Changing curves

Monitoring growth of children and adolescents in The Netherlands

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Chapter 2

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Chapter 3

Schönbeck Y, van Dommelen P, HiraSing RA, van Buuren S. Trend in height of Turkish and Moroccan children living in The Netherlands. PloS ONE. 2015 10(5): e0124686.

Chapter 4

Schönbeck Y, Talma H, Van Dommelen P, Bakker B, Buitendijk SE, HiraSing RA, Van Buuren S. 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.

Chapter 5

van Dommelen P, Schönbeck Y, HiraSing RA, van Buuren S. Call for early prevention: prevalence rates of overweight among Turkish and Moroccan children in The Netherlands. European Journal of Public Health. 2015 [Epub ahead of print].

Chapter 6

van Dommelen P, Schönbeck Y, van Buuren S, HiraSing RA. Trends in a life threatening condition: morbid obesity in Dutch, Turkish and Moroccan children in The Netherlands. PLoS ONE. 2014 9(4): e94299.

Chapter 7

Schönbeck Y, van Dommelen P, HiraSing RA, van Buuren S. Thinness in the era of obesity: trends in children and adolescents in The Netherlands since 1980. European Journal of Public Health. 2015 25(2): 268-73.

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Chapter 1

General introduction

GROWTH MONITORING

Monitoring human growth gives information on the health status of a population, e.g. prevalence rates of overweight and obesity and the average height of the population, and allows comparison both within and between countries. At the individual level, it is used to detect abnormal growth trajectories, which may reflect growth disorders, nutritional problems, or other underlying illnesses[1,2]. The Netherlands have a rich tradition of growth studies, which have been performed in 1955, 1965, 1980, 1997, and 2009[3-7]. These large, nationwide studies provide insights into the development of height and weight of Dutch children over time. They resulted in growth references, which are being used extensively by preventive youth health care workers and pediatricians for growth screening and monitoring of children. The studies resulted in many (inter) national publications, and the 1980 study population forms part of the population used for the calculation of the international cut offs for thinness and overweight[8-10]. Apart from health purposes, these growth references are useful in the field of ergonomics, for example for determining optimal dimensions of school furniture, helmets, and clothing.

Height

Growth can be seen as 'a mirror of the condition of society'[11]. Over the past decades, there have been important health gains throughout the world. For example, childhood morbidity and mortality have been reduced considerably by better (preventive) health care, especially regarding infectious disease[12]. These advances in health are the result of major developments in science, technology, and medicine. Also, education, income and infrastructure have improved[13], which enabled better housing, nutrition and hygiene. These factors have contributed to an increase in the mean height of populations in developed countries. An optimal environment could in time lead to the maximum attainable mean height of a population.

In The Netherlands, the mean height has increased steadily since 1858[6,14]. This positive trend was interrupted by relatively short periods of agricultural and economic crisis, for example World War I and II, when the mean height stagnated or even decreased[15]. The Fourth Dutch Growth Study in 1997 showed that the Dutch formed the world's tallest population, for as far as height data on country levels were available. However, the rate of population height increment slowed down in The Netherlands, from 2.7 cm per decade in the fifties to 1.3 cm per decade in the nineties (see Figure 1)[6]. For optimal detection of growth disorders, up-to-date growth charts are required. Because the mean height over time increased, the Dutch growth charts have been updated every 10 to 15 years since 1955, using data from Dutch Growth Studies. Information about the current height of the Dutch population can tell us whether Dutch children became even taller since 1997, and whether the current Dutch growth references need updating.

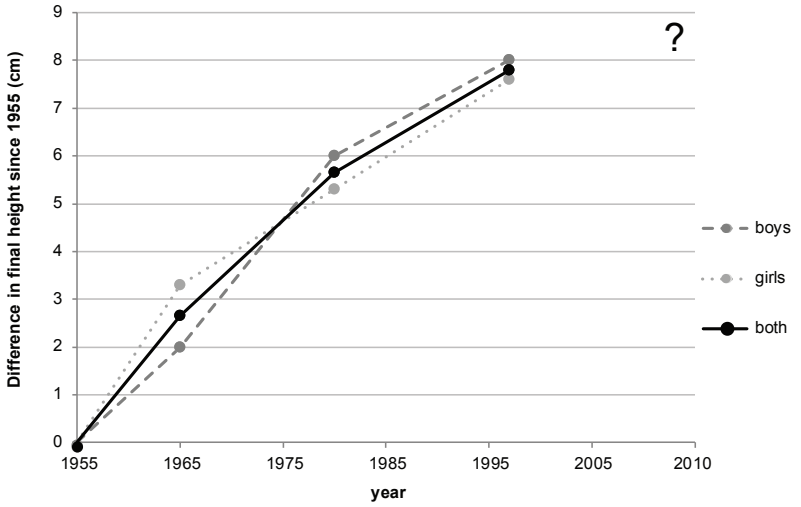

Figure 1. *The difference in final height in 1965, 1980 and 1997 with 1955 of Dutch boys and girls.*

Apart from the Dutch being the tallest population, the 1997 study also revealed differences up to 10 cm in mean height between children of Turkish or Moroccan origin and children of Dutch descent[16,17]. Therefore, origin specific growth charts for these two major immigrant groups in The Netherlands were constructed. Substantial height differences of immigrant children compared to native children have been described before, and their height also differs from the height of peers in the country of origin[16-19], probably due to differences in living conditions. It is unknown how the height of immigrant groups has developed since 1997. The 1997 growth charts may need updating.

Overweight and obesity

While progress in the economy and development of a country may result in better health (care) and a taller population, it may also lead to increased prevalence rates of overweight and obesity. The Fourth Dutch Growth Study showed that in 1997 the overweight and obesity rates were dramatically higher than in 1980. Childhood overweight and obesity have both psychological and physical health consequences. The immediate risks associated with childhood obesity include high blood pressure, high cholesterol, increased risk of type 2 diabetes, low self-esteem, and depressive symptoms[20-22]. The longer term risk is that overweight and obese children and adolescents are more likely to become obese adults, which increases the risk for chronic diseases like cardiovascular disease, hypertension, diabetes mellitus type 2 and even premature mortality[23,24]. Between 1980 and 1997, the prevalence of children with overweight almost doubled. In boys, the prevalence rate rose from 5 to 9 percent, and

in girls from 7 to 12 percent. Obesity rates even tripled, from 0.3% to 0.9% (boys), and from 0.5% to 1.6% (girls)[25]. The prevalence of overweight and obesity in children varied between ethnic backgrounds. Among children of Moroccan origin, overweight was seen twice and obesity 3.5 times as often as in their Dutch peers. In children of Turkish origin, the prevalence rate of overweight was 2.5 times as high, and of obesity 4.5 (girls) to 5.8 (boys) times as high as in those of Dutch origin[16,17].

Management of overweight and obesity

The alarming rise in the prevalence of overweight and obesity initially did not lead to action. Health care providers, researchers and policy makers saw overweight and obesity mainly as an individual problem. It took years to realize that overweight and obesity are also a burden for society. Awareness was low in parents, children, and youth health care workers[26]. In 2002, an overweight center (Kenniscentrum Overgewicht) was founded, subsidized by the Dutch government. The aim was to increase accessibility of research and knowledge, and to stimulate research, regarding etiology, prevention and treatment of overweight. A study using routinely collected data from youth health care institutes showed that overweight and obesity had increased further between 1997 and 2003[27]. In 2004, the so called Signaleringsprotocol Overgewicht in de Jeugdgezondheidzorg' was launched[28]. The aim of this protocol was to introduce a uniform method for identifying overweight and obesity in children aged 2 to 18 years for youth health care professionals. The protocol consisted of a flow chart, growth charts and a body mass index (BMI)-nomogram. The protocol is developed for youth health care professionals, as longitudinal monitoring of growth, including measurement of height and weight, of all children in The Netherlands belongs to their tasks. These regular, free of charge routine health care checkups are ideal for (early) detection and intervention. As no evidence-based treatment for overweight and obesity was available, the best practice-based 'Overbruggingsplan Overgewicht' was introduced in 2005 for youth health care professionals. Its purpose was to prevent further weight increase, relative to height, in overweight children aged 2 to 18 years, by acting on five core elements[29]:

- Promoting breast feeding (primary prevention);
- Increasing outdoor play and exercise (primary and secondary prevention);
- Increasing regular and healthy breakfast (primary and secondary prevention);
- Reducing use of sweetened soft drinks (primary and secondary prevention);
- Reducing watching TV or computer (primary and secondary prevention).

The 'Overbruggingsplan Overgewicht' provided clear recommendations for the prevention of overweight for children per age group. It helped youth health care workers to construct a tailored plan for overweight and obese children, based on the above mentioned core elements. This plan was made together with the child and

his/her parents. The program has been widely adopted. Gradually, the attention for overweight has increased over the past decade. Many interventions, projects, and (public) campaigns aiming at overweight have been developed. These efforts are likely to have raised awareness of the problem in parents, children and health care providers. Numerous (local) initiatives with different methodologies to reduce the prevalence of childhood overweight and obesity have been deployed, but their long-term success in terms of reducing the obesity prevalence remains uncertain. Results from community-based approaches including a school component are promising, although not uniformly positive[30-33]. The effect of these actions and interventions to reduce the prevalence of childhood overweight and obesity at the national level are unknown.

Morbid obesity

The risk for co-morbidity rises with the severity of obesity in young children and adolescents[34,35]. A recent Dutch study showed that among children with morbid obesity, 56% had hypertension and 67% had at least one cardiovascular risk factor[34]. From our previous growth studies, we know that the percentage of children with obesity rose more than the percentage of children with overweight between 1980 and 1997[7]. We do not know, however, whether only the prevalence of children with obesity increased, or also the degree of obesity. In 2000, Cole et al. published age and sex specific international cut offs for BMI, to define childhood overweight and obesity[10]. No international accepted criteria for morbid obesity in children were available until 2012. In 2012, the international cut offs were updated[8]. With these updated cut offs, childhood obesity can now be classified into the same subcategories as used in adults: obesity I (corresponding to an adult BMI of 30 to 35 kg/m^2), obesity II (adult BMI of 35 to 40 kg/m^2), obesity III (adult BMI of 40 kg/m^2 and higher). Studying trends in these subclasses of childhood obesity provides insight in (shifts in) the severity of obesity in Dutch children.

Thinness

Overweight and obesity are now well on the agenda. Some are concerned, however, that programs to prevent overweight and obesity in children may cause unintended harm[36,37]. A study in primary and secondary schools in The Netherlands found that a negative body image and weight loss behavior were present in normal weight children, already at the age of 9-10 years. At the age of 13-14 years, 8.7% of boys and 27.5% of girls found themselves too fat, in spite of having a normal body weight[38]. Such negative body images and dietary behaviors could result in rising rates of thinness. Since the rising prevalence rates of overweight and obesity in The Netherlands, no information on trends in thinness is available.

THE FIFTH DUTCH GROWTH STUDY

In 2007, the Dutch Ministry of Health, Welfare and Sport granted the Fifth Dutch Growth Study. This study was carried out by TNO, in cooperation with the VU Medical Center Amsterdam and the Leiden University Medical Center. The study was approved by the Medical Ethical Review Board of Leiden University Medical Center. The main aims of the study were to assess the trends in overweight and obesity, and in height in children in The Netherlands and to update national growth references. The Dutch Growth Studies have been designed so that the results over the years could be compared.

In the 1997 study, for the first time, separate data on children of Turkish and Moroccan origin, two main immigrant groups in The Netherlands, were collected. These groups were also included in the Fifth Dutch Growth Study.

The Fifth Dutch Growth Study had a cross-sectional design. Anthropometric data of children aged 0-21 years were collected by trained health care professionals between May 2008 and October 2009. Length (until two years of age), height (from 2 years of age), weight, waist circumference, hip circumference, and mid upper arm circumference were measured. Background information was obtained from the child and/or his/her parents by a health care worker and recorded in a questionnaire. The sample was stratified by region at the level of Municipal Health Services (MHS), sex, and age according to national distributions. Data collection was performed during routine health care visits at 28 Well Baby Clinics (ages: 1, 2, 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, and 45 months) and at 23 MHS (ages: 5.5 and 7.5 years). From the age of 9 years onwards, children were invited personally by the MHS after being selected in an age- and sex-stratified random sampling procedure from the registers of the Municipal Register Office. Children of Turkish and Moroccan origin were oversampled in the four largest cities (Amsterdam, Rotterdam, Utrecht and The Hague), where most of them live. To obtain sufficient participants in certain strata, additional measurements took place at randomly selected primary and secondary schools, in two high schools, two universities and a youth festival, and we added random samples from two high quality studies performed by trained staff at primary schools in Amsterdam (GGD Amsterdam, n=270) and vocational education in the east of The Netherlands (Deltion College Zwolle/OPOZ VU-Windesheim, n=342)[7].

Exclusion criteria for the Fifth Dutch Growth Study were similar to those for the previous Dutch Growth Studies. Children with diagnosed growth disorders and children on medication known to interfere with growth were excluded. Children that were not of Dutch, Turkish or Moroccan origin were excluded.

The sample provided data of 10,030 children of Dutch origin. The distributions of educational level of the child and geographical region of the study sample were

compared to the national distributions to check for representativeness[39]. We used the Multivariate Imputation by Chained Equation (MICE) method to correct for educational levels and geographical regions that were underrepresented[40]. This resulted in the adding of 1,975 imputed cases, amounted to a total sample size of 12,005 children of Dutch origin (5,811 boys, 6,194 girls) aged 0-21 years[7]. Table 1 presents the number of children included per growth study.

Table 1. *Number of children per growth study[3-7].*

Year	Dutch	Turkish	Moroccan
1955	16,910	-	-
1965	54,776	-	-
1980	42,000	-	-
1997	14,500	2,904	2,882
2009	12,005*	2,582	2,616

* including 1,975 imputed cases

No measurements for head circumference and pubertal stage (except for menarcheal status) were obtained in the Fifth Dutch Growth Study. There were no significant differences in these measures between 1980 and 1997 and there were no reasons to expect changes between 1997 and 2009[5,6,41]. The references for head circumference and pubertal development were, therefore, not updated. Data on the age of menarche were obtained and have been presented elsewhere[42].

AIM OF THIS THESIS

This thesis presents the data on height and weight from the Fifth Dutch Growth Study from 2009. We aim to (A) assess height differences between 1997 and 2009 in Dutch, Turkish and Moroccan children; (B) study trends in the prevalence of overweight and obesity in Dutch, Turkish and Moroccan children in The Netherlands; (C) determine trends in morbid obesity in children; (D) explore trends in childhood thinness.

This lead to the following research questions:

1. What is the height per age in 2009 of Dutch, Turkish and Moroccan children living in The Netherlands?
2. What is the trend in height since 1955 (Dutch children) and since 1997 (Turkish and Moroccan children)?
3. What are the differences in height of Dutch, Turkish and Moroccan children across demographic characteristics (e.g. sex, ethnicity, geographical region, level of education)?

4. What are the prevalence rates of thinness, overweight, obesity and morbid obesity in 2009 in Dutch, Turkish and Moroccan children living in The Netherlands?
5. What are the trends in prevalence rates of thinness, overweight, obesity and morbid obesity since 1980 (Dutch children) or since 1997 (Turkish and Moroccan children)?
6. What are the differences in the prevalence rates of thinness, overweight, obesity and morbid obesity across demographic characteristics (e.g. sex, ethnicity, geographical region, level of education)?

OUTLINE OF THIS THESIS

This thesis presents results from the Fifth Dutch Growth Study.
The first part of the thesis reports our findings about the height of children in The Netherlands. **Chapter 2** shows the trend in height of Dutch children since 1955. We also present the mean height of Dutch children aged 0-21 years in 2009 and look at differences in height between geographical regions and levels of education. In **Chapter 3** we describe the height of Turkish and Moroccan children aged 0-18 years in The Netherlands in 2009, study the trend since 1997, and compare mean height across levels of education. We present new ethnic specific growth references and discuss the need for such references.
The second part of the thesis focuses on the BMI of children. **Chapter 4** presents prevalence rates and trends of overweight and obesity in 2009 in Dutch children aged 2-21 years. We compare prevalence rates across time (1980 - 1997 - 2009), geographical regions, and levels of education. In **Chapter 5** we present the prevalence rates of overweight and obesity in 2009 in Turkish and Moroccan children aged 2-18 years living in The Netherlands. Trends since 1997 are described and prevalence rates are compared to those in Dutch children. Furthermore, we explore differences in food and exercise behaviors between Dutch, Turkish and Moroccan children. **Chapter 6** reports the proportion of extreme obesity and its trend among Dutch (since 1980), Turkish and Moroccan (since 1997) children aged 2-18 years in The Netherlands. In **Chapter 7** we focus on trends in thinness in 2 -18 year old Dutch (since 1980), Turkish and Moroccan (since 1997) children, and compare the BMI distributions of 1980, 1997, and 2009. **Chapter 8** is a general discussion of the results, and describes implications for clinical practice and further research. **Chapter 9** is the summary of the results.

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Chapter 2

The world's tallest nation has stopped growing taller: the height of Dutch children from 1955 to 2009

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ABSTRACT

Background: Records show that mean height in The Netherlands has increased since 1858. This study looks at whether this trend in the world's tallest nation is continuing. We consider the influence of the geographical region, and of the child and parental education, on changes in height. **Methods:** We compared the height of young Dutch people aged 0-21y as determined on the basis of the growth study of 2009, with the height data from growth studies conducted in 1955, 1965, 1980, and 1997. **Results:** The analysis sample included 5,811 boys and 6,194 girls. height by age was the same as in 1997. Mean final height was 183.8 cm (SD=7.1 cm) in boys and 170.7 cm (SD=6.3 cm) in girls. The educational levels of both children and their parents are positively correlated with mean height. since 1997, differences between geographical regions have decreased but not vanished, with the northern population being the tallest. **Conclusion:** The world's tallest population has stopped growing taller after a period of 150 years, the cause of which is unclear. The Dutch may have reached the optimal height distribution. alternatively, growth-promoting environmental factors may have stabilized in the past decade, preventing the population from attaining its full growth potential.

AUTHOR CONTRIBUTIONS

Conceived and designed the study: YS HT PvD BB SEB RAH SvB. Performed the study: YS HT PvD SvB. Analyzed the data: YS PvD SvB. Contributed materials/analysis tools: BB SEB RAH. Wrote the paper: YS HT PvD BB SEB RAH SvB.

INTRODUCTION

Over the past decades, human height has increased in most industrialized countries. This trend has been the result of improvements in the nutritional, hygienic, economic, and health status of the populations in question[1]. Such factors may allow disadvantaged individuals in particular to grow taller. However, we have not found any reduction in height variation[2]. It appears that individuals benefit more or less equally from improvements in living conditions. Do we believe that we could all be giants if living conditions for humans were to improve further, or is there some maximum (and presumably optimal) population average beyond which our species will not grow, no matter how favorable the circumstances? Although being tall is often associated with being healthy, this may not always be the case. Taller adults have, for example, higher rates of several types of cancer[3]. The question of whether there is a maximum population average is almost impossible to answer, but studies of trends in mean height and of height variations in tall populations could suggest a possible direction.

The Dutch population is the tallest in the world and has been well studied. Before 1955, population height in The Netherlands was estimated on the basis of data for conscripts, i.e., men, and nonrandom samples from the population. Between 1955 and 1997, there were four large cross-sectional nationwide growth studies. These studies showed that young Dutch adults are among the tallest people in the world, with women measuring almost 171 cm on average and men 184 cm on average in 1997[4].

In The Netherlands, people have been getting taller since 1858[2,5]. At that time, conscripts had an average height of 163 cm. This indicates a height gain of 21 cm over a period of 140 years. In The Netherlands, as in most Northern European countries, the upward trend is slowing down significantly[2,6], and it even appears to be reversing in the United States[7].

This article presents new data about height from the Fifth Dutch Growth Study, which was carried out in 2009. The main research questions are: Is the 140 years trend of increasing height in the world's tallest nation still continuing? If not, has there been a compression of height variation? Do geographical region and educational levels affect the development of mean height?

METHODS

Data Sources

Data for the earlier Dutch growth studies were collected in 1955, 1965, 1980, and 1997 and published elsewhere[2,24-26]. The Fifth Dutch Growth Study was a cross-sectional study that collected data for a representative sample of children aged 0-21y in The Netherlands between May 2008 and October 2009. The sample was stratified by region

(regions of Municipal Health Services), sex, and age in line with national distributions [27]. Until the age of 4y, measurements were performed during regular periodical health examinations in 28 Well Baby Clinics at the ages of 1, 2, 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, and 45 months. Between the ages of 4 and 8y, children were measured at 23 Municipal Health Service offices during two regular preventive health assessments performed at the ages of ~5.5 and 7.5y. From the age of 9y onward, children were invited personally by the Municipal Health Services after being selected in an age- and sex-stratified random sampling procedure from the registers of the Municipal Register Office. Furthermore, we conducted measurements at randomly selected primary and secondary schools, at two colleges and two universities across the country, and at a national youth festival. The collection was supplemented by data from two recent large, high-quality studies performed by trained staff at primary schools in Amsterdam (Municipal Health Services in Amsterdam) and at a vocational education institution in the east of The Netherlands (Deltion College Zwolle/OPOZ VU-Windesheim). Random samples from these data (n=270 and n=342, respectively) were added to the data for this study.

Ethics Statement

Data collection for growth studies is a part of routine youth health care in The Netherlands and is not regarded as medical research. Before the measurement, oral consent was obtained from each child (and from the parent when children were younger than 16y). Cooperation, or lack thereof, was recorded on the questionnaire. Data were analyzed anonymously. The Medical Ethics Review Board of Leiden University Medical Center approved the study and the manner in which consent was obtained.

Exclusion Criteria

Exclusion criteria for the Fifth Dutch Growth Study were similar to those for the previous Dutch growth studies: children with diagnosed growth disorders and those on growth-interfering medication were excluded (2.4% of the total population). Children with one or two parents born outside The Netherlands[28] were excluded from the analyses presented in this article. Results with respect to children of Turkish and Moroccan origin will be described elsewhere.

Measurements

Trained health-care professionals carried out the standardized measurements. Infant length was measured to the nearest 0.1 cm in the supine position until 2y of age. From 2y of age onward, standing height was measured to the nearest 0.1 cm. The children's demographic characteristics were obtained from the parents or from adolescents themselves by health-care professionals using a questionnaire.

Variable Definitions

The sample was divided into five geographical regions: North (Friesland, Groningen, Drenthe), East (Overijssel, Gelderland, Flevoland), West (Noord-Holland, Zuid-Holland, Utrecht - not including the four major cities), South (Zeeland, Noord-Brabant, Limburg), and the four major Dutch cities (Amsterdam, Rotterdam, Utrecht, and The Hague). The educational level of the child was determined at the time of measurement. If an adolescent older than 15y had left the educational system, the highest completed education was recorded. The educational level of the parents was defined as the educational level of the highest educated parent and broken down into low, middle, high, and unknown[29]. For the purposes of data cleaning and the comparison of height changes between 1997 and 2009, SDSs were calculated for each age using the 1997 height references[2,30].

Statistical Analyses

Data were cleaned using descriptive statistics that included frequency tables, contingency tables, and scatter plots. Outliers, defined as values more than +5 SDSs or less than +5 SDSs, were checked for data entry errors and corrected wherever possible. If no correction was possible, these measurements were considered erroneous and defined as missing. The distributions for child and parental educational levels and for geographical regions were compared with the national distributions[31] to check for representativeness. We used the multivariate imputation by chained equation method[32,33] to correct for educational levels or geographical regions that were underrepresented. The imputation model was based on age, sex, height SDS, weight SDS, waist SDS, hip SDS, parental height, birth weight, ethnicity, socioeconomic status score[34], educational levels of the children and parents, and geographical region. Passive imputation was performed on the interactions between age and region, age and all SDSs, age squared, and age squared and all SDSs. There was no adjustment for the transition from length to height measurements, given that the age of the transition from length to height measurement differs from child to child in daily practice. Length and height were smoothly joined. SDS reference values for height by age in 2009 were calculated using the LMS method[35]. For these calculations, the data of 146 children aged 22-25y were added to the dataset to obtain stable-fit results at the age of 21y. These subjects were excluded from further analysis. The LMS method calculates three smooth curves representing skewness (L curve), the median (M curve), and coefficient of variation (S curve) to establish SDS lines. L values of 1 indicate normality, and smaller values represent progressively greater skewness. The M curve is the 0 SDS line or 50th centile curve. The S curve defines the coefficient of variation, and when multiplied by 100, it can be interpreted as a percentage. The smoothing parameters (effective degrees of freedom) for the L, M, and S curves were chosen by creating worm plots:

local detrended quantile-quantile plots of the SDS of the reference samples across 16 age groups[36]. A log transformation was applied to the age axis. The curves were fitted as cubic splines. Finally, estimates were made of the age-related SDS reference values for height in 2009. Differences in mean heights between the samples of 2009, 1997, 1980, 1965, and 1955 were computed for each age group. 'Mean height' in this article refers to the 50th percentile of the reference charts, unless otherwise indicated. Children from the 2009 study with a birth weight of <2,500 g were not excluded from the comparisons because their inclusion has only a slight effect on mean height by age and because, as in 1997, they were included in the calculation of the height references. Multivariate analysis (ANOVA) was conducted to assess the associations and trends for the demographic variables (geographical region, child educational level, and parental educational level) with height SDS in 2009 and differences between 1997 and 2009. Consequently, the values were corrected for the effects of the other two factors. R version 2.9.0 with the GAMLSS package[37] was used for imputation and for estimating the height SDS reference values. All other statistical analyses were performed in SPSS version 17.0 for Windows.

RESULTS

The sample comprised of 10,030 children of Dutch origin and 1,975 imputed cases, resulting in an analysis sample of 12,005 children (5,811 boys and 6,194 girls) aged 0-21y. Table 1 lists the numbers of children in each age group.

Height by age and sex was normally distributed, and therefore SDSs could easily be calculated as (height - mean height)/SD. Table 2 summarizes the mean and SD for height extracted from the height references, classified according to age and sex. Extended tables are available from the authors on request.
New growth diagrams were constructed for boys and girls aged 0-21y, including 2.5, 2, 1, 0, -1, -2, -2.5, and -3 SD lines. The -3 SD line was added for practical reasons because the Dutch referral criteria require children with a height SDS of less than -3 SD to be referred for short stature.

Table 1. *Number of observations per age and sex in the Fifth Dutch Growth Study.*

Age (y)	Boys (n)	Girls (n)
0-1	999	992
1-2	536	543
2-3	343	349
3-4	311	308
4-5	138	184
5-6	187	214
6-7	161	210
7-8	202	224
8-9	226	246
9-10	233	254
10-11	318	367
11-12	280	287
12-13	255	294
13-14	196	235
14-15	256	307
15-16	245	265
16-17	163	178
17-18	205	179
18-19	180	185
19-20	166	158
20-21	137	165
21-22	74	50
Total	5,811	6,194

Table 2. *Mean height and SD extracted from height references for boys and girls per age.*

	Height			
	Boys		Girls	
Age (y)	Mean	SD	Mean	SD
0.0767[a]	54.4	2.3	53.7	2.3
0.2500	60.9	2.4	59.7	2.4
0.5000	68.0	2.5	66.4	2.5
0.7500	72.9	2.6	72.9	2.6
1.0000	76.7	2.7	75.0	2.8
1.2500	79.9	2.8	78.4	2.9
1.5000	82.8	2.9	81.5	3.1
1.7500	85.6	3.1	84.4	3.2
2.0000	88.4	3.2	87.1	3.3
3.0000	97.8	3.7	97.0	3.8
4.0000	105.5	4.2	104.9	4.2
5.0000	113.2	4.7	112.1	4.7
6.0000	119.9	5.1	118.8	5.1
7.0000	126.2	5.4	125.3	5.4
8.0000	132.5	5.8	131.3	5.8
9.0000	138.5	6.2	137.3	6.1
10.0000	143.7	6.6	143.5	6.5
11.0000	149.0	7.0	149.7	6.7
12.0000	155.2	7.6	155.7	6.9
13.0000	161.8	8.2	160.8	6.9
14.0000	168.5	8.3	164.5	6.9
15.0000	175.2	7.9	166.9	6.8
16.0000	179.1	7.6	168.3	6.7
17.0000	181.0	7.4	169.2	6.6
18.0000	182.4	7.2	169.7	6.5
19.0000	183.6	7.1	170.1	6.4
20.0000	183.8	7.1	170.5	6.3
21.0000	183.8	7.1	170.7	6.3

a 0.0767=4 weeks

Figures 1A and 1B show the new growth diagrams for boys and girls aged 1-21y. Similar growth diagrams were established for children aged 0-15 months and 0-4y. Note that there is no visual evidence of the pubertal height growth spurt in the growth diagram for girls.

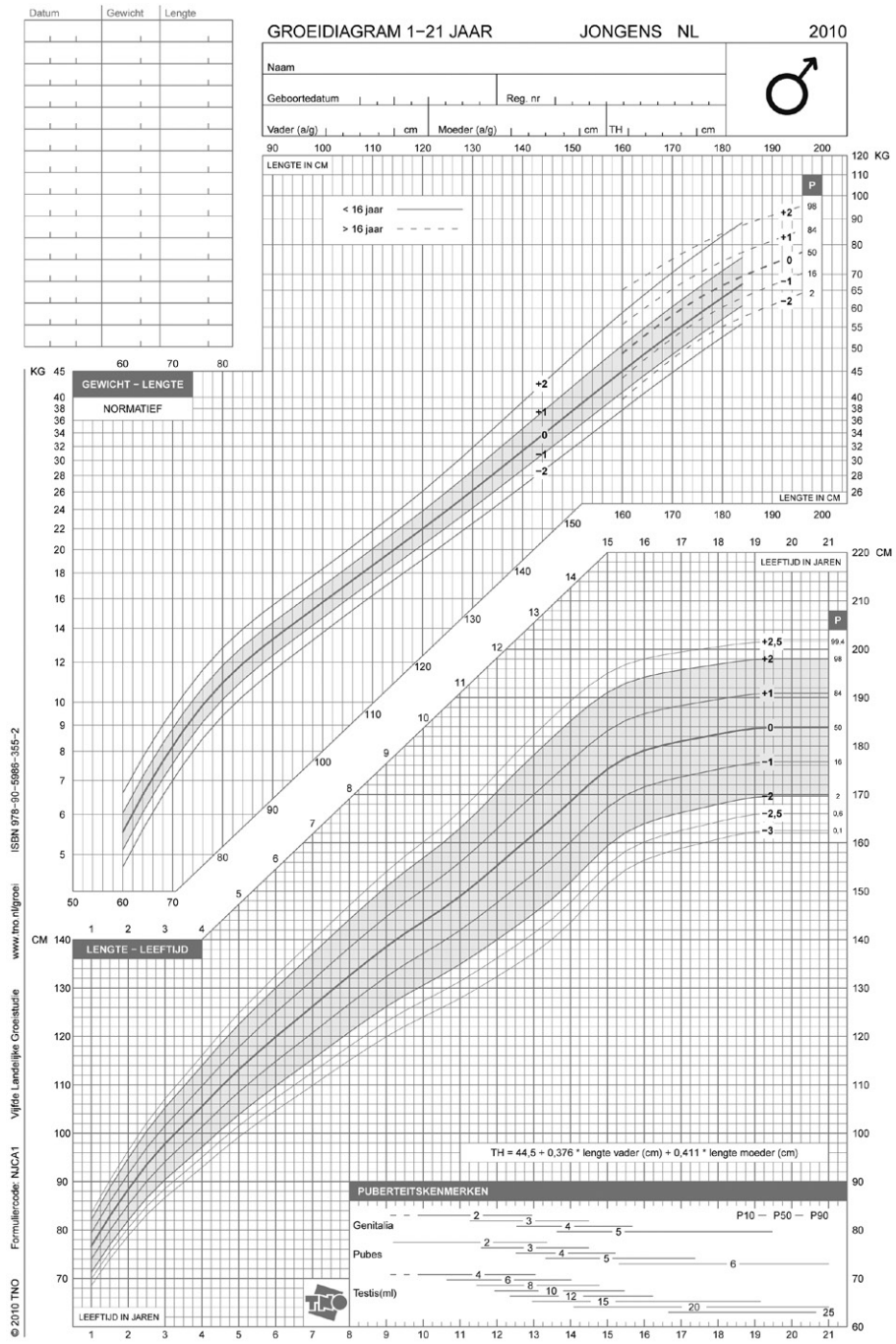
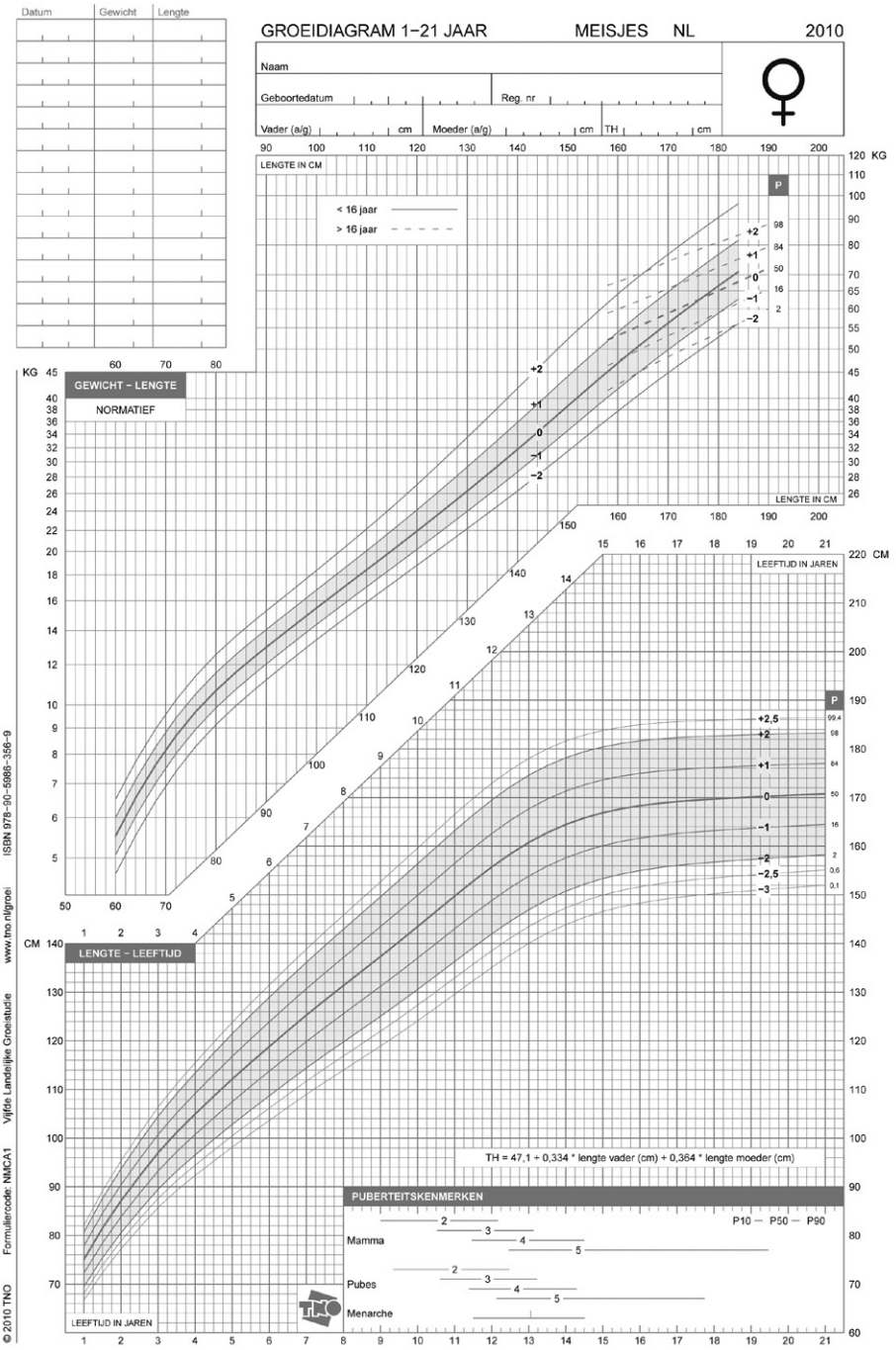


Figure 1A. *New Dutch growth diagrams, including height by age references for boys aged 1-21y.*



Figuur 1B. *New Dutch growth diagrams, including height by age references for girls aged 1-21y.*

Figure 2 shows the trend in the mean final height in boys and girls from 1955 to 2009. The figure illustrates that the upward secular trend in the mean final height of young Dutch adults has stopped. Mean final height was 183.8 cm (SD=7.1 cm) in Dutch boys and 170.7 cm (SD=6.3 cm) in Dutch girls. These heights do not differ significantly from the heights in 1997 (184.0 cm for boys and 170.6 cm for girls). Figure 2 indicates that the pace of the increase in secular height over the years slowed down both in boys and girls, falling to almost zero in 2009.

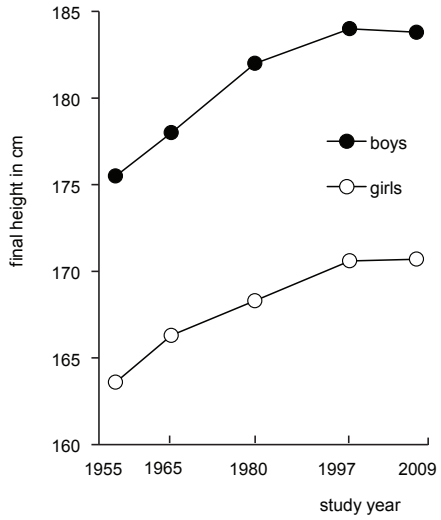


Figure 2. *Mean final height in Dutch boys (filled circles) and girls (open circles) in 1955-2009.*

Figure 3 shows, for Dutch children aged 1-21y, the height difference with respect to 1955 in 1965, 1980, 1997, and 2009 for each age. The figure clearly shows an increase in height for the period 1955-1997, especially from the age of 4y onward, with the increase being more marked in boys than in girls. This figure also shows that the secular trend has stopped since 1997, not only for final height but also for all ages, with the 1997 and 2009 lines being a close match for all ages. There is only a small difference in height at the ages of 11-13y in boys and girls and at the age of 15y in boys. These differences are more pronounced in boys (0.7-1.2 cm) than in girls (0.4-0.5 cm). This may indicate slightly earlier puberty.

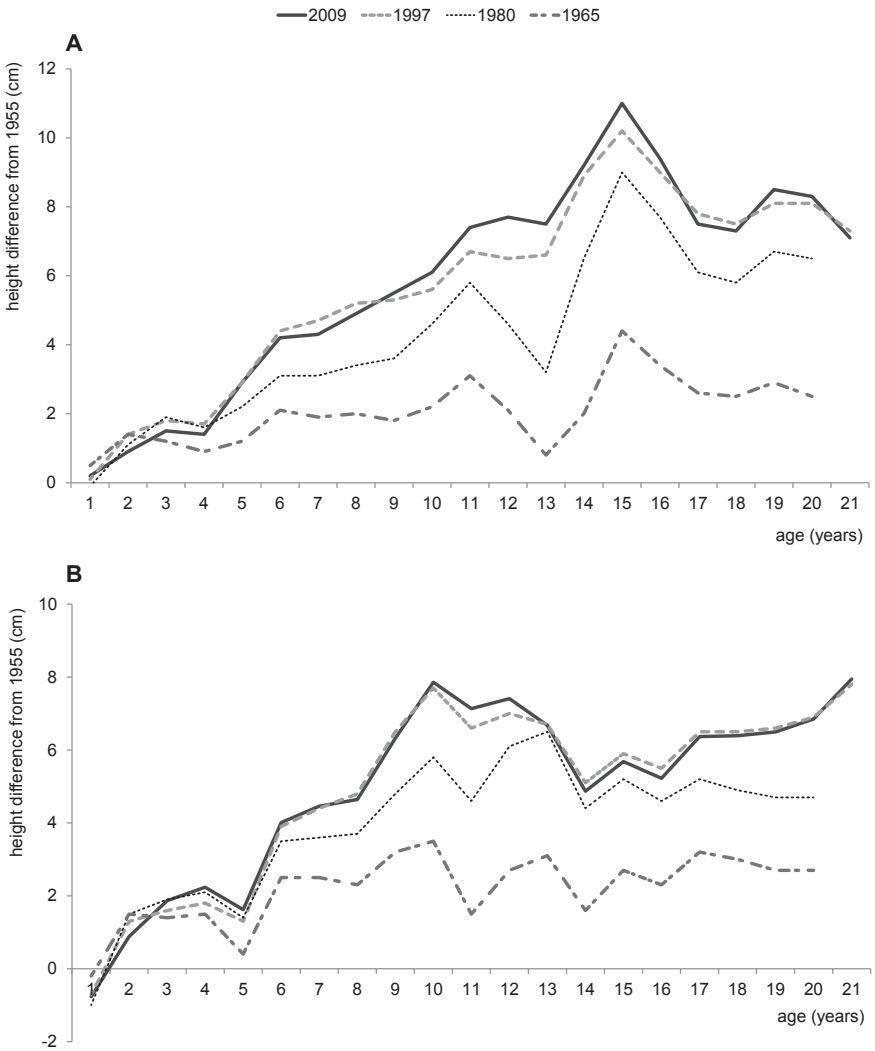


Figure 3. *Height increase since 1955 by age in (A) Dutch boys and (B) girls in 2009 (solid line), 1997 (striped line), 1980 (dotted line), and 1965 (gray striped lines).*

Figure 4 presents the mean height SDS of Dutch children aged 0-21y by geographical region, level of child education, and level of parental education in 1997 and 2009, corrected for each of the two other factors. Variation across the geographical regions has lessened since 1997. The mean height SDSs in the north and in the south are closer to the overall mean (Figure 4a). The mean height SDS in the north of the country is still significantly higher than that in the south (difference=0.22 SDS; p<0.001) and the major cities (0.12 SDS; p=0.018). This means that 21 year old boys and girls from the north are on average 1.6 and 1.4 cm taller, respectively, than those from the south.

Figure 4b,c shows that, in 2009, as in 1997, mean height SDS increased in line with the educational levels of children and their parents. Since 1997, mean height SDS has not changed significantly. Nevertheless, the mean height SDS of children with lower levels of education was significantly lower than that of those with higher levels of education in 2009 (p=0.003), whereas this difference was non-significant in 1997 (p=0.438), indicating that 21y olds with lower levels of education are on average 1.4 cm (boys) and 1.2 cm (girls) shorter than those with higher levels of education. At the age of 21y, boys of lower-educated parents are on average 0.8 cm shorter than those of higher-educated parents. For girls, this difference is 0.7 cm.

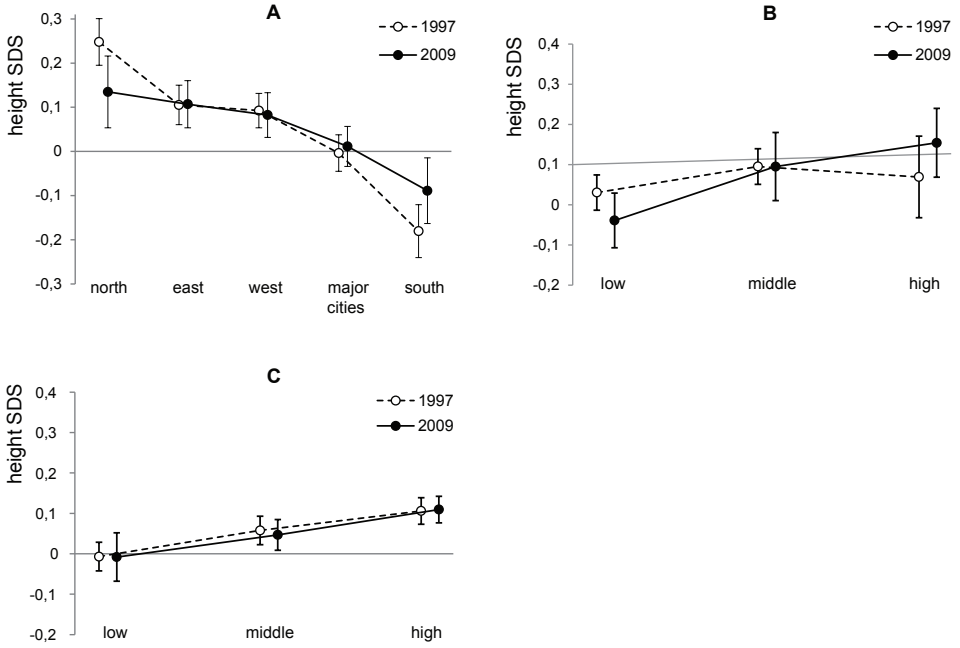


Figure 4. *Differences in height SDS by (A) geographical region, (B) educational level of the child, and (C) highest completed education of parents between 1997 (open circles) and 2009 (filled circles). Values are means, adjusted for the effects of the other factors. SDS, standard deviation scores.*

DISCUSSION

This study shows that the height of Dutch children in 2009 is very similar to that in 1997. There was a slight increase in mean height in early puberty in boys and girls, indicating that they were taller at a younger age than in 1997. However, this did not affect the final height, as no significant differences in final height were seen as compared with 1997. There was no compression of height variation observed.

It is remarkable that the secular height trend spanning 150 years has come to an end, at least temporarily. The cause is not yet clear. Economic factors are not likely to be involved because gross domestic product in The Netherlands did not level off; indeed, it rose exponentially between 1920 and 2008[8]. We also looked at the course of the Life Situation Index (LSI) between 1974 and 2008. This index was established by The Netherlands Institute for Social Research to measure the progress of Dutch society using indicators that go beyond mere economic growth. The index incorporates indicators in eight domains: health, sport, social participation (loneliness, volunteering), cultural/leisure activities, housing, mobility, holidays, and possession of assets[9,10]. The LSI rose substantially between 1974 and 2008. Between 1990 and 2008, the differences in LSI scores between socioeconomic classes decreased.

This was mainly due to a higher rise in the LSI score for lower socioeconomic groups[9]. A correlation between height and LSI has not been demonstrated, but one would expect a positive correlation, as with economic growth. The rise in LSI mentioned here and the reduction in the variation in LSI scores across socioeconomic groups do not therefore explain the break in the Dutch height trend. Children of parents born outside The Netherlands were excluded from the analyses. The so-called third-generation immigrants, those with parents born in The Netherlands but grandparents born outside The Netherlands, were not excluded. This group makes up an increasing proportion of the population in The Netherlands but is still relatively small. On the basis of data on the country of birth of the grandparents, only 4-5% of our study population were from the third generation. Although the third-generation immigrants may be partly accountable for the flattening of the Dutch growth trend, this group is too small to fully explain the stagnation in height. Moreover, children known to have a diagnosed growth disorder or who were on growth-interfering medication were excluded from the sample. It is possible that some growth disorders and growth-interfering medication were not mentioned by a child or parent, or were not in the medical records and therefore were missed by the healthcare provider. This could lead to an underestimation of mean height per age. However, we believe that even if we missed some children, they would form only a very small part of the sample size per age. Moreover, the same method for inquiring about and exclusion of growth disorders and medication was applied in 1997. Therefore, it is unlikely that growth disorders and growth-interfering medication

influenced the height difference between 1997 and 2009. There will always be some differences in, for example, the genetic background and socioeconomic status in a given population, leading to height variations. Given that the Dutch are the tallest people in the world, and that they are no longer growing taller, we could hypothesize that the mean height of the population has reached the maximum possible. It could be that the distribution of population characteristics in The Netherlands, including environmental factors, is the 'best' achievable at the country level, leading to a mean population height of 184 cm for boys and 171 cm for girls.

Alternatively, growth-promoting environmental factors may have stabilized in the past decade, preventing the Dutch from fulfilling their full growth potential. We could hypothesize that current lifestyles have a negative effect on height. Komlos[11], who looked at differences in height and BMI between Dutch and US children, also suggested this. Where insufficient food intake may have led to stunting decades ago, easy access to food/fast food nowadays leads to unhealthy eating habits. For example, the high consumption of milk in The Netherlands, which has been linked to tallness[12], declined over the past decade from 63 liter per capita per year in 2000 to 60 in 2010[13]. Unhealthy eating habits may lead to inadequate nutrient intake, which may result in lower height. Furthermore, an unhealthy diet in combination with less energy expenditure due to a sedentary lifestyle leads to an increase in overweight and obesity, a phenomenon that has also been observed in Dutch children[14]. Higher BMI is associated with earlier onset of maturation and menarche, which, in turn, are related to lower height[15,16]. If our hypothesis is valid, adopting healthier lifestyles (including healthier diet and more activity) could result in the reemergence of the positive height trend in the future.

No pubertal height growth spurt can be observed in the growth diagram for girls. This is due to the fact that Dutch growth studies are cross-sectional studies. These growth diagrams are suitable for monitoring child height over time, but one should bear in mind that these charts do not fully represent how an individual child typically grows. Only children with both parents born in The Netherlands

were included. The selection of children of Dutch decent may complicate comparisons of height/final height between countries because some countries include all ethnic groups in their data. On the basis of data for other ethnic groups in the dataset of the Fifth Dutch Growth Study, we estimated an adjusted final height that includes other ethnic groups. The adjusted mean final height would be 183.8 - 0.4 = 183.4 cm in boys and 170.7 - 0.3 = 170.4 cm in girls. These numbers are an estimate of final height for all children living in The Netherlands, irrespective of ethnicity. As the differences between the Dutch and the non-Dutch groups are substantial, separate growth references were constructed for children of Moroccan and Turkish decent, the two largest minorities in The Netherlands. These will be presented elsewhere. We found that the height difference between the north and the south of The Netherlands has diminished since

1997. This was seen irrespective of child and parental educational levels. This change could be explained by factors such as fewer health inequalities or changes in national motility, in other words more migration between geographical regions. However, we found no evidence indicating a reduction of health inequalities between these regions, and there have been no major shifts in motility in The Netherlands since 1997 that could explain the phenomenon[17]. Random sampling variation between the 1997 and 2009 study may have contributed to the smaller north-south difference. However, both studies were nationally representative. The study population of the Fifth Dutch Growth Study was large and randomly selected, and advanced imputation techniques were carried out for underrepresented groups to obtain a representative sample. Although we do not have a firm explanation for the reduction in height inequality between the north and the south of The Netherlands, the 1.6 cm (boys) and 1.4 cm (girls) difference in 21 year olds seem very plausible because they are similar to the 2 cm north-south difference found in a large Dutch study based on self-reported growth data[18]. It is remarkable that the difference in mean height SDS for children with lower and higher education levels has increased since 1997. This suggests that the inequality associated with education has increased. We found no explanation for this in the literature of national registries. It should be noted that there have been no significant changes in the mean height SDS in any of the categories since 1997. Monitoring this trend is important because larger height differences can be a sign of increasing health inequalities. The upward secular height trend has slowed in most Northern European countries[2,6]. Conscript data show that height in Danish and Norwegian men remained stable between 2000 and 2009, and an earlier study based on self-reported data from Dutch adults also indicated that the secular increase in height had come to a halt (18-20). Despite the stagnating secular trend, the Dutch are still the tallest people in the world, followed directly by the Danish, who are reported to have a mean height of 183.7 cm (men) and 168.6 cm (women), and the Norwegians, with averages of 182 cm (men) and 169 cm (women)[21,22]. Pineau et al.[23] found boys in the Dinaric Alps to be 1.5 cm taller than their Dutch counterparts, whereas girls reach heights similar to their Dutch counterparts. Although this study looks at a region rather than a country, and corrects boys' height for growth after the age of 17y, it indicates that young adults from this region in Eastern Europe are also tall. In fact, men in the Balkans were already among the tallest in Europe in the 19th century[11]. Future studies of population height are expected to reveal whether the maximum mean population height is indeed 184 cm for boys and 171 for girls. The new Dutch reference charts are available at http://www.tno.nl/growth.

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Chapter 3

Trend in height of Turkish and Moroccan children living in The Netherlands

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ABSTRACT

Objectives: To study trends in height of Turkish and Moroccan immigrant children living in The Netherlands, to investigate the association between height and background characteristics in these children, and to calculate height-for-age-references data for these groups. **Design:** Nationwide cross-sectional data collection from children aged 0 to 18 years by trained professionals in 1997 and 2009. The study population consisted of 2,822 Turkish 2,779 Moroccan, and 13,705 Dutch origin children in 1997and 2,548 Turkish, 2,594 Moroccan, and 11,255 Dutch origin children in 2009. **Main outcome measures:** Mean height in cm, and mean height standard deviation scores. **Results:** In 2009, mean height at the age of 18y was similar for Turkish and Moroccan children: 177 cm for boys and 163 cm for girls, which was 2 to 3 cm taller than in 1997. Still, Turkish and Moroccan adolescents were 5.5 cm (boys) to 7 cm (girls) shorter than their Dutch peers. No significant differences were found in mean height standard deviation scores across the educational level of the parents, geographical region, primary language spoken at home, and immigrant generation. **Conclusions:** While the secular height increase in Dutch children came to a halt, the trend in Turkish and Moroccan children living in The Netherlands continued. However, large differences in height between Turkish and Moroccan children and Dutch children remain. We found no association with the background characteristics. We recommend the use of the new growth charts for children of Turkish and Moroccan origin who have a height-for-age below -2SD on the growth chart for Dutch children.

AUTHOR CONTRIBUTIONS

Conceived and designed the study: YS PvD RAH SvB. Performed the study: YS. Analyzed the data: YS. Contributed materials/analysis tools: YS PvD SvB. Wrote the paper: YS PvD RAH SvB.

INTRODUCTION

Secular trends of height have been extensively documented in many populations. However, data on the development of height of immigrant populations over time are scarce. Large differences in height exist between countries and ethnic background[1-4]. Children of immigrants typically differ in height from autochthonous children, as well as from their peers living in their parent's country of origin[2-5].

The nationwide study in 1997 revealed substantial differences in height between children of Dutch origin and those of Turkish and Moroccan origin living in The Netherlands[3,4]. At the age of 18 years, children of Turkish and Moroccan origin were 9 to 10 cm shorter than their Dutch peers. For this reason, origin-specific growth charts for these groups have been made available. These charts can be used to evaluate height of children of Turkish or Moroccan origin who are considered short on the regular Dutch growth references, which are based on children of Dutch origin. Since 1997, the height of children of Dutch origin has not increased any further[6]. It is not yet known if this is also the case in children of Turkish and Moroccan origin. If height of these children converges towards the Dutch growth patterns, the question arises whether origin-specific charts are still needed.

Given the importance of environmental factors on human growth[7,8], the height of immigrants is expected to converge to the height of the hosting population. Very little is known about the speed of this process, and which factors influence it. The speed of the process is likely to depend in the amount of social acculturation. We would, therefore, expect to see smaller height differences with the autochthonous population in immigrant families with a faster adaptation to the country in which they live.

In this paper, we describe the trend in height since 1997 of children of Turkish and Moroccan origin living in The Netherlands. We compare their height with the height of Dutch children, and with height of children living in Turkey and Morocco. Furthermore, we investigate the association between height and the educational level of the parents, geographical region, primary language spoken at home, and immigrant generation. We present new height-for-age reference data for 0 to 18 year olds of Turkish and Moroccan origin.

METHODS

Ethics statement

Data collection of growth studies is part of routine youth health care in The Netherlands, and is not regarded as medical research[9]. In the Dutch nationwide surveys, written informed consent was not needed. Verbal consent was obtained from each child (and/or parent for children younger than 16 years). Cooperation, or lack thereof, was

registered on the questionnaire. The data were analyzed anonymously. The Medical Ethical Review Board of Leiden University Medical Center approved of the study and the way consent was obtained.

Study population

Cross-sectional growth data of Dutch, Turkish and Moroccan children aged 0 to18 years and living in The Netherlands were collected within the Fourth Dutch Growth Study from 1997 and the Fifth Dutch Growth Study from 2009. Origin was defined according to the country of birth of the parents[10]: Dutch if both parents were born in The Netherlands; Turkish if the mother was born in Turkey, or if the mother was born in The Netherlands and the father in Turkey; Moroccan if the mother was born in Morocco, or if the mother was born in The Netherlands and the father in Morocco. Data were obtained at Well Baby Clinics, Municipal Health Services (MHS), schools and a festival. To obtain sufficient data of Turkish and Moroccan children, oversampling was done in the four major cities Amsterdam, Rotterdam, The Hague and Utrecht, where most Turkish and Moroccan children in The Netherlands live. In 2009, the MHS in Amsterdam and The Hague supplemented the sample with existing growth data of Turkish and Moroccan children (n=910, and n=1,529). The methodology of the growth studies was similar, with the objective to allow comparison over time. For more detail, see the original publications[3,4,11-13].

Exclusion criteria

The exclusion criteria for both studies were similar. Children with diagnosed growth disorders and those on medication known to interfere with growth were excluded. Children with an origin other than Dutch, Turkish or Moroccan were excluded.

Measurements

The measurements were standardised and were performed by trained health care professionals. Infants' length was measured to the nearest 0.1 cm in the supine position until two years of age. From around two years of age, standing height was measured to the nearest 0.1 cm. Demographic characteristics of the children were obtained from the children or their parents by health care professionals by means of a questionnaire.

Variable definitions

The sample was divided into two geographical regions: major cities (Amsterdam, Rotterdam, Utrecht, and The Hague) and non-major cities (all other regions). Educational level of the parents was defined as the educational level achieved by the highest educated parent, and categorized into low, middle, and high[14] (not available for the supplemented sample of Turkish and Moroccan children from The Hague in 2009).

Primary language spoken at home was classified as Dutch or non-Dutch, and immigrant generation as 1st/2nd generation or 3rd generation. Third generation Turkish and Moroccan children were Dutch children (both parents born in The Netherlands) with at least one grandparent born in Turkey or Morocco, respectively. Data on language and generation were only available for 2009 and not for the supplemented samples of Turkish and Moroccan children from The Hague and Amsterdam.

Statistical analyses

Data were cleaned using descriptive statistics including frequency tables, contingency tables and scatter plots. Standard deviation scores (SDS)[15] per age were calculated using the 1997 origin-specific height references[3,4,11]. Outliers, defined as values over +5 SDS or below -5 SDS were checked for data entry errors and corrected. If no correction was possible, these measurements were considered erroneous and defined as missing. The difference between length and height in Dutch children in 1997 was 0.4cm[11]. In daily practice, the transition from length to height measurement depends on the age at which a child can properly stand up straight. This makes a smooth joint' at the age of two years the preferred way to handle the difference between length and height. No adjustments of the data were necessary to obtain a good fit of the data.

Three separate sets of reference values were used to define SDS. SDS based on the 1997 origin-specific height references were only used for data cleaning. To compare height SDS across origin and cross generations in 2009, SDS were calculated using the 2009 Dutch height references[6]. For all other comparisons, the origin-specific height references presented in this paper were used for SDS calculation.

Reference values for height-for-age in 2009 were calculated using the LMS method[16]. The LMS method summarizes the SDS lines by three smooth curves representing skewness (L curve), the median (M curve), and coefficient of variation (S curve). L values of 1 indicate normality and smaller values represent progressively greater skewness. The M curve is the 0 SDS line or 50th centile curve. The S curve defines the coefficient of variation. The choice of the smoothing parameters (effective degrees of freedom, edf's) for the L, M, and S curves was made by creating worm plots: local detrended QQ plots of the SDS of the reference sample across 16 age groups[17]. The curves were fitted as cubic splines. Finally, the age-related reference values were estimated. In case of a normal distribution, so if L=1, the reference values can be summarized by the mean and standard deviation (SD) per age.

Unadjusted (differences in) mean height and mean height SDS are presented. Linear regression was used to test the association of height SDS in 2009 with geographical region, educational level of the parents, primary language spoken at home and generation for Turkish and Moroccan children, corrected for sex, age, and age squared. P-values <0.05 (two-sided) were considered statistically significant. R version 2.9.0

with GAMLSS-package was used for the imputation and for estimating the height SDS reference values[18]. All other statistical analyses were performed in IBM SPSS Statistics version 20.0 for Windows.

RESULTS

Table 1 presents baseline characteristics for the 1997 and 2009 populations. The Dutch samples were representative for the Dutch population in terms of geographical region and educational level of the child[11,12]. The Turkish and Moroccan samples were oversampled in the major cities, with 100% living in the major cities in the 1997 sample, and 87% in the 2009 sample.

Table 1: *Background characteristics of the study populations in 1997 and 2009.*

		Turkish				Moroccan				Dutch			
		1997 (n=2,822)		2009 (n=2,548)		1997 (n=2,779)		2009 (n=2,594)		1997 (n=13,705)		2009* (n=11,255)	
		n	%	n	%	n	%	n	%	n	%	n	%
Sex	boys	1,459	51.7	1,296	50.9	1,412	50.8	1,270	49.0	7,044	51.4	5,434	48.3
	girls	1,363	48.3	1,252	49.1	1,367	49.2	1,324	51.0	6,661	48.6	5,821	51.7
Age	0-4 years	938	33.2	935	36.7	915	32.9	915	35.3	5,737	41.9	4,703	41.8
	5-11 years	890	31.5	1,112	43.6	875	31.5	1,222	47.1	3,001	21.9	3,409	30.3
	12-18 years	994	35.2	501	19.7	989	35.6	457	17.6	4,967	36.2	3,143	27.9
Parental education	low	2,045	72.5	551	21.6	2,110	75.9	513	20.1	4,042	29.5	1,638	14.5
	medium	244	8.6	351	13.8	71	2.6	318	12.3	4,562	33.3	3,829	34.0
	high	53	1.9	174	6.8	33	1.2	175	6.7	4,485	32.7	4,841	43.0
	unknown	480	17.0	1,472	57.8	565	20.3	1,578	60.8	616	4.5	947	8.4
Region	major city	2,815	99.8	2,154	84.5	2,764	99.5	2,301	88.7	1,398	10.2	2,112	18.8
	outside city	5	0.2	394	15.5	13	0.5	293	11.3	12,265	89.5	9,146	81.2
	unknown	2	0.1	-	-	2	0.1	-	-	42	0.3	-	-
Language	Dutch	-	-	313	12.3	-	-	612	23.6	-	-	8,907	79.1
	other	-	-	947	37.2	-	-	679	26.2	-	-	71	0.6
	unknown	-	-	1,288	50.5	-	-	1,303	50.2	-	-	2,277	20.2
Third generation**		-	-	50	-	-	-	-	44	-	-	-	-

* Including 1,801 imputed cases

** These children are included in the Dutch sample and only categorized as Turkish or Moroccan for the analyses regarding immigrant generation. Therefore no proportion was calculated.

Height of Turkish and Moroccan children in The Netherlands in 2009

Table 2 shows the new reference values for height-for-age (mean height and SD per age) of Turkish and Moroccan boys and girls living in The Netherlands in 2009. Height-for-age was normally distributed. Final height in girls was reached at the age of 16 (Moroccan) and 17 (Turkish) years. Height at the age of 18y was similar for Turkish and Moroccan adolescents: around 177 cm for boys and almost 163 cm for girls. SD estimates were higher in adolescents of Moroccan origin.

No significant differences were found in mean height SDS of Turkish or Moroccan children living in the major cities versus those living outside of these cities. In Turkish children, mean height SDS was slightly higher among those of higher educated parents, but this was not statistically significant. No such trend was seen in Moroccan children. Mean height SDS of Turkish and Moroccan children who speak Dutch at home did not differ from that of children from non-Dutch speaking families. Of the small group of third generation children (n=50 for Turkish, n=44 for Moroccan origin), 74% was under the age of two years, and 87% was under four years of age. We, therefore, compared height across generations in children under four years of age. Mean height of Turkish and Moroccan third generation children was respectively 0.02 SDS lower and 0.14 SDS higher compared to children from the first and second generation, but this was not statistically significant.

Height of Turkish and Moroccan children in 1997 and 2009

Figure 1 compares the height difference between 2009 and 1997 in cm per age of Turkish and Moroccan boys (A) and girls (B). From the age of one year (Turkish) and two years (Moroccan) onward, the boys were taller than in 1997, reaching a difference of 3.2 to 3.5 cm at the age of 18 years. In girls, we saw an increase in height compared to 1997 from the age of two years (Moroccan) and four years (Turkish) onwards. At the age of 18 years, girls were 1.9 (Moroccan) to 2.7 (Turkish) cm taller than in 1997. These data correspond to a positive trend in final height of 2.8 cm/decade for Turkish and Moroccan boys and 1.9 cm/decade for Turkish and Moroccan girls.

Table 2: *Reference values for height-for age: mean height and standard deviation (SD) of Turkish and Moroccan boys and girls in The Netherlands in 2009.*

	Turkish				Moroccan			
	Boys		Girls		Boys		Girls	
	(n=1,296)		(n=1,252)		(n=1,270)		(n=1,324)	
age (years)	mean (cm)	SD (cm)	mean (cm)	SD (cm)	mean (cm)	SD (cm)	mean (cm)	SD (cm)
0.0767*	54.9	2.0	53.5	2.3	54.4	2.0	52.9	2.0
0.25	60.8	2.2	59.2	2.3	60.2	2.2	58.9	2.1
0.50	68.0	2.4	66.1	2.4	67.1	2.4	65.8	2.3
0.75	73.2	2.5	71.3	2.5	72.1	2.6	71.1	2.5
1.00	77.3	2.7	75.6	2.5	76.1	2.8	75.0	2.6
1.25	80.7	2.8	79.3	2.6	79.5	3.0	78.1	2.8
1.50	83.6	3.0	82.6	2.7	82.4	3.1	80.9	2.9
1.75	86.2	3.1	85.3	2.9	85.1	3.2	83.7	3.0
2.00	88.6	3.1	87.8	3.0	87.7	3.3	86.5	3.1
3.00	97.4	3.5	96.3	3.4	96.8	3.7	96.0	3.6
4.00	105.6	3.9	104.0	3.9	104.5	4.0	103.5	3.9
5.00	112.6	4.4	110.9	4.3	111.4	4.4	110.2	4.2
6.00	118.3	4.8	117.0	4.6	117.7	4.8	116.8	4.5
7.00	123.6	5.2	122.8	5.0	123.9	5.2	123.0	4.9
8.00	129.5	5.8	128.1	5.4	129.4	5.7	128.5	5.4
9.00	135.3	6.3	133.9	5.8	134.5	6.1	134.1	6.1
10.00	140.6	6.8	140.5	6.2	140.1	6.6	140.2	6.9
11.00	145.9	7.2	147.5	6.4	145.4	7.2	147.0	7.3
12.00	151.9	7.6	153.2	6.4	150.5	7.7	152.9	7.3
13.00	158.2	7.8	156.9	6.3	156.3	8.1	157.4	7.0
14.00	164.0	7.7	159.4	6.2	163.3	8.3	160.5	6.7
15.00	168.7	7.5	160.9	6.1	169.9	8.1	162.4	6.5
16.00	172.7	7.2	161.9	6.0	174.0	7.9	162.8	6.5
17.00	175.4	6.9	162.6	6.0	176.1	7.8	162.8	6.5
18.00	176.8	6.8	162.6	6.0	177.2	7.7	162.8	6.5

*0.0767=4 weeks

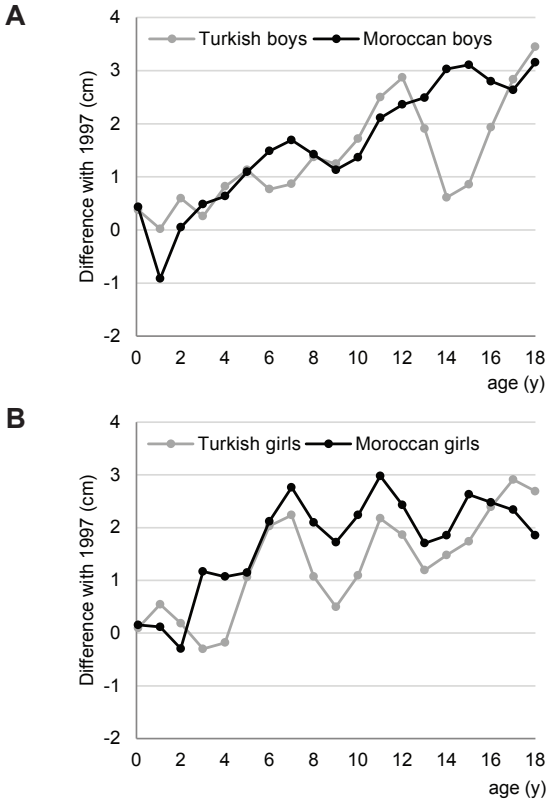

Figure 1. *Height difference with 1997 (horizontal line at 0 cm) of Turkish and Moroccan boys (A) and girls (B) aged 0-18y in 2009.*

Height of Turkish and Moroccan children versus Dutch children in 2009

Figure 2 shows the height difference in cm between Dutch children (horizontal line at 0 cm) and Turkish and Moroccan children in 2009. Overall, we saw lower growth rates in Turkish and Moroccan children compared to Dutch children from the age of one year onwards. Moroccan boys were shorter from birth onwards, and Turkish boys from the age of four years onwards. Similarly, Moroccan girls were shorter than their Dutch peers from birth, while Turkish girls began to diverge from the Dutch from two years of age. At the age of 18 years, the height differences reached around -5.5 cm in boys and -7.0 cm in girls. The bumps' between the age of 9 and 11 years in the downward line reflect the faster progression through puberty in Turkish and Moroccan children compared to the Dutch[4,19,20].

Third generation Turkish and Moroccan children were respectively 0.02 and 0.13 SDS shorter than the Dutch children under four years of age, which was not significantly different, and based on small numbers.

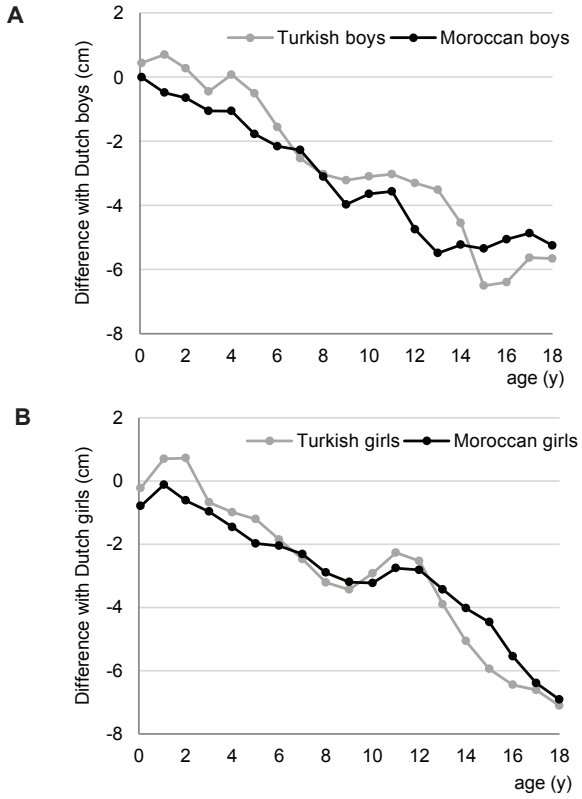

Figure 2. *Height difference with Dutch children (horizontal line at 0 cm) of Turkish and Moroccan boys (A) and girls (B) aged 0-18y in 2009.*

At all levels of parental education, mean height SDS of Dutch children was higher than of Turkish and Moroccan children. The difference between Turkish and Dutch children was largest among those with low educated parents (low: -0.25 SDS, middle: -0.18 SDS, high: -0.12 SDS, $p<0.001$ for all comparisons). This trend was not seen in Moroccan children (low: -0.34 SDS, middle: -0.40 SDS, high: -0.34 SDS, $p<0.001$ for all comparisons).

Comparison with data from WHO and Turkey and Morocco

Figure 3 compares mean height-for-age of Dutch, Dutch Turks, Turkish Turks and WHO children[3,6,21,22]. Clear differences exist between Dutch and Turkish children living in The Netherlands in 2009. We also see the trend in height of Turkish children in The Netherlands between 1997 and 2009. The data from Turkey represent height-for-age from 2004-2006 of Turkish children from mixed socioeconomic background living in Ankara[22]. Compared to the Dutch Turks in 2009, the Turkish boys in Turkey were taller at most ages, while the Turkish girls in Turkey were shorter that their Turkish peers

in The Netherlands. The final height of Turkish boys in Turkey was similar to that of Turkish boys in The Netherlands in 2009, while the girls in Turkey grew more like the Turkish girls in The Netherlands in 1997. Height of children aged 0-4 years did not show large differences with available data from Turkey, representing children with a high socioeconomic background (data not shown)[3,23]. The final height of the WHO children was similar to the 2009 height of Dutch Turks (and Dutch Moroccans), but before the age of 13/14 years WHO children were considerably shorter.

For Morocco, no recent national growth references were available. One paper from 1995 presented national references, but they were presented as hard to read charts and the exact data were not available on request[24]. From the chart we read a final height of around 174 cm for boys and 161 cm for girls, which is in between the final height in 1997 and 2009 of Moroccan children in The Netherlands.

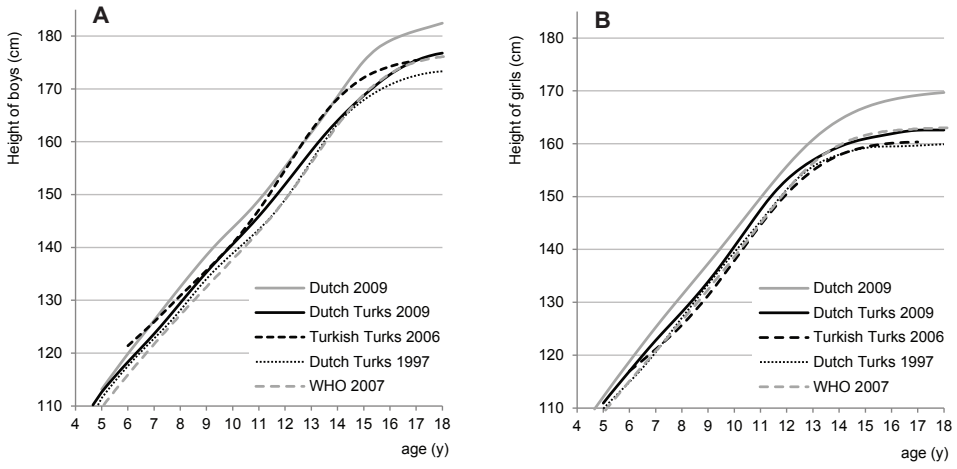

Figure 3. *Different height-for-age references for boys (A) and girls (B): Dutch 2009[6], Dutch Turks 2009, Turkish Turks in Ankara 2006[22], Dutch Turks 1997[3], and WHO 2007[21].*

DISCUSSION

This study shows a positive trend in height since 1997 in both Turkish and Moroccan children living in The Netherlands. Final height increased in both groups at a rate of 2.8 cm per decade in boys and 1.9 cm per decade for girls. This is remarkable since the secular height increase in Dutch children vanished between 1997 and 2009. The net result is a smaller height difference between Dutch children and Turkish and Moroccan children living in The Netherlands. Still, 18-year old Turkish and Moroccan children are 5.5 cm (boys) to 7 cm (girls) shorter than Dutch children. If the current trends remain, it will take twenty to forty years before the Turkish and Moroccan children catch -up with the height of the Dutch.

Previous studies found that the differences in height between immigrants and indigenous populations could be explained by socioeconomic status rather than by place of birth[25]. In addition, the level of acculturation was found to be associated with the prevalence of overweight, and could possibly also affect height[26-28]. In our study, geographical region, educational level of the parents, primary language spoken at home, and immigrant generation did not explain the difference in height. The height of third generation immigrant children of Moroccan origin lay in between that of the Dutch and second generation Moroccan immigrant children. This could indicate that socioeconomic status and/or acculturation have a positive effect on height, as we know from Dutch registries that immigrants from the second generation are higher educated than those from the first generation[29]. It could also indicate that there are biological effects on growth that may take several generations to overcome, such as low height-for-age of the mother. However, such trend' across generations was not found in children of Turkish origin, and the differences were not statistically significant. The number of third generation children was too small to draw conclusions. We have to wait for future growth studies to reveal growth differences across generations in more detail, and to determine if growth of the third generation immigrant children converges more towards the height of the Dutch children.

A limitation of our study is that we only had few parameters available, and that the number of missing values was relatively high. Although this was mainly due to the use of supplemented data, rather than parents not wanting to provide the data, we cannot rule out that the missing data biased our results. It would be interesting to include additional parameters to measure acculturation in future (growth) studies, like employment, income, length of stay in The Netherlands, dietary habits, interaction with Dutch society, and values and attitudes towards cultural origin and beliefs.

Turkish and Moroccan immigrants arrived in The Netherlands during the 1970's and 1980's for work. The group consisted mainly of lowly educated farmers from rural areas in Turkey and Morocco. Children living in rural areas in Turkey are shorter than children

living in Turkey's larger cities, where the socioeconomic status is generally higher[22,30]. The Turkish children in The Netherlands are substantially taller than the children living in rural areas in Turkey nowada[30], so the height gain is large. This phenomenon was also seen in other countries[2,5] and is likely to be due to better nutrition, hygiene and health status. Height of Turkish children in The Netherlands from the age of 13 years onwards is now similar to that of children of higher socioeconomic background in Istanbul[31]. No proper comparison of height of Moroccan children living in The Netherlands versus Morocco could be made, as recent data from Morocco are lacking.

The observed differences in height between Turkish, Moroccan and Dutch children have implications for clinical practice. The present study documents a considerable increase in height compared to the Turkish and Moroccan population in 1997, which makes the origin-specific charts of 1997 outdated. At the same time, there still was a 5.5 cm to 7 cm difference in final height between the Dutch and Turkish or Moroccan children in 2009. Therefore, using only the Dutch growth charts for Turkish and Moroccan children would classify many children as having short stature, while in fact their height is normal when compared to their ethnic peers. As an alternative, we considered using the WHO references for non-Dutch children who do not grow according to the Dutch references. However, the WHO references lay below the origin-specific references until the age of 13/14 years. Consequently, using the WHO references could result in missing Turkish and Moroccan children that would be classified as short stature on the origin-specific references. We therefore decided to update the origin specific growth charts.

We recommend using the Dutch growth charts for all children in The Netherlands, and the origin-specific growth charts for Turkish and Moroccan children who have a height-for-age below -2SD on the Dutch growth charts. For children of other origins living in The Netherlands who are short relative to the Dutch references, we recommend using the WHO references as a fall back.

Future growth studies aiming at height of Turkish and Moroccan children are important to monitor the development of the trend in height of these children. The growth charts for Dutch, Turkish, and Moroccan children are available at http://tno.nl/growth.nl.

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Chapter 4

Increase in prevalence of overweight in Dutch children and adolescents: a comparison of nationwide growth studies in 1980, 1997 and 2009

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ABSTRACT

Objective: To assess the prevalence of overweight and obesity among Dutch children and adolescents, to examine the 30 years trend, and to create new body mass index reference charts. Design: Nationwide cross-sectional data collection by trained health care professionals. Participants: 10,129 children of Dutch origin aged 0-21 years. **Main Outcome Measures:** Overweight (including obesity) and obesity prevalences for Dutch children, defined by the cut-off values on body mass index references according to the International Obesity Task Force. **Results:** In 2009, 12.8% of the Dutch boys and 14.8% of the Dutch girls aged 2-21 years were overweight and 1.8% of the boys and 2.2% of the girls were classified as obese. This is a two to three fold higher prevalence in overweight and four to six fold increase in obesity since 1980. Since 1997, a substantial rise took place, especially in obesity, which increased 1.4 times in girls and doubled in boys. There was no increase in mean BMI SDS in the major cities since 1997. **Conclusions:** Overweight and obesity prevalences in 2009 were substantially higher than in 1980 and 1997. However, the overweight prevalence stabilized in the major cities. This might be an indication that the rising trend in overweight in The Netherlands is starting to turn.

AUTHOR CONTRIBUTIONS

Conceived and designed the study: YS HT PvD BB SEB RAH SvB. Performed the study: YS HT PvD SvB. Analyzed the data: YS PvD SvB. Contributed materials/analysis tools: BB SEB RAH. Wrote the paper: YS HT PvD BB SEB RAH SvB.

INTRODUCTION

Over the past three decades childhood overweight and obesity have reached epidemic proportions in most industrialized countries[1]. In some European countries, such as the Scandinavian countries and The Netherlands, the prevalence of childhood overweight and obesity are lower than in Mediterranean countries. Nonetheless, the proportion of overweight children has also been rising in those countries[2]. In The Netherlands overweight rates almost doubled between 1980 and 1997, from five to nine percent in boys and from seven to twelve percent in girls; obesity rates even tripled from 0.3 to 0.9% and from 0.5 to 1.6% in boys and girls respectively[3,4]. This increase in prevalence rates will have a substantial economic impact. The WHO estimates that, at present, adult overweight and obesity are responsible for about six percent of health care expenditure in the European Region[5].

Childhood overweight has both psychological and health consequences. In the short run, overweight leads to conditions including high blood pressure, diabetes mellitus type 2, high cholesterol, depressive symptoms and low self-esteem. In the long run, children with overweight or obesity are more likely to become obese as adults[6,7], which translates into increased risk for chronic diseases, including cardiovascular disease, hypertension, diabetes mellitus type 2 and even premature mortality[8,9]. In addition, obese adults who were overweight before the age of 8 years are found to be heavier in adulthood than those who became overweight in adolescence or adulthood[10]. A recent study found that body mass index (BMI) change between the ages of two to six years specifically, contributes to adult overweight[11]. Early prevention of childhood overweight is therefore of utmost importance. Up to date national prevalence rates of overweight and obesity are essential to monitor the development of overweight and obesity. The Netherlands holds a unique position in the world because regular nationwide growth studies have been conducted since 1955[12-15]. These studies all used similar methodologies for sampling and measuring children up to 20 years of age. The Dutch 1980 study was the largest of the six studies used to calculate the now widely adopted cut-off values for overweight and obesity for children[16].

This paper presents the first results from the Fifth Dutch Growth Study, conducted between 2008-2010, which extends the Dutch tradition in growth studies. This paper reports the current distribution of BMI in Dutch children in the form of BMI reference charts and age-related prevalences for overweight and obesity. We compare these to results obtained in earlier studies. In addition, we study the relationship between BMI and geographical region, educational level of the child and educational level of the parents. Last, we evaluate the trends since the Dutch Growth Study in 1980.

METHODS

Ethics statement

Data collection of growth studies is part of routine youth health care in The Netherlands[17], and is not regarded as medical research. Before measurement, oral consent was obtained from each child (and parent for children younger than 16 years). Cooperation, or lack thereof, was registered on the questionnaire. Data were analyzed anonymously. The Medical Ethical Review Board of Leiden University Medical Center approved of the study and the way consent was obtained.

Data sources

The Fifth Dutch Growth Study is a cross-sectional study in which data were collected on the growth of children aged 0-21 years in The Netherlands. The measurements took place between May 2008 and October 2009. The sample was stratified by region (regions of Municipal Health Services (MHS)), sex and age, according to national distributions[18]. Until 4 years of age, measurements were performed in regular periodical health examinations in 28 Well Baby Clinics at the ages of 1, 2, 3, 6, 9, 12, 15, 18, 21, 24, 30, 36 and 45 months. Between the ages of four to eight years, children were measured at 23 MHS offices during two regular preventive health assessments performed at the ages of approximately 5.5 and 7.5 years. From age nine years onward, children received a personal invitation from the MHS after being randomly drawn, stratified for age and sex, from the register of the Municipal Register Office. In addition, we collected measurements within randomly selected primary and secondary schools, in two high schools, two universities and at a youth festival. The collection was supplemented by data from two recent large, high quality studies performed by trained staff at primary schools in Amsterdam (GGD Amsterdam, Amsterdam) and vocational education in the east of The Netherlands (Deltion College Zwolle/OPOZ VU-Windesheim). From these datasets, random samples (n=270 and n=342 respectively) were added to the dataset for this study. The study was approved by the Medical Ethical Review Board of Leiden University Medical Center.

Exclusion criteria

Exclusion criteria for the Fifth Dutch Growth Study were similar to those for the previous Dutch Growth Studies: children with diagnosed growth disorders and those on medication known to interfere with growth were excluded. In accordance to the growth study in 1997, but in contrast to previous Dutch Growth Studies, infants with a birth weight below 2500 g were included. Children of non-Dutch parents[19] were excluded from the analyses presented in this paper. Results regarding children of Turkish and Moroccan origin will be published elsewhere.

Measurements

The measurements were standardized and were performed by trained health care professionals. Infants' length was measured to the nearest 0.1 cm in the supine position until two years of age. From two years of age, standing height was measured to the nearest 0.1 cm. Infants up to 15 months of age were weighed naked on calibrated baby scales. Older children were weighed wearing underwear only, on calibrated mechanical or electronic step scales. Weight was rounded to the nearest 0.01 kg for infants and to the nearest 0.1 kg for older children. A questionnaire, filled in by a health care professional, was used to collect demographic variables.

Variable definitions

The sample was clustered into four geographical regions: North (Friesland, Groningen, Drenthe), East (Overijssel, Gelderland, Flevoland), West (Noord-Holland, Zuid-Holland, Utrecht - not including the major cities) and South (Zeeland, Noord-Brabant, Limburg). A fifth region was formed by the four largest Dutch cities (Amsterdam, Rotterdam, Utrecht, and The Hague). The educational level of the child was determined at the time of measurement. If an adolescent of over 15 years of age had left the educational system, the highest completed education was recorded. The educational level of the parents was defined as the educational level of the highest educated parent and categorized into low, middle, and high level[20]. BMI was calculated as weight/height^2 and expressed as kg/m^2. Overweight and obesity prevalence rates were calculated for 2009, 1997 and 1980 using the International Obesity Task Force (IOTF) cut-off values[16]. All overweight figures in this paper include obesity. For data cleaning purposes and for comparison of BMI changes between 1997 and 2009, standard deviation scores (SDS) per age were calculated using the 1997 references[4,12,21,22].

Statistical analysis

Data were cleaned using descriptive statistics including frequency tables, contingency tables and scatter plots. Outliers, defined as values over or below 5 SDS were checked for data entry errors and corrected where possible. If no correction was possible, these measurements were considered erroneous and defined as missing. The distributions of educational level of the child and geographical region were compared to the national distributions[23] to check for representativeness. We used the Multivariate Imputation by Chained Equation (MICE) method[24] to correct for educational levels or geographical regions that were underrepresented. The imputation model was based on age, sex, height SDS, weight SDS, waist SDS, hip SDS, parental height, birth weight, ethnicity, socioeconomic status score[25], educational level of the child and parents, and geographical region. Passive imputation was performed on the interactions between age and region, age and all SDS, age squared, and age squared and all SDS.

The distribution of BMI in the population depends on age and tends to be positively skewed. Therefore, BMI reference values for 2009 were calculated using the LMS method[26]. This method summarizes the SDS lines by three smooth curves representing skewness (L curve), the median (M curve), and coefficient of variation (S curve). L values of 1 indicate normality and smaller values represent progressively greater skewness. The M curve is the 0 SDS line or 50th centile curve for BMI. The S curve defines the coefficient of variation, and multiplied by 100 it can be interpreted as a percentage. The choice of the smoothing parameters (effective degrees of freedom, edf's) for the L, M, and S curves was made by creating worm plots: local detrended Q-Q plots ('Q' stands for quantile) of the SDS of the reference sample across 16 age groups[27]. The curves were fitted as cubic splines. Finally, the age-related BMI reference values for 2009 were estimated.

The relative proportion of obesity among overweight children was calculated by dividing the proportion of obese children by the proportion of overweight (including obese) children. To determine if the trend in overweight differed between children living inside and outside the major cities, we compared prevalences in both regions between 1997 and 2009 for boys and girls separately and tested for significance by the Chi-square-tests. To determine if trends in BMI SDS between 1997 and 2009 varied between different geographical regions and between children of low, middle and higher educated parents, we calculated mean BMI SDS (using the 1997 references as described above) with 95% confidence intervals for children aged two years and older for each category of these variables for 1997 and 2009. R version 2.9.0 with GAMLSS-package[28] was used for the imputation and for estimating the BMI SDS reference values. All other statistical analyses were performed in SPSS version 17.0 for Windows.

Results

The sample provided 10,030 children of Dutch origin and 1,975 imputed cases, resulting in an analysis sample of 12,005 children (5,811 boys, 6,194 girls) aged 0-21 years. In total, data of 4,382 children aged 0-3 years and of 7,623 children aged 4-21 years were available. Data of 146 children aged 22-25 years were included in the dataset for fitting BMI reference charts, but they were excluded for further analyses.
Table 1 presents the LMS values for BMI by age and sex. It shows that, for example, for boys aged 5 years the median (M) BMI was 15.64 whilst for girls this was 15.62, and that the coefficient of variation (S) of BMI was about 8% in infancy and rose up to 13-14% in adolescence.

Table 1. *LMS values for BMI (kg/m^2) in Dutch 0-21 year olds in 2009 by age and sex.*

	Boys (n=5,885)			Girls (n=6,219)		
age (y)	L	M	S	L	M	S
0.0767*	1.0597	14.75	0.0858	0.2714	14.55	0.0839
0.2500	0.7708	16.26	0.0834	0.2900	15.73	0.0830
0.5000	0.4610	17.06	0.0809	0.2990	16.63	0.0821
0.7500	0.2431	17.22	0.0792	0.2968	16.88	0.0814
1.0000	0.0836	17.18	0.0783	0.3027	16.76	0.0808
1.2500	0.0462	17.05	0.0778	0.3309	16.55	0.0805
1.5000	0.1643	16.85	0.0776	0.3770	16.34	0.0806
1.7500	0.2797	16.65	0.0776	0.4351	16.17	0.0809
2.0000	0.3933	16.47	0.0776	0.5040	16.05	0.0813
3.0000	0.7878	15.90	0.0792	0.8663	15.89	0.0843
4.0000	1.1531	15.60	0.0826	1.2123	15.75	0.0893
5.0000	1.4839	15.64	0.0877	1.4526	15.62	0.0960
6.0000	1.7273	15.67	0.0942	1.6097	15.67	0.1043
7.0000	1.8811	15.88	0.1015	1.6905	15.90	0.1133
8.0000	1.9500	16.20	0.1089	1.6968	16.21	0.1221
9.0000	1.9418	16.52	0.1157	1.6492	16.61	0.1297
10.0000	1.8837	16.86	0.1216	1.5695	17.09	0.1357
11.0000	1.8026	17.27	0.1265	1.4788	17.62	0.1395
12.0000	1.7129	17.75	0.1303	1.4011	18.21	0.1408
13.0000	1.6228	18.31	0.1328	1.3516	18.83	0.1402
14.0000	1.5405	18.94	0.1343	1.3280	19.47	0.1383
15.0000	1.4692	19.59	0.1350	1.3249	20.06	0.1359
16.0000	1.4075	20.21	0.1349	1.3348	20.58	0.1333
17.0000	1.3522	20.78	0.1345	1.3518	21.01	0.1308
18.0000	1.2999	21.26	0.1338	1.3720	21.36	0.1286
19.0000	1.2490	21.68	0.1330	1.3935	21.63	0.1268
20.0000	1.2007	22.07	0.1321	1.4151	21.85	0.1253
21.0000	1.1559	22.44	0.1313	1.4361	22.05	0.1240

y = age in years
*0.0767 = 4 weeks
L = Box-Cox power transformation required to remove the skewness of the distribution
M= median
S = coefficient of variation

Figure 1 shows the BMI distribution that correspond to the fitted LMS values for both sexes, including the 0, ±1, ±2, and -3 SDS lines. For comparison, the charts include the international cut-off values for thinness grade II and III, overweight and obesity[16,29]. The distribution was highly skewed. From the age of three years on, the distance between the +1 and +2 SDS lines was 1.5 to 3 times as wide as between the -1 and -2 SDS lines at all ages. The +2, +1, ±2 and ±3 SDS lines corresponded well to the international cut-off values for respectively obesity, overweight, thinness grade II and III, although the IOTF

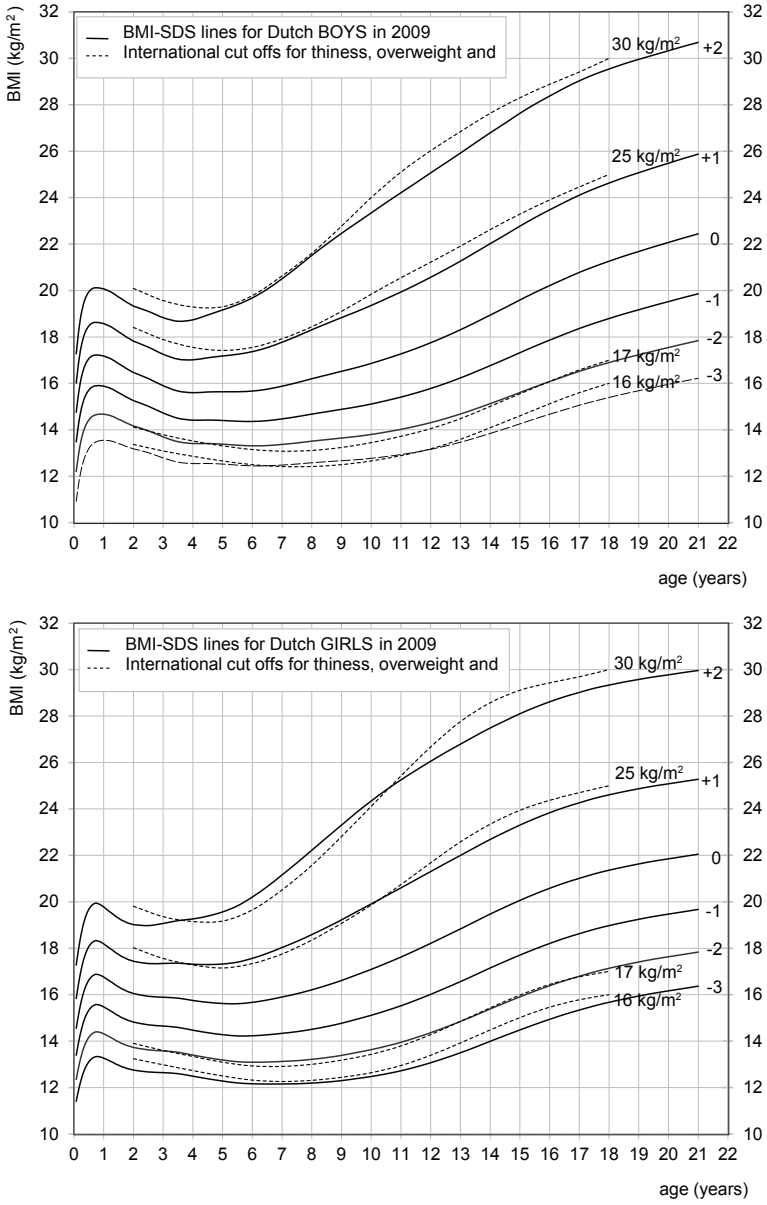

Figure 1. *BMI distribution for Dutch boys and girls in 2009. The solid lines represent -3 (0.1th percentile), -2 (2.3th), -1 (16th), 0 (50th), +1 (84th), +2 (97.7th) SDS. The dotted lines represent international cut-off values for obesity (30 kg/m²), overweight (25 kg/m²), thinness grade II (17 kg/m²) and thinness grade III (16 kg/m²)[16,29]. Effective degrees of freedom (edf) of the model of boys: 12 (M curve), 3 (S curve), 3 (L curve). Effective degrees of freedom (edf) of the model of girls: 9 (M curve), 4 (S curve), and 3 (L curve).*

cut-off values for obesity were a bit higher than the +2 SDS line for girls from the age of 11 years onward. In general, the median (0 SDS) curves for boys and girls were very similar, although BMI values for boys up to one year of age were slightly higher and during puberty slightly lower than for girls.

Table 2 presents the mean BMI for boys and girls at all ages in 1980, 1997 and 2009. The mean BMI rose in both boys and girls. Since 1997, mean BMI in boys increased with 0 to 3%, and compared with 1980, it was up to 5% higher. In girls, mean BMI rose 0 to 2.4% since 1997 and was up to 4.5% higher than in 1980. The rise in mean BMI was seen in boys aged four years and older and in girls from the age of three years onwards, with the largest relative increase occurring around the age of eight to ten years.

Table 2. *Median (P50) BMI in 1980, 1997 and 2009 by age and sex.*

	Boys			Girls		
year	**1980**	**1997**	**2009**	**1980**	**1997**	**2009**
age (y)						
2.0	16.6	16.4	16.5	16.2	16.1	16.1
3.0	15.9	15.9	15.9	15.7	15.7	15.9
4.0	15.5	15.6	15.6	15.4	15.5	15.8
5.0	15.3	15.5	15.6	15.2	15.4	15.6
6.0	15.2	15.5	15.7	15.1	15.5	15.7
7.0	15.3	15.6	15.9	15.3	15.7	15.9
8.0	15.5	15.8	16.2	15.5	16.0	16.2
9.0	15.7	16.1	16.5	15.9	16.3	16.6
10.0	16.1	16.4	16.9	16.4	16.7	17.1
11.0	16.6	16.8	17.3	16.9	17.2	17.6
12.0	17.1	17.3	17.8	17.5	17.8	18.2
13.0	17.7	17.9	18.3	18.1	18.5	18.8
14.0	18.3	18.5	18.9	18.7	19.2	19.5
15.0	18.8	19.2	19.6	19.3	19.8	20.1
16.0	19.4	19.9	20.2	19.8	20.3	20.6
17.0	20.0	20.4	20.8	20.3	20.8	21.0
18.0	20.5	20.9	21.3	20.7	21.2	21.4
19.0	21.0	21.4	21.7	21.1	21.5	21.6
20.0	21.5	21.8	22.1	21.6	21.8	21.9
21.0	NA	22.1	22.4	NA	22.1	22.1

y = age in years
NA = not available

Table 3 compares overweight and obesity prevalence rates in 2009 with 1980 and 1997 for Dutch boys and girls[3,4]. From this table we calculated an increase of 20-40% in overweight and of 40-100% in obesity since 1997. Figure 2 graphs these prevalence rates by age. At the age of two years, overweight and obesity prevalence rates in 2009

were slightly lower than in 1980 and similar to those in 1997. However, after the age of two years, the 2009 prevalence rates exceeded the rates observed in 1980 and 1997. For girls, the gap started to widen from the age of two years, whereas for boys this occurred from the age of four years. The largest gap with the previous studies was found around the ages of seven and eight years, when 15-19% of the children were overweight and 2-3% were obese. At some ages, we observed a three to four fold increase in the amount of overweight since 1980. For obesity, this ratio was even higher.

Table 3. *Prevalence rates (%) of overweight (including obesity) and obesity according to IOTF cut-off values[16] in 1980, 1997 and 2009 by age and sex.*

	Overweight						Obesity					
	Boys			Girls			Boys			Girls		
age (y)	1980	1997	2009	1980	1997	2009	1980	1997	2009	1980	1997	2009
2.0	9.6	7.4	8.0	9.9	8.2	8.3	1.0	0.5	0.7	0.9	0.7	0.7
3.0	6.0	8.0	7.8	8.4	10.2	12.8	0.4	0.7	0.8	0.8	1.2	1.6
4.0	5.5	9.7	9.1	8.8	12.3	16.3	0.3	1.1	1.1	0.8	1.7	2.6
5.0	5.2	11.8	12.8	8.6	14.3	18.1	0.3	1.6	2.0	0.8	2.4	3.3
6.0	4.4	12.0	13.7	7.4	15.5	18.5	0.2	1.6	2.1	0.6	2.7	3.4
7.0	3.7	11.1	14.3	7.3	15.9	18.8	0.1	1.4	2.1	0.6	2.6	3.4
8.0	3.5	10.2	14.7	7.1	14.8	18.0	0.1	1.2	2.2	0.6	2.3	3.2
9.0	3.3	9.0	13.7	6.8	13.2	17.0	0.1	1.1	2.0	0.5	1.9	2.8
10.0	3.2	7.8	12.5	6.6	11.8	16.2	0.1	0.9	1.7	0.5	1.5	2.5
11.0	3.2	7.2	11.9	6.3	10.5	15.0	0.1	0.8	1.6	0.4	1.2	2.1
12.0	3.4	7.1	11.9	6.1	9.6	13.6	0.2	0.7	1.6	0.4	1.1	1.8
13.0	3.6	7.1	12.0	6.0	9.1	12.5	0.2	0.7	1.6	0.4	1.0	1.6
14.0	3.9	7.3	12.4	6.1	9.1	12.2	0.2	0.7	1.7	0.4	1.0	1.5
15.0	4.2	7.7	12.9	6.2	9.4	12.3	0.2	0.7	1.8	0.4	1.1	1.5
16.0	4.7	8.1	13.4	6.4	10.0	12.8	0.3	0.7	1.9	0.4	1.2	1.6
17.0	5.2	8.5	13.8	6.5	10.6	13.3	0.3	0.7	2.0	0.4	1.3	1.7
18.0	5.5	8.5	13.7	6.5	10.9	13.6	0.3	0.6	1.9	0.3	1.4	1.7
19.0	7.8	10.7	16.3	7.6	12.6	15.1	0.5	0.8	2.2	0.3	1.5	1.9
20.0	10.6	13.0	19.0	8.7	14.3	16.4	0.6	0.9	2.6	0.3	1.7	2.1
21.0	NA	15.5	22.0	NA	16.1	17.7	NA	1.0	3.0	NA	1.9	2.2
2.0-21.0*	5.1**	9.4	13.3	7.2**	11.9	14.9	0.3**	0.9	1.8	0.5**	1.6	2.2

y = age in years
NA = not available
* = mean prevalence for children aged 2-21 years
** = mean prevalence for children aged 2-20 years, as data for 21 years olds in 1980 were not available

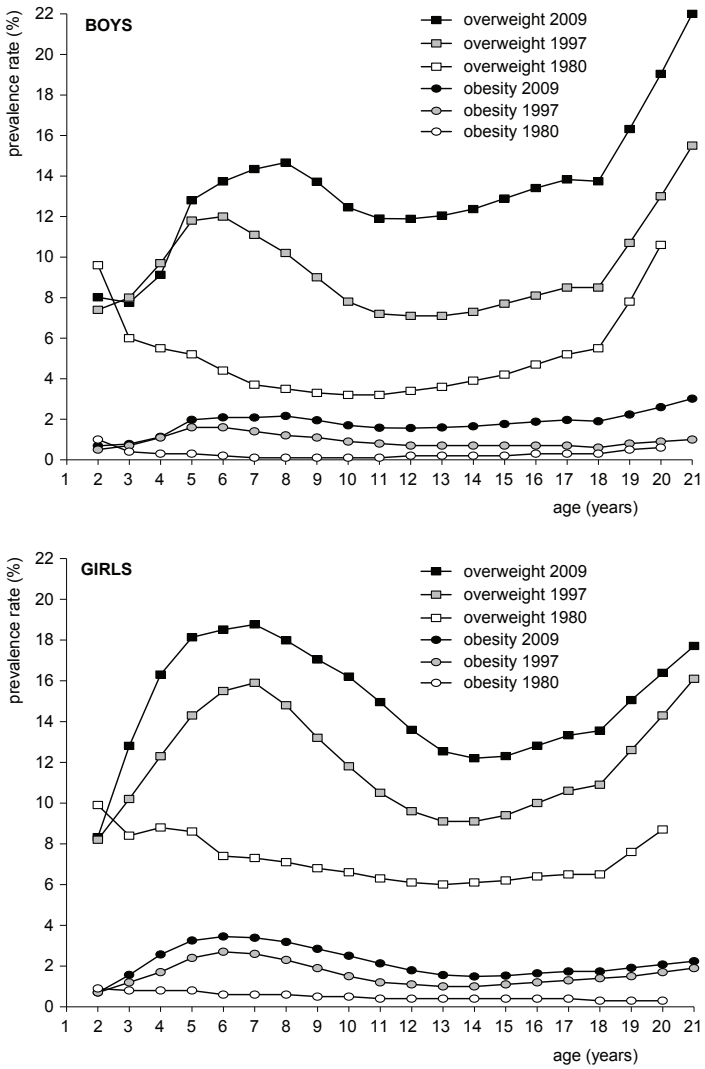

Figure 2. *Prevalence of overweight and obesity in Dutch boys and girls according to international cut-off values[16].*

From Table 3 we calculated an increase of the relative proportion of obesity among overweight boys from 6% in 1980, through 10% in 1997, up to 14% in 2009. In girls, similar figures were found, starting at 7% in 1980, rising to 14% in 1997 and reaching 15% in 2009. Although the rise from 1997 to 2010 was not statistically significant (p=0.08 for boys and p=0.491 for girls), there was a rising trend in the severity of overweight. Figure 3 presents the effect of geographical region and educational level of the parents on BMI SDS and compares these figures in 2009 with 1997. The mean BMI

SDS of children whose parents had a low education was clearly higher than in those of higher educated parents. BMI SDS increased in all groups compared to 1997, but the increase was smallest in children of parents with a high educational level. Across the geographical regions we saw no large differences in BMI SDS in 2009. In 1997, in contrast, the BMI SDS in the major cities was much higher and in the west of the country it was lower than in the other regions. When we looked within the regions, we noticed a significant increase in BMI SDS since 1997 in all regions except for the major cities. In the major cities, the mean BMI SDS in 2009 even lay beneath 1997, although their 95% confidence intervals overlap. This corresponded well with the overweight prevalences that stabilized in the major cities (14.1% in 1997 vs. 14.4% in 2009, p=0.796), but rose substantially in the other regions (9.0% in 1997 vs. 12.9% in 2009, p<0.001).

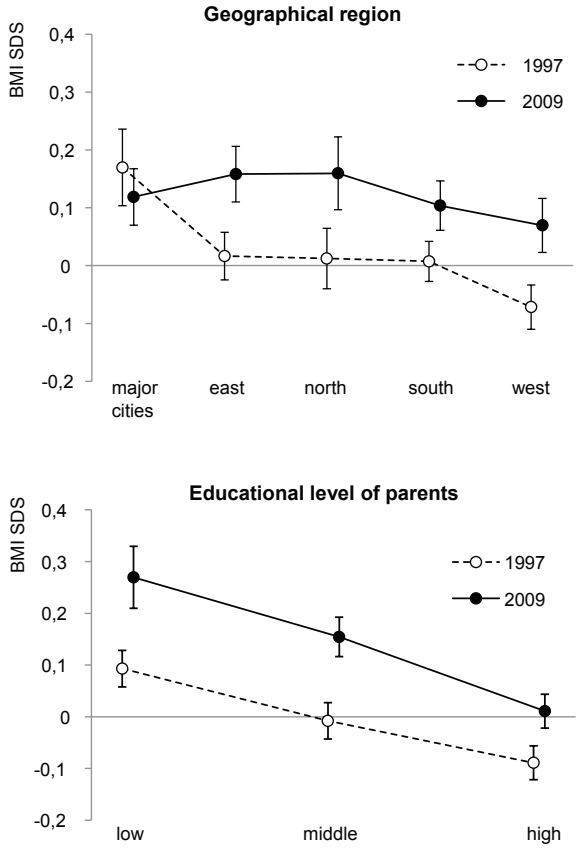

Figure 3. *Mean BMI SDS per geographical regions and parental education in 1997 and 2009. Mean BMI SDS with 95% confidence interval per geographical region and level of parental education in 1997 and 2009.*

DISCUSSION

The percentage of Dutch children with overweight and obesity in 2009 is higher than in 1997. Currently, 13-15% of the Dutch children are overweight. This is a two to three fold increase of the 1980 overweight prevalence rates. Two percent of the Dutch children are obese, which is four to six times the prevalence found in 1980. Further, compared to 1997, when the Dutch overweight epidemic became apparent, a large increase in both overweight and obesity has occurred. Although the Dutch prevalences are still relatively low compared to other developed countries[30,31], our data strongly indicate that overall overweight and obesity in The Netherlands are still increasing, not only in the number of children classified as overweight or obese, but also in the relative proportion of obesity among those children who are overweight. Another important finding in this study is that the prevalence of overweight among Dutch children stabilized in the major cities. This finding is supported by a recent study in The Hague, one of these major cities. No increasing trend was observed in the prevalence of overweight in Dutch boys in The Hague between 1999 and 2007 and a decrease in prevalence was found among Dutch girls[32]. Many present day prevention strategies in The Netherlands aim at populations in the major cities and this stabilization may be the effect of these programs. We wish to add that our data do not allow any conclusions about these programs' effectiveness. In addition, it should be noted that the overweight prevalence in 1997 was much higher in the major cities than in the rest of the country and that the stabilization caused the major cities to blend in with the other regions regarding overweight prevalence. Nevertheless, these may be the first signs that the overweight prevalence begins to level off among those at highest risk. A study by Van den Hurk[33] predates the present study by about five years. Van den Hurk et al. was based on a convenience sample and did not feature quality assurance like ours with respect
to the measurement methodology. Nonetheless, they found similar overweight prevalences in The Netherlands around 2003 as we now find in 2009. This could mean that the overweight prevalence has stabilized after 2003, and that the major increases in prevalence must have taken place before 2003. This is in line with the evidence that has emerged from several developed countries suggesting that the rise in the prevalence has slowed appreciably, or even plateaued between 1995 and 2008[34]. Although most of their overweight and obesity prevalences are much higher than in our study, these may be small glimpses of hope that the worst in terms of continuing increase might be over. Although various factors have been identified as possible causes for the increase in childhood overweight and obesity, the exact cause of the current rise is unknown, and could also differ between people. It is, however, known that overweight is a result of an imbalance between energy intake and expenditure, and it is generally assumed that the overweight epidemic is mainly due to environmental factors, as genetic

changes would not occur at this rate[35]. Parental knowledge of causes of overweight and of healthy food is often insufficient. A Dutch study showed that only 34% of the parents of young children had sufficient knowledge on causes of overweight, 61% on the consequences of overweight, and 49% on healthy food[36]. Other studies in The Netherlands found that 50% of the parents did not recognize overweight in their child and 87% of the parents with an overweight child did not worry about their child's weight[37,38]. To tackle the overweight problem, intervention programs that lead to long-lasting lifestyle changes and reductions in the prevalence of overweight and obesity are needed. So far, intervention programs have had little success. Although it is not a randomized trial, the French total-community approach EPODE seems promising. First results from two small towns showed that between 2002 and 2004 the prevalence of overweight decreased from 13.2% to 8.8%, and was significantly lower than in nearby comparison towns[39]. Future results from EPODE, which has been extended to more than 200 towns in Europe, and other total-community programs should provide more information about the effectiveness of an environmental approach that involves and activates entire neighbourhoods and communities.

A recent longitudinal study provided evidence of the importance of the age period two to six years for the risk of becoming overweight as an adult[11]. It is remarkable that in our study at the age of two years, the overweight prevalence has not changed over the last 30 years. It could mean that prevention efforts aimed at children before the age of two years are in fact too early in life. Moreover, our data show peak prevalences at the ages of seven and eight years, with the steepest increase before the age of five. This pattern suggests that life style changes may have occurred between 1980 and 2009 that especially affect children between 2 and 6 years of age. Our findings are thus entirely consistent with, and in fact reinforce, the findings by De Kroon, and emphasize the importance of early prevention and intervention regarding

childhood overweight and obesity. For monitoring BMI in children in The Netherlands, up until now reference chart describing the BMI distribution in the population, with or without IOTF cut-off values, have been used[40]. As the BMI continued to rise, the population distribution becomes less suitable for monitoring purposes. We therefore decided to create normative BMI reference charts that only include international cut-off values for overweight, obesity, thinness grade II and thinness grade III, which correspond to a BMI of 30, 25, 17 and 16 kg/m^2 respectively at the age of 18 years[16,29,41].

CONCLUSION

The results of the Fourth Dutch Growth Study in 1997 created awareness regarding the problem of overweight and obesity in The Netherlands. Many preventive programs have been implemented and are currently being evaluated. Our study shows that

despite all the efforts, overall overweight and obesity prevalences have increased since 1997. However, the finding that the prevalence in the major cities, where many of these preventive programs have been implemented on a large scale, has stabilized, may imply that increased awareness, prevention and intervention strategies have started to turn the rising trend in overweight around. Continuation of these efforts is needed to fight the obesity epidemic nationwide, as in absolute levels there is still a considerable societal and health problem. Monitoring of the development of childhood overweight and obesity on the national level remains important to track developments in childhood overweight and obesity over the next decades.

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Chapter 5

Call for early prevention: prevalence rates of overweight among Turkish and Moroccan children in The Netherlands

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ABSTRACT

Background: Monitoring overweight in risk groups are necessary. Our aim is to assess the trend in overweight and obesity in Turkish and Moroccan children in The Netherlands since 1997, and to monitor the levels of lifestyle-related behaviors in 2009. **Methods:** We selected cross-sectional data of Turkish and Moroccan children aged 2-18y from two national Growth Studies performed in 1997 and 2009 in The Netherlands. Lifestyle-related behaviors were obtained in the 2009 study by questionnaire. **Results:** In 2009, 31.9% of Turkish and 26.6% of Moroccan children had overweight, while this was respectively 26.7% and 19.6% in 1997. Already at 2y, 21.1% in Turkish and 22.7% in Moroccan children had overweight in 2009. The prevalence of obesity was above 4% from 3y onwards. High (i.e. ≥25%) prevalence rates of non-healthy lifestyle-related behaviors were found for not having breakfast (26-49%) among Turkish and Moroccan adolescent (i.e. 15-18y) girls, consuming no fruit (29-45%), and watching TV/PC ≥2 hours (35-72%) among all Turkish and Moroccan adolescents, no walking/cycling to school/day care among preschool children (2-4y) (28-56%) and adolescents (34-94%), drinking ≥2 glasses of sweet beverages (44-74%), and being <1 hour physically active (29-65%) among all children. **Conclusion:** An upward trend of overweight and obesity occurred in Turkish and Moroccan children. Already at 2y of age, one out of five Turkish and Moroccan children had overweight, which calls for early prevention with attention to specific lifestyle-related behaviors.

AUTHOR CONTRIBUTIONS

Conceived and designed the study: PvD YS RAH SvB. Performed the study: PvD. Analyzed the data: PvD. Contributed material/analysis tools: PvD YS SvB. Wrote the paper: PvD YS RAH SvB.

INTRODUCTION

Over the past three decades childhood overweight has reached epidemic proportions in most industrialized countries[1,2]. Between 1955 and 2009, we conducted five national growth studies in The Netherlands to develop growth charts for youth health care and to study trends in overweight and thinness[3-13]. These studies show that in 2009, 14% of Dutch children were overweight, 2% were obese, and 0.59% were morbidly obese[9,10,12]. This was a two to three fold higher prevalence in overweight, a four to six fold increase in obesity, and a seven to eight fold increase in morbid obesity since 1980[5]. In the two most recent studies, performed in 1997 and 2009, we also focused on the two largest ethnic minorities in The Netherlands originating from Turkey and Morocco[7-9]. In 1997, 27% of Turkish children and 20% of Moroccan children were overweight, while this was 10% in Dutch children[7-9]. These results show that Turkish and Moroccan children in The Netherlands are at a higher risk for overweight. Therefore, monitoring levels and trends of overweight and obesity in these risk groups are necessary.

Overweight is often attributed to an imbalance between energy intake and energy expenditure[1]. The Dutch guideline for overweight in youth health care provides a changing plan aiming at exercise, playing outside, daily breakfast, fewer sweet beverages and fast-food, and less time spent in front of the television or computer, with fewer energy-rich snacks[14]. Monitoring the levels of these lifestyle-related behaviors during childhood provides the health professional with information on the specific behaviors that need special attention in order to prevent, detect and provide treatment to children with overweight.

The aim of our study is to assess the trend in overweight and obesity in Turkish and Moroccan children in The Netherlands since 1997, and to monitor the levels of lifestyle-related behaviors in 2009. We used the extended International Obesity Task Force (IOTF) cut-offs to define overweight and obesity[15].

METHODS

Ethics Statement

Data collection for growth studies is one of the tasks of youth health care in The Netherlands. For these growth studies, written consent was not needed. Data were analyzed anonymously. Before measurement, consent was obtained for each child. The study and the way consent was obtained were approved by the Medical Ethical Review Board of Leiden University Medical Centre.

Data

Cross-sectional height and weight data of Turkish and Moroccan children were selected from the Fourth Dutch Growth Study in 1997 (n=2,223 and n=2,204 aged 2-20y olds respectively) and the Fifth Dutch Growth Study in 2009 (n=2,148 and n=2,181 aged 2-25y olds respectively)[6-12]. Data were obtained at Well Baby Clinics, Municipal Health Services (MHS), schools and a festival. In 2009, two additional samples were provided by the MHS of Amsterdam and The Hague. Children of Turkish and Moroccan descent were oversampled in the four major cities Amsterdam, Rotterdam, The Hague, and Utrecht, where most children of Turkish and Moroccan origin in The Netherlands live. Lifestyle-related behaviors in the 2009 sample were obtained from the children or their parents by health professionals by means of a questionnaire (n=883 Turkish and n=896 Moroccan children). All measurements were standardized and performed by trained health professionals. Height was measured to the nearest 0.1 cm. Children were weighed, wearing underwear only, or a correction was made for clothes, on calibrated mechanical or electronic step scales. Weight was rounded to the nearest 0.1 kg. Children with diagnosed growth disorders and those on medication known to interfere with growth were excluded.

Measurements

Ethnicity was defined according to the country of birth of the parents. Turkish: if mother was born in Turkey, or if mother was born in The Netherlands and father was born in Turkey; Moroccan: if mother was born in Morocco, or if mother was born in The Netherlands and father was born in Morocco. Parental education was defined as the educational level of the highest educated parent and categorized into low, medium and high [16]. We obtained information on the following lifestyle-related behaviors: having breakfast (yes, no, unknown), eating fruit (yes, no, unknown), the number of sweet beverages (i.e. soft drinks) (<1 glass, 1, 2, 3, >3 glasses, unknown), the duration of time watching TV/PC (<30 min, 30-60 min, 60-120 min, 120-240 min, ≥4hrs, unknown), the duration of physical activity (e.g. walking, cycling, sports, outdoor playing) (<30 min, 30-60 min, 60-120 min, ≥2hrs, unknown), transport to school/day care (walking by them self, cycling by them self, by car, different, unknown). We asked to give information about the previous day (yesterday). For example; did the child have breakfast yesterday? Potential risk behaviors were defined as not having breakfast, not eating fruit, drinking ≥2 glasses of sweet beverages, watching TV/PC ≥2 hours, <1 hour physically active, neither walking nor cycling to school/day care[14].

Statistical analyses

Prevalence rates of overweight (including obesity) and obesity by age, sex, ethnicity and year were calculated using the extended international (IOTF) body mass index

(BMI: kg/m^2) cut offs applied to the BMI references from the Dutch national growth studies in 1997 and 2009[15]. The BMI references of the Dutch, Turkish and Moroccan children in 1997 and the Dutch in 2009 have already been published[7-10]. To obtain the BMI references of the Turkish and Moroccan children in 2009, we used the LMS method in the GAMLSS package[17,18]. With L (skewness), M (median), and S (coefficient of variation) references, each BMI can be converted into a Standard deviation Score (SDS) or z-score. SDS of measurement x is calculated as ((x/M)L - 1)/LS (when $L \neq 0$) or ln(x/M)/S (when L=0). This SDS expresses the measurement in relation to BMI of children of Turkish or Moroccan origin in The Netherlands in 2009 in units of standard deviations above or below the median and is useful to detect trends in both mean and variability.
Relative risks (RR) and their 95% confidence intervals (95%CI) were estimated for overweight (including obesity) and obesity between boys and girls, and between 1997 and 2009. Also, RR's (95%CI) were estimated for obesity within overweight between 1997 and 2009.
Similar to overweight, prevalence rates of potential risk behaviors were also calculated by age, sex and ethnicity (in the 2009 sample). To obtain smooth prevalence rates, we performed logistic regression analyses with each behavior as dependent variable and age (in years), age squared (to include a potential U-shaped relation) centered on mean age, sex, ethnicity, all two-way interactions with sex and origin and the three-way interactions year, sex and ethnicity, and age squared centered on mean age, sex and ethnicity as independent variables. Predicted probabilities were obtained from each model to obtain the prevalence rates. Logistic regression analyses were also performed in subgroups of sex and ethnicity to confirm the found relations.
P-values <0.05 (two-sided) were considered statistically significant. R version 2.9.0 with GAMLSS-package[18] was used to estimate the BMI references for the Turkish and Moroccan children in The Netherlands. All other statistical analyses were performed in SPSS version 20.0 for Windows.

RESULTS

Tables 1 and 2 show the BMI references of respectively the Turkish and Moroccan children in 2009. Figure 1 presents the trends of overweight and obesity between 1997 and 2009 in The Netherlands in 2-18y olds. There have been significant upward trends in overweight in Turkish and Moroccan children (respectively RR=1.19, 95%CI(1.09-1.31) and RR=1.36, 95%CI(1.22-1.52)). In 2009, 31.9% of Turkish, and 26.6% of Moroccan children had overweight, while this was respectively 26.7% and 19.6% in 1997. Also for obesity, significant upward trends occurred in children of Turkish and Moroccan origin (respectively RR=1.40, 95%CI(1.12-1.74) and RR=1.55, 95%CI(1.20-2.00)). In 2009, the prevalence of obesity was 8.4% in Turkish and 6.5% in Moroccan children, while this

was respectively 6.0% and 4.2% in 1997. Non-significant upward trends were found in the proportion of obesity within overweight children. Obesity increased from 22 to 26% in Turkish overweight children (RR=1.19, 95%CI(0.97-1.45) and from 21% to 24% in Moroccan overweight children (RR=1.14, 95%CI(0.90-1.44)). Relatively small differences in overweight between low and high educated parents were found in Turkish (33.2% low versus 27.5% high) and Moroccan children (25.4% low versus 22.1% high).

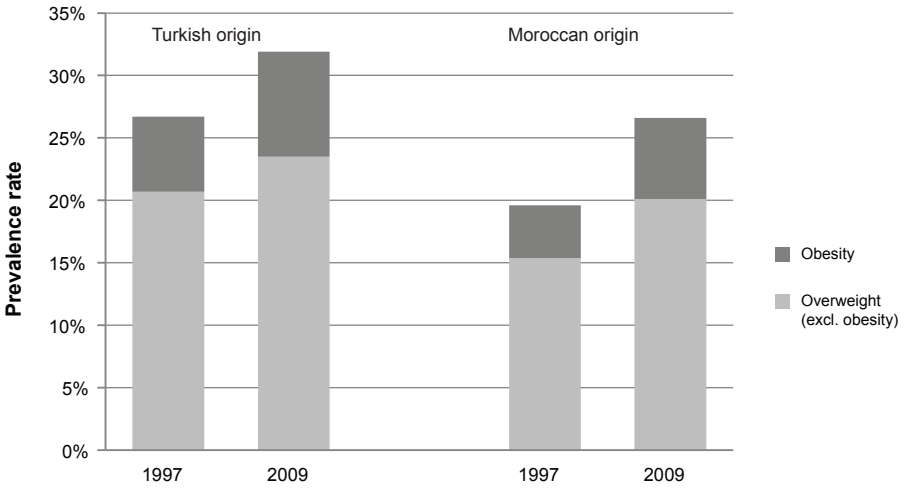

Figure 1. *Trends in prevalence of overweight and obesity in The Netherlands among boys and girls of Turkish and Moroccan origin in 1997 and 2009.*

Table 1. *LMS values for the BMI (kg/m^2) references in Turkish 0-21 year olds in 2009 by age and sex.*

	Boys			Girls		
age (y)	L	M	S	L	M	S
0.0767*	-0.115	16.78	0.0953	-0.104	15.13	0.0852
0.2500	-0.332	17.29	0.0944	-0.291	16.30	0.0858
0.5000	-0.592	17.74	0.0934	-0.507	17.22	0.0864
0.7500	-0.802	17.90	0.0930	-0.679	17.52	0.0869
1.0000	-0.973	17.85	0.0930	-0.826	17.46	0.0873
1.2500	-1.111	17.69	0.0934	-0.962	17.27	0.0877
1.5000	-1.225	17.48	0.0941	-1.089	17.02	0.0883
1.7500	-1.319	17.30	0.0949	-1.207	16.76	0.0891
2.0000	-1.395	17.15	0.0957	-1.316	16.54	0.0902
3.0000	-1.574	16.69	0.1004	-1.648	16.14	0.0962
4.0000	-1.631	16.39	0.1082	-1.830	16.04	0.1045
5.0000	-1.622	16.25	0.1186	-1.884	15.96	0.1140
6.0000	-1.577	16.42	0.1297	-1.816	16.12	0.1243
7.0000	-1.516	16.89	0.1399	-1.672	16.56	0.1350
8.0000	-1.448	17.50	0.1484	-1.506	17.23	0.1447
9.0000	-1.379	18.16	0.1546	-1.352	18.06	0.1530
10.0000	-1.311	18.82	0.1586	-1.220	18.92	0.1595
11.0000	-1.247	19.45	0.1609	-1.108	19.70	0.1643
12.0000	-1.187	20.03	0.1619	-1.014	20.36	0.1675
13.0000	-1.131	20.58	0.1618	-0.936	20.94	0.1693
14.0000	-1.080	21.09	0.1610	-0.873	21.48	0.1702
15.0000	-1.032	21.57	0.1598	-0.819	21.96	0.1705
16.0000	-0.987	22.03	0.1583	-0.772	22.39	0.1705
17.0000	-0.945	22.45	0.1568	-0.730	22.77	0.1703
18.0000	-0.905	22.86	0.1553	-0.692	23.11	0.1699
19.0000	-0.867	23.25	0.1537	-0.657	23.43	0.1696
20.0000	-0.830	23.62	0.1522	-0.625	23.72	0.1692

y = age in years, * 0.0767 = 4 weeks, L = skewness, M = median, S = coefficient of variation

Table 2. *LMS values for the BMI (kg/m^2) references in Moroccan 0-21 year olds in 2009 by age and sex.*

	Boys			Girls		
age (y)	L	M	S	L	M	S
0.0767*	2.642	15.62	0.0850	-1.705	14.94	0.1029
0.2500	1.990	16.67	0.0861	-1.719	16.08	0.0999
0.5000	1.203	17.59	0.0861	-1.732	17.03	0.0970
0.7500	0.568	17.90	0.0848	-1.739	17.37	0.0947
1.0000	0.060	17.90	0.0833	-1.745	17.40	0.0926
1.2500	-0.351	17.77	0.0822	-1.750	17.26	0.0908
1.5000	-0.685	17.59	0.0818	-1.755	17.09	0.0894
1.7500	-0.954	17.41	0.0822	-1.761	16.95	0.0885
2.0000	-1.169	17.24	0.0831	-1.766	16.83	0.0883
3.0000	-1.666	16.68	0.0871	-1.781	16.28	0.0930
4.0000	-1.861	16.22	0.0922	-1.773	16.05	0.0984
5.0000	-1.883	15.93	0.0983	-1.733	16.02	0.1040
6.0000	-1.792	15.99	0.1065	-1.662	16.14	0.1131
7.0000	-1.649	16.34	0.1165	-1.570	16.48	0.1252
8.0000	-1.506	16.81	0.1279	-1.473	16.98	0.1387
9.0000	-1.388	17.33	0.1393	-1.380	17.59	0.1518
10.0000	-1.304	17.86	0.1496	-1.293	18.23	0.1630
11.0000	-1.259	18.43	0.1575	-1.215	18.89	0.1713
12.0000	-1.242	19.01	0.1629	-1.144	19.56	0.1769
13.0000	-1.240	19.59	0.1663	-1.080	20.21	0.1802
14.0000	-1.245	20.17	0.1682	-1.020	20.84	0.1816
15.0000	-1.253	20.73	0.1691	-0.964	21.42	0.1819
16.0000	-1.262	21.26	0.1695	-0.911	21.95	0.1818
17.0000	-1.271	21.76	0.1698	-0.859	22.44	0.1816
18.0000	-1.279	22.24	0.1701	-0.811	22.89	0.1816
19.0000	-1.286	22.69	0.1705	-0.764	23.31	0.1817
20.0000	-1.291	23.11	0.1709	-0.719	23.71	0.1818

y = age in years, * 0.0767 = 4 weeks, L = skewness, M = median, S = coefficient of variation

Figure 2 shows the prevalence of overweight and obesity in The Netherlands among Turkish and Moroccan children in 2009. Already at 2y, 21.1% in Turkish and 22.7% in Moroccan children had overweight. No significant differences were found between boys and girls of Turkish origin (32.6% and 31.2%, RR=0.96 95%CI(0.85-1.09)) and Moroccan origin (24.8% vs. 28.3%, RR=1.14 95%CI(0.99-1.31)). In Turkish and Moroccan children, the prevalence of obesity was above 4% from 3y onwards.

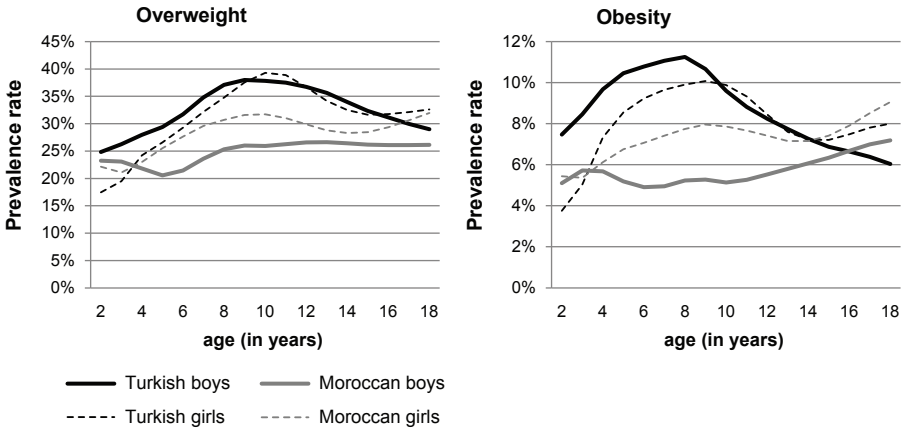

Figure 2. *Prevalence of overweight (left) and obesity (right) in The Netherlands among boys and girls of Turkish and Moroccan origin in 2009.*

Figures 3 A-E show the prevalence rates of non-healthy lifestyle-related behaviors among Turkish and Moroccan children aged 2-18 years. High (i.e. ≥25%) prevalence rates of non-healthy lifestyle-related behaviors were found for not having breakfast (26-49%) among Turkish and Moroccan adolescent (i.e. 15-18y) girls. High rates among all Turkish and Moroccan adolescents were found for consuming no fruit (29-45%), watching TV/PC ≥2 hours (35-72%), and walking/cycling to school (34-94%). Among all children, high rates were found for drinking ≥2 glasses of sweet beverages (44-74%), and being <1 hour physically active (29-65%). The rates for being <1 hour physically active were higher among adolescent girls (57-65%) compared to adolescent boys (29-33%). Among preschool children (2-4y), high rates were found for drinking ≥2 glasses of sweet beverages (50-61%), being <1 hour physically active (39-56%), and no walking/cycling to day care (28-56%).

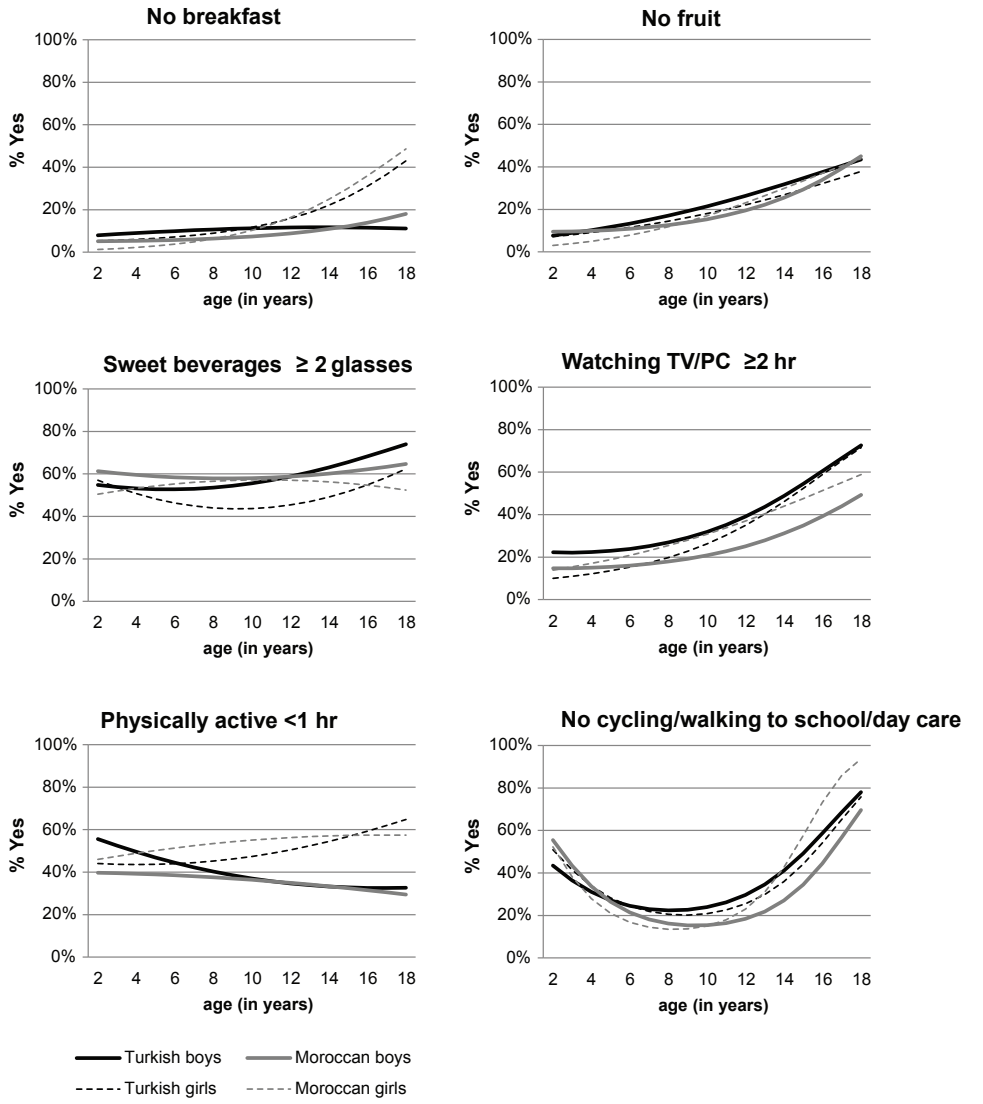

Figure 3. *Prevalence of not having breakfast (A), not eating fruit (B), drinking ≥2 glasses of sweet beverages (C), watching TV/PC ≥2 hours (D), <1 hour physically active (E), neither walking nor cycling to school/day care (F). We asked to give information about the previous day (yesterday).*

DISCUSSION

Our study showed a significant increase in overweight and obesity between 1997 and 2009 in 2-18y old children of Turkish and Moroccan origin in The Netherlands. In 2009, the prevalence of overweight was 31.9% in Turkish children and 26.6% in Moroccan children. These overweight rates were two fold higher than children of Dutch origin in The Netherlands[10]. More than 20% of Turkish and Moroccan children in The Netherlands already had overweight at 2 years of age. High prevalence rates of non-healthy lifestyle-related behaviors were found, also in very young children.

One out of five Turkish and Moroccan 2y olds in The Netherlands had overweight. This could potentially be attributed to a high maternal BMI before pregnancy[19], a high weight gain due to composition and amount of food during the first six months of life[19], and cultural and religious norms influencing non-healthy lifestyle-related behaviors[20]. A low socio-economic status explains part of the differences, but the overweight prevalence rates are still higher among Turkish and Moroccan children compared to Dutch children with a low socio-economic status[10,12]. The prevalence of non-healthy lifestyle-related behaviors among Turkish and Moroccan children is high and already starts at an early age. Our data reveal that already at 2-4y of age, high prevalence rates of non-healthy lifestyle-related behaviors were found for daily drinking ≥2 glasses of sweet beverages, being <1 hour physically active, and no walking/cycling to day care.

The higher rates of obesity in Turkish and Moroccan children compared to Dutch children are in agreement with the systematic review of obesity and cardiovascular disease risk among Turkish and Moroccan migrant groups in Europe. A general finding is that obesity appears to be more common among Turkish and Moroccan migrant groups in Europe than among the populations of the countries they have emigrated to[21]. This is in agreement with our study as overweight rates in children and adolescents in Turkey in 2000-2010 varied between 9.9-17.6%[22], which is lower than 31.9% in Turkish children in The Netherlands. Similarly, overweight rates (defined as BMI>+2 SD at the WHO chart) in children in Morocco varied between 8.7-17.8%[23-25], which is lower than 26.6% in Moroccan children in The Netherlands.

Currently, the first signs of stabilizing or even declining overweight and obesity rates in children in developed countries, including a very slow decline in the city of The Hague in The Netherlands, have been published[26-28]. However, the decline in overweight and obesity in The Hague was most pronounced in children of Dutch origin. In general agreement with our study, the study in The Hague showed that in 3-16y old children of Turkish origin, 24.8% were overweight in 1999, and 32.4% in 2011. Compared to the study in The Hague, overweight in our 2009 sample was more pronounced in children of Moroccan origin (26.6% in 2-18y olds vs 22.8% in 3-16y olds in 2011), but less pronounced in our 1997 sample (19.6% in 2-18y olds vs. 22.1% in 3-16y olds in 1999).

These differences may be caused by regional differences, year of study, and age group. Since, both studies do not show a decline in overweight among children of Turkish and Moroccan origin in The Netherlands, this further increases the large gap between origins and reveals that current prevention and intervention strategies might not reach and affect all groups equally. Cultural and ethnic differences in parental attitudes, beliefs and norms towards overweight, food, eating practices and exercise exist[20,29] and need to be acknowledged for prevention and intervention programs to be adopted by specific groups. Programs that include a family, community, and school component seem most promising to prevent overweight[30,31].

A limitation of our study is that we were not able to study associations between lifestyle-related behaviors and overweight, because of the cross-sectional design of our study (no causality) and the fact that we asked questions concerning the previous day (complicates measuring general/consistent behavior). A strength of our study is the consistent methodology and inclusion/exclusion criteria, and objective measurements of height and weight in the large national growth studies in 1997 and 2009.

This study shows that the prevalence rates of overweight, obesity, and non-healthy lifestyle-related behaviors among Turkish and Moroccan children, already among the very young ones, are alarmingly high. There is a need for early culturally-tailored prevention that already starts during pregnancy (maternal BMI), focusses on nutrition in the first six months of life, and addresses healthy lifestyle-related behaviors during childhood.

ACKNOWLEDGEMENTS

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KEY POINTS

- Significant upward trends of overweight and obesity occurred in Turkish and Moroccan children in the Netherlands. In 2009, the prevalence of overweight was 31.9% in Turkish children and 26.6% in Moroccan children.
- Already at 2 years of age, one out of five Turkish and Moroccan children in the Netherlands had overweight.
- Health professionals should be aware of fast weight gain or a high weight between birth and 2 years of age and start appropriate interventions early.

- Specific lifestyle-related behaviours should be addressed before 2 years of age: <2 glasses of sweet beverages a day, ≥1 h physically active and walk/cycle to day care.

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Chapter 6

Trends in a life threatening condition: morbid obesity in Dutch, Turkish and Moroccan children in The Netherlands

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ABSTRACT

Background: Morbid obesity can be a life threatening condition. The aim of our study is to assess the trend in morbid obesity in The Netherlands among children of Dutch origin since 1980, and among children of Turkish and Moroccan origin since 1997. **Methods and Findings:** Cross-sectional height and weight data of children of Dutch, Turkish and Moroccan origin aged 2-18 years were selected from three national Dutch Growth Studies performed in 1980, 1997 and 2009 (n=54,814). Extended international (IOTF) cut-offs in childhood were used to define morbid obesity (obesity class II and III combined). The morbidity index for overweight was calculated as the prevalence of morbid obesity divided by the prevalence of overweight. Our study showed that the prevalence of morbid obesity in children of Dutch origin was 0.59% in boys and 0.53% in girls in 2009. Significant upward trends occurred since 1980 and 1997. The prevalence was three to four fold higher in Turkish children compared to Dutch children. The Turkish children also had an upward trend since 1997, but this was only statistically significant in boys. The prevalence of morbid obesity in Moroccan children was two to three fold higher than in Dutch children, but it remained almost stable between 1997 and 2009. The Dutch and Turkish children showed an upward trend in morbidity index for overweight since respectively 1980 and 1997, while the Moroccan children showed a downward trend since 1997. In 2009, children of low educated parents had the highest prevalence rates of morbid obesity; 1.06% in Dutch, 2.11% in Turkish and 1.41% in Moroccan children. **Conclusions and Significance:** An upward trend of morbid obesity in Dutch and Turkish children in The Netherlands occurred. Monitoring and reducing the prevalence of childhood morbid obesity is of high importance for these children, health care and the community.

AUTHOR CONTRIBUTIONS

Conceived and designed the study: PvD YS SvB RAH. Performed the study: PvD. Analyzed the data: PvD. Contributed material/analysis tools: PvD YS SvB. Wrote the paper: PvD YS SvB RAH.

INTRODUCTION

Over the past three decades childhood overweight and obesity have reached epidemic proportions in most industrialized countries[1]. Although the Dutch prevalence rates of childhood overweight and obesity are still low compared to other developed countries[2,3], both rates were higher than in 1980. In 2009, fourteen percent of Dutch children were overweight and two percent were obese[3]. This is a two to three fold higher prevalence in overweight and four to six fold increase in obesity since 1980[4]. Upward trends were also found in the two largest ethnic minorities in The Netherlands originating from Turkey and Morocco.

Obesity is a leading preventable cause of chronic illnesses and death and has emerged as one of the most serious public health concerns in the 21st century[5]. Excessive body weight is associated with various diseases like cardiovascular diseases, diabetes mellitus type 2, and certain types of cancer[6]. The risks increase with higher BMI levels at the upper end of the distribution[7]. Obesity has been found to reduce life expectancy by two to four years, while morbid obesity even reduces life expectancy by ten years[7].

Therefore, in adults obesity has been broken down into three classes; class I obesity (30.0-34.9 kg/m^2), class II obesity (35.0-39.9 kg/m^2) and class III obesity (≥40.0 kg/m^2). Only recently, in 2012, extended international (IOTF) cut-offs for childhood obesity classes II and III were presented[8]. Also in children, morbid obesity can be a life threatening condition[9]. Childhood morbid obesity often causes hypertension, dyslipidemia, insulin resistance/diabetes, fatty liver disease, and psychosocial complications[10]. In a study in 2005-2007 in The Netherlands among 307 children with severe obesity, 56% had hypertension and 67% had at least one cardiovascular risk factor[11]. A study among 230,000 Norwegian adolescents showed that morbid obesity was associated with increased mortality in middle age from a wide variety of systemic diseases[12]. The aim of our study is to apply the extended international (IOTF) cut-offs on the national Dutch growth studies to assess the trend in morbid obesity (class II and III combined) in The Netherlands among children of Dutch origin since 1980, and among children of Turkish and Moroccan origin since 1997. The Dutch growth studies offer a unique opportunity to study trends covering the time period before which the worldwide obesity epidemic emerged.

METHODS

Ethics Statement

Data collection of growth studies is part of routine youth health care in The Netherlands, and is not regarded as medical research. In the Dutch nationwide surveys, written informed consent was not needed. Verbal consent was obtained from each child (and

parent for children younger than 16 years) before measurement. To document the process, cooperation, or lack thereof, was registered on the questionnaire. The Medical Ethical Review Board of Leiden University Medical Centre approved of the study and the way consent was obtained.

Data

Cross-sectional height and weight data of children of Dutch, Turkish and Moroccan origin aged 2-18 years living in The Netherlands were selected from the Third Growth Study in 1980 (n=30,020)[4], the Fourth Growth Study in 1997 (n=13,900)[13] and the Fifth Growth Study in 2009 (n=10,894)[3]. Data were obtained at Well Baby Clinics, Municipal Health Services (MHS), schools and a festival (in 1997 and 2009). To obtain sufficient samples of Turkish and Moroccan children, oversampling was done in the four major cities Amsterdam, Rotterdam, The Hague, and Utrecht, where most children of Turkish and Moroccan origin in The Netherlands live. Measurements in all Dutch Growth studies were identical and were standardized and performed by trained health care professionals. Height was measured to the nearest 0.1 cm. Children were weighed, wearing underwear only, or a correction was made for clothes, on calibrated mechanical or electronic step scales. Weight was rounded to the nearest 0.1 kg. Children with diagnosed growth disorders and those on medication known to interfere with growth were excluded from these surveys. More details on the design of these surveys have been published before[3,4,13].

Statistical analyses

Dutch origin was defined as both mother and father born in The Netherlands, Turkish origin was defined as mother born in Turkey, or mother born in The Netherlands and father born in Turkey. Similarly, Moroccan origin was defined as mother born in Morocco, or mother born in The Netherlands and father born in Morocco. Parental education was defined as the educational level of the highest educated parent and categorized into low, medium and high[14]. Prevalence rates for morbid obesity were calculated with the extended international (IOTF) cut-offs (class II and III combined) for children[8]. These cut-offs were obtained by a centile at the growth curve of six large nationally representative cross-sectional growth studies, including The Third Dutch Growth Study in 1980[4]. At age 18 years, this centile passed through the cut-off point of 35 kg/m^2 for adults class II obesity. Since the number of children was not evenly distributed across age years, we first calculated the prevalence rates per year of age, and then averaged these rates. Chi-square and Fisher's exact tests were performed to test for differences in prevalence rates. A log-binomial model was used to test if differences in prevalence rates between ethnic groups in 2009 are due to differences in the educational level of the parents, after adjustment for sex and age of the child. P-values

<0.05 (two-sided) were considered statistically significant. As the risk of morbidity in overweight children increases with higher BMI, we calculated the morbidity index for overweight. The morbidity index is used in other studies to categorize the severity of a disease, for example diabetes mellitus[15] and coronary risk factors[16]. In our study, the morbidity index for overweight was calculated as the prevalence of morbid obesity divided by the prevalence of overweight expressed as a percentage. The statistical analyses were performed in SPSS version 20.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

Morbid obesity in children of Dutch origin

Figure 1 and Table 1 show the trend in morbid obesity in The Netherlands among children of Dutch origin since 1980, and among children of Turkish and Moroccan origin since 1997. Table 1 shows that the overall trends and prevalence rates were almost similar between boys and girls of Dutch origin. Between 1980 and 1997 there has been an upward trend in the prevalence of morbid obesity in boys and girls of Dutch origin (respectively, p<0.001 and p<0.01). Upward trends were also found between 1997 and 2009 in boys and girls (both p<0.05). Almost in all age groups, there has been an increase in the prevalence of morbid obesity. In 2009, 0.59% in boys and 0.53% in girls were morbidly obese.

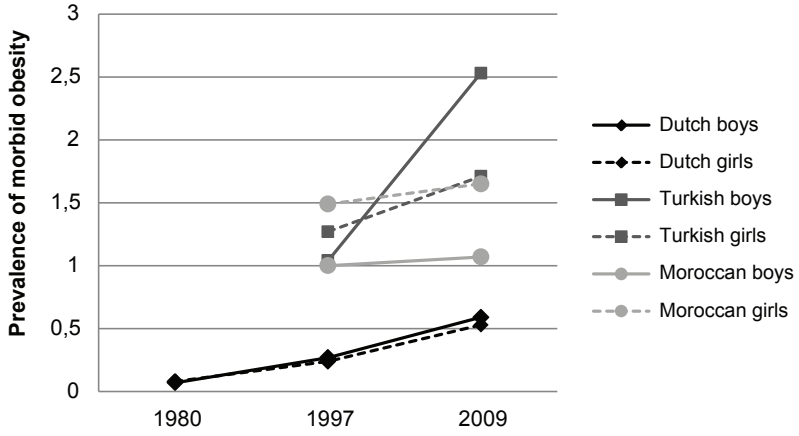

Figure 1. *The trend in morbid obesity in The Netherlands among children of Dutch origin since 1980, and among children of Turkish and Moroccan origin since 1997.*

Table 1. *The trend in morbid obesity in The Netherlands among children of Dutch origin since 1980, and among children of Turkish and Moroccan origin since 1997.*

	age (y)	%(n) of morbid obesity in 1980		%(n) of morbid obesity in 1997		%(n) of morbid obesity in 2009	
Dutch boys	2-5y	0.14	(4943)	0.44	(961)	0.53	(757)
	6-11y	0.12	(4611)	0.37	(1367)	0.62	(1158)
	12-18y	0.00	(5818)	0.08	(2667)	0.60**	(1210)
	Total	0.07	(15372)	0.27***	(4995)	0.59*	(3125)
Dutch girls	2-5y	0.32	(4747)	0.37	(980)	1.00	(817)
	6-11y	0.03	(4609)	0.05	(1361)	0.63*	(1318)
	12-18y	0.00	(5292)	0.34***	(2292)	0.17	(1360)
	Total	0.08	(14648)	0.24**	(4633)	0.53*	(3495)
Turkish boys	2-5y			0.37	(194)	4.58**	(543)
	6-11y			0.84	(400)	2.53	(281)
	12-18y			1.59	(525)	1.36	(255)
	Total			1.04	(1119)	2.53*	(1079)
Turkish girls	2-5y			1.06	(156)	1.54	(501)
	6-11y			0.66	(399)	3.50*	(291)
	12-18y			1.90	(469)	0.27	(244)
	Total			1.27	(1024)	1.71	(1036)
Moroccan boys	2-5y			2.66	(179)	1.78	(485)
	6-11y			0.67	(390)	0.43	(371)
	12-18y			0.35	(507)	1.22	(204)
	Total			1.00	(1076)	1.07	(1060)
Moroccan girls	2-5y			2.84	(187)	2.24	(444)
	6-11y			1.99	(384)	1.25	(403)
	12-18y			0.29	(482)	1.65*	(252)
	Total			1.49	(1053)	1.65	(1099)

*p<0.05, **p<0.01,***p<0.001 tested with previous growth study.

Morbid obesity in children of Turkish origin

Table 1 shows that the prevalence of morbid obesity is higher in Turkish children compared to the Dutch. An upward trend was noticed in Turkish boys between 1997 and 2009 ($p<0.05$). In 2009, 2.53% of the Turkish boys were morbidly obese. In 2009, the prevalence in Turkish girls was slightly higher (1.71%) than in 1997 (1.27%). There was a rise in the prevalence up to twelve years of age, significantly in 2-5 year old boys ($p<0.01$) and 6-11 year old girls ($p<0.05$).

Morbid obesity in children of Moroccan origin

The overall prevalence of morbid obesity in Moroccan boys and girls remained almost stable over time (see Table 1). However, in the age group 12-18 years, there was an

upward trend in girls ($p<0.05$) and a (non-significant) upward trend in boys, while the other age groups showed a (non-significant) downward trend. In all age groups, girls had higher prevalence rates than boys in 2009. The overall prevalence of morbid obesity in 2009 was 1.07% in boys and 1.65% in girls.

Morbidity index for overweight

Table 2 presents the morbidity index for overweight among Dutch children between 1980 and 2009 and among Turkish and Moroccan children between 1997 and 2009. In 2009, the highest morbidity index for overweight was found in Turkish boys (7.76%). Moroccan and Turkish girls had the second and third highest morbidity index for overweight of respectively 5.83% and 5.48%. The lowest morbidity index for overweight (3.61%) was found in Dutch girls. The Dutch and Turkish children showed an upward trend in morbidity index for overweight since respectively 1980 and 1997, while the Moroccan children showed a downward trend since 1997.

Table 2. *The trend in morbidity index for overweight defined as the prevalence of morbid obesity divided by the prevalence of overweight (%) in The Netherlands among children (2-18 years) of Dutch origin since 1980, and among children of Turkish and Moroccan origin since 1997.*

	Boys			Girls		
Ethnicity	MI-O (%) in 1980	MI-O (%) in 1997	MI-O (%) in 2009	MI-O (%) in 1980	MI-O (%) in 1997	MI-O (%) in 2009
Dutch	1.52	3.03	4.72	1.13	2.09	3.61
Turkish		4.37	7.76		4.31	5.48
Moroccan		6.33	4.31		6.39	5.83

MI-O: Morbidity Index for Overweight

Morbid obesity and educational level in 2009

In 2009, 18% of Dutch children had low educated parents, while this was 58% in Turkish and 60% in Moroccan children. Dutch children of low educated parents had the highest prevalence of morbid obesity (1.06%), while those of medium and high educated parents had the lowest prevalence rates of morbid obesity (respectively 0.51% and 0.16%). Similar results were found in children of Turkish and Moroccan origin. For Turkish children, the prevalence of morbid obesity was 2.11% in low educated parents, 1.09% in medium, and 1.10% in high educated parents. In Moroccan children, these rates were respectively 1.41%, 0.68%, and 1.16%. After adjustment for educational level, the differences in morbid obesity rates between Turkish and Dutch children (from relative risk (RR)= 4.1, 95%CI(2.7-6.3) to RR=2.0, 95%CI(0.97-4.3)) and between Moroccan and Dutch children (from RR=2.7, 95%CI(1.7-4.4) to RR=1.3, 95%CI(0.5-3.1)) were less pronounced.

DISCUSSION

This study is the first that presents trends of morbid obesity based on the extended international (IOTF) cut-offs in Dutch children, and also in Turkish and Moroccan children living in The Netherlands. We showed that the prevalence of morbid obesity in children of Dutch origin was 0.59% in boys and 0.53% in girls in 2009. Significant upward trends occurred since 1980 and 1997. The prevalence rates were much higher in children of Turkish (2.53% in boys and 1.71% in girls) and Moroccan (1.07% in boys and 1.65% in girls) origin in 2009. Turkish children showed an upward trend before twelve years of age, while the results of the Moroccan children showed the opposite; an upward trend aged twelve years onwards. The morbidity index for overweight was highest among the Turkish and Moroccan children, which reveals that overweight is more severe in children of Turkish and Moroccan origin compared to children of Dutch origin. The severity of overweight increased between 1980 and 2009 in Dutch children, and between 1997 and 2009 in Turkish children, while a decrease between 1997 and 2009 was observed in Moroccan children. Part of the ethnic differences in morbid obesity rates can be explained by the educational level of the parents, as more Turkish and Moroccan children have low educated parents and morbid obesity is more prevalent among children of low educated parents.

The extended (IOTF) cut-offs encourage direct comparison of trends in child morbid obesity worldwide. The cut-offs are less arbitrary and more internationally applicable than other definitions, such as centiles on the United States (US) growth charts[17.] Until now, the prevalence of morbid obesity by the extended international (IOTF) cut-offs has only been reported in one study in New Zealand[18]. This study was limited to secondary school students and did not report information on trends. They showed that among 9,107 secondary school students in 2007, the prevalence of morbid obesity was 2.5%. Our study showed that the prevalence of morbid obesity in secondary school children of Dutch, Turkish and Moroccan origin was much lower in 2009 than the New Zealand secondary school children in 2007. Other studies applied as cut-off for extreme or severe obesity the 99th percentile or a BMI≥120% of the 95th percentile[19,20] for age and sex according to the growth charts of the 2000 Center for Disease Control (CDC)[17], which complicates a fair comparison.

At eighteen years, a BMI≥120% of the 95th CDC growth chart corresponds to a BMI of 34.8 kg/m^2 in boys and 36.4 kg/m^2 in girls. A study in millions of US pre-school children living in low income families showed that the prevalence of extreme obesity (≥120% of the P95 CDC) increased from 1.75% in 1998 to 2.22% in 2003 and decreased to 2.07% in 2010[19]. Another study among 42,559 US children aged 3-5 years between 2007 and 2010 reported a prevalence of extreme obesity (≥120% of the P95 CDC) of 1.6%[20]. Among US children aged 2 to 19 years, the prevalence of extreme obesity (≥P99 CDC)

was 3.8%[21] and in 6.9% of U.S. sixth graders in the HEALTHY cohort[22]. A study in New Zealand among 3,275 schoolchildren aged 4-15 year showed that the prevalence of extreme obesity (≥P99 CDC) was 2.7% in 2002[23].

In agreement with our study, high differences in prevalence rates among ethnic groups within countries were reported[18- 23]. In our study part of the ethnic differences in morbid obesity rates can be explained by the educational level of the parents. Families with low educated parents may lack resources, both economical and knowledge, which can reduce their ability to control weight gain by making healthy food choices and taking opportunities for physical activity[24-26]. Ethnic differences in morbid obesity may also be explained by differences in cultural opinions about body shape and acceptable weight gain[27-29].

Also, cultural and religious norms influencing dietary and physical activity patterns may play a role[27-29]. It is reported that children of Turkish origin in The Netherlands watch more TV[30], play less outdoor[31], have a higher snack intake[31], and less often have breakfast[30] compared to children of Dutch origin. All these results show that interventions or prevention programs should pay attention to the cultural aspects and educational level of the targeted population.

A particular strength of our study is the consistent methodology and inclusion/exclusion criteria, and objective measurements of height and weight in the large national growth studies between 1980 and 2009. The baseline growth study was performed in 1980, before the worldwide obesity epidemic started. Therefore, the growth studies offer a unique opportunity to monitor trends in a period of increasing levels of BMI. The data were collected from all regions in The Netherlands and are, therefore, assumed to be generalizable for the results of The Netherlands. A limitation of our study is that we only present the prevalence rates of morbid obesity in children of Turkish and Moroccan origin in 1997 and 2009, since the 1980 study did not provide a sufficiently large sample of children of Turkish and Moroccan origins. Another limitation is the limited sample size within the three age categories of the Turkish and Moroccan children that complicates a good insight into age-related trends. Further research is needed to evaluate the trends of morbid obesity within age categories of children of non-Dutch origin.

An upward trend in overweight and obesity between 1980 and 2009 was already reported in The Netherlands[3]. Our findings show upward trends in morbid obesity as well. Monitoring and reducing the prevalence of childhood morbid obesity is of high importance for these children, health care and the community.

Childhood obesity leads to chronic illnesses[10,11] and increased risk of mortality in middle age[12]. Therefore, an upward trend in morbid obesity and morbidity index for overweight may have a higher impact on health costs, than an upward trend in overweight. For this reason, it is important to monitor not only overweight, but also morbid obesity

and the morbidity index for overweight. The Partnership Overweight Netherlands (PON) provides an integrated health care standard for obesity involving strategies for diagnosis and early detection of high-risk individuals as well as appropriate combined lifestyle interventions for those who are overweight and obese and, when appropriate, additional medical therapies[32].

CONCLUSIONS

Upward trends of morbid obesity in Dutch and Turkish children in The Netherlands occurred since respectively 1980 and 1997, while this prevalence remained almost stable in Moroccan children since 1997. The Dutch and Turkish children also showed an upward trend in morbidity index for overweight since respectively 1980 and 1997, while the Moroccan children showed a downward trend since 1997. Monitoring trends of morbid obesity according to international comparable cut-offs for BMI is important, because of the great impact on health care and costs.

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Chapter 7

Thinness in the era of obesity: trends in children and adolescents in The Netherlands since 1980

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ABSTRACT

Background: Although children both at the upper and lower tail of the body mass index (BMI) distribution are at greater health risk, relatively little is known about the development of thinness prevalence rates in developed countries over time. We studied trends in childhood thinness and assessed changes in the BMI distribution since the onset of the obesity epidemic. **Methods:** Growth data from 54 814 children aged 2-18 years of Dutch, Turkish and Moroccan origin living in The Netherlands were used. Anthropometric measurements were performed during nationwide cross-sectional growth studies in 1980 (only Dutch), 1997 and 2009. Prevalence rates of thinness grades I, II and III were calculated according to international cut-offs. BMI distributions for 1980, 1997 and 2009 were compared. **Results:** Since 1980, thinness (all grades combined) reduced significantly from 14.0% to 9.8% in children of Dutch origin, but the proportion of extremely thin children (grade III) remained constant. Thinness in children of Moroccan origin decreased significantly from 8.8% to 6.2% between 1997 and 2009. No significant difference was observed in children of Turkish origin (5.4% in 1997 vs. 5.7% in 2009). Thinness occurred most often in children aged 2-5 years. There were no differences between boys and girls. The BMI distribution widened since 1980, mainly due to an upward shift of the upper centiles. **Conclusion:** Since the onset of the obesity epidemic, prevalence rates of thinness decreased. However, we found a small but persistent group of extremely thin children. More research is needed to gain insight into their health status.

AUTHOR CONTRIBUTIONS

Conceived and designed the study: YS PvD RAH SvB. Performed the study: YS. Analyzed the data: YS. Contributed materials/analysis tools: YS PvD SvB. Wrote the paper: YS PvD RAH SvB.

INTRODUCTION

The last decades witnessed a rising trend in childhood overweight and obesity in many countries. Although children both at the upper and the lower tails of the body mass index (BMI) distribution are at greater health risk, relatively little is known about the prevalence rates of thinness over time. Thinness, i.e. low BMI for age, may have substantial consequences for child development, health and well-being. Thinness may reflect malnutrition and can result from poor feeding and eating practices or from underlying health conditions, such as coeliac disease or eating disorders[1]. Other health risks associated with (childhood) thinness include stunting, weakened or failing immune system, osteoporosis, anemia and fertility problems later in life[2-5].

Overweight and obesity have increased over the last decades, also in The Netherlands[6]. If the whole population experienced a similar upward shift in BMI, one would expect a reduction of the thinness prevalence. Alternatively, if only those who were already relatively heavy showed an upward shift, the thinness prevalence would remain stable. Finally, finding a higher prevalence rate of thinness would be counterintuitive in the current obesity era. Some have suggested, however, that programs to prevent overweight and obesity in children may actually cause unintended harm[7,8]. A recent Dutch study found a negative body image and weight loss behavior among a substantial proportion of normal weight children in primary and secondary schools[9]. This could manifest itself in a rising thinness prevalence. Each of these scenarios would have a different effect on the BMI distribution of the population; the distribution would move upwards as a whole in the first scenario, widen due to an upward shift at the upper end of the BMI distribution in the second scenario and widen as a result of upward and downward shifts of respectively, the upper and lower end of the BMI distribution in the third scenario. Data on trends of thinness rates in developed countries are scarce, especially for severe grades of thinness. We hypothesized that thinness prevalence rates could be linked to overweight and obesity figures. Children of Turkish and Moroccan origin, the two main immigrant groups in The Netherlands, were found to be substantially shorter and more often overweight and obese than their peers of Dutch origin[10-12]. Therefore, comparison of thinness rates across ethnicity is of interest. The Dutch growth studies offer a unique opportunity to study thinness rates and its trend, covering also the time period before the worldwide obesity epidemic. Our aims were to (i) study trends in thinness in The Netherlands among children of Dutch origin since 1980; (ii) study trends in thinness among children of Turkish and Moroccan origin since 1997 and (iii) assess how the BMI distribution has changed in the light of the obesity epidemic.

METHODS

Data sources

Cross-sectional growth data of children aged 2-18 years of Dutch, Turkish and Moroccan origin were extracted from the 1980 (only Dutch origin), 1997 and 2009 Dutch Growth Studies. Measurements were performed across the country. The 1980 dataset was larger than the datasets in 1997 and 2009; with the knowledge from previous Dutch growth studies in 1955, 1965 and 1980 about the general shape of growth curves and expected variation within the population, it was calculated that smaller sample sizes (fewer children per age group and fewer age groups) were needed in 1997 and 2009. The methodologies for the growth studies in 1997 and 2009 were similar. The study samples were stratified by age, sex, geographical region and educational level of the child. The distribution of geographical region and indicators for socioeconomic status (SES) [parental occupation (1980) and educational level of the child (1997 and 2009)] of the three samples of children of Dutch origin were compared with national population distributions at the time of the studies to check for representativeness. All three samples were considered representative for the entire population of children of Dutch origin in The Netherlands. To obtain sufficient children of Turkish and Moroccan origin, we oversampled children from the four major cities (Amsterdam, Rotterdam, The Hague and Utrecht), where most children of Turkish and Moroccan origin in The Netherlands live. Details on the methodologies have been published before[6,13,14].
Data collection for growth studies is one of the tasks of youth health care in The Netherlands. For these growth studies, written consent was not needed. Data were analyzed anonymously. Before measurement, consent was obtained for each child. The study and the way consent was obtained were approved by the Medical Ethical Review Board of Leiden University Medical Centre.

Measurements

All anthropometric measurements were standardized and performed by trained healthcare professionals. Height was measured to the nearest 0.1 cm. Children were weighed, wearing underwear only, on calibrated mechanical or electronic step scales. Weight was rounded to the nearest 0.1 kg. A questionnaire, filled in by a health care professional, was used to collect demographic variables.

Variable definitions

Ethnic origin was defined according to the country of birth of the parents. Dutch: if both parents were born in The Netherlands; Turkish: if mother was born in Turkey, or if mother was born in The Netherlands and father was born in Turkey; Moroccan: if mother was born in Morocco, or if mother was born in The Netherlands and father was

born in Morocco. BMI was calculated as weight (kg)/height^2 (m^2). For 1997 and 2009, SES was classified according to the highest educational level of the parents (low/middle/high). For 1980, no data on the educational level of the parents was available. When comparing SES across time, we used the highest' occupation of the parents in 1980 as a proxy for educational level. Occupation of the parents was coded into low/middle/ high according to the prestige of the occupation. This classification was assessed by Statistics Netherlands[15].

Exclusion criteria

Exclusion criteria were similar in all three Dutch Growth Studies. Children with diagnosed growth disorders and those on medication known to interfere with growth were excluded. As there are no international BMI cut-off values for thinness for children aged <2 years, these children were excluded. Children with an ethnic origin other than Dutch, Turkish or Moroccan were also excluded.

Statistical analysis

We used the age- and sex-specific cut-offs for thinness grades I, II and III as proposed by Cole and Lobstein,16 which correspond to the following BMI ranges at the age of 18 years: 17.0-18.5 kg/m^2 (thinness grade I), 16.0-17.0 kg/m^2 (thinness grade II) and <16.0 kg/m^2 (thinness grade III). Each child was categorized as thinness grade I, grade II, grade III or no thinness. Thinness categories were exclusive, so, for example, the prevalence of thinness grade I did not include thinness grades II and III. Differences in the prevalence of thinness between groups and across time were tested using logistic regression analyses, correcting for age (in years), age squared (to include a potential U-shaped relation) and sex. P-values <0.05 (two-sided) were considered statistically significant. For the comparison of BMI distributions between 1980, 1997 and 2009, previously published BMI distributions were used[6,13,14]. Statistical analyses were performed in IBM SPSS Statistics version 20.0 for Windows and Microsoft Excel 2010 (version 14).

RESULTS

Study population

In total, BMI data of 54 814 children aged 2-18 years were available. Table 1 presents the number of children per ethnic group and per study year. SES increased across the years. In 1980, the SES of 55% of the children of Dutch origin was classified as low, compared with 36% in 1997 and 18% in 2009. In children of Turkish origin, the percentage of low SES decreased from 90% in 1997 to 58% in 2009 and in those of Moroccan origin from 97% to 60%.

Table 1. *Baseline characteristics of the study participants per ethnic group and study year.*

			Dutch		Turkish		Moroccan	
		1980	1997	2009	1997	2009	1997	2009
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Sex	Boys	15,372 (51)	4,995 (52)	3,125 (47)	1,119 (52)	1,079 (51)	1,076 (51)	1,060 (49)
	Girls	14,648 (49)	4,633 (48)	3,495 (53)	1,024 (47)	1,036 (49)	1,053 (49)	1,099 (51)
Age	2-5y	9,690 (32)	1,940 (20)	1,574 (24)	350 (16)	1,044 (49)	366 (17)	929 (43)
	6-11y	9,220 (31)	2,728 (28)	2,476 (37)	799 (37)	572 (27)	774 (36)	774 (36)
	12-18y	11,110 (37)	4,959 (52)	2,570 (39)	994 (46)	499 (24)	989 (47)	456 (21)
SES	Low	15,235 (55)	3,264 (36)	1,039 (18)	1,733 (90)	379 (58)	1,821 (97)	355 (60)
	Middle	10,334 (37)	2,923 (32)	2,141 (38)	165 (9)	184 (28)	43 (2)	148 (25)
	High	2,253 (8)	2,849 (32)	2,503 (44)	37 (2)	91 (14)	16 (1)	86 (15)
		%	%	%	%	%	%	%
BMI	Overweight[a]							
	Boys	5.1	9.4	13.3	23.4	32.5	15.8	25.2
	Girls	7.2	11.9	14.9	30.2	31.7	24.5	29.1
	Obesity							
	Boys	0.3	0.9	1.8	5.2	8.4	3.1	6.0
	Girls	0.5	1.6	2.2	7.2	8.0	5.4	7.5

SES: socio-economic status
[a] including obesity

Thinness in 2009 in children of Dutch origin

In 2009, the prevalence of thinness (all grades combined) in children and adolescents of Dutch origin aged 2-18 years was 9.8% (Table 2). There were no significant differences in the prevalence of thinness between boys and girls. Thinness occurred most often in children aged 2-5 years and least often in the age group of 6 to 11-year-olds. This was consistent across all grades of thinness. The prevalence of thinness in high SES children was 11.1% and 9.4% in low SES children, but these differences were not significant.

Table 2. *Prevalence (percent) of thinness grades for Dutch boys and girls per age group.*

	Dutch boys				Dutch girls				Total			
		Thinness grade				Thinness grade				Thinness grade		
Age (years)	Total	I	II	III	Total	I	II	III	Total	I	II	III
2-5y	13.0	11.3	1.3	0.37	12.5	9.9	1.9	0.79	12.8	10.6	1.6	0.58
6-11y	7.5	6.8	0.6	0.14	8.2	6.7	1.2	0.35	7.9	6.7	0.9	0.24
12-18y	9.1	7.8	1.0	0.30	10.4	8.8	1.2	0.38	9.8	8.3	1.1	0.34
Total	9.5	8.3	0.9	0.26	10.1	8.3	1.4	0.47	9.8	8.3	1.2	0.36

Thinness since 1980 in children of Dutch origin

Table 3 shows that between 1980 and 2009 there has been a downward trend in the prevalence of thinness grades I and II in both boys and girls of Dutch origin (both p<0.001). This trend remained present after correction for SES. The prevalence of thinness grade III in boys and girls in 2009 was lower than in 1980, but this was not statistically significant. Thinness in children of Turkish and Moroccan origin In 2009, the prevalence of thinness (all grades combined) in children of Turkish and Moroccan origin was lower than in children of Dutch origin, also after correction for SES [5.7%; (p<0.01), and 6.2% (p<0.05) vs. 9.8%, respectively]. The thinness prevalence of children of Turkish origin did not differ significantly from that of Moroccan origin. There were no significant differences between boys and girls in any of the ethnic groups. The prevalence of thinness was significantly lower in 2009 compared with 1997 in children of Moroccan origin (2.6%, p=0.002), but not in those of Turkish origin (+0.3%, non-significant).

Table 3. *Prevalence (percent) of thinness grades for Dutch boys and girls aged 2-18 years in 1980, 1997 and 2009.*

		Dutch boys	Dutch girls	Total	Time trend total[a]
Thinness grade	Year	2-18 years	2-18 years	2-18 years	OR [95% CI] [b]
Total	1980	13.5	14.5	14.0	1
	1997	12.4	11.1	11.8	0.84 [0.78;0.90]
	2009	9.5	10.1	9.8	0.70 [0.64;0.76]
I	1980	11.5	11.8	11.6	1
	1997	10.5	9.3	9.9	0.85 [0.79;0.92]
	2009	8.3	8.3	8.3	0.71 [0.64;0.78]
II	1980	1.6	2.1	1.9	1
	1997	1.7	1.4	1.5	0.80 [0.66;0.96]
	2009	0.92	1.4	1.2	0.66 [0.53;0.83]
III	1980	0.38	0.59	0.48	1
	1997	0.27	0.35	0.31	0.81 [0.55;1.15]
	2009	0.26	0.47	0.36	0.81 [0.54;1.23]

[a] Corrected for age, age squared and sex
[b] Odds ratio (OR) with 95% confidence interval (CI)

BMI distribution in 1980, 1997 and 2009

Figure 1 compares the BMI distributions of children of Dutch origin in 1980, 1997 and 2009. It shows that the BMI distribution has widened considerably since 1980, in both boys and girls. For example, in 18 year old boys in 1980 the difference between +2 and 2

SD for BMI was 9.0 kg/m^2 (26.2 kg/m^2 to 17.2 kg/m^2). In 1997, this had expanded to 10.4 kg/m^2 and in 2009 it had grown to 12.6 kg/m^2, indicating that the BMI distribution for 18 year old boys widened by >40% since 1980. In 18 year old girls the BMI distribution in 1980 was already broader than in boys (10.5 kg/m^2), but had still increased by 16% in 2009 (12.2 kg/m^2). Figure 1 shows that while the 0 and +2 SD lines moved upwards substantially, no clear trend of the 2 SD line was observed since 1980.

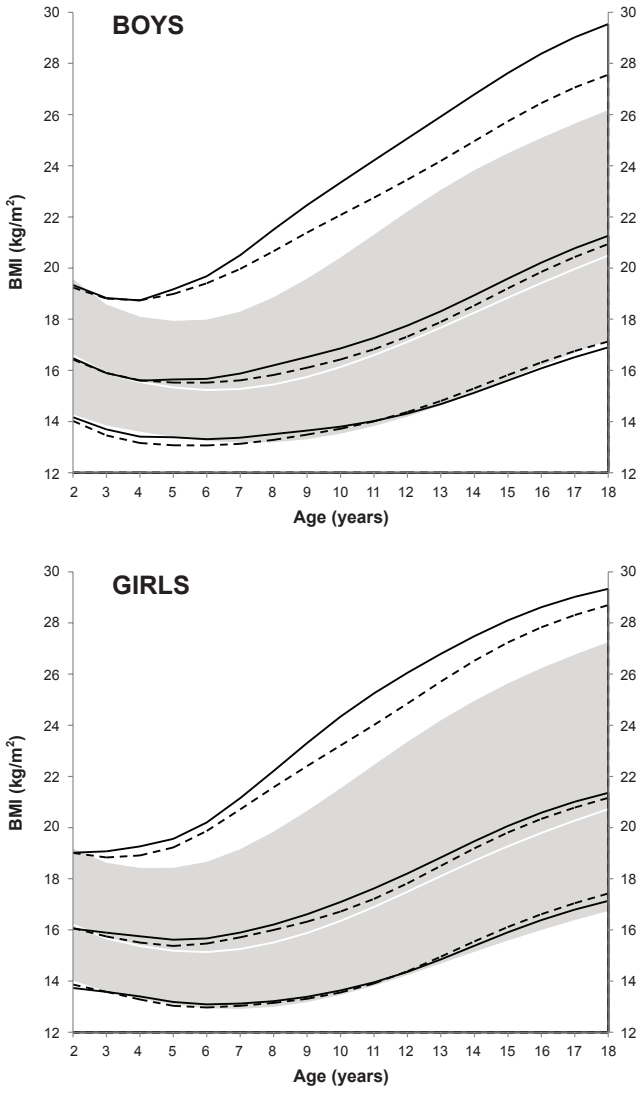

Figure 1 *The -2, 0 and +2 BMI SD lines for boys (top) and girls (bottom) in 1980 (grey area, white line), 1997 (dotted lines) and 2009 (solid lines)[6, 13,14].*

DISCUSSION

Thinness was present in about 10% of children and adolescents of Dutch origin in The Netherlands in 2009. Almost 2% was classified as having thinness grades II or III. Thinness was more prevalent in children <6 years. No significant differences were observed across levels of SES. Since 1980, the prevalence of thinness grades I and II decreased significantly, whereas there was no significant trend in the prevalence of extreme thinness (grade III). Over the same time period, prevalence rates of childhood overweight and obesity doubled or even tripled.[6] The BMI distribution in The Netherlands has thus widened over the period 1980-2009[6,13,14]. The increased spread in BMI is due to an upward shift of the upper SD lines, whereas at the same time a small group of constant size classified as thinness III keeps the lower SD lines in place.

The prevalence rates of thinness in children of Turkish and Moroccan origin were lower than in those of Dutch origin, also after correction for SES. Compared with 1997, thinness decreased in those of Moroccan origin, but not in those of Turkish origin. This is in line with the overweight and obesity prevalence rates in these groups, which were higher in children of Turkish and Moroccan origin compared with Dutch origin. Also, compared with 1997, overweight and obesity increased more in the Moroccan than in the Turkish group[12]. However, while overweight and obesity in Turkish and Moroccan children tripled or quadrupled the prevalence in Dutch children, thinness prevalence rates in these groups were at most only half as high as in those of Dutch origin. This indicates that children of Turkish and Moroccan origin have a consistently higher BMI throughout the entire distribution.

The datasets used in this study are large and cover the period during which the obesity epidemic emerged. This allowed us to study the trend in thinness during this interesting period and to estimate prevalence rates for the more severe and rare grades of thinness. Even in these large studies, analyses concerning subsets of the sample may be underpowered due to the relatively small numbers. A lack of power could be the reason why the difference in prevalence rates of thinness across SES was non-significant, and similarly for the difference in thinness grade III between 1980 and 1997 and 1980 and 2009. However, a decrease in the prevalence of thinness grade III since 1997 is unlikely to have occurred, as not even a non-significant downward trend was observed. Electronic health records for children were standardized in the year 2009, so we expect that future growth studies will be able to process larger samples using routinely collected data.

As stated in the method section, children with known growth disorders, or on medication known to interfere with growth were excluded. Some of these conditions, for example, coeliac disease, may be related to thinness. We therefore, cannot rule out a slight underestimation of the presented prevalence rates. As the exclusion criteria

were the same across the study years, we do not expect this to affect the presented trends in thinness.

The downward trend we observed in thinness grade I is consistent with other studies in developed countries that use smaller age ranges and/or (slightly) different cut-offs to define thinness[17-21]. In the USA, the prevalence of thinness, defined as a BMI below the fifth percentile of the sex-specific BMI-for-age growth charts of the Centers for Disease Control and Prevention, has diminished from 5.3% to 3.5% since the early 1970s among 2 to 19-year-olds[17]. One study found a decrease of the thinness prevalence between 1994 and 2000 only in girls (aged 15-16 years)[23]. Other studies found no statistically significant trends,[24-26] possibly due to small sample sizes or short time frames. A follow-up study in Gothenburg, Sweden, found an increase in the prevalence of underweight (all grades combined) in 18 to 19-year-olds between 1992-93 and 2008-09[22]. A large study in 6 to 16-year-olds in Australia and a large study in 5-year-olds in the UK showed stable prevalence rates of <2% for thinness grades II and III combined since 1985,[20,27] which does not match the decrease that we found in the prevalence of grade II thinness. Furthermore, in this study from the UK, a significant interaction was found between birth year and SES. In our study, SES was not significantly associated with thinness in any of the study years and no significant interaction was found with SES and the year of study. On the other hand, the more important finding is that in both studies, like in ours, no rising prevalence rates were found, despite the concerns about the unintended effects of current obesity programs. Of course, results for one country may not apply to another, but when taken together, the data contain no evidence for unwanted side effects of obesity prevention programs.

The prevalence rates presented in this article were based on new international cut-offs, which were developed to enable comparison of thinness prevalence across countries and across time. According to these criteria, almost 10% of the Dutch youth is thin. Not all of these children are malnourished or need treatment. Cole et al.[28] proposed that 'a BMI of 17 at the age of 18 (thinness grade II) is a suitable cut-off to use as a basis for an international definition of thinness in children and adolescents'. In the Dutch growth charts, cut-offs for thinness grades II and III are displayed[28,29]. The choice for these lower cut-offs is supported by findings obtained by using the 2007 WHO growth reference for BMI-for-age for children aged 6-18 years[30]. Applying the 2 SD and 3 SD lines from this reference as cut-offs results in an even more stringent definition of thinness and severe thinness. Of the children classified as thinness grade II, 71% had a BMI below the 2 SD line of the WHO reference and none below the 3 SD line. Among those classified as thinness grade III, 100% had a BMI below the 2 SD line and 46% below the 3SD line of the WHO BMI-for-age reference. The Dutch growth charts, together with the professional's clinical view and the child's background information, can help to identify children at increased health risk. The growth charts can also be used to monitor the

development of a child's BMI over time. We found a decrease in thinness since the onset of the obesity epidemic in children of Dutch origin, which means that fewer children run health risks due to a low BMI for age. The prevalence of thinness in children of Moroccan origin was also lower in 2009 than in 1997, which was not the case in those of Turkish origin. The BMI distribution has broadened due to an upward shift at the high end of the BMI distribution (due to increased obesity), combined with the presence of a small, but persistent group of extremely thin children. Our research suggests that this is a small hard core group whose size is relatively constant and cannot be reduced further. More research is needed to gain insight into the health status of these children.

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Chapter 8

General discussion

GENERAL DISCUSSION

The studies in this thesis focused on the growth of children living in The Netherlands in 2009. We found that the spectacular rise in height of the Dutch population during the last 150 years came to a halt. In 2009, the average final height at age 21 was 184 cm for boys and 171 cm for girls[1]: an increase of almost twenty centimeter (for men) since the 1850's[2]. At the age of 18 years, boys and girls of Turkish and Moroccan origin were two to three centimeter taller than in 1997, but they were still 5.5 to 7 cm shorter than their Dutch peers in 2009[3]. The prevalence rates of overweight and obesity in 2009 were higher than in 1997. Moreover, the severity increased: relatively more children were classified as (morbidly) obese[4,5]. Overweight and obesity rates were two to three times higher in children of Turkish and Moroccan origin compared to children with Dutch parents[6]. At the same time, thinness rates declined in children of Dutch and Moroccan origin, and remained constant in those of Turkish origin[7].

Table 1. *Prevalence rates of overweight, obesity, and morbid obesity in children aged 2 to 18 years in The Netherlands in 1980, 1997 and 2009.*

	Overweight* (%)			Obesity* (%)			Morbid obesity* (%)		
	1980	1997	2009	1980	1997	2009	1980	1997	2009
Boys									
Dutch	4.6	8.7	12.3	0.3	0.9	1.7	0.07	0.27	0.59
Turkish	-	23.5	32.3	-	5.0	8.5	-	1.04	2.53
Moroccan	-	15.6	24.5	-	3.0	5.6	-	1.00	1.07
Girls									
Dutch	7.1	11.5	14.7	0.5	1.5	2.2	0.08	0.24	0.53
Turkish	-	29.4	31.1	-	6.8	7.8	-	1.27	1.71
Moroccan	-	23.2	28.2	-	5.1	7.1	-	1.49	1.65

*overweight includes (morbid) obesity, obesity includes morbid obesity

The tallest population

Despite the stagnation in the secular height trend, the Dutch are still the world's tallest population[6,8], even if children of non-Dutch origin are included[1]. It is not completely understood why the Dutch are the tallest. Studies among twins suggest that nowadays around eighty percent of the variation in human height in the can be explained by genetic differences, and the remaining twenty percent by environmental factors[9-12]. Genetics may play a role in explaining differences between populations. However, due to the fact that the Dutch were amongst the shorter populations in the mid-90th

century[13,14], and the relatively short time frame, changes in genetics cannot explain the height gain of 20 cm since the 1850's. More likely, the increase in height reflects improvements in environmental factors, such as improved hygiene, better food, and less infectious diseases. A parallel development has occurred in other Western European countries. The high consumption of milk compared to other countries[15] is sometimes mentioned to explain why the Dutch are so tall. De Beer estimated that the increase in Dutch milk consumption between the late 19th and first half of the 20th century contributed as much as 15% to the height gain over this period[16]. Another factor to explain the tallness of the Dutch is the relatively low level of economic and health inequity in The Netherlands. Due to universal health insurance, social insurance, and a redistributive policy to control income inequity, the number of very poor and deprived people is low in The Netherlands[17]. Furthermore, the Dutch introduced a unique and extensive preventive youth health care system in the beginning of the 20th century. It offers free of charge routine health care visits for all children and their parents, including advice regarding nutrition and hygiene, and health status assessment and vaccination for all children.

Stagnation in secular trend in height in Dutch children

We do not know why the 150 year increase in population height has come to a halt. The growth studies have a cross sectional design, so no causality can be proven. A possible explanation of the stagnation in height gain is an increased number of so called 'third generation immigrant children', i.e., children with grandparents born outside of The Netherlands, who are on average shorter. However, this group constitutes only four to five percent of the total study population, and is therefore too small to have a major impact on the total.

An alternative explanation is that 184 cm for men and 171 cm for women is the maximum attainable population mean height, i.e., a biological maximum. The idea of a biological maximum is that a further increase in mean height would not be favorable due to negative health consequences. For example, tallness has been linked to increased risk of certain cancers and of venous thromboembolism[18,19]. By implication, this would mean that the environmental factors have reached the most favorable distribution, and that further improvement of these factors is either not possible, or does not lead to additional growth. It may also be that growth-promoting environmental factors can improve further, but did not between 1997 and 2009. For example, the per capita milk consumption has been decreasing[20]. Thus, if milk has a growth-promoting effect, then a reduction in consumption may contribute to a halt in secular trend. Also, rates of overweight and obesity in Dutch children in 2009 were higher than in 1997[4,5]. Unhealthy dietary behavior can lead to inadequate nutrient intake, which may result in suboptimal growth. In addition, high BMI values have been linked to an earlier onset

of puberty, which has been associated with lower final height[21-23]. Data from the Dutch growth studies did show a decrease in age at menarche between 1997 and 2009[24], but the cross sectional study design does not differentiate between co-occurrence and causality. Moreover, the effect on height will be relatively small and is therefore unlikely to explain the halt in height gain.

Height gain in children of Turkish and Moroccan origin

While the height of children of Dutch origin remained constant between 1997 and 2009, final height of children of Turkish and Moroccan origin increased by two (girls) to three (boys) centimeter over this period[3]. Still, at age 18 years, Turkish and Moroccan children were on average 5.5 cm (boys) to 7 cm (girls) shorter.

The parents of most of the Turkish and Moroccan children in The Netherlands are low educated and originate from rural Turkey and Morocco. They came to The Netherlands in the 1970's and 1980's for work. This improvement in their socioeconomic and health status compared to their country of origin is likely to have a positive effect on the height of their offspring. We did see this in our results. The Turkish children in The Netherlands are currently taller than their peers in rural Turkey with a low to moderate socioeconomic status[25]. The final height of Turkish adolescents in The Netherlands is now similar to that of Turkish adolescents of higher socioeconomic background in Istanbul[26-28]. A large height gain in immigrant children was also seen in other countries[29,30] and is likely to be due to improved nutrition, hygiene, and health. It has been suggested that it takes several (up to six) generations to fully benefit from improved environmental conditions in terms of height, to avoid too rapid catch-up[31]. The number of third generation Turkish and Moroccan children in our study was too small to draw conclusions about differences in height between generations[3]. Future growth studies should reveal if the height gap between Turkish, Moroccan, and Dutch children decreases further, and at what pace.

Further increase in overweight and obesity

The Dutch Growth Studies showed that childhood overweight and obesity rates increased dramatically between 1980 and 1997[32,33]. In the Fifth Dutch Growth Study from 2009, we found even higher prevalence rates of overweight, obesity and morbid obesity in children of Dutch, Turkish and Moroccan origin (see Table 1)[4-6]. Body mass index standard deviation scores (BMI-SDS) increased across all levels of parental education and in all geographical regions, except for the major cities, were no changes were observed[5]. The severity of overweight increased: the morbidity index (MI), i.e. the relative proportion of morbid obesity among those with overweight, rose in children of Dutch (since 1980) and Turkish (since 1997) origin[4]. The highest MI was observed in Turkish boys (7.8% morbid obesity among those with overweight). The lowest MI

in 2009 was found among Dutch girls (3.6%). In children of Moroccan origin, the MI showed a downward trend since 1997. In children of Dutch origin, we found peak prevalence rates of overweight and obesity at the age of seven and eight years, and the steepest increase before the age of five years[4]. In children of Turkish and Moroccan origin, prevalence rates of overweight and obesity at the age of two years were already three fold higher than in children of Dutch origin[6]. High rates of non-healthy lifestyle-related behaviors were found in all age groups of Turkish and Moroccan children, and were already present at age two to four years. Large differences in overweight rates between ethnic groups were also seen in other studies in The Netherlands[34,35]. De Hoog et al. found that these higher rates could largely be attributed to maternal BMI before pregnancy and weight gain of the child during the first six months[34]. The cause of this higher weight gain during the first six months is unknown. It could not be explained by the infant feeding pattern (breast feeding duration, introduction of formula feeding and complementary feeding). The composition and amount of food could have played a role[36]. The full explanation for ethnic differences in weight gain, also at older ages, is complex and likely includes a combination of genetic, biological, cultural, socioeconomic and environmental factors and interactions among them[37].

Our findings indicate that efforts to reduce childhood overweight until 2009 did not result in lower overall prevalence rates compared to 1997. However, in the major cities mean BMI-SDS in 2009 was comparable to 1997. It was only recently, that more signs of stabilizing or even declining overweight and obesity rates in children in developed countries, including some areas in The Netherlands, were published[38-41]. Although these results have not been linked directly to specific interventions, this might be a sign that increased awareness and prevention programs start to pay off.

IMPLICATIONS FOR PRACTICE

Current Dutch growth charts

The Dutch growth charts are developed to detect abnormal growth in children in The Netherlands and have been updated in 2010. We advise health care workers to use the standard Dutch height-for-age growth chart for child of all origins living in The Netherlands (see Chapter 2, Figure 1 for an example of the Dutch growth charts). As children of Turkish and Moroccan origin were still considerable shorter than their Dutch peers, we have updated the height-for-weight growth charts for children of Turkish and Moroccan origin. We recommend application of the new growth charts for children of Turkish and Moroccan origin that have a height-for-age below -2 standard deviations on the Dutch growth chart.

The current weight-for-height and weight-for age growth charts are normative'; they do not describe the current weight-for-height distribution, but are based on the

growth study data from 1980, i.e., data from before the onset of the obesity epidemic[42]. As a result of the increased overweight prevalence rates, the BMI growth charts also no longer present the current distribution of the BMI. These charts display the international cut offs for thinness grade II, grade III, overweight and obesity[42-44]. These normative' charts are the same for children of Dutch, Turkish, and Moroccan origin.
The growth references for pubertal stage (except for menarcheal age[24]), head circumference, sitting height, leg length, and sitting height-height ratio have not been updated, as there were no clinically significant changes between 1980 and 1997, and/or no significant changes were expected to have occurred since 1997. For these measures the growth references are still based on data from 1997. The reference values for waist circumference, hip circumference and waist-hip ratio are also still based on 1997 data, as the 2009 data were less suitable for growth references due to the increased overweight rates compared to 1997.

Reducing overweight and obesity

Despite the signals from our and other studies that overweight and obesity prevalence rates are stabilizing or even declining in some areas and groups, prevention of overweight continues to be of great importance. Overweight and obesity are preventable and curable conditions. Childhood obesity leads to serious medical and psychosocial problems and puts children at an increased risk for adult morbidity and mortality[45-49]. Although the rates in The Netherlands are relatively low compared to other countries, they are still considerably higher than thirty years ago[4,5]. The health effects in the long run are likely to become a substantial health and economic burden. Finkelstein et al. estimated the lifetime incremental medical cost of an obese child in the U.S.A. relative to a normal weight child to be around $19,000[50]. This figure does not include non-medical costs, like reduced productivity. Such indirect costs are estimated to account for 54-59% of the total cost of obesity[51]. Reducing the rates of overweight and obesity should therefore remain high on the agenda.
The Dutch growth charts for weight-for height and BMI, in combination with the recent Dutch youth health care guidelines Overweight' and Food and Eating Behavior' can help youth health care workers in detecting children at risk[42,53,56]. The lack of an international well-established definition for overweight in children younger than two years of age could wrongly suggest that overweight is not an issue in this age group. However, in children of Turkish and Moroccan origin, overweight, obesity, and morbid obesity rates were already high at the age of two years. The weight-for-age and weight-for-height growth charts can be used by youth health care workers to detect high body weight in under-two-year-olds[53]. A high body weight from the age of 5 to 6 months, but also fast weight gain (>0.67 SD) at any moment between birth and two years of age, are associated with a high body weight at the age of 5 to 13 years[55].

(Tailored) prevention and intervention strategies

Despite efforts to reduce overweight and obesity figures in The Netherlands, childhood overweight and obesity rates in 2009 were higher than in 1997[4,5]. Only few interventions have been found effective in reducing childhood overweight and obesity. Community, school and/or family components seem important in the effectiveness of overweight programs[56-58]. Although not supported by randomized studies, the French community-based EPODE (together lets prevent childhood obesity') approach shows promising results in reducing childhood obesity in France and Belgium[59,60]. In France, the difference in the obesity prevalence rates between socioeconomic groups decreased in EPODE-cities[60]. In The Netherlands, the EPODE approach has been implemented as the JOGG-program[61]. In 2009, the government, together with twenty parties from the industry, major cities, and civil society signed a covenant which aims to implement JOGG in 75 Dutch municipalities by the end of 2015. By July 2014, 62 municipalities had been included. Data from the first JOGG-city report slightly lower prevalence rates in 2012 than in 2006[41]. A study by De Wilde et. al reported decreasing and stabilizing trends in overweight and obesity between 2007 and 2011 in children aged 3 to 16 years of different origins in The Hague, The Netherlands[39]. Furthermore, they showed that the rates of obesity in children of Dutch and Moroccan origin dropped more than overweight rates, indicating that overweight children became less obese. However, they also found that the decline in overweight and obesity was most pronounced in children of Dutch origin. This further increases the already large gap between origins, with children of Turkish origin still having the highest prevalence rates. It also suggests that the current prevention and intervention strategies might not reach and affect all groups equally. It could be that current strategies insufficiently take into account cultural and ethnic differences in parental attitudes, beliefs and norms towards overweight and obesity, food, eating practices and exercise exist[62,63]. Tailored approaches that do consider these difference might increase parental involvement in these high risk groups. Parental involvement in primary and secondary prevention of childhood overweight and obesity is of great importance[56], as parental knowledge, attitudes and skills influence children's behavior[56,58].

Health care workers in youth health care, and also in the care for pregnant women (e.g. midwifes, gynecologists, general practitioners), should create awareness of the consequences of childhood overweight and obesity in the short and long run, and inform them how to prevent or, if already developed, reduce it. Important tools for this are the guidelines for Overweight' and Food and Eating Behavior', that provide important information for both health care workers and parents[42,53,54]. These guidelines are currently being implemented.

Future Growth Studies

Future national growth studies should reveal how the national trends in overweight and obesity among children in The Netherlands develop, and if these trends are similar across children of different origin. New growth studies could also inform us if the world's tallest population will grow any taller, and if the height of children of Turkish and Moroccan origin converges more towards the height of the Dutch. More insight into suitable cut offs for overweight and obesity in under two-year-olds, and into the causes of rapid weight gain in infants and young children, specifically of Turkish and Moroccan origin, is desired to identify clues for prevention.

New opportunities for monitoring growth have become available by the introduction of electronic health records in youth health care in 2009. The routinely collected height and weight data could be used to monitor height, weight, and BMI in a large dataset, and, possibly, with shorter time intervals. The latter is especially important for the monitoring of national overweight and obesity rates. Although measurements of height and weight of children and adolescents might differ slightly between organizations, and less background information will be available, these data could provide valuable insight in trends over time. It is not yet known if such data would make classical Dutch Growth Studies redundant. Therefore, a study on yearly prevalence rates based on country wide routinely obtained height and BMI data since 2009 would be of great value. Such a study would give insight into the development of height and BMI since 2009. It would also allow comparison of the data from the Fifth Dutch Growth Study in 2009 with the routinely obtained data in 2009. One of the drawbacks of the routinely acquired data was the fact that no routine youth health care visits were available after the age of 13 years. Fortunately, an extra routine check at the age of 15/16 years is currently being implemented, though the data might be unsuitable if height and weight are self-reported. To determine future trends in final height in Dutch adolescents, data collection in 18 to 21 year olds will still be necessary.

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Chapter 9

Summary

Samenvatting

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SUMMARY

Monitoring human growth provides information about the health status of a population, for example the prevalence of overweight and obesity, or the mean height. At the individual level, it is used for the detection of abnormal growth trajectories in children, which may reflect nutritional problems or underlying illness. In The Netherlands, national growth studies have been carried out in 1955, 1965, 1980, 1997. These large, nationwide studies allow comparison of height and weight data of Dutch children over time. In 2009, the Fifth Dutch Growth Study was conducted. For this study, growth data and background characteristics of 0 to 21 year old children living in The Netherland have been collected in 2008 and 2009. The study population includes 12,005 children of Dutch origin, 2,594 of Turkish origin and 2,548 of Moroccan origin. This thesis presents the main results.

In The Netherlands, mean height has increased steadily since 1858. The growth study from 1997 showed that the Dutch were by then the world's tallest population. It also showed that the rate at which growth increased per generation slowed down. In **Chapter 2** we calculated new height-for-age reference values and looked at the course of this height trend in the children of Dutch origin. We found that in 2009 the secular increase in height came to a halt after 150 years. At age 21 years, the mean height of boys was 183.8 cm, and of girls 170.7 cm. Children with a higher educational level or with higher educated parents, were taller than those with a lower educational level. The differences in mean height across geographical regions decreased, but did not completely vanish: children in the north of the country are still slightly taller than those living in the south of the country. It is not completely clear why the Dutch have stopped growing taller. They might have reached the optimal height distribution. Alternatively, growth promoting environmental factors may have stabilized over the past decade, preventing the population from reaching its full growth potential.

In the growth study of 1997, data on the growth of children of Turkish and Moroccan origin were collected. Young adults of Turkish and Moroccan origin were nine to ten cm shorter than children of Dutch origin. In **Chapter 3** we studied the height of children of Turkish and Moroccan origin in 2009. We found that the mean height of these children increased, while the height of the Dutch stagnated. At age 18 years, Turkish and Moroccan boys on average measured 177 cm, and girls 163 cm. This was an increase of 2 to 3 cm since 1997, but still they were 5 to 7 cm shorter than their Dutch peers. We found no differences in height across educational level, geographical region, language spoken at home, or immigrant generation. Because of the height gain since 1997, the growth charts for children of Turkish and Moroccan origin have been updated.

We recommend the use of the new growth charts for those children of Turkish and Moroccan origin that have a height-for-age below -2 standard deviation on the regular Dutch growth chart.

The growth study from 1997 revealed that the prevalence rates of childhood overweight and obesity rose dramatically between 1980 and 1997, with prevalence rates being highest in the major cities. Since then, many efforts to reduce the prevalence rates of childhood overweight and obesity have been undertaken, many aiming at the major cities. In **Chapter 4**, the 2009 overweight and obesity prevalence rates for children of Dutch origin were presented. In 2009, 12.8% of the Dutch boys and 14.8% of the Dutch girls aged 2 to 21 years were overweight. Of the boys, 1.8% was obese, in girls this was 2.2%. This was a two- to threefold higher prevalence in overweight and a four- to six fold increase in obesity since 1980. Like in 1997, the body mass index (BMI) was inversely related to the level of education of the parents. The mean SD-score of BMI increased in all regions since 1997, except for the major cities. This might be a sign that the rising trend in overweight in The Netherlands is starting to turn.

In 1997, alarming prevalence rates of overweight and obesity were found in children of Turkish and Moroccan origin, which were two to almost three times as high as in those of Dutch origin. In **Chapter 5** we present prevalence rates of overweight and obesity in children of Turkish and Moroccan origin in 2009. In 2009, 31.9% of the Turkish and 26.6% of the Moroccan children had overweight. This was significantly higher than in 1997. Already at the age of two years, prevalence rates for overweight were above twenty percent. Obesity rates were above four percent from the age of three years onwards. We also asked about unhealthy lifestyle-related behaviors the day before the measurements. High (i.e. ≥25%) prevalence rates of unhealthy lifestyle-related behaviors were found for drinking two or more glasses of sweet beverages (44-74%) and being less than one hour physically active (29-65%) among all children, consuming no fruit (29-45%) and watching TV/PC for 2 hours or more (35-72%) among all Turkish and Moroccan adolescents (15 to 18 years), not having breakfast (26-49%) among Turkish and Moroccan adolescent girls, and not walking/cycling to school/day care among preschool children (2 to 4 years) (28-56%) and adolescents (34-94%). These results call for early prevention, with attention for specific lifestyle-related behaviors.

Obesity is a leading preventable cause of chronic illness and death. The healthrisk increases with higher BMI levels. Therefore, in adults, obesity has been subdivided into three classes: class I (30.0-34.9 kg/m^2), class II (35.0-39.9 kg/m^2), and class III (≥40.0 kg/m^2). In 2012, international cut offs for class II and class III childhood obesity became available. In **Chapter 6** we assess the trend in morbid obesity (class II and class III combined)

among children of Dutch origin since 1980, and among those of Turkish and Moroccan origin since 1997. In 2009, the prevalence of morbid obesity in children of Dutch origin was 0.59% in boys and 0.53%in girls. There were significant upward trends since 1980 and 1997. The prevalence was three to four fold higher in children of Turkish origin and two to three fold higher among those of Moroccan origin compared to those of Dutch origin. Among children of Turkish origin, the prevalence rates were higher in 2009 than in 1997. We introduced the morbidity index, calculated as the prevalence of morbid obesity divided by the prevalence of overweight. The value of this index increased among children of Dutch origin (since 1980) and Turkish origin (since 1997), and decreased among their Moroccan peers (since 1997). Morbid obesity occurred most often in children of low educated parents.

Although children both at the upper and lower tail of the BMI distribution are at greater health risk, relatively little is known about the development of thinness prevalence rates in developed countries over time. In 2007, international cut offs to define thinness in children were published, with categories that correspond to the following BMI-ranges at the age of 18 years: grade I (17.0-18.5 kg/m^2), grade II (16.0-17.0 kg/m^2), and grade III (<16.0 kg/m^2). In **Chapter 7** we studied trends in childhood thinness and assessed changes in the BMI distribution since 1980. We found a substantial decrease in the prevalence of overall thinness in children of Dutch origin, from 14.0% in 1980 to 9.8% in 2009. However, the prevalence of thinness grade III remained constant. Thinness in children of Moroccan origin decreased, from 8.8% in 1997 to 6.2% in 2009. No trend was observed among those of Turkish origin (5.4% in 1997, 5.7% in 2009). Thinness occurred most often in children aged two to five years. There were no significant differences between boys and girls. We concluded that the BMI distribution has widened since 1980, mainly due to an upward shift of the upper centiles of the BMI distribution.

Chapter 8 briefly summarizes the results of this thesis. We discuss the use of the Dutch growth charts in daily practice, and stress the importance of early detection of overweight and obesity in children. Furthermore, we underline the importance of tailored approaches targeting high risk groups (children of low educated parents, and children of non-Dutch origin) in the battle against overweight and obesity. Future growth studies are needed to evaluate the effect of prevention and intervention strategies on national prevalence rates of overweight, obesity and morbid obesity, and on the overweight morbidity index. Such studies will also reveal if the Dutch will grow any taller, and if those of Turkish and Moroccan origin will approach the height of the Dutch more, and at what rate. Finally, we discuss options for future growth studies.

SAMENVATTING

Het monitoren van groei geeft informatie over de gezondheidsstatus van een populatie. Bijvoorbeeld over de prevalentie van overgewicht en obesitas, of de gemiddelde lengte. Op individueel niveau wordt groeimonitoring ingezet voor het opsporen van afwijkende groeipatronen bij kinderen, die kunnen wijzen op voedingsproblemen of onderliggende ziekte. In Nederland zijn landelijke groeistudies uitgevoerd in 1955, 1965, 1980 en 1997. Deze grote, landelijke studies maken het mogelijk om gegevens over de lengte en het gewicht van Nederlandse kinderen over de tijd te vergelijken. In 2009 is de Vijfde Landelijke Groeistudie uitgevoerd. Voor dit onderzoek zijn in 2008 en 2009 groeigegevens en achtergrondkenmerken verzameld van in Nederland wonende kinderen van 0 tot 21 jaar. De onderzoekspopulatie omvat de gegevens van 12.005 kinderen van Nederlandse afkomst, 2.594 van Turkse afkomst en 2.548 van Marokkaanse afkomst. In dit proefschrift worden de hoofdresultaten beschreven.

In Nederland is de gemiddelde lengte sinds 1858 geleidelijk toegenomen. Uit de groeistudie van 1997 bleek dat Nederlanders op dat moment de langste populatie ter wereld waren. Uit die studie werd ook duidelijk dat het tempo van de groei per generatie afnam. In **Hoofdstuk 2** hebben we nieuwe referentiewaarden berekend voor lengte-naar-leeftijd. Ook hebben we gekeken naar de trend in lengte bij kinderen van Nederlandse afkomst. We vonden dat de stijgende trend in lengte na 150 jaar was gestagneerd. Op de leeftijd van 21 jaar was de gemiddelde lengte van jongens 183,8 cm en van meisjes 170,7 cm. Kinderen met een hogere opleiding, of met ouders met een hoger opleidingsniveau, waren langer dan kinderen met een lagere opleiding, of met ouders met een lager opleidingsniveau. Het verschil in gemiddelde lengte tussen geografische regio's was kleiner geworden, maar nog niet compleet verdwenen: kinderen in het noorden van Nederland waren nog steeds iets langer dan kinderen in het zuiden. Het is niet volledig duidelijk waardoor de trend in lengtegroei van kinderen van Nederlandse afkomst na 150 jaar is gestagneerd. Mogelijk heeft de Nederlandse bevolking de optimale verdeling van lengte voor een populatie bereikt. Een andere verklaring kan zijn dat de omgevingsfactoren die de afgelopen decennia zorgden voor de lengtetoename gestabiliseerd zijn sinds 1997, waardoor de populatie zijn groeipotentieel niet volledig kan benutten.

In de groeistudie van 1997 werden gegevens over de groei van kinderen van Turkse en Marokkaanse afkomst verzameld. Adolescenten van Turkse en Marokkaanse afkomst waren negen tot tien centimeter kleiner dan hun leeftijdsgenoten van Nederlandse afkomst. In **Hoofdstuk 3** onderzochten we de lengte in kinderen van Turkse en Marokkaanse afkomst in 2009. We vonden dat de gemiddelde lengte van deze kinderen steeg, terwijl de lengte van kinderen van Nederlandse afkomst stagneerde. Op de

leeftijd van 18 jaar waren Turkse en Marokkaanse jongens gemiddeld 177 cm, en meisjes 163 cm. Dit was een toename van 2 tot 3 cm sinds 1997, maar zij waren nog steeds 5 tot 7 cm korter dan hun Nederlandse leeftijdsgenoten. We vonden geen verschillen in lengte per opleidingsniveau, geografische regio, taal die thuis werd gesproken, of generatie. In verband met de toegenomen lengte sinds 1997 zijn de groeicurven voor kinderen van Turkse en Marokkaanse afkomst geüpdatet. Wij adviseren het gebruik van deze nieuwe groeicurven voor kinderen van Turkse en Marokkaanse afkomst indien zij een lengte-voor-leeftijd hebben die kleiner is dan -2 standaarddeviaties op de reguliere Nederlandse groeicurve.

Uit de groeistudie van 1997 bleek dat de prevalenties van overgewicht en obesitas bij kinderen sterk waren gestegen tussen 1980 en 1997. De hoogste prevalenties werden gevonden in de grote steden. Sindsdien zijn er veel pogingen ondernomen om de prevalentie van overgewicht en obesitas bij kinderen te verlagen. Deze interventies waren vooral gericht op de grote steden. In **Hoofdstuk 4** werden de prevalenties voor overgewicht en obesitas bij kinderen van Nederlandse afkomst gepresenteerd. In 2009 had 12,8% van de Nederlandse jongens en 14,8% van de Nederlandse meisjes in de leeftijd van 2 tot 21 jaar overgewicht. Van de jongens was 1,8% obees, bij meisjes was dit 2,2%. Dit was een twee- tot driemaal hogere prevalentie voor overgewicht en een vier- tot zesvoudige toename van obesitas sinds 1980. Net als in 1997 was de body mass index (BMI) omgekeerd gerelateerd aan het opleidingsniveau van de ouders. De gemiddelde standaarddeviatiescore van de BMI was toegenomen in alle regio's sinds 1997, met uitzondering van de grote steden. Dit kan een teken zijn dat de stijgende trend in overgewicht in Nederland begint te keren.

In 1997 werden alarmerende prevalenties van overgewicht en obesitas bij kinderen van Turkse en Marokkaanse afkomst gevonden. Deze waren twee- tot bijna driemaal zo hoog als bij kinderen van Nederlandse afkomst. In **Hoofdstuk 5** presenteerden we de prevalentie van overgewicht en obesitas bij kinderen van Turkse en Marokkaanse afkomst in 2009. In 2009 had 31,9% van de Turkse en 26,6% van de Marokkaanse kinderen overgewicht. Al op de leeftijd van twee jaar werden prevalenties van boven de twintig procent gevonden voor overgewicht. De prevalentie van obesitas lag vanaf de leeftijd van drie jaar boven de vier procent. We vroegen ook naar ongezonde leefstijl-gerelateerde op de dag voor de metingen. We vonden hoge (≥25%) prevalenties voor het drinken van twee of meer glazen zoete drank (44-74%) en minder dan een uur lichaamsbeweging (29-65%) bij alle kinderen, geen fruit eten (29-45%) en twee of meer uur TV/PC kijken (35-72%) bij alle Turkse en Marokkaanse adolescenten (15-18 jaar), niet ontbijten (26-49%) bij Turkse en Marokkaanse adolescente meisjes, en niet lopen of fietsen naar het kinderdagverblijf bij peuters (2-4 jaar) (28-56%) of naar school

bij adolescenten (34-94%). Deze resultaten vragen om vroege preventie met aandacht voor specifieke leefstijl-gerelateerde gedragingen.

Obesitas is een belangrijke vermijdbare oorzaak van chronische ziekte en mortaliteit. Het Gezondheidsrisico neemt toe bij een hogere BMI. Daarom is obesitas voor volwassenen onderverdeeld in drie klassen: klasse I (30,0-34,9 kg/m^2), klasse II (35,0-39,9 kg/m^2) en III (≥40,0 kg/m^2). Sinds 2012 zijn er internationale afkapwaarden voor klasse II en klasse III obesitas bij kinderen beschikbaar. In **Hoofdstuk 6** bestudeerden we de trend in morbide obesitas (klasse II en klasse III gecombineerd) bij kinderen van Nederlandse afkomst sinds 1980, en bij kinderen van Turkse en Marokkaanse afkomst sinds 1997. In 2009 was de prevalentie van morbide obesitas bij kinderen van Nederlandse afkomst 0,59% bij jongens en 0,53% bij meisjes. Er waren significante opwaartse trends sinds 1980 en 1997. De prevalentie was drie tot vier keer hoger. Bij kinderen van Turkse afkomst en bij kinderen van Marokkaanse afkomst twee- tot driemaal hoger in vergelijking met kinderen van Nederlandse afkomst. Bij kinderen van Turkse afkomst lagen de prevalenties in 2009 hoger dan in 1997. We introduceerden de morbiditeit index, berekend als de prevalentie van morbide obesitas gedeeld door de prevalentie van overgewicht. De waarde van deze index steeg bij kinderen van Nederlandse afkomst (sinds 1980) en Turkse afkomst (sinds 1997), en daalde bij kinderen van Marokkaanse afkomst (sinds 1997). Morbide obesitas kwam het meest voor bij kinderen van laag opgeleide ouders.

Hoewel kinderen zowel aan de bovenkant als aan de onderkant van de BMI-verdeling een verhoogd gezondheidsrisico hebben, is er relatief weinig bekend over de ontwikkeling van de prevalentie van ondergewicht in ontwikkelde landen met de tijd. In 2007 werden internationale afkapwaarden voor ondergewicht bij kinderen gepubliceerd, met categorieën die overeenkomen met de volgende BMI-ranges op de leeftijd van 18 jaar: graad I (17,0-18,5 kg/m^2), graad II (16,0-17,0 kg/m^2) en graad III (<16,0 kg/m^2). In **Hoofdstuk 7** bestudeerden we trends in ondergewicht bij kinderen en beoordeelden we verandering in de BMI-verdeling sinds 1980. We vonden een aanzienlijke daling in de prevalentie van ondergewicht (alle categorieën samen) bij kinderen van Nederlandse afkomst, van 14,0% in 1980 naar 9,8% in 2009. Echter, de prevalentie van ondergewicht graad III bleef constant. Ondergewicht bij kinderen van Marokkaanse afkomst was gedaald van 8,8% in 1997 naar 6,2% in 2009. Er werd geen trend waargenomen bij kinderen van Turkse afkomst (5,4% in 1997, 5,7% in 2009). Ondergewicht kwamen het meest voor bij kinderen van twee tot vijf jaar. Er waren geen significante verschillen tussen jongens en meisjes. We concludeerden dat de BMI-verdeling is verbreed sinds 1980, voornamelijk als gevolg van een opwaartse verschuiving van de bovenste centielen van de BMI-verdeling.

Hoofdstuk 8 geeft een korte samenvatting van de resultaten van dit proefschrift. Tevens wordt daarin het gebruik van groeidiagrammen in de dagelijkse praktijk besproken en het belang van vroege signalering van overgewicht en obesitas in kinderen benadrukt. Ook wordt het belang onderstreept van een aanpak specifiek gericht op hoog-risico groepen (kinderen van laag opgeleide ouders, en kinderen van niet-Nederlandse afkomst) in de strijd tegen overgewicht en obesitas. Toekomstige groeistudies zijn nodig om het effect van preventie- en interventiestrategieën op de nationale prevalentie van overgewicht, obesitas en morbide obesitas te evalueren. Daarnaast zal uit dergelijke studies blijken of kinderen van Nederlandse afkomst in de toekomst nog langer worden. Ook zal daaruit duidelijk worden of de lengte van kinderen van Turkse en Marokkaanse afkomst de lengte van kinderen van Nederlandse afkomst verder zal naderen, en in welk tempo. Tot slot bespreken we mogelijkheden voor toekomstige groeistudies.

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Standing on the shoulders of giants... (Isaac Newton)

CURRICULUM VITAE

Yvonne Schönbeck was born on November 15th 1978 in Rhenen, The Netherlands. She attended primary school at De Klimop in Veenendaal and secondary school at Pallas Athene College in Ede. In 1997, she graduated and went abroad for a year of travelling. In 1998, she started her studies in Biomedical Health Sciences at the Radboud University in Nijmegen, The Netherlands. She graduated with a degree in Epidemiology, with a focus on Mother & Child Care. Her three internships resulted in one national and three international peer-reviewed publications. After her studies, she became a junior researcher at the Julius Center for Health Sciences and Primary Care in Utrecht, The Netherlands, where she set up a randomized controlled trial on the effectiveness of influenza and pneumococcal vaccinations in young children with recurrent respiratory tract infections. In 2005, she started working as a research scientist at TNO Child Health in Leiden, The Netherlands, where she participated in research projects mainly concerning Midwifery, Mother & Child Care, and Youth Health Care. Among others things, she was involved in the development of a decision tool for prenatal screening for Down Syndrome, the development of a multidisciplinary guideline for breastfeeding, the monitoring of several national neonatal screening programs, and the (co-)writing of multiple national and international scientific publications. Between 2007 and 2010, she worked full time on the preparations, data collection and analyses for the Fifth Dutch Growth study, which would form the basis of this PhD thesis. The project resulted in new growth diagrams for the Dutch Youth Health Care System in 2010. After finishing the Fifth Dutch Growth Study, there was time again to work on multiple projects simultaneously and finalizing her PhD thesis. Besides research, she performs internal quality audits at TNO, and is project leader on several national and international projects in the field of child health.