Trends in body mass index distribution and prevalence of thinness, overweight and obesity in two cohorts of Surinamese South Asian children in The Netherlands

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▸ Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/archdischild-2012-303045).

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Received 18 September 2012
Revised 9 January 2013
Accepted 10 January 2013
Published Online First 31 January 2013

To cite: de Wilde JA, Zandbergen-Harlaar S, van Buuren S, *et al*. *Arch Dis Child* 2013;**98**:280–285.

ABSTRACT

Objectives Asians have a smaller muscle mass and a larger fat mass at the same body mass index (BMI) than most other ethnic groups. Due to a resulting higher cardiometabolic risk, the BMI cut-offs for overweight and obesity were lowered for adults. For Asian children universal criteria apply. The objectives of this study were to determine the normal BMI distribution and assess the BMI class distribution in a reference cohort of affluent South Asian children born before the obesity epidemic and to assess the influence of the obesity epidemic on the distributions.

Methods Historical cohort study with 4350 measurements of height and weight of two cohorts (born 1974–1976 and 1991–1993) of Surinamese South Asian children living in The Netherlands, analysed with WHO Child Growth References and International Obesity Task Force (IOTF) BMI cut-offs.

Results The reference cohort 1974–1976 was significantly lighter (BMI Z-score=−0.63; 95% CI −0.69 to −0.58) and more variable (SD=1.19) than WHO reference. Total thinness prevalence was exceptionally high, both in cohort 1974–1976 (WHO 38.3%; IOTF 36.4%) and 1991–1993 (WHO 23.6%; IOTF 23.9%). Overweight and obesity prevalences were low in the reference cohort (WHO respectively 6.0% and 2.1%; IOTF 5.3%, 0.9%), but much higher in cohort 1991–1993 (WHO 13.6%, 9.1%; IOTF 11.7%, 6.0%).

Conclusions The low mean BMI Z-score and high prevalence of thinness are likely expressions of the characteristic body composition of South Asians. Universal BMI cut-offs should be applied carefully in South Asian populations as thinness prevalence is likely to be overestimated and obesity underestimated. The development of ethnic specific cut-offs is recommended.

What is already known on this topic

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

What this study adds

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

INTRODUCTION

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

The nutritional status of children and adults is generally assessed with the body mass index (BMI) as an indirect measure of body fat. To assess health risks associated with low or high percentages of body fat, universal BMI cut-off values, suitable for all ethnic groups, were recommended by WHO.[6 7] During the past decades increasing evidence has shown that South Asian populations are predisposed to a lower BMI because of a typical 'thin-fat' body composition, comprising of a smaller lean body mass but larger fat stores at equivalent BMI levels compared with other ethnic groups.[8–10] In differing degrees most Asian subpopulations display this body composition and consequently cardiometabolic risks for these groups are higher at lower BMI levels.[9 11] For this reason WHO has recommended lowering the BMI cut-off values for overweight and obesity for all Asian adults, respectively, from 25 to 23 kg/m^2 and from 30 to 27.5 kg/m^2.[12]

Even though South Asian children and adolescents have a similar body composition to adults, with comparable increased cardiometabolic risks,[8 13–15] BMI cut-offs for South Asian children have not been lowered. Considering the differences in body composition between ethnic groups, the BMI distribution in a healthy population of South Asian children, unaffected by the obesity epidemic, is expected to be shifted to the left, relative to the BMI distribution of a universal reference population. However, knowledge about the normal BMI and BMI class distribution in such a population is currently lacking, but may support the decision to establish BMI criteria specific for South Asian children.

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

METHODS

Subjects and data collection

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

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

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

Inclusion criteria

All available medical records were checked for the presence of any disorder or medicine use that could have affected growth, such as thyroid disease, diabetes, coeliac disease, cerebral palsy, scoliosis, congenital heart disease, prolonged use (>1 year) of oral corticosteroids and treatment for short stature. If present, these records were excluded from the analyses. Furthermore, only singleton children with a gestational age of ≥37 weeks were included in the study as multiple birth and preterm birth may have a long-lasting influence on childhood growth.[19–21]

Anthropometric measurements

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

WHO Child Growth Standard (for ages 0–4 years)[22] and Reference (5–19 years),[7] further referred to as WHO, were applied to calculate BMI Z-scores of each measurement. A Z-score of −2, −1, +1 and +2 SD at 18 years of age corresponds respectively to a BMI of 17.3, 19.2, 24.9 and 29.2 kg/m^2 in boys and 16.4, 18.6, 24.8 and 29.5 kg/m^2 in girls. As cut-offs to determine the BMI class we used a value of <−2 SD for severe thinness, ≥−2 SD and <−1 SD for thinness, ≥+1 SD and <+2 SD for overweight and ≥+2 SD for obesity.

BMI class was also determined by using a second set of sex and age specific BMI cut-off values for ages 2–18 years that were constructed to pass the adult BMI cut-offs at age 18 for severe thinness (<17 kg/m^2), thinness (≥17 and <18.5 kg/m^2), overweight (≥25 and <30 kg/m^2) and obesity (≥30 kg/m^2).[23 24] The cut-offs for overweight and obesity were adopted by the International Obesity Task Force (IOTF) and are often named IOTF cut-offs. In this paper, we will use the term IOTF to designate the whole set of BMI criteria.

Statistical analyses

Continuous variables are reported as means with 95% CI, and categorical variables as percentages and number of observations. Differences in the distribution of the study characteristics between the two cohorts were tested with either the independent-samples t test for continuous variables or the χ^2 test for categorical variables. Unequal variance and equal variance t tests were used to examine differences in BMI Z-scores between cohort 1974–1976 and cohort 1991–1993. Differences in prevalence of severe thinness, thinness, overweight and obesity between both cohorts were analysed in strata according to age group (3–5, 6–8 and 13–15 years). For analyses of differences in prevalence of BMI classes between groups, BMI classes were dichotomised into severe thinness and not severe thinness, thinness and not thinness, overweight and not overweight, and obesity and not obesity. The resulting variables were analysed with logistic regression analyses with cohort as an independent variable. As age groups were unequally distributed between the cohorts and as age shows an almost linear relationship with the outcome variable, age was added to the model as continuous variable. Other confounding factors, such as country of birth (Surinam, The Netherlands, other and unknown) and sex, were also included in the adjusted model as categorical variables.

A p value <0.05 (two-sided) was considered statistically significant. All statistical analyses were conducted with IBM SPSS Statistics, V.20.

RESULTS

A total of 2015 children with 4350 height and weight measurements were included in the study (figure 1). The main difference between the two cohorts was that most children of cohort 1991–1993 were born in The Netherlands (90.5%), compared with just 35.7% of cohort 1974–1976 (table 1). Furthermore,

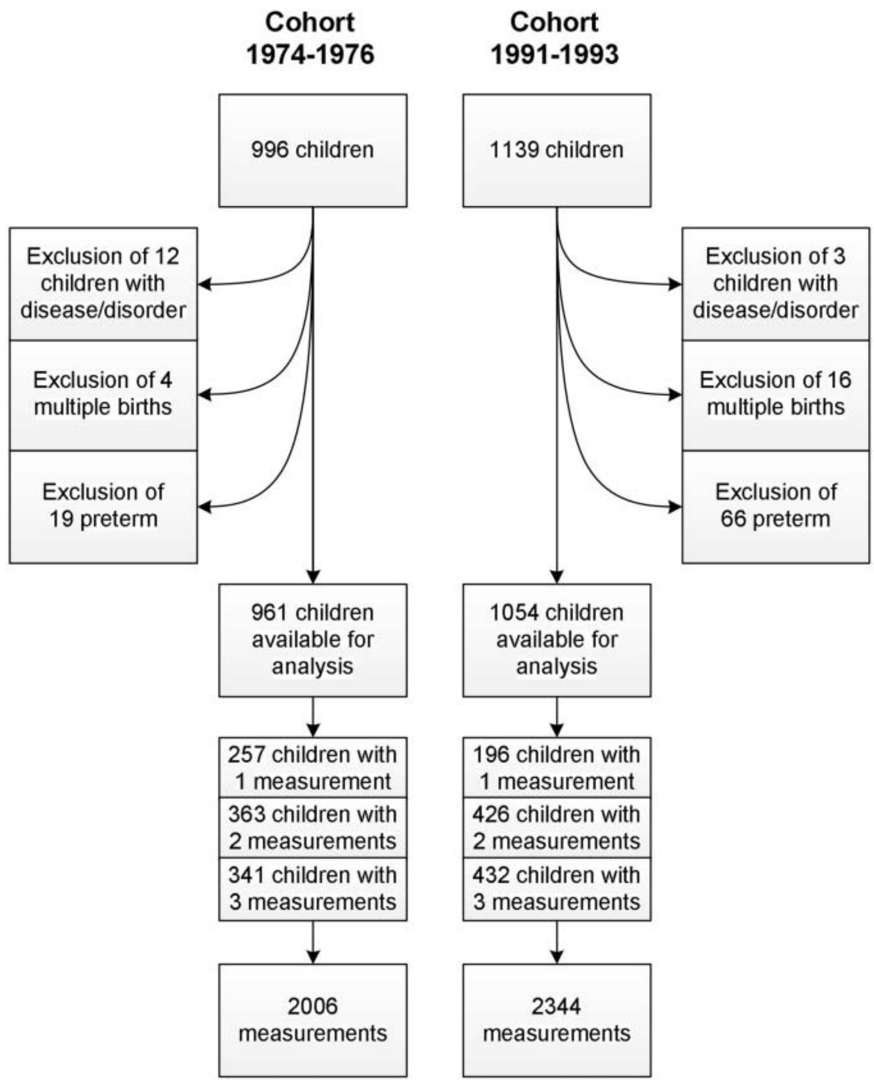

Figure 1 Selection procedure of cohort 1974–1976 and cohort 1991–1993.

cohort 1991–1993 had more measurements at ages 3–5 and 13–15 years.

Compared with the normal distribution of WHO, cohort 1974–1976 had a lower mean BMI Z-score (mean=−0.63; 95% CI −0.69 to −0.58), was more variable (SD=1.19) and was slightly positively skewed (figure 2, and see additional online supplementary data). The mean BMI Z-score of cohort 1991–1993 was similar to that of WHO distribution (mean=0.01; 95% CI −0.05 to 0.06), but the variability was even larger (SD=1.37) than in cohort 1974–1976 and the

Table 1 Population characteristics of cohort 1974–1976 and cohort 1991–1993

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

*p<0.001.

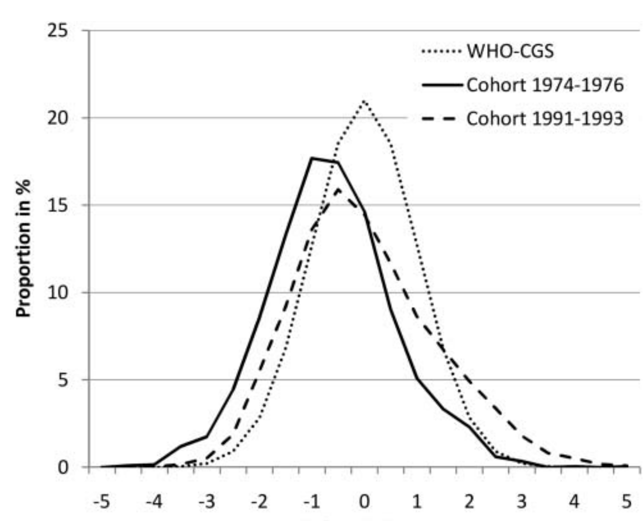

Figure 2 Body mass index (BMI) Z-Score distribution of ages 3–15 years of cohort 1974–1976 and cohort 1991–1993, compared with the distribution of WHO Child Growth Standard and Reference.

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

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

*p<0.05.
**p<0.01.
***p<0.001.
BMI, body mass index.

distribution was more positively skewed. As the left side of the cohort 1991–1993 curve was still shifted to the left, relative to WHO, it indicates there were more children with a lower BMI. In addition, the large tail to the right indicates a large proportion of children with a higher than average BMI.

The calculated BMI class prevalences based on both sets of BMI cut-offs confirmed these findings (tables 2 and 3). Although there were some discrepancies between the prevalences calculated with WHO and IOTF the distributional patterns were largely similar.

Cohort 1974–1976 generally showed a high overall prevalence of severe thinness and thinness with combined prevalence rates of 38.3% (WHO) and 36.4% (IOTF). Especially in the youngest age group 3–5 years total thinness (including severe thinness) rates were high (WHO 39.6%; IOTF 45.7%) while overweight and obesity rates were very low. Cohort 1991–1993 had a similarly high total thinness prevalence at ages 3–5 years, but the rates decreased rapidly with age, while overweight and obesity prevalence increased at the same time. The overall combined overweight and obesity prevalence in cohort 1991–1993 was with 22.7% (WHO) and 17.7% (IOTF) more than twice that of cohort 1974–1976. Where overweight rates had doubled compared with cohort 1974–1976, obesity rates had increased fourfold to sixfold.

DISCUSSION

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

In India, the prevalence of thinness/undernutrition is still the highest in the world,[5] despite generally better socio-economic circumstances and lower poverty levels than in many other developing countries, a situation that has been called the 'South Asian enigma'.[25] A recent Indian study found a total thinness prevalence, based on the IOTF criteria, of around 70% in rural Indian schoolchildren 5–12 years of age.[26] Caucasian children in The Netherlands aged 2–18 years had in 1980 a prevalence of severe thinness and thinness of 1.5%–2.9% and 11.4%–12.1%, respectively, figures that had only slightly changed in 1997[27] and that are much lower than in both cohorts. On the other hand, the doubling of the overweight prevalence in Dutch Caucasian children between 1980 and 1997[28] parallels the increase seen in our study between cohort 1974–1976 and cohort 1991–1993, whereas the increases in obesity were much larger in Surinamese South Asian children.

Rates of overweight and obesity in contemporary 14–17-year-old children living in affluent urban areas in India are with 16.0% and 5.0% similar to those found in 13–15-year-old Surinamese South Asian children of cohort 1991–1993.[3] Recent studies of Indian adolescents in the UK generally found higher rates of overweight and obesity than in cohort 1991–1993 of our study.[29 30]

Table 3 Body mass index (BMI) class prevalences (%) based on BMI cut-offs of International Obesity Task Force per age group of cohort 1974–1976 and cohort 1991–1993, with unadjusted and adjusted (for sex, age and child's country of birth) OR (between cohort effect) and 95% CI

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

*p<0.05.
**p<0.01.
***p<0.001.

Implications for clinical practice

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

Therefore, without ethnic specific cut-off values for the determination of thinness, overweight and obesity in South Asian children, a proper nutritional assessment will remain difficult.

Several recent studies have proposed lowered BMI cut-offs to determine overweight and obesity in South Asian children,[32–34] but consensus has not been reached over which set of BMI cut-offs is most suitable, perhaps because of the different designs and limitations of the studies. Although we encourage the development of ethnic specific BMI cut-offs for thinness, overweight and obesity for South Asian children aged 2–18 years, we would recommend these to be developed with the state-of-the-art methods that were used to establish the WHO reference and IOTF cut-offs.[7 23] Even though these BMI criteria are purely statistically defined, and therefore more or less arbitrary, there are presently few available alternatives. A set of South Asian specific cut-offs derived in this manner would complement the existing sets of BMI criteria of WHO and IOTF and make them more comparable. Nevertheless, strong evidence based research relating the defined BMI cut-offs with actual health outcomes during childhood (or even adulthood) remains highly needed.

Strengths and limitations

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

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

CONCLUSIONS

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

Acknowledgements We would like to thank Ron Smit for his help with extracting the data from the electronic record system. We also want to thank Lisa Steenhauer for proofreading the paper.

Funding None.

Contributors JdW and BJCM conceived and designed the study. SZH and JdW conducted the analyses and wrote the first draft of the article. JdW, SZH, SVB and BJCM made significant contributions to the interpretation of the data and revising the article, and have approved the final version for submission.

Competing interests None.

Provenance and review Not commissioned; externally peer reviewed.

REFERENCES

1 Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006;1:11–25.
2 de Onis M, Blossner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. *Am J Clin Nutr* 2010;92:1257–64.
3 Khadilkar VV, Khadilkar AV, Cole TJ, *et al*. Overweight and obesity prevalence and body mass index trends in Indian children. *Int J Pediatr Obes* 2011;6:e216–24.
4 Jafar TH, Qadri Z, Islam M, *et al*. Rise in childhood obesity with persistently high rates of undernutrition among urban school-aged Indo-Asian children. *Arch Dis Child* 2008;93:373–8.
5 6th report on the world nutrition situation. Geneva: United Nations Standing Committee on Nutrition 2009. http://www.unscn.org/files/Publications/RWNS6/report/SCN_report.pdf (accessed 2 May 2012).
6 WHO Expert Committee. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995;854:1–452.
7 de Onis M, Onyango AW, Borghi E, *et al*. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007;85:660–7.
8 Yajnik CS, Lubree HG, Rege SS, *et al*. Adiposity and hyperinsulinemia in Indians are present at birth. *J Clin Endocrinol Metab* 2002;87:5575–80.
9 Deurenberg-Yap M, Chew SK, Deurenberg P. Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. *Obes Rev* 2002;3:209–15.
10 Wickramasinghe VP. Hattori chart based evaluation of body composition and its relation to body mass index in a group of Sri Lankan children. *Indian J Pediatr* 20112002;79:632–9.
11 Lear SA, Kohli S, Bondy GP, *et al*. Ethnic variation in fat and lean body mass and the association with insulin resistance. *J Clin Endocrinol Metab* 2009;94:4696–702.
12 WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004;363:157–63.
13 Ehtisham S, Crabtree N, Clark P, *et al*. Ethnic differences in insulin resistance and body composition in UK adolescents. *J Clin Endocrinol Metab* 2005;90:3963–9.
14 Jafar TH, Islam M, Poulter N, *et al*. Children in South Asia have higher body mass-adjusted blood pressure levels than white children in the USA: a comparative study. *Circulation* 2005;111:1291–7.
15 Whincup PH, Gilg JA, Papacosta O, *et al*. Early evidence of ethnic differences in cardiovascular risk: cross sectional comparison of British South Asian and white children. *BMJ* 2002;324:635.
16 Den Haag in cijfers—Bevolkingsgegevens gemeente Den Haag. Municipality of The Hague 2012. http://denhaag.buurtmonitor.nl/quickstep/QsPrintPresentation.aspx?sel_code=add919ed-e2a1–4aa4-a79a-b1ba8a59e64a (accessed 10 Nov 2012).
17 Hindoestanen. Wikipedia 2012. http://nl.wikipedia.org/wiki/Hindoestanen (accessed 10 Nov 2012).
18 Step-by-step plan RC review. The Hague: Central Committee on Research Involving Human Subjects (CCMO), 2012. http://www.ccmo-online.nl/main.asp?pid=10&sid=30&ssid=51 (accessed 10 Nov 2012).
19 Euser AM, de Wit CC, Finken MJ, *et al*. Growth of preterm born children. *Horm Res* 2008;70:319–28.
20 Luke B, Leurgans S, Keith L, *et al*. The childhood growth of twin children. *Acta Genet Med Gemellol (Roma)* 1995;44:169–78.
21 van Dommelen P, de Gunst M, van der Vaart A, *et al*. Growth references for height, weight and body mass index of twins aged 0–2.5 years. *Acta Paediatr* 2008;97:1099–104.
22 WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl* 2006;450:76–85.
23 Cole TJ, Bellizzi MC, Flegal KM, *et al*. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;320:1240–3.
24 Cole TJ, Flegal KM, Nicholls D, *et al*. Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* 2007;335:194.
25 Nube M. The Asian enigma: predisposition for low adult BMI among people of South Asian descent. *Public Health Nutr* 2009;12:507–16.
26 Mondal N, Sen J. Thinness is a major underlying problem among Indian children. *J Trop Pediatr* 2010;56:456–8.
27 van Buuren S. Body-mass index cut-off values for underweight in Dutch children. *Ned Tijdschr Geneeskd* 2004;148:1967–72.
28 Hirasing RA, Fredriks AM, van BS, *et al*. Increased prevalence of overweight and obesity in Dutch children, and the detection of overweight and obesity using international criteria and new reference diagrams. *Ned Tijdschr Geneeskd* 2001;145:1303–8.
29 Saxena S, Ambler G, Cole TJ, *et al*. Ethnic group differences in overweight and obese children and young people in England: cross sectional survey. *Arch Dis Child* 2004;89:30–6.
30 Taylor SJ, Viner R, Booy R, *et al*. Ethnicity, socio-economic status, overweight and underweight in East London adolescents. *Ethn Health* 2005;10:113–28.
31 Shaw NJ, Crabtree NJ, Kibirige MS, *et al*. Ethnic and gender differences in body fat in British schoolchildren as measured by DXA. *Arch Dis Child* 2007;92:872–5.
32 Duncan JS, Duncan EK, Schofield G. Ethnic-specific body mass index cut-off points for overweight and obesity in girls. *N Z Med J* 2010;123:22–9.
33 Khadilkar VV, Khadilkar AV, Borade AB, *et al*. Body mass index cut-offs for screening for childhood overweight and obesity in Indian children. *Indian Pediatr* 2012;49:29–34.
34 Wickramasinghe VP, Lamabadusuriya SP, Cleghorn GJ, *et al*. Defining anthropometric cut-off levels related to metabolic risk in a group of Sri Lankan children. *Ann Hum Biol* 2011;38:537–43.

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Arch Dis Child 2013 98: 280-285 originally published online January 31, 2013
doi: 10.1136/archdischild-2012-303045