlands to determine thinness, overweight and obesity, based on BMI distributions in an affluent South Asian reference population that was born before the obesity epidemic. As the overweight and obesity cut-offs correspond to the lowered adult BMI cut-offs for (South) Asian populations,[3] they are expected to offer a more reliable tool for assessing the nutritional status of South Asian children, and may thus contribute to the early prevention of cardiometabolic disorders.

Table 2 *Boys –South Asian BMI cut-offs for thinness, overweight and obesity by sex and age, based on Surinamese South Asian and Asian Indian populations*

Age in years	Surinamese South Asian					Asian Indian [13]	
	Thinness (-2 SD)	Thinness (BMI 15)	Overweight (BMI 23)	Obesity (BMI 25)	Obesity (BMI 27.5)	Overweight (BMI 23)	Obesity (BMI 28)
Z-score (Percentile)	-2.00 (P2.3)	-1.47 (P7.1)	0.88 (P81.1)	1.27 (P89.8)	1.70 (P95.5)	0.36 (P64.0)	1.22 (P88.8)
2	13.1	13.7	16.7	17.3	17.9	NA	NA
2.5	12.8	13.4	16.3	16.9	17.5	NA	NA
3	12.6	13.1	16.0	16.6	17.3	NA	NA
3.5	12.4	12.9	15.8	16.4	17.1	NA	NA
4	12.2	12.7	15.7	16.3	17.1	NA	NA
4.5	12.1	12.6	15.6	16.2	17.1	NA	NA
5	11.9	12.4	15.5	16.2	17.1	15.8	17.9
5.5	11.8	12.4	15.5	16.3	17.2	15.9	18.1
6	11.8	12.3	15.6	16.4	17.4	16.0	18.4
6.5	11.8	12.3	15.7	16.6	17.7	16.1	18.7
7	11.8	12.4	15.9	16.8	18.0	16.3	19.0
7.5	11.9	12.4	16.2	17.1	18.4	16.5	19.3
8	12.0	12.6	16.4	17.5	18.8	16.8	19.7
8.5	12.1	12.7	16.8	17.9	19.3	17.0	20.1
9	12.2	12.8	17.1	18.2	19.8	17.3	20.5
9.5	12.4	13.0	17.4	18.7	20.3	17.6	21.0
10	12.5	13.1	17.8	19.1	20.8	17.9	21.4
10.5	12.6	13.3	18.2	19.5	21.3	18.3	21.9
11	12.8	13.5	18.5	20.0	21.9	18.6	22.4
11.5	12.9	13.6	18.9	20.4	22.4	19.0	22.9
12	13.0	13.8	19.3	20.8	22.8	19.3	23.3
12.5	13.1	13.9	19.6	21.2	23.3	19.7	23.8
13	13.2	14.1	20.0	21.6	23.8	20.0	24.3
13.5	13.3	14.2	20.3	22.0	24.2	20.4	24.7
14	13.4	14.3	20.7	22.4	24.6	20.7	25.1
14.5	13.5	14.4	21.0	22.8	25.0	21.0	25.5
15	13.6	14.5	21.3	23.1	25.4	21.3	25.9
15.5	13.6	14.6	21.6	23.4	25.8	21.6	26.3
16	13.7	14.7	21.9	23.8	26.2	21.9	26.7
16.5	13.7	14.8	22.2	24.1	26.5	22.2	27.0
17	13.8	14.9	22.5	24.4	26.9	22.4	27.4
17.5	13.8	14.9	22.7	24.7	27.2	22.7	27.7
18	13.8	15.0	23.0	25.0	27.5	23.0	28.1

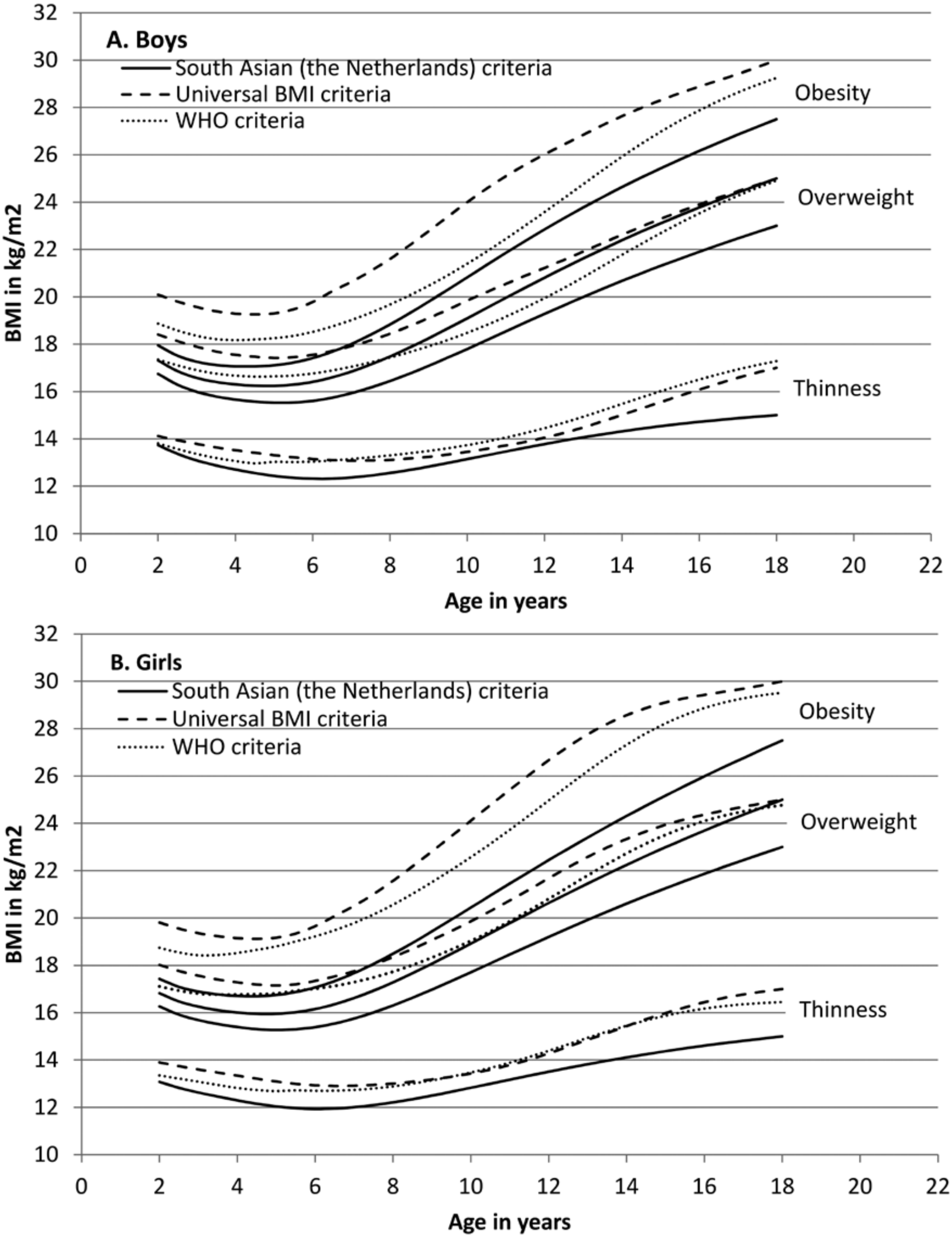
NA=Not available

Table 3 *Girls –South Asian BMI cut-offs for thinness, overweight and obesity by sex and age, based on Surinamese South Asian and Asian Indian populations*

Age in years	Surinamese South Asian					Asian Indian [13]	
	Thinness (-2 SD)	Thinness (BMI 15)	Overweight (BMI 23)	Obesity (BMI 25)	Obesity (BMI 27.5)	Overweight (BMI 23)	Obesity (BMI 28)
Z-score (Percentile)	-2.00 (P2.3)	-1.92 (P2.7)	0.83 (P79.5)	1.24 (P89.2)	1.67 (P95.2)	0.34 (P63.3)	1.24 (P89.3)
2	13.0	13.1	16.3	16.8	17.4	NA	NA
2.5	12.8	12.8	15.9	16.5	17.1	NA	NA
3	12.6	12.6	15.7	16.3	16.9	NA	NA
3.5	12.4	12.5	15.5	16.1	16.8	NA	NA
4	12.2	12.3	15.4	16.0	16.7	NA	NA
4.5	12.1	12.1	15.3	15.9	16.7	NA	NA
5	12.0	12.0	15.3	16.0	16.7	15.4	17.6
5.5	11.9	12.0	15.3	16.0	16.9	15.5	17.8
6	11.9	11.9	15.4	16.2	17.1	15.6	18.0
6.5	11.9	11.9	15.5	16.4	17.3	15.8	18.2
7	11.9	12.0	15.8	16.6	17.7	16.0	18.5
7.5	12.0	12.1	16.0	16.9	18.1	16.2	18.9
8	12.1	12.2	16.3	17.3	18.5	16.5	19.3
8.5	12.3	12.3	16.6	17.7	18.9	16.8	19.7
9	12.4	12.5	17.0	18.1	19.4	17.1	20.2
9.5	12.6	12.7	17.3	18.5	19.9	17.4	20.7
10	12.7	12.8	17.7	18.9	20.4	17.8	21.2
10.5	12.9	13.0	18.1	19.4	21.0	18.2	21.7
11	13.1	13.2	18.5	19.8	21.5	18.6	22.2
11.5	13.2	13.3	18.8	20.2	22.0	19.0	22.8
12	13.4	13.5	19.2	20.6	22.4	19.4	23.3
12.5	13.6	13.7	19.6	21.0	22.9	19.8	23.8
13	13.7	13.8	19.9	21.5	23.4	20.2	24.3
13.5	13.9	14.0	20.3	21.9	23.9	20.5	24.8
14	14.0	14.1	20.6	22.2	24.3	20.9	25.2
14.5	14.1	14.2	20.9	22.6	24.7	21.2	25.6
15	14.2	14.4	21.3	23.0	25.2	21.5	26.0
15.5	14.4	14.5	21.6	23.3	25.6	21.7	26.3
16	14.5	14.6	21.9	23.7	26.0	22.0	26.7
16.5	14.6	14.7	22.2	24.0	26.4	22.3	27.0
17	14.7	14.8	22.4	24.4	26.8	22.5	27.3
17.5	14.8	14.9	22.7	24.7	27.1	22.8	27.6
18	14.9	15.0	23.0	25.0	27.5	23.0	27.9

NA=Not available

Figure 2 *South Asian (the Netherlands) BMI cut-offs, based on adult BMI of 15, 23, 25, and 27.5 kg/m², and universal (BMI of 17, 25, and 30 kg/m²) and WHO BMI (-2 SD, +1 SD, and +2 SD) cut-offs for thinness, overweight and obesity, boys (A) and girls (B)*



The BMI distributions of this reference population, and of a prosperous Asian Indian population,[26] were similarly shaped, and as a result the determined BMI cut-offs for overweight and obesity based on these BMI distributions were largely similar.[13] Compared with the WHO Child Growth Reference Study[19,37] the BMI distribution in Surinamese South Asian children differed considerably. Thinness cut-offs based on an SD of -2 resulted in very low BMI values for boys, equivalent to a BMI of 13.8 kg/m^2 at age 18. In girls the values corresponded to a BMI of 14.9 kg/m^2 at 18 years of age, which is around 2 BMI points below the universally recommended thinness cut-off for adults (17 kg/m^2). This is in concordance with the adult BMI cut-off for overweight in Asian populations which, at 23 kg/m^2, is also2 BMI points lower than the universal BMI cut-off.[3]

The strengths of this study include the reliable and extensive data, the large sample size and the availability of longitudinal BMI data of a cohort born before the obesity epidemic. However, as this study encompassed cohort data, with the last measurements performed up to the early 1990's, there may have been some influence of the obesity epidemic that was likely to have started in the Netherlands as early as the late 1980's. Nevertheless, if there was an effect, it is expected to have had a minimal influence, as the children were by then early teenagers and the obesity epidemic would have a greater impact on younger children.

One of the limitations of creating BMI cut-offs based on observational data, as in this study and for the universal and WHO BMI cut-offs, is that they contain no direct information about body composition. While the centile curves used as cut-off level are linked to the established adult BMI cut-off levels associated with risk of morbidity at 18y, a similar body composition (including similar health risks) is assumed above the specific centile at every age in childhood. However, there may be differences in the distribution of body compositions between separate age groups.

A recent study of Sri Lankan children showed that younger children had a considerably lower body fat percentage than older children.[14] If this finding is also applicable to our population, the calculated cut-offs will overestimate overweight and obesity in the younger age groups.

Waist circumference as a measure of central obesity was not available to our study, but could have had added value, considering that abdominal obesity was previously shown to be highly prevalent in urban Asian Indian children.[38]

Another limitation of our set of BMI criteria is that the cut-offs were not confirmed by data of actual health outcomes. However, in two recent studies that proposed adjusted BMI cut-off values for overweight and obesity in South Asian children[13,14] the validity of these cut-offs were tested by performing metabolic panel blood tests and blood pressure measurements. In the first study the BMI cut-offs were based on body fat percentage cut-offs, which resulted in BMI values considerably lower than the values determined in our study.[14] Nevertheless, validity testing showed that the new obesity cut-offs had a higher sensitivity (37-54%) in detecting cardiometabolic risks than the universal criteria (6-11%), while the specificity was equally high (94%).[39] The second study, the Asian Indian study with which the determined BMI cut-offs in the present study were compared, found increased cardiometabolic risks in 43-47% of the overweight children and in 72-80% of the obese children[13] As the BMI cut-offs of this study were largely similar to the values determined in our study, the results are expected to be equally applicable to South Asian children in the Netherlands, although further research is needed to confirm this. An advantage of the present study, in contrast to the Asian Indian study, is that the cut-offs were based on historical data of healthy affluent South Asian children that were unaffected or minimally affected by the obesity epidemic. In addition, cut-offs to determine thinness, and cut-offs for children below 5 years of age were also provided.

Many children of the cohort had a low BMI, which may be due to socioeconomic factors. However, as socioeconomic indicators were not available, their relation to BMI is unknown. Nevertheless, the prevalence of childhood undernutrition in Suriname was found to be low up till 1990.[40] Furthermore, as Surinamese migrants to the Netherlands in the 1970's had an educational level similar to the Dutch,[41] the socioeconomic factors are not expected to differ from the native Dutch population. Therefore the BMI distribution of this study's population is considered representative of affluent South Asian children in the Netherlands.
It is unknown how comparable Surinamese South Asians are with South Asian populations in other countries, as mixed marriages between South Asians and other ethnic groups in Suriname, and the separation of the population for over a century, may have changed the genetic make-up. However, as Surinamese South Asians have married predominantly within their own ethnic group,[28,42] the population is expected to be fairly genetically homogenous and still comparable to other South Asian populations. The change in diet of South Asians living in Suriname may have influenced their body composition and cardiometabolic risks, but, although South Asian babies in Suriname were shown to be heavier than babies in India, a similar body composition was found.[43] The similarity in the shape of the BMI distribution of Surinamese South Asian children in our study and of Asian Indian children[13] indicates that this may also apply to older children. Moreover, as the prevalence of cardiometabolic disorders in Surinamese South Asians was shown to be at least as high[44,45] as in South Asian populations in other countries,[46–48] including South Asia,[49] the association between body composition and risk of disease is likely to be similar to South Asians living in other countries.

In conclusion, there is convincing evidence that in South Asian children the present universal BMI cut-offs do not adequately represent the body fat percentage and associated health risks. Therefore, assessments of the nutritional status based on these BMI criteria may lead to unnecessary interventions for 'thin' South Asian children, whereas interventions for overweight and obesity may start at much higher BMI levels than desirable. The BMI cut-offs to determine thinness, overweight and obesity developed in the present study specifically for South Asian children living in the Netherlands, should allow more accurate assessments of their nutritional status and aid in the prevention of cardiometabolic disorders. Further research is needed to determine the ability of these new BMI criteria to predict health risks associated with a low or high BMI.

REFERENCES

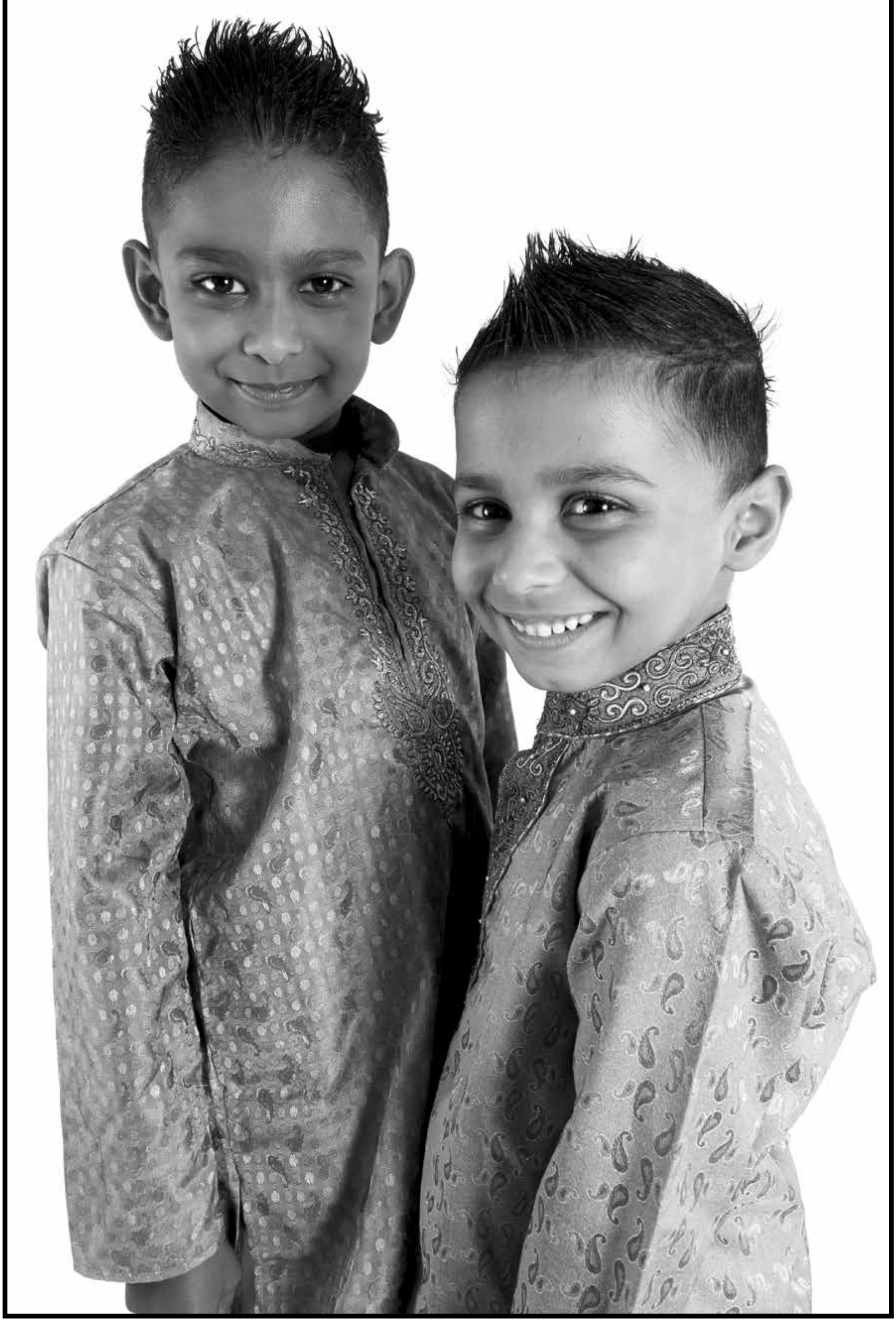
1. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; 854):1-452.
2. Deurenberg-Yap M, Chew SK, Lin VF, Tan BY, van Staveren WA, Deurenberg P. Relationships between indices of obesity and its co-morbidities in multi-ethnic Singapore. *Int J Obes Relat Metab Disord* 2001; 25(10):1554-1562.
3. World Health Organization Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004; 363(9403):157-163.
4. Low S, Chin MC, Ma S, Heng D, Deurenberg-Yap M. Rationale for redefining obesity in Asians. *Ann Acad Med Singapore* 2009; 38(1):66-69.
5. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. *Int J Obes (Lond)* 2011; 35(2):167-187.
6. Deurenberg-Yap M, Chew SK, Deurenberg P. Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. *Obes Rev* 2002; 3(3):209-215.
7. Gray LJ, Yates T, Davies MJ *et al*. Defining obesity cut-off points for migrant South Asians. *PLoS One* 2011; 6(10):e26464.
8. Misra A, Chowbey P, Makkar BM *et al*. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. *J Assoc Physicians India* 2009; 57):163-170.
9. Ehtisham S, Crabtree N, Clark P, Shaw N, Barrett T. Ethnic differences in insulin resistance and body composition in United Kingdom adolescents. *J Clin Endocrinol Metab* 2005; 90(7):3963-3969.
10. Whincup PH, Gilg JA, Papacosta O *et al*. Early evidence of ethnic differences in cardiovascular risk: cross sectional comparison of British South Asian and white children. *BMJ* 2002; 324(7338):635.
11. Yajnik CS, Lubree HG, Rege SS *et al*. Adiposity and hyperinsulinemia in Indians are present at birth. *J Clin Endocrinol Metab* 2002; 87(12):5575-5580.
12. Duncan JS, Duncan EK, Schofield G. Ethnic-specific body mass index cut-off points for overweight and obesity in girls. *N Z Med J* 2010; 123(1311):22-29.
13. Khadilkar VV, Khadilkar AV, Borade AB, Chiplonkar SA. Body Mass Index Cut-offs for Screening for Childhood Overweight and Obesity in Indian Children. *Indian Pediatr* 2012; 49(1):29-34.
14. Wickramasinghe VP, Lamabadusuriya SP, Cleghorn GJ, Davies PS. Defining anthropometric cut-off levels related to metabolic risk in a group of Sri Lankan children. *Ann Hum Biol* 2011; 38(5):537-543.
15. Pandey RM, Madhavan M, Misra A, Kalaivani M, Vikram NK, Dhingra V. Centiles of anthropometric measures of adiposity for 14- to 18-year-old urban Asian Indian adolescents. *Metab Syndr Relat Disord* 2009; 7(2):133-141.
16. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; 320(7244):1240-1243.
17. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* 2007; 335(7612):194.
18. WHO multicentre growth reference study group. WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl* 2006; 450):76-85.
19. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007; 85(9):660-667.
20. de Onis M. The use of anthropometry in the prevention of childhood overweight and obesity. *Int J Obes Relat Metab Disord* 2004; 28 Suppl 3):S81-S85.

21. Nube M. The Asian enigma: predisposition for low adult BMI among people of South Asian descent. *Public Health Nutr* 2009; 12(4):507-516.
22. de Onis M., Habicht JP. Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. *Am J Clin Nutr* 1996; 64(4):650-658.
23. de Onis M, Blossner M, Borghi E, Frongillo EA, Morris R. Estimates of global prevalence of childhood underweight in 1990 and 2015. *JAMA* 2004; 291(21):2600-2606.
24. UN Inter-agency Group for Child Mortality Estimation: Levels & Trends in Child Mortality. Report 2010. New York: United Nations Children's Fund; 2010. Available from: http://www.childinfo.org/files/Child_Mortality_Report_2010.pdf.
25. De Wilde JA, Zandbergen-Harlaar S, van BS, Middelkoop BJ. Trends in body mass index distribution and prevalence of thinness, overweight and obesity in two cohorts of Surinamese South Asian children in The Netherlands. *Arch Dis Child* 2013; 98(4):280-285.
26. Khadilkar VV, Khadilkar AV, Cole TJ, Sayyad MG. Crosssectional growth curves for height, weight and body mass index for affluent Indian children, 2007. *Indian Pediatr* 2009; 46(6):477-489.
27. de Onis M. Growth curves for school age children and adolescents. *Indian Pediatr* 2009; 46(6):463-465.
28. De Klerk CJM. De immigratie der Hindostanen in Suriname. 1ste druk. Amsterdam: Urbi et Orbi, 1953.
29. Balchin I, Steer PJ. Race, prematurity and immaturity. *Early Hum Dev* 2007; 83(12):749-754.
30. Patel RR, Steer P, Doyle P, Little MP, Elliott P. Does gestation vary by ethnic group? A London-based study of over 122,000 pregnancies with spontaneous onset of labour. *Int J Epidemiol* 2004; 33(1):107-113.
31. TambyRaja RL. The prematurity paradox of the small Indian baby. *Indian J Pediatr* 1991; 58(4):415-419.
32. Central Committee on Research Involving Human Subjects: Step-by-step plan RC review. The Hague: CCMO; 2012. Available from: http://www.ccmo-online.nl/main.asp?pid=10&sid=30&ssid=51.
33. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes* 2012; 7(4):284-294.
34. Cole TJ. The LMS method for constructing normalized growth standards. *Eur J Clin Nutr* 1990; 44(1):45-60.
35. van Buuren S, Fredriks M. Worm plot: a simple diagnostic device for modelling growth reference curves. *Stat Med* 2001; 20(8):1259-1277.
36. Duncan JS, Duncan EK, Schofield G. Accuracy of body mass index (BMI) thresholds for predicting excess body fat in girls from five ethnicities. *Asia Pac J Clin Nutr* 2009; 18(3):404-411.
37. WHO multicentre growth reference study group. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: WHO, 2006.
38. Misra A, Shah P, Goel K *et al*. The high burden of obesity and abdominal obesity in urban Indian schoolchildren: a multicentric study of 38,296 children. *Ann Nutr Metab* 2011; 58(3):203-211.
39. Wickramasinghe VP, Arambepola C, Bandara P *et al*. Distribution of obesity-related metabolic markers among 5-15 year old children from an urban area of Sri Lanka. *Ann Hum Biol* 2013; 40(2):168-174.
40. Schweitz R, Mopurgo R, Sietaram MA, Hirasing RA. [Increase in number of admissions and increased mortality due to malnutrition in children in Paramaribo]. *Ned Tijdschr Geneeskd* 1996; 140(13):717-718.
41. Ganzeboom, H. B. G. and Sno, T. E.: [Social mobility and achieved status of Surinamese in Suriname en Surinamese in the Netherlands]. Amsterdam: Vrije Universiteit, faculty of Social Sciences; 2012. Available from: http://home.fsw.vu.nl/hbg.ganzeboom////Pdf/2012-ganzeboom-sno-surimob93.pdf.

42. Mungra G. [Hindustani families in the Netherlands] [Leiden: Centrum voor Onderzoek van Maatschappelijke Tegenstellingen, Rijksuniversiteit Leiden; 1990.
43. van Steijn L., Karamali NS, Kanhai HH *et al*. Neonatal anthropometry: thin-fat phenotype in fourth to fifth generation South Asian neonates in Surinam. *Int J Obes (Lond)* 2009; 33(11):1326-1329.
44. Middelkoop BJ, Kesarlal-Sadhoeram SM, Ramsaransing GN, Struben HW. Diabetes mellitus among South Asian inhabitants of The Hague: high prevalence and an age-specific socio-economic gradient. *Int J Epidemiol* 1999; 28(6):1119-1123.
45. Bindraban NR, van Valkengoed IG, Mairuhu G *et al*. Prevalence of diabetes mellitus and the performance of a risk score among Hindustani Surinamese, African Surinamese and ethnic Dutch: a cross-sectional population-based study. *BMC Public Health* 2008; 8):271.
46. Garduno-Diaz SD, Khokhar S. Prevalence, risk factors and complications associated with type 2 diabetes in migrant South Asians. *Diabetes Metab Res Rev* 2012; 28(1):6-24.
47. Agyemang C, Kunst A, Bhopal R *et al*. A cross-national comparative study of blood pressure and hypertension between English and Dutch South-Asian- and African-origin populations: the role of national context. *Am J Hypertens* 2010; 23(6):639-648.
48. Agyemang C, Kunst AE, Bhopal R *et al*. Diabetes prevalence in populations of South Asian Indian and African origins: a comparison of England and the Netherlands. *Epidemiology* 2011; 22(4):563-567.
49. Ghaffar A, Reddy KS, Singhi M. Burden of non-communicable diseases in South Asia. *BMJ* 2004; 328(7443):807-810.

PART 3

Main findings



CHAPTER 8

Summary, general discussion, and directions for future research

8.1 SUMMARY

In South Asian populations worldwide type 2 diabetes mellitus and cardiovascular diseases (together called cardiometabolic diseases) are more prevalent than in most other ethnic groups.[1,2] These diseases generally develop at a lower BMI than in other ethnic groups, because South Asian adults generally have a body composition with a larger fat mass but simultaneously a smaller lean body (muscle and bone) mass at similar BMI levels compared with other ethnic groups.[1,3–5] This is often called a 'thin-fat' body composition.[6] Therefore, in India the universally used BMI cut-offs to detect overweight and obesity[7] in adults were lowered from 25 to 23 kg/m^2 and from 30 to 25 kg/m^2 respectively, as these values show a better agreement with the increased cardiometabolic risks than the universal BMI-cut-off values.[8]
Also in South Asian babies, children and adolescents cardiometabolic risks were shown to be increased at a lower weight or BMI.[9–11] Several sets of lowered BMI cut-offs were proposed for the assessment of the nutritional status and associated health risks in South Asian children,[3,12–14] but consensus has not been reached about the appropriateness of such cut-offs.[15]
In addition, it is unclear if (universal) growth standards to assess length and height such as the WHO references adequately describe growth in a prosperous South Asian population living in a western country. Normal values of weight, height, and BMI of affluent South Asian children living in a western country are currently not available.

The aims of this thesis were firstly, to find epidemiological evidence to support the hypothesis that affluent South Asian children living in a Western country are lighter and shorter than children from other ethnic groups, as such evidence could support the use of adjusted growth standards and anthropometric indicators for South Asian children.
Secondly, to develop South Asian specific height-for-age (0-20 years) and BMI-for-age (2-18 years) references and compare these with other (universal) references, and thirdly, to determine appropriate BMI cut-off values for thinness, overweight and obesity for South Asian children 2-18 years, and compare these with other sets of BMI criteria. Achieving these aims will likely contribute to a better understanding of which anthropometric values are to be considered normal for South Asians. Furthermore, the application of ethnic specific growth references and cut-offs is expected to allow for a better assessment of height and BMI in this group, of which the latter may aid in the prevention of diabetes and cardiovascular diseases in South Asians.

PART 1 - Epidemiology
In **chapter 2** it was shown that the mean birth weight of South Asian babies did not change over a period of 35 years, while in 2006-2009 it was around 450 grams lower than in Dutch neonates. Based on universal birth weight standards the prevalence of low birth weight and small-for-gestational-age was very high. However, relative to ethnic specific standards the rates were concordant with those found in Dutch babies. Despite the stability of the birth weight of South Asian neonates over the studied period, South Asian babies have generally gained weight since the 1970s, indicated by a decrease in the prevalence of small-for-gestational-age over the studied

period.
The study described in **chapter 3** showed that a reference cohort of Surinamese South Asian children in the Netherlands aged 3-15 years, born before the obesity epidemic (1974-1976), also had a considerably lower mean BMI z-score than the “standard” population of WHO.
In particular, the total prevalence of thinness, based on universal (WHO) cut-off criteria, was disproportionately high with rates of 36-38%, while simultaneously the overweight (including obesity) rates were very low (6-9%). Also in a cohort of South Asian children born in the Netherlands during the obesity epidemic (1991-1993) the thinness prevalence was high (24%), but now combined with high overweight rates (18-23%). These findings suggest that current universal BMI cut-offs overestimate thinness and, despite the apparently high rate found in the recent cohort, underestimate overweight in this population, rendering these cut-offs unsuitable for assessing the nutritional status of South Asian children.
The idea that universal cut-offs underestimate overweight and obesity in South Asian children was also supported by findings from a contemporary population of South Asian children. Mean BMI z-score (based on universal BMI references) in this group was found to be much lower than of Dutch, Turkish, and Moroccan children (**chapter 5**), and the prevalence of overweight (including obesity) was only slightly higher than in Dutch children (**chapters 4 and 5**), which is likely to represent an underestimate of the true cardiovascular and metabolic risks in the South Asian group.

PART 2 - Growth references

Chapter 6 presents height-for-age charts based on height of South Asian children in the Netherlands. The growth pattern of this ethnic group, as indicated by the shape of the height-for-age charts, was similar to that of a contemporary population of children in India. In particular, the height-for-age charts of a historical cohort of South Asian children in the Netherlands, born between 1974 and 1976, coincided largely with current Asian Indian height-for-age charts, suggesting a similar genetic make-up. Contemporary South Asian children in the Netherlands were taller at every age than those Asian Indian children, which may be attributable to differences in socioeconomic and environmental factors.
Compared to Dutch children South Asian children in the Netherlands were on average 0.5-0.6 standard deviation (SD) shorter up to the age of 14 years in boys and 12 years in girls, after which the differences increased to 1.5 to 1.7 SD at 20 years of age. The final height at 20 years of South Asian boys was 10 cm shorter than in their Dutch counterparts. In girls the difference in final height was 11 cm.
Larger discrepancies in growth patterns were found between the South Asian and the WHO height references over the whole age range. Between birth and the age of 5 years South Asian children in the Netherlands were 0.1 to 1.1 SD shorter than the “standard” WHO population. However, from the age of 5 years, boys were 0.1 to 0.6 SD taller till 14 years of age and girls 0.2 to 0.4 SD till the age of 12, after which the WHO population became increasingly taller.
The difference in final height was 3 cm in boys and 4 cm in girls.
Menarche in South Asian girls is about 1.7 years earlier than in Dutch girls, which may account

for the 11 cm difference in final height between these two groups. The final height of South Asian children is 3 cm shorter than of Turkish and Moroccan children and 3-4 cm shorter than found in the WHO population. Because of these differences, it is doubtful whether universal height-for-age references may work well to assess the height of South Asian children.

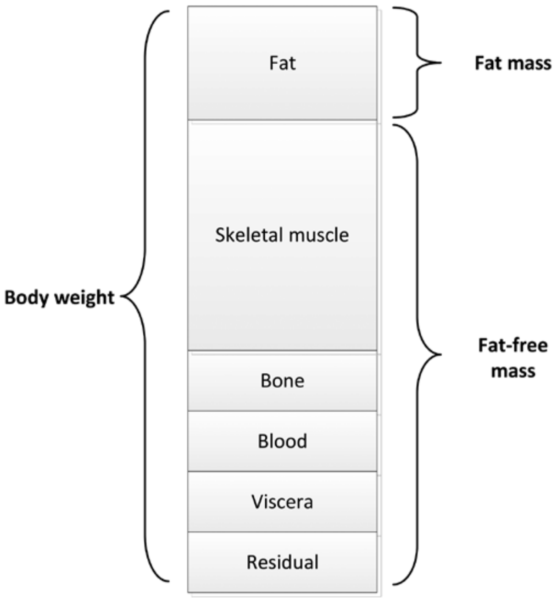
Chapter 7 provides BMI-for-age references based on a reference cohort of Surinamese South Asian children born between 1974 and 1976 (before the obesity epidemic). Compared with current Asian Indian BMI references the BMI was similarly distributed, although the mean BMI in South Asian in the Netherlands was lower and the distribution showed less variation. In the same study BMI cut-offs for overweight and obesity were created to correspond, at 18 years of age, with the adult BMI cut-offs of 23 kg/m^2 for overweight and 25 kg/m^2 for obesity which were previously proposed to be used for Asian Indian populations. A BMI of 15 kg/m^2 at 18 years of age was chosen as cut-off to determine thinness as this value corresponded in girls with the commonly used -2 SD criterion and because similarly to the lowered overweight cut-offs this value was 2 BMI-points lower than the universal cut-off for thinness. However, in boys a BMI of 15 kg/m^2 corresponded with the 7th percentile. The application of these South Asian specific BMI criteria is expected to better reflect their body composition which aids in the proper assessment of the nutritional status of this group, at least in the Netherlands.

8.2 GENERAL DISCUSSION: THE RELATION BETWEEN BODY COMPOSITION AND CARDIOMETABOLIC RISKS IN SOUTH ASIANS

Overnutrition and cardiometabolic risks

The human body composition can be described at several levels: I. atomic, II molecular, III cellular, IV tissue, and V whole body.[16] The use of weight or BMI references can be regarded as a level V (whole body) description. Nevertheless, BMI-for-age, as in this thesis, is commonly used to estimate the body composition at the tissue level (figure 1), because it is highly correlated with the fat mass, easy to use, inexpensive and non-invasive.[17] However, the sensitivity for identifying children with a high fat mass or increased cardiometabolic risks is moderate to high, depending on the population.[18] As BMI is unable to properly distinguish between the fat mass and the fat-free (lean) mass, it is unlikely to reach a very high sensitivity. The fat mass simply varies too much at the same BMI level.[14] In addition, the use of universal BMI-for-age references and cut-offs further limits the sensitivity in certain ethnic groups, as the relation between BMI and the fat mass,[19–21] and between BMI and cardiometabolic risks,[10,22] differs markedly between ethnic groups. Several studies have found that population specific BMI references and cut-offs are superior in detecting excess fat or cardiometabolic risks than universal BMI criteria.[18,22] Therefore, the application of population specific references and cut-offs, such as those described in this thesis, likely optimises the overall sensitivity in detecting excess fat and cardiometabolic risks.

Figure 1 *Body composition: tissue level description*[16]



Undernutrition and cardiometabolic risks

The relation between overnutrition, expressed in adiposity, and cardiovascular and metabolic risks has been well established.[7,23] Paradoxically, undernutrition in early childhood, usually expressed in a low birth weight, is also associated with increased (future) cardiometabolic risks.[24–26] To explain this association several hypotheses have been proposed[27–31] of which the 'thrifty* phenotype hypothesis' or 'foetal origins hypothesis',[28] has been studied extensively. It postulates that under- or malnutrition during the foetal development 'reprograms' the body's glucose-insulin axis as an adaptation to nutritional scarcity, which ultimately leads to an increased risk of cardiometabolic diseases. The most compelling evidence supporting this hypothesis comes from studies of the 'Dutch famine' (or 'Hunger winter', 1944-1945) during the 2nd World War, which found that prenatal exposure to famine was related to a higher risk of cardiovascular disease and insulin resistance later in life compared with unexposed subjects.[32,33] Similar results were found in a follow-up study of adults that during pregnancy or early childhood were exposed to the Biafran famine in Nigeria (1967-1970).[34]

Is low birth weight the expression of undernutrition?

Though the association between a low birth weight, as a proxy for intrauterine undernutrition, and subsequent disease was confirmed repeatedly,[28] low birth weight remains a surrogate measure of fatness and does not distinguish the truly undernourished from well nourished but lean babies. Therefore, it remains unsure if these studies' subjects were truly undernourished.[35]

* *Thrifty* means several things: in the context of the 'thrifty phenotype hypothesis' synonyms like economical, sparing, provident and preserving apply.

As we also showed in this thesis, low birth weight (<2500 g) is highly prevalent in South Asian children living in the Netherlands but it is unlikely that these babies are truly undernourished. South Asian neonates living in India were also shown to have a considerably lower mean birth weight than UK babies but they were not undernourished, as indicated by a generally normal subcutaneous fat mass[6] but simultaneously a smaller lean body mass. Nevertheless, the relation between a low birth weight and insulin resistance has also been shown in Asian Indian neonates and older children. Compared with UK babies (generally lighter) Asian Indian babies were found to be hyperinsulinemic (a high insulin concentration in the blood).[11] It may well be that these children remain more prone to hyperinsulemia or insulin resistance. Follow-up of a cohort of children in India showed that those born with a low birth weight were more insulin resistant at age 4 years[36] and 8 years of age[37] than children born with a higher birth weight.
In conclusion, South Asian babies are generally lighter at birth, but most are not undernourished. Though an increased risk of cardiometabolic disease in South Asians is already present at a young age, a direct relation with undernutrition seems unlikely.

Is low birth weight the expression of fat mass or fat-free mass?
Most research of the 'thrifty phenotype hypothesis' focussed on the fat mass, but there is also evidence supporting a relation to the fat-free or muscle mass. Several studies found that birth weight or birth weight-for-gestational-age is related to fat-free mass and not fat mass, a relationship that even extends into older age.[35,38–40] Moreover, the amount of postnatal muscle mass has been shown to be highly influenced by genetic factors, accounting for 50 to 80 percent of the variability.[41–43] Therefore, a neonate's birth weight is likely more the reflection of (genetically determined) muscle mass than of fat mass.

How is the muscle mass related to insulin resistance?
One of the functions of the hormone insulin is to regulate the glucose (energy) delivery to the body's cells, for which it primarily interacts with muscle cells.[44] When these cells become less sensitive to insulin - a state called insulin resistance - the body's feedback mechanism increases the insulin production in an attempt to restore the glucose transport into the cells.[45] It is plausible that, since skeletal muscle is the primary target of insulin action, a smaller muscle mass itself may already lead to insulin resistance, as there are simply less points of interaction (receptors). This mechanism may be supported by studies showing an association between a low muscle mass and reduced insulin sensitivity, independent of the fat mass.[46,47] Therefore, the association between birth weight and insulin resistance is likely moderated by the muscle mass.
As also the amount of body fat has been shown to be a moderator of insulin resistance, showing higher prevalences of insulin resistance with increasing body fat or BMI/weight both in neonates and adults,[37,46,48–50] the glucose-insulin axis is most likely moderated both by muscle and fat mass. Subjects with a low birth weight or born small-for-gestational-age, who subsequently showed 'catch-up growth' in weight or BMI (likely because of fat deposition), were shown to be the most at risk for developing cardiometabolic diseases.[51–53] The most insulin resistant Asian Indian babies were those born large (>3500 g).[54] Although not known, these large babies may

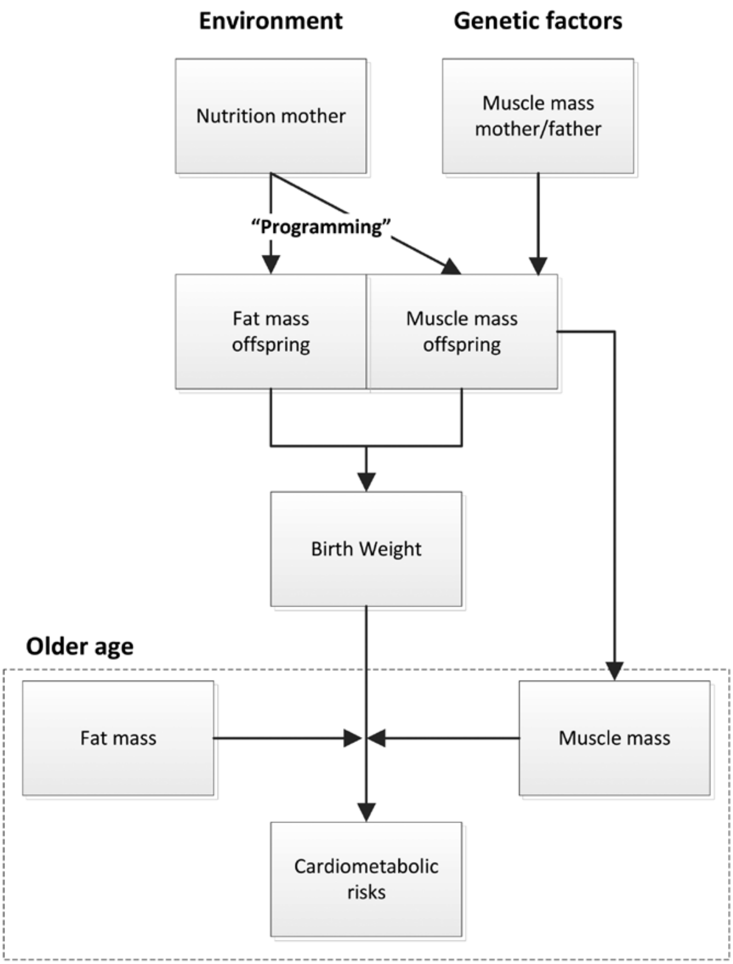
have actually had a small muscle mass but a large fat mass. Insulin resistance in 8-year old Asian Indian children was also highly prevalent in those born with a low birth weight but that had gained a large fat mass.[37] It is likely that a large fat mass ultimately determines if cardiometabolic diseases develop in individuals with a low muscle mass.
In conclusion, we hypothesize that, independent of undernutrition or low birth weight, the amount of muscle and fat in relation to the body size moderates the subsequent risk of cardiovascular disease and type 2 diabetes. Those with a low muscle mass but a large fat mass are then likely to suffer the highest risk for developing cardiometabolic diseases.

Why are South Asians predisposed to develop a small muscle mass?
Both the 'thrifty phenotype hypothesis 'and the 'thrifty genotype hypothesis',[30] postulate that insulin resistance could have been advantageous in times of starvation.
A study of fetal undernutrition in sheep showed that in the sheep's offspring the density of insulin-sensitive muscle cells was reduced. It is plausible that similar mechanisms are also active in humans, leading to the development of a lower muscle mass in undernourished fetuses, and consequently to a predisposition to insulin resistance.[55] The underlying mechanism is called 'programming' or 'developmental plasticity' by which fetal development and metabolism is constantly adapted to environmental changes. There are several mechanisms by which an organism is programmed through environmental cues. For instance, the fetus' gene expression may be changed by epigenetic alterations of the DNA, and also the tissue differentiation may be influenced in response to the environmental circumstances. With the ability of epigenetic changes to be imprinted in the DNA, the changes in the gene expression may become hereditary. [56]
Where programming during early development is usually a short term adaptation to an unexpected environment, natural selection of specific genes that are advantageous during prolonged periods of low energy availability provide a more sustainable adaptation.
India has been an agricultural society since 9,000 BC.[57] A vegetarian diet, that is usually less energy dense, has been the predominant diet in South Asia for millennia.[58] For that reason, the population has always been highly dependent on the crop yields to be able to feed the population. Droughts and policy mismanagement have frequently lead to crop failures, and consequently to frequent periods of famine. The past 2,500 years at least 90 famines were recorded,[59] but the true number is likely to be much higher. Especially during the 18th and 19th century, famines have had devastating societal consequences, with an estimated total death count of 60 million people.[60] These conditions may have been the trigger to a natural selection of those best adapted to nutritional deprivation, leading to the development of a 'thrifty genotype'. One of the thrifty adaptations to nutritional scarcity that may have evolved in South Asian populations is the generally smaller muscle mass. Since a smaller muscle mass is associated with a lower basal metabolic rate,[61] it automatically lowers the energetic demand of the body.

In conclusion, evidence is increasing that in the relation between birth weight and the risk of cardiometabolic diseases both environmental and genetic factors play a role. [56] However, in the case of South Asians, the typical thin-fat body composition and as a consequence the extremely

high risk of developing cardiometabolic diseases, has been more likely naturally selected in the population as a long term thrifty adaptation to nutritional deprivation.
The conceptual model in figure 2 shows the hypothesised relationship between a low birth weight and cardiometabolic disease risks.

Figure 2 *Conceptual model of the association between birth weight and cardiometabolic risks*



8.3 IMPLICATIONS

Health care professionals
With the current universal child growth standards health risks in South Asian children are inadequately detected. Underweight or thinness are overestimated while overweight and obesity are underestimated. Both the overestimation of thinness and underestimation of overweight may add to the development of cardiovascular disease and type 2 diabetes mellitus.

Catch-up growth of thin infants has been repeatedly shown, both in Asian Indians and in other ethnic groups, to increase the risk of cardiometabolic disease.[37,51,62] However, parents of thin children are often advised to have their children gain weight, which in turn will lead to the development of fat in stead of muscle, and consequently to increased cardiometabolic risks. On the other hand, South Asian children at risk for developing cardiometabolic diseases (with a large fat mass but a small muscle mass) are not adequately detected with current universal screening methods, resulting in preventive measures and interventions to start late or not at all. The application of the BMI cut-offs presented in this thesis likely lead to less misclassifications of the nutritional status and may therefore aid in the prevention of cardiovascular diseases and diabetes mellitus type 2. Furthermore, the use of ethnic specific BMI criteria in clinical practice may lead to parents becoming more aware of what is considered a healthy weight or BMI for their child at an earlier stage.

Although South Asian children in the Netherlands were on average shorter than Dutch children, the use of the current Dutch height reference charts may be sufficient for assessing the height of South Asian children, except during the first 6 months after birth and during adolescence. In boys between the age of 6 months and 14 years and in girls between 6 months and 12 years the difference in length/height with Dutch children remained fairly stable at the -0.5 SD level, indicating similar growth patterns. Also for Turkish and Moroccan children in the Netherlands youth health care professionals are recommended to use the height-for-age charts of Dutch children and switch to the ethnic specific height-for-age charts if in doubt, for instance if the height deviates from the child's own growth channel (the relative distance from the SD-lines).[63] As the differences in height between South Asian children and Dutch children increase during adolescence, the application of ethnic specific charts during this period may aid in the proper assessment of height.

Policy makers

Commonly, underweight prevalence rates follow a country's socioeconomic development. In the case of India this rule does not seem to apply, a paradox called the 'Asian enigma'.[64] While India's economic growth is greater and poverty levels are lower than in many other developing countries, the undernutrition rates (based on universal criteria) have only slightly changed in the past decades.[65] Still, India has the highest childhood underweight rates in the world.[66] Even though it is known that the body composition of South Asians differs from other ethnic groups,[5,6,20] the high thinness rates are mostly related to pathology, in most cases to malnutrition and undernutrition.[65,67] Nevertheless, current evidence indicates that most thin South Asian children, as indicated by a low BMI, are not undernourished at all, as a normal or even high fat mass is found in these children.[6,68] In addition, we showed that even healthy affluent South Asian children living in a western country have high levels of thinness (based on universal BMI criteria). This suggests that ethnic specific weight and BMI criteria are needed to be able to properly assess the nutritional status of South Asian children. Application of South Asian specific growth standards will likely solve this 'Asian enigma'.

The support of South Asian governments and organisations like WHO and Unicef for implementing such standards may likely result in an improvement of the future health of South Asian populations. Although the height references and BMI cut-offs presented in this thesis have not been validated with actual health outcomes, and the suitability for other South Asian populations has not been tested, these may provide a better tool for assessing the nutritional status of this ethnic group than the current universal height references and BMI criteria.

8.4 CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

The epidemiological studies of this thesis generally support the hypothesis that also in a developed country as the Netherlands South Asian children are predisposed to a lower weight and BMI. Furthermore, these studies also suggest that current universal criteria to assess a child's nutritional status are unsuitable for South Asian populations. To be able to better assess the nutritional status and height development we developed height-for-age references and BMI cut-offs, based on measurements of South Asian children living in the Netherlands.

As the studies of this thesis were restricted to South Asian children in the Netherlands, the results cannot directly be generalised to South Asian populations in other countries, even though the developed height-for-age and BMI-for-age charts were highly compatible to current Asian Indian charts. Therefore, further research is needed to confirm that length/height, especially length during infancy, and body composition in South Asian populations in other countries are similar to South Asian children in the Netherlands.
Furthermore, as the BMI cut-offs of this thesis were statistically derived, the second step is to validate these BMI criteria with actual body composition data and (cardiometabolic) health outcomes, such as blood pressure, blood lipids, and insulin resistance.
As we hypothesized that the actual muscle mass and fat mass may be moderators in the relation between (birth) weight/BMI and the subsequent health risks, it is also recommended to study the cardiometabolic risk profiles in relation to direct measures of body composition (muscle mass and fat mass) instead of surrogate measures such as weight and BMI. Such studies might provide new insights into the causal pathway leading to the development of cardiometabolic diseases.

REFERENCES

1. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. *Int. J Obes (Lond)* 2011; 35(2):167-187.
2. Wulan SN, Westerterp KR, Plasqui G. Ethnic differences in body composition and the associated metabolic profile: a comparative study between Asians and Caucasians. *Maturitas* 2010; 65(4):315-319.
3. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004; 363(9403):157-163.
4. Chiu M, Austin PC, Manuel DG, Shah BR, Tu JV. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. *Diabetes Care* 2011; 34(8):1741-1748.

5. Deurenberg-Yap M, Chew SK, Deurenberg P. Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. *Obes Rev* 2002; 3(3):209-215.
6. Yajnik CS, Fall CH, Coyaji KJ *et al*. Neonatal anthropometry: the thin-fat Indian baby. The Pune Maternal Nutrition Study. *Int J Obes Relat Metab Disord* 2003; 27(2):173-180.
7. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; 854):1-452.
8. Misra A, Chowbey P, Makkar BM *et al*. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. *J Assoc Physicians India* 2009; 57):163-170.
9. Ehtisham S, Crabtree N, Clark P, Shaw N, Barrett T. Ethnic differences in insulin resistance and body composition in United Kingdom adolescents. *J Clin Endocrinol Metab* 2005; 90(7):3963-3969.
10. Whincup PH, Gilg JA, Papacosta O *et al*. Early evidence of ethnic differences in cardiovascular risk: cross sectional comparison of British South Asian and white children. *BMJ* 2002; 324(7338):635.
11. Yajnik CS, Lubree HG, Rege SS *et al*. Adiposity and hyperinsulinemia in Indians are present at birth. *J Clin Endocrinol Metab* 2002; 87(12):5575-5580.
12. Duncan JS, Duncan EK, Schofield G. Ethnic-specific body mass index cut-off points for overweight and obesity in girls. *N Z Med J* 2010; 123(1311):22-29.
13. Khadilkar VV, Khadilkar AV, Borade AB, Chiplonkar SA. Body Mass Index Cut-offs for Screening for Childhood Overweight and Obesity in Indian Children. *Indian Pediatr* 2012; 49(1):29-34.
14. Wickramasinghe VP, Lamabadusuriya SP, Cleghorn GJ, Davies PS. Defining anthropometric cut-off levels related to metabolic risk in a group of Sri Lankan children. *Ann Hum Biol* 2011; 38(5):537-543.
15. Viner RM, Cole TJ, Fry T *et al*. Insufficient evidence to support separate BMI definitions for obesity in children and adolescents from south Asian ethnic groups in the UK. *Int J Obes (Lond)* 2010; 34(4):656-658.
16. Wang ZM, Pierson RN, Jr., Heymsfield SB. The five-level model: a new approach to organizing body-composition research. *Am J Clin Nutr* 1992; 56(1):19-28.
17. Boeke CE, Oken E, Kleinman KP, Rifas-Shiman SL, Taveras EM, Gillman MW. Correlations among adiposity measures in school-aged children. *BMC Pediatr* 2013; 13):99.
18. Reilly JJ, Kelly J, Wilson DC. Accuracy of simple clinical and epidemiological definitions of childhood obesity: systematic review and evidence appraisal. *Obes Rev* 2010; 11(9):645-655.
19. Deurenberg P, urenberg-Yap M, Foo LF, Schmidt G, Wang J. Differences in body composition between Singapore Chinese, Beijing Chinese and Dutch children. *Eur J Clin Nutr* 2003; 57(3):405-409.
20. Shaw NJ, Crabtree NJ, Kibirige MS, Fordham JN. Ethnic and gender differences in body fat in British schoolchildren as measured by DXA. *Arch Dis Child* 2007; 92(10):872-875.
21. Wickramasinghe VP, Arambepola C, Bandara DM *et al*. Validity of newly-developed BMI and waist cut-off values for Sri Lankan children. *Ann Hum Biol* 2013;)
22. Wickramasinghe VP, Arambepola C, Bandara P *et al*. Distribution of obesity-related metabolic markers among 5-15 year old children from an urban area of Sri Lanka. *Ann Hum Biol* 2013;)
23. Dietz WH. Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics* 1998; 101(3 Pt 2):518-525.
24. Hales CN, Barker DJ. Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis. *Diabetologia* 1992; 35(7):595-601.
25. Prentice AM, Moore SE. Early programming of adult diseases in resource poor countries. *Arch Dis Child* 2005; 90(4):429-432.
26. Whincup PH, Kaye SJ, Owen CG *et al*. Birth weight and risk of type 2 diabetes: a systematic review. *JAMA* 2008; 300(24):2886-2897.
27. Wells JC. Ethnic variability in adiposity and cardiovascular risk: the variable disease selection hypothesis. *Int J Epidemiol* 2009; 38(1):63-71.

28. Hales C, Barker D. Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis. *Int J Epidemiol* 2013; 42(5):1215-1222.
29. Hattersley AT, Tooke JE. The fetal insulin hypothesis: an alternative explanation of the association of low birthweight with diabetes and vascular disease. *Lancet* 1999; 353(9166):1789-1792.
30. Neel JV. The "thrifty genotype" in 1998. *Nutr Rev* 1999; 57(5 Pt 2):S2-S9.
31. Stoger R. The thrifty epigenotype: an acquired and heritable predisposition for obesity and diabetes? *Bioessays* 2008; 30(2):156-166.
32. de Rooij SR, Painter RC, Phillips DI *et al*. Impaired insulin secretion after prenatal exposure to the Dutch famine. *Diabetes Care* 2006; 29(8):1897-1901.
33. Painter RC, de Rooij SR, Bossuyt PM *et al*. Early onset of coronary artery disease after prenatal exposure to the Dutch famine. *Am J Clin Nutr* 2006; 84(2):322-327.
34. Hult M, Tornhammar P, Ueda P *et al*. Hypertension, diabetes and overweight: looming legacies of the Biafran famine. *PLoS One* 2010; 5(10):e13582.
35. Rogers I. The influence of birthweight and intrauterine environment on adiposity and fat distribution in later life. *Int J Obes Relat Metab Disord* 2003; 27(7):755-777.
36. Yajnik CS, Fall CH, Vaidya U *et al*. Fetal growth and glucose and insulin metabolism in four-year-old Indian children. *Diabet Med* 1995; 12(4):330-336.
37. Bavdekar A, Yajnik CS, Fall CH *et al*. Insulin resistance syndrome in 8-year-old Indian children: small at birth, big at 8 years, or both? *Diabetes* 1999; 48(12):2422-2429.
38. Hediger ML, Overpeck MD, Kuczmarski RJ, McGlynn A, Maurer KR, Davis WW. Muscularity and fatness of infants and young children born small- or large-for-gestational-age. *Pediatrics* 1998; 102(5):E60.
39. Murtaugh MA, Jacobs DR, Jr., Moran A, Steinberger J, Sinaiko AR. Relation of birth weight to fasting insulin, insulin resistance, and body size in adolescence. *Diabetes Care* 2003; 26(1):187-192.
40. Singhal A, Wells J, Cole TJ, Fewtrell M, Lucas A. Programming of lean body mass: a link between birth weight, obesity, and cardiovascular disease? *Am J Clin Nutr* 2003; 77(3):726-730.
41. Arden NK, Spector TD. Genetic influences on muscle strength, lean body mass, and bone mineral density: a twin study. *J Bone Miner Res* 1997; 12(12):2076-2081.
42. Macdonald-Wallis C, Tobias JH, Smith GD, Lawlor DA. Relation of maternal prepregnancy body mass index with offspring bone mass in childhood: is there evidence for an intrauterine effect? *Am J Clin Nutr* 2010; 92(4):872-880.
43. Seeman E, Hopper JL, Young NR, Formica C, Goss P, Tsalamandris C. Do genetic factors explain associations between muscle strength, lean mass, and bone density? A twin study. *Am J Physiol* 1996; 270(2 Pt 1):E320-E327.
44. Saltiel AR, Kahn CR. Insulin signalling and the regulation of glucose and lipid metabolism. *Nature* 2001; 414(6865):799-806.
45. Saltiel AR. Insulin resistance in the defense against obesity. *Cell Metab* 2012; 15(6):798-804.
46. Lear SA, Kohli S, Bondy GP, Tchernof A, Sniderman AD. Ethnic variation in fat and lean body mass and the association with insulin resistance. *J Clin Endocrinol Metab* 2009; 94(12):4696-4702.
47. Srikanthan P, Hevener AL, Karlamangla AS. Sarcopenia exacerbates obesity-associated insulin resistance and dysglycemia: findings from the National Health and Nutrition Examination Survey III. *PLoS One* 2010; 5(5):e10805.
48. Dyer JS, Rosenfeld CR, Rice J, Rice M, Hardin DS. Insulin resistance in Hispanic large-for-gestational-age neonates at birth. *J Clin Endocrinol Metab* 2007; 92(10):3836-3843.
49. Fall CH, Stein CE, Kumaran K *et al*. Size at birth, maternal weight, and type 2 diabetes in South India. *Diabet Med* 1998; 15(3):220-227.
50. McCance DR, Pettitt DJ, Hanson RL, Jacobsson LT, Knowler WC, Bennett PH. Birth weight and non-insulin dependent diabetes: thrifty genotype, thrifty phenotype, or surviving small baby genotype? *BMJ* 1994; 308(6934):942-945.
51. Jaquet D, Leger J, Levy-Marchal C, Czernichow P. Low birth weight: effect on insulin sensitivity and lipid metabolism. *Horm Res* 2003; 59(1):1-6.

52. Levy-Marchal C, Czernichow P. Small for gestational age and the metabolic syndrome: which mechanism is suggested by epidemiological and clinical studies? *Horm Res* 2006; 65 Suppl 3):123-130.
53. Vaag A, Jensen CB, Poulsen P *et al*. Metabolic aspects of insulin resistance in individuals born small for gestational age. *Horm Res* 2006; 65 Suppl 3):137-143.
54. Yadav KK, Gupta R, Gupta A, Gupta M. Insulin levels in low birth weight neonates. *Indian J Med Res* 2003; 118):197-203.
55. Costello PM, Rowlerson A, Astaman NA *et al*. Peri-implantation and late gestation maternal undernutrition differentially affect fetal sheep skeletal muscle development. *J Physiol* 2008; 586(9):2371-2379.
56. Gluckman PD, Hanson MA. Living with the past: evolution, development, and patterns of disease. *Science* 2004; 305(5691):1733-1736.
57. Gupta AK. Origin of agriculture and domestication of plants and animals linked to early Holocene climate amelioration. *Current Science* 2004; 87(1):54-59.
58. Spencer C. The Heretic's Feast. A History of Vegetarianism. first. London: UPNE, 1995.
59. Murton B. Famine. In: Kiple KF, Ornelas KC, editors. The Cambridge World History of Food. New York: Cambridge University Press; 2012. 1411-1427.
60. Timeline of major famines in India during British rule. Wikipedia; 2014. Available from: http://en.wikipedia.org/wiki/Timeline_of_major_famines_in_India_during_British_rule.
61. Soares MJ, Piers LS, O'Dea K, Shetty PS. No evidence for an ethnic influence on basal metabolism: an examination of data from India and Australia. *Br J Nutr* 1998; 79(4):333-341.
62. Ong KK. Size at birth, postnatal growth and risk of obesity. *Horm Res* 2006; 65 Suppl 3):65-69.
63. TNO. JGZ-richtlijn Signalering van en verwijscriteria bij kleine lichaamslengte. Leiden: TNO, 2010. http://www.ncj.nl/programmalijn-kennis/landelijke-werkdocumenten/richtlijn/?item=29
64. Nube M. The Asian enigma: predisposition for low adult BMI among people of South Asian descent. *Public Health Nutr* 2009; 12(4):507-516.
65. Wang Y, Chen HJ, Shaikh S, Mathur P. Is obesity becoming a public health problem in India? Examine the shift from under- to overnutrition problems over time. *Obes Rev* 2009; 10(4):456-474.
66. 6th report on the world nutrition situation. Geneva: United Nations Standing Committee on Nutrition; 2009. Available from: www.unscn.org/files/Publications/RWNS6/report/SCN_report.pdf.
67. Mondal N, Sen J. Thinness is a major underlying problem among Indian children. *J Trop Pediatr* 2010; 56(6):456-458.
68. Wickramasinghe VP. Hattori chart based evaluation of body composition and its relation to body mass index in a group of Sri Lankan children. *Indian J Pediatr* 2012; 79(5):632-639.

Nederlandse samenvatting

INLEIDING

Hindostanen

De onderzoeken in dit proefschrift richten zich op kinderen uit een relatief kleine etnische groep in Nederland, de Hindostanen (mensen oorspronkelijk afkomstig uit Zuid-Azië)*, waarvan er naar schatting 160 tot 180 duizend in Nederland wonen. De voorouders van de meeste Hindostanen in Nederland migreerden tussen 1873 en 1916 vanuit de arme en overbevolkte Indiase staten Uttar Pradesh en Bihar naar de voormalige Nederlandse kolonie Suriname om te werken op de plantages als contractarbeiders. In de periode rondom de onafhankelijkheid van Suriname (in 1975) hebben vervolgens veel Surinaamse Hindostanen zich in Nederland gevestigd, met name in de grote steden. Den Haag herbergt de grootste populatie van Nederland met ongeveer 40.000 representanten, ongeveer 8% van de Haagse bevolking.

Beoordeling van groei bij kinderen: referenties en standaarden

Om de groei en voedingstoestand bij kinderen te kunnen beoordelen worden in Nederland bij alle kinderen periodiek metingen gedaan (zoals van lengtegroei en gewicht). Deze metingen worden in het algemeen vergeleken met referentiewaarden, die meestal weergegeven worden als zogenaamde groeicurven (=referentiecurven). Een dergelijke curve beschrijft de verdeling van de specifieke maat in een bepaalde populatie kinderen. Hiermee kan de gezondheidszorg-professional afwijkingen van het gemiddelde bij kinderen uit die populatie signaleren.
Meestal zijn referentiecurven gebaseerd op groeigegevens van kinderen uit een gezonde welvarende populatie met weinig beperkingen qua voeding, sociaaleconomische factoren en omgevingsinvloeden. Dergelijke referenties reflecteren de optimale groei voor die specifieke populatie. Deze zijn in essentie normatief en worden (groei)standaarden genoemd.
Omdat uit onderzoek is gebleken dat kinderen uit zulke 'standaard' populaties wereldwijd tot de leeftijd van 5 jaar in hun groei niet veel verschillen, heeft de Wereldgezondheidsorganisatie WHO een universele groeistandaard ontwikkeld die gebaseerd is op de groeigegevens van kinderen uit alle continenten.
Om afwijkingen in de groei of voedingstoestand op te sporen worden individuele metingen door middel van referentiecurven beschreven in een standaard deviatiescore (=z-score) of een percentiel, een waarde die aangeeft hoeveel de meting afwijkt van het (normatieve) gemiddelde. Om kinderen te identificeren met een mogelijk gezondheidsprobleem zijn afkapwaarden bepaald waarboven of waaronder het risico op dergelijke problemen verhoogd is.

Beoordeling van de voedingstoestand: gewicht en Body Mass Index (BMI)

De voedingstoestand (ondergewicht, normaal gewicht, overgewicht) bij volwassen en kinderen wordt in het algemeen beoordeeld met indirecte maten voor de vetmassa zoals gewicht en BMI.

* *Zuid-Azië* wordt in de internationale literatuur veel gebruikt om de bevolkingsgroep van het Indiase subcontinent (India, Pakistan, Bangladesh en Sri Lanka) aan te duiden. De bevolking van wie de (voor) ouders afkomstig zijn uit Zuid-Azië, wordt in de internationale literatuur aangeduid als Zuid-Aziaten, in Nederland als Hindoestanen of Hindostanen. Beide termen worden door elkaar gebruikt, maar de voorkeur gaat uit naar de term 'Hindostanen' omdat daarmee de hele bevolkingsgroep wordt aangeduid, terwijl 'Hindoestanen' verwijst naar volgers van het Hindoeïsme.

Voor volwassenen (vanaf 18 jaar) worden in het algemeen vaste BMI-afkappunten gebruikt om de voedingstoestand in te schatten. Hierbij duidt een BMI van kleiner dan 18,5 kg/m^2 ondergewicht aan, een BMI tussen 18,5 en 25 een normaal gewicht, een BMI tussen 25 kg/m^2 en 30 kg/m^2 overgewicht, en een BMI groter dan 30 kg/m^2 ernstig overgewicht (obesitas).
Omdat de lichaamsverhoudingen en lichaamssamenstellingen bij kinderen veranderen tijdens de ontwikkeling zijn vaste BMI afkappunten voor hen niet geschikt. Voor de beoordeling van de voedingstoestand vanaf de leeftijd van 2 jaar worden om die reden wereldwijd de universele BMI afkappunten van de International Obesity Taskforce (IOTF) of de WHO geadviseerd. De waarden variëren naar leeftijd en geslacht, en kruisen op 18-jarige leeftijd de BMI-afkappunten voor volwassenen.

Hindostanen en een verhoogd gezondheidsrisico
Bij Hindostanen komen diabetes mellitus type 2 (ook wel bekend als ouderdomssuikerziekte) en hart- en vaatziekten veel vaker voor dan in de meeste andere etnische groepen. Samen worden deze ziekten ook wel cardiometabole ziekten genoemd. De ontwikkeling ervan hangt nauw samen met de aanwezigheid van overgewicht, een overmaat aan lichaamsvet. Echter, bij Hindostanen ontstaan cardiometabole ziekten in het algemeen al bij een lagere BMI dan in andere etnische groepen, omdat de lichaamssamenstelling verschillend is. Zo hebben ze bij dezelfde BMI een grotere vetmassa en tegelijkertijd een kleinere spiermassa dan andere etnische groepen. Om die reden zijn in India de BMI afkappunten voor overgewicht en obesitas verlaagd, respectievelijk van 25 naar 23 kg/m2 en van 30 naar 25 kg/m2, omdat deze afkapwaarden beter overeenstemmen met de verhoogde cardiometabole risico's dan de universele waarden.

Ook bij Hindostaanse kinderen en adolescenten is aangetoond dat de cardiometabole risico's al verhoogd zijn bij een lager gewicht of een lagere BMI dan bij kinderen en jongeren uit andere etnische groepen. In verschillende studies zijn verlaagde BMI afkappunten voor gebruik in Zuid-Aziatische populaties voorgesteld om de voedingstoestand en geassocieerde gezondheidsrisico's beter te kunnen inschatten. Echter, tot op heden is nog geen consensus bereikt over welke BMI afkappunten het meest geschikt zijn. Daarnaast zijn norm waarden voor gewicht, lengte en BMI voor welvarende Hindostaanse kinderen die in een Westers land wonen momenteel niet beschikbaar. Ook is het onduidelijk of universele groeistandaarden voor de beoordeling van de lengte, het gewicht en de BMI op de kinderleeftijd zoals ontwikkeld door de WHO (World Health Organization=Wereldgezondheidsorganisatie) de groei van Hindostaanse kinderen voldoende beschrijven.

Doelen proefschrift
Het eerste doel van dit proefschrift is om epidemiologisch bewijs te vinden dat de hypothese ondersteunt dat welvarende Hindostaanse kinderen in een Westers land lichter en kleiner zijn dan kinderen uit andere etnische groepen. Dergelijk bewijs zou het gebruik van aangepaste groeicurven en groei-indicatoren bij Hindostaanse kinderen kunnen ondersteunen.
Ten tweede is het doel om lengte-naar-leeftijd (0-20 jaar) en BMI-naar-leeftijd curven (0-18 jaar)

te ontwikkelen specifiek voor Hindostaanse kinderen én om deze te vergelijken met andere groeireferenties of – standaarden. Als laatste was het doel om BMI afkapwaarden vast te stellen voor de bepaling van ondergewicht, overgewicht en obesitas bij Hindostaanse kinderen van 2-18 jaar oud, en om deze te vergelijken met andere BMI criteria (waaronder de universele afkappunten). Het bereiken van deze doelen draagt naar verwachting bij aan een groter inzicht in welke maten en waarden als norm voor Hindostaanse kinderen kunnen worden beschouwd. Daarnaast wordt verwacht dat de toepassing van etnisch-specifieke groeireferenties en afkappunten voor Hindostaanse kinderen leidt tot een betere beoordeling van de lengte en de BMI. Vooral van een betere beoordeling van de BMI wordt verwacht dat dit een bijdrage kan leveren in de preventie van diabetes en hart- en vaatziekten.

METHODE

Registratiegegevens Jeugdgezondheidszorg
De onderzoeken in dit proefschrift zijn allen gebaseerd op gegevens die routinematig zijn geregistreerd in dossiers van de Jeugdgezondheidszorg in Den Haag. De Jeugdgezondheidszorg nodigt alle kinderen en jongeren in Nederland op vaste leeftijden uit voor preventieve gezondheidsonderzoeken (PGO) door jeugdartsen en jeugdverpleegkundigen. Tussen 0 en 4 jaar worden gemiddeld 15 van dergelijke gezondheidsonderzoeken uitgevoerd en tussen 5 en 18 jaar momenteel nog 4. Het bereik van deze onderzoeken is in het algemeen hoog ; tot wel 90-100% van de kinderen wordt gezien. Tijdens een PGO worden onder meer screeningen verricht zoals van ogen en oren, vaccinaties gegeven, en gezondheidsinformatie en adviezen verstrekt. Tijdens de meeste bezoeken worden metingen gedaan van de lengte en het gewicht. Dit levert een ware schat aan gegevens op waarmee de gezondheid op zowel individueel als op groepsniveau gemonitord kan worden. Voor dit proefschrift is deze schat aangeboord om verschillende wetenschappelijke vraagstellingen te kunnen beantwoorden.

RESULTATEN

DEEL 1 - Epidemiologie
In hoofdstuk 2 wordt beschreven dat het gemiddelde geboortegewicht bij Hindostaanse baby's onveranderd is gebleven gedurende een periode van 35 jaar. In de periode 2006-2009 was het gemiddelde geboortegewicht van Hindostaanse baby's ongeveer 450 gram lager dan van pasgeborenen van Nederlandse afkomst. Gebaseerd op universele geboortegewicht standaarden kwamen een laag geboorte gewicht (<2500 gram) en dysmaturiteit (= een geboortegewicht onder de 10e percentiel voor de zwangerschapsduur) bij Hindostaanse baby's erg veel voor. Echter, met de toepassing van etnisch specifieke standaarden waren de cijfers in overeenstemming met de cijfers bij Nederlandse baby's.
Ondanks de stabiliteit van het gemiddelde geboortegewicht van Hindostaanse baby's zijn ze naar zwangerschapsduur wel zwaarder geworden sinds de 70'er jaren, wat werd aangeduid door een afname in het percentage dysmaturiteit.
De studie beschreven in **hoofdstuk 3** liet zien dat een referentiecohort van Surinaams-

Hindostaanse kinderen, geboren vóór de obesitas epidemie (1974-1976) en met metingen tussen 3 en 15 jaar oud, aanzienlijk lagere gemiddelde BMI Standaard Deviatie Scores had dan de 'standaard' populatie van de WHO. Daarbij bleek ondergewicht (thinness) disproportioneel veel voor te komen (36-38%) wanneer de cijfers waren gebaseerd op universele BMI afkappunten. Tegelijkertijd waren overgewicht (inclusief obesitas) cijfers relatief laag (6-9%). Ook in een cohort Surinaams-Hindostaanse kinderen geboren tijdens de obesitasepidemie (1991-1993) was de ondergewicht prevalentie hoog (24%), maar daarbij was ook de overgewicht prevalentie fors hoger (18-23%). Deze bevindingen suggereren dat de huidige universele BMI afkappunten bij Hindostaanse kinderen het vóórkomen van ondergewicht overschatten en, ondanks de ogenschijnlijk hoge overgewichtcijfers in het meest recente cohort, overgewicht onderschatten. Deze afkappunten lijken dan ook ongeschikt voor het beoordelen van de voedingstoestand van Hindostaanse kinderen.
In een hedendaagse populatie Hindostaanse kinderen was de gemiddelde BMI z-score (gebaseerd op universele BMI referenties) veel lager dan bij kinderen van Nederlandse, Turkse en Marokkaanse afkomst **(hoofdstuk 5)**. Ook de prevalentie van overgewicht (inclusief obesitas) was zeker ten opzichte van de prevalentie bij Marokkaanse en Turkse kinderen maar weinig hoger dan bij Nederlandse kinderen **(hoofdstukken 4 en 5).** Omdat Hindostanen in het algemeen een hoger vetpercentage hebben bij een lagere BMI suggereren deze bevindingen dat de overgewichtcijfers een onderschatting representeren van de ware cardiometabole risico's in de Hindostaanse groep. In hoofdstuk 5 wordt daarnaast getoond dat het vóórkomen van overgewicht (inclusief obesitas) afnam tussen 1999 en 2011 bij kinderen van Nederlandse afkomst. Bij kinderen van Marokkaanse en Hindostaanse komaf bleef het percentage kinderen met overgewicht (inclusief obesitas) stabiel, maar wanneer alleen naar obesitas werd gekeken was er sprake van een afnemende trend sinds 1999. Bij Turkse kinderen is overgewicht sinds 1999 weliswaar toegenomen, maar vanaf 2007 is er sprake van een stabilisatie van de overgewicht en obesitascijfers.

DEEL 2 – Groeireferenties

In **Hoofdstuk 6** worden lengte-naar-leeftijd curven gepresenteerd die gebaseerd zijn op de lengte van een historische en een hedendaagse populatie Hindostaanse kinderen in Nederland. Het groeipatroon van deze etnische groep, gerepresenteerd in de vorm van de groeicurven, was vergelijkbaar met het groeipatroon in een actuele populatie kinderen uit India. In het bijzonder, de lengte-naar-leeftijd curven van het historische referentiecohort Hindostaanse kinderen, geboren tussen 1974 en 1976, vielen vrijwel samen met recente Indiase lengte-naar-leeftijd curven, wat een vergelijkbare genetische aanleg suggereert. Hedendaagse Hindostaanse kinderen in Nederland waren op elke leeftijd langer dan de Indiase kinderen, wat mogelijk kan worden toegeschreven aan verschillen in sociaaleconomische en omgevingsfactoren.
Vergeleken met kinderen van Nederlandse afkomst waren Hindostaanse kinderen gemiddelde 0,5-0,6 Standaard Deviaties (SD) kleiner tot de leeftijd van 14 jaar in jongens en 12 jaar in meisjes, waarna de verschillen verder toenamen tot 1,5-1,7 SD op de leeftijd van 20 jaar.

De eindlengte op 20-jarige leeftijd van Hindostaanse jongens was 10 cm korter dan bij Nederlandse jongens. Bij meisjes was het verschil in volwassen eindlengte 11 cm.
Ook tussen de Hindostaanse en de WHO lengte referenties werden discrepanties in het groeipatroon gevonden over de gehele leeftijdslinie. Tussen de geboorte en de leeftijd van 5 jaar waren Hindostaanse kinderen in Nederland 0,1 tot 1,1 SD korter dan de 'standaard' WHO populatie. Echter, vanaf 5-jarige leeftijd, waren Hindostaanse jongens 0,1-0,6 SD langer tot de leeftijd van 14 jaar en Hindostaanse meisjes 0,2 tot 0,4 SD tot de leeftijd van 12 jaar. Hierna werd de WHO populatie in toenemende mate weer langer. Het verschil in eindlengte was bij jongens 3 cm en bij meisjes 4 cm.
De eerste menstruatie (menarche) was bij Hindostaanse meisjes ongeveer 1,7 jaar vroeger dan bij Nederlandse meisjes. Dit kan mogelijk het verschil van 11 cm in eindlengte verklaren tussen deze twee etnische groepen. De eindlengte van Hindostaanse kinderen is ongeveer 3 cm korter dan die van Turkse en Marokkaanse kinderen, en gemiddeld 3-4 cm korter van de WHO populatie. Vanwege de verschillen in groeipatroon tussen etnische groepen is het de vraag of universele lengte-naar-leeftijd referenties voldoende bruikbaar zijn voor de beoordeling van de lengte bij Hindostaanse kinderen.
Hoofdstuk 7 presenteert BMI-naar-leeftijd referenties gebaseerd op het historische Hindostaanse referentiecohort dat geboren was vóór de obesitasepidemie. Vergeleken met recente Indiase BMI referenties, was de vorm van de BMI verdeling vergelijkbaar, terwijl de gemiddelde BMI van Hindostaanse kinderen in Nederland lager was en de verdeling minder variatie vertoonde. Daarnaast zijn in deze studie ook BMI afkappunten voor het bepalen van overgewicht en obesitas bij Hindostaanse kinderen vastgesteld die op 18-jarige leeftijd corresponderen met de BMI afkappunten voorgesteld voor volwassenen in India: 23 kg/m2 voor overgewicht en 25 kg/m2 voor obesitas. Een BMI van 15 kg/m2 op 18-jarige leeftijd werd gekozen als afkappunt voor ondergewicht (thinness) omdat deze waarde bij meisjes correspondeerde met het vaak gebruikte criterium voor ondergewicht van -2 SD. Daarnaast is de grootte van deze verlaging vergelijkbaar met het 2 BMI punten lagere Indiase afkappunt voor overgewicht. Bij jongens, echter, correspondeerde een BMI van 15 kg/m2 met de 7e percentiel (7% van de metingen lag onder dit criterium), wat vrij hoog blijft.
Verwacht wordt dat deze Hindostaanse BMI afkappunten de specifieke lichaamssamenstelling van Hindostanen beter representeren. De toepassing ervan zal naar verwachting leiden tot een betere beoordeling van de voedingstoestand bij deze groep, ten minste in Nederland en mogelijk ook in andere welvarende landen. Vanwege de vroegere opsporing van overgewicht kan het daarnaast mogelijk bijdragen aan de preventie van diabetes type 2 en hart- en vaatziekten.

BESCHOUWING

In **Hoofdstuk 8** worden bovenstaande bevindingen nader beschouwd, in het bijzonder de relatie tussen over- en ondergewicht en cardiometabole risico's bij Hindostanen. In dit kader is veel onderzoek gedaan naar de 'thrifty phenotype hypothese' (vrij vertaald 'spaarzaam fenotype hypothese'). Hierin wordt een verband gelegd tussen ondervoeding vóór de geboorte

- in de meeste studies gerepresenteerd door een laag geboortegewicht - en cardiometabole ziekten op latere leeftijd. Echter, bij Hindostaanse baby's, die vaak een laag geboortegewicht hebben, is het lage geboortegewicht meestal geen uiting van ondervoeding, maar reflecteert het eerder een andere lichaamssamenstelling met een kleinere spiermassa. Het is aannemelijk dat in de relatie tussen een laag geboortegewicht en verhoogd cardiometabole risico's de grootte van de spiermassa een rol speelt. Wanneer individuen geboren met een kleine spiermassa daarnaast op latere leeftijd een grotere vetmassa ontwikkelen, lijkt het risico op diabetes en hart- en vaatziekten nog verder te worden vergroot.

Om onder- en overgewicht bij Hindostaanse kinderen adequaat te kunnen opsporen wordt aanbevolen de etnisch specifieke BMI afkappunten te gebruiken omdat de overschatting van ondergewicht en de onderschatting van overgewicht bij deze groep juist kunnen leiden tot de ontwikkeling van cardiometabole ziekten. Immers, ouders van 'te lichte' kinderen krijgen vaak het advies om hun kind aan te laten komen, wat in het geval van Hindostaanse kinderen juist kan leiden tot een vergroting van de vetmassa en daarmee tot verhoogde cardiometabole risico's. Aan de andere kant worden Hindostaanse kinderen met een hoge vetmassa pas laat opgespoord met de universele BMI afkappunten, waardoor (preventieve) interventies ook pas laat starten. Omdat de validiteit van de in dit proefschrift gepresenteerde BMI criteria nog niet is onderzocht, dat wil zeggen dat ze daadwerkelijk kinderen met een hoge vetmassa en verhoogde cardiometabole risico's opsporen, moet hiernaar nog nader onderzoek worden verricht.
Daarnaast is onduidelijk van zowel de Hindostaanse BMI afkappunten als van de lengte-naar-leeftijd curven of deze ook geschikt zijn voor andere Zuid-Aziatische populaties, zoals de Indiase. Ook hiernaar is nader onderzoek nodig.
Als laatste wordt aanbevolen om nader onderzoek te doen naar cardiometabole risicoprofielen in relatie tot directe maten voor de lichaamssamenstelling, zoals spier- en vetmassa, in plaats van indirecte maten zoals (geboorte)gewicht en BMI. Dergelijke studies zouden nieuwe inzichten kunnen opleveren in de oorzakelijke wegen die leiden tot de ontwikkeling van diabetes mellitus type 2 en hart- en vaatziekten.

List of peer-reviewed publications

Dankwoord

Curriculum Vitae

LIST OF PEER-REVIEWED PUBLICATIONS

1. Heerdink-Obenhuijsen N, Kamphuis M, Fleuren MA, van Velzen-Mol HW, de Wilde JA. [The Dutch Child Health Care guideline 'early detection of congenital heart disease in the age group 0-19 years']. *Ned Tijdschr Geneeskd* 2006; 150(32):1764-1767.
2. de Wilde JA, van Dommelen P, Middelkoop BJ, Verkerk PH. Trends in overweight and obesity prevalence in Dutch, Turkish, Moroccan and Surinamese South Asian children in the Netherlands. *Arch Dis Child* 2009; 94(10):795-800.
3. van Dommelen P, Kamphuis M, van Leerdam FJ, de Wilde JA, Rijpstra A, Campagne AE, Verkerk PH. The short- and long-term effects of simple behavioral interventions for nocturnal enuresis in young children: a randomized controlled trial. *J Pediatr* 2009; 154(5):662-666.
4. Olds T, Maher C, Zumin S, Peneau S, Lioret S, Castetbon K, Bellisle, De WJ, Hohepa M, Maddison R, Lissner L, Sjoberg A, Zimmermann M, Aeberli I, Ogden C, Flegal K, Summerbell C. Evidence that the prevalence of childhood overweight is plateauing: data from nine countries. *Int J Pediatr Obes* 2011; 6(5-6):342-360.
5. Theunissen MHC, de Lijster GPA, de Wilde JA, Kocken PL. Signaleren in de JGZ: Ontwikkeling en bruikbaarheid van een standaard vragenlijst ten behoeve van het preventief gezondheidsonderzoek 5-6 en 10-11 jarigen. *TSG* 2013; 91:415-421.
6. de Wilde JA, Zandbergen-Harlaar S, van Buuren S, Middelkoop BJ. Trends in body mass index distribution and prevalence of thinness, overweight and obesity in two cohorts of Surinamese South Asian children in The Netherlands. *Arch Dis Child* 2013; 98(4):280-285.
7. de Wilde JA, van DP, Middelkoop BJ. Appropriate body mass index cut-offs to determine thinness, overweight and obesity in South Asian children in the Netherlands. *PLoS One* 2013; 8(12):e82822.
8. de Wilde JA, van Buuren S, Middelkoop BJ. Trends in birth weight and the prevalence of low birth weight and small-for-gestational-age in Surinamese South Asian babies since 1974: cross-sectional study of three birth cohorts. *BMC Public Health* 2013; 13:931.
9. van der Plas E, Zijp G, Froeling F, de Wilde J, van de Voort L,Hack W. Orchidopexy in late childhood often associated with previously normal testicular position. *Eur J Pediatr Surg* 2013; 23(4):276-282.
10. de Wilde JA, Verkerk PH, Middelkoop BJ. Declining and stabilising trends in prevalence of overweight and obesity in Dutch, Turkish, Moroccan and South Asian children 3-16 years of age between 1999 and 2011 in the Netherlands. *Arch Dis Child* 2014; 99(1):46-51.
11. de Wilde JA, Verkerk PH, Middelkoop BJ. [Number of overweight children slowly declines]. *Ned Tijdschr Geneeskd* 2014; 158:A7350.
12. de Wilde JA, van Dommelen P, van Buuren S, Middelkoop BJ. Height of South Asian children in the Netherlands aged 0-20 years: secular trends and comparisons with current Asian Indian, Dutch and WHO references. *Ann Hum Biol* 2014; early online. DOI: 10.3109/03014460.2014.926988.

DANKWOORD

Ik had zelf nooit gedacht dat het er van zou komen, een proefschrift schrijven. Door verschillende collega's ben ik vaak gestimuleerd dit te doen, maar ik hield dit steeds beleefd af. Uiteindelijk was dit proefschrift toch een onvermijdelijkheid. Bij de totstandkoming ervan zijn vele mensen belangrijk geweest die ik hierbij wil bedanken.

Mijn promotoren. **Barend Middelkoop**, ik waardeer onze inspirerende brainstorm sessies. Mede daardoor is het idee voor dit proefschrift ontstaan. Dank voor het lezen van elk concept alsof het de eerste keer was, en natuurlijk voor je toegankelijkheid en het delen van je expertise. **Stef van Buuren**, dank voor het delen van je kennis en je bereidheid om lopende de rit tweede promotor te worden. Je constructieve commentaren op de artikelen waren van grote meerwaarde.

De leden van 'de promotiecommissie'. Ik ben vereerd dat jullie de moeite wilden nemen om mijn proefschrift kritisch te lezen en beoordelen. Ik waardeer de leerzame en soms uitgebreide feedback die ik heb ontvangen.

Paul Verkerk, Jouw visie en kritische blik triggerde me om anders te denken en kijken naar het werk in de JGZ. Ik waardeer je scherpe blik en je analytische vermogen, maar ook je humor en onze 'dagelijkse' gesprekken.

Remy Hirasing. Tijdens het Nederlands Congres Volksgezondheid gaf je aan dat ik een promotie heel goed zelf kon gaan organiseren. Dat was het keerpunt in het denken over deze 'onderneming'. Dank voor je enthousiasme, hart voor JGZ, en onze discussies.

Marianne Zwartendijk, voor je vertrouwen en de gelegenheid die je gaf om jeugdarts-onderzoeker te kunnen worden.

Geertje Ariëns. Dank voor de constructieve adviezen, prettige omgang en jouw steun bij de 'interne subsidiëring' van verschillende onderzoeken.

Alle JGZ (oud-)collega's van zowel de GGD Haaglanden als van Jong Florence voor het registreren van de routine gegevens in het digitale dossier. In het bijzonder wil ik de jeugdverpleegkundigen van onze afdeling bedanken die op Haagse scholen aanvullende metingen hebben verricht voor de groeistudie en die daarvoor vaak (door weer en wind) met alle apparatuur op de fiets naar scholen gingen.

Alle ouders en kinderen die de moeite hebben genomen om speciaal naar de scholen te komen en de vragenlijsten in te vullen voor de Hindostaanse groeistudie. Daarnaast ook de ouders die naar reguliere JGZ-onderzoeken kwamen. Zonder de gegevens die tijdens deze preventieve onderzoeken zijn vastgelegd was dit proefschrift niet mogelijk geweest.

Sharda Doelam, als student heb je me met je sprankelende persoonlijkheid erg geholpen bij de organisatie van de 'Hindostaanse groeistudie' op de twee Hindoe basisscholen. Veel dank daarvoor. **Silvia Zandbergen-Harlaar**, voor het meedenken en natuurlijk voor het schrijven van het conceptartikel voor je afstuderen.

Alle studenten die op de scholen en tijdens het Milan festival hebben geholpen met de metingen en het verzamelen van additionele gegevens.

Ron Smit en **Marion Groeneveld**, jullie wil ik hierbij nogmaals bedanken voor het toegankelijk maken van de geregistreerde gegevens in de digitale dossiers.

Janine Kallenbach, voor je vertrouwen en de mogelijkheid die je bood om dit proefschrift te kunnen schrijven.

Bianca Das, voor je constante ondersteuning en stimulering, en voor het vinden van constructieve oplossingen om mijn onderzoeken te kunnen uitvoeren.

Paula van Dommelen, voor het sparren, je hulp bij de analyses, en natuurlijk ´onze´ humor, die niet iedereen begrijpt.

Kees Slager, voor de mogelijkheid om in het begin meerdere dagen achtereen in jouw huis in Veere te kunnen werken/schrijven. En naast jou, wil ik natuurlijk **mijn moeder** bedanken voor de zorgzaamheid als ik er weer eens was.

Lisa Steenhauer, dank dat je de tijd wilde nemen om 'proofreader' te zijn.
Michiel Steenhauer, 'lifelong friend', dank voor het er gewoon zijn, soms dichtbij , soms ver weg.

Varsha Gopal, voor de gelegenheid die je gaf om jouw 'guitige' jongens te mogen fotograferen voor dit proefschrift. **Ishaan en Reyhaan**, jullie wil ik bedanken voor jullie geduld en goede poses tijdens de (voor jullie lange) fotosessie.

José Noé, in de eindfase was je onmisbaar bij de opmaak van dit proefschrift. Ondanks verschillende knelpunten is het gelukt! Veel dank voor alle tijd en energie die je erin hebt gestoken.

Paranimph **Ellen Ricke**, voor je enthousiasme, je bruisende ideeën en onze inspirerende gesprekken.

Paranimph en 'best friend' **Boudewijn Lelieveldt**, voor je relativeringsvermogen, tips en 'heads up' tijdens mijn promotietraject.

Sheila Scheuermann, voor de gelegenheid die je bood om in je huis ongestoord te kunnen werken aan én worstelen met mijn artikelen.

Ik wil **alle anderen** bedanken die interesse toonden in mijn onderzoek en me daarmee vaak inspireerden.

En last but not least, **mijn gezin**. **Sascha**, je begrip voor mijn ambities, je flexibiliteit en je steun hebben uiteindelijk tot dit resultaat geleid. **Milan** en **Luka**, mijn jongens, ondanks dat jullie het niet altijd leuk vonden dat ik er weer eens niet was, wil ik ook jullie bedanken voor jullie (onbewuste) flexibiliteit en geduld.

CURRICULUM VITAE

Jeroen de Wilde was born on January 16, 1970 in Wageningen. At age one, he moved to Middelburg (Zeeland), where he completed secondary school (Gymnasium β) in 1988. He studied medicine at Leiden University and received his medical degree in 1997. Besides his medical training, in 1994 he completed a photography study at the Fotovakschool in Apeldoorn.

During his medical study, Jeroen had become interested in prevention, in particular the work of the Youth Health Care Service. For that reason during his medical training he did an internship at the Youth Health Care of the GGD (=Community Health Service) Duin- en Bollenstreek, where he worked as a public health physician ('schoolarts') after receiving his medical degree. In 1998, he then started working at the Youth Health Care at the GGD The Hague (now GGD Haaglanden) where he still works. In 1999 he began his training as a Public Health physician at TNO in Leiden. During this specialisation he became increasingly fascinated by scientific research and in particular the use of routinely registered medical data for scientific research. After completing his specialization, he worked part-time as a researcher at TNO for two years, next to his work as a public health physician in The Hague. Now, he still remains involved in the research at TNO as "guest scientific officer".

From 2011, Jeroen has worked as a senior researcher at the Youth Health Care in The Hague. In addition to the studies on growth and obesity in children in the city of The Hague, he leads and collaborates in several research projects. In 2013, Jeroen received the Flora van Laar encouragement prize for several of his studies in Youth Health Care including the studies of this thesis. From January 2015, he coordinates the Academic Collaborative Center "Samen voor de Jeugd', which is thé melting pot for applied scientific research in the 'Care for Youth' practice.
After his promotion, Jeroen wants to focus on the analysis of all remaining data he collected as part of the 'Hindustani growth study' .

Jeroen is married to Sascha. They have two sons, Milan (2004) and Luka (2005).