International Journal of Obesity (2003) 27, 1121–1126

0307-0565/03 $25.00
www.nature.com/ijo

PAPER

Screening for childhood obesity: international *vs* population-specific definitions. Which is more appropriate?

WPC Fu[1]*, HC Lee[1], CJ Ng[1], Y-KD Tay[1], CY Kau[1], CJ Seow[1], JK Siak[1] and CY Hong[2]

[1]*Faculty of Medicine, National University of Singapore, Singapore; and* [2]*Department of Community, Occupational and Family Medicine, National University of Singapore, Singapore*

AIM: The objectives of this study are: (1) to study the relation between body mass index (BMI), percentage-weight-for-height (PWH) and percentage body fat (PBF) in Singaporean Chinese children; (2) to assess the applicability of an international definition of obesity (the International Obesity Task Force (IOTF) BMI) as a screening tool to detect childhood obesity, as compared with the current Singapore population-specific definition using PWH.
METHODS: A total of 623 Chinese children aged 6–11 y (321 males, 302 females) were recruited from a school by proportionate (40%) stratified random sampling. BMI and PWH were calculated from weight and height, while PBF was derived using leg-to-leg bioelectrical impedance analysis. The strength of association among the three indices of obesity was assessed using Spearman's correlation coefficient. Obese children were defined as those above the 95th percentile of PBF in each age–gender-specific group. Sensitivity and specificity of IOTF-BMI cutoff values and PWH cutoff values were compared by testing their ability to correctly identify obese children.
RESULTS: All three indices correlated well with one another (BMI:PWH $r=0.83$, BMI:PBF $r=0.87$, PWH:PBF $r=0.76$). Prevalence of obesity was lower using IOTF-BMI cutoffs (6.9%) than using PWH cutoffs (16.4%). The sensitivity and specificity of IOTF-BMI cutoff values were 75.0 and 96.0%, respectively, with sensitivity differing between boys (83.3%) and girls (66.6%) ($P=0.35$). In comparison, PWH cutoff values had higher sensitivity (91.6%) but lower specificity (86.6%), with no significant difference between the genders.
CONCLUSION: IOTF-recommended BMI cutoff values had low sensitivity and may underestimate the local prevalence of childhood obesity. For screening purposes, we recommend that population-specific measures rather than international cutoff values be used.
International Journal of Obesity (2003) **27,** 1121–1126. doi:10.1038/sj.ijo.0802385

Keywords: childhood obesity; screening; IOTF; body mass index; population-specific

Introduction

Childhood obesity has become a worldwide epidemic with significant medical, psychosocial and economic consequences.[1,2] The prevalence of childhood obesity is increasing rapidly worldwide,[2] and there is mounting concern on the need for early prevention and treatment of childhood obesity. Obesity in childhood tends to persist into adulthood[3] and is associated with an increase in adult mortality and morbidity, including type II diabetes mellitus, cardiovascular, orthopaedic and respiratory disease.[1,2,4] Thus, the accurate identification of the obese child in health screening programmes for early intervention is of paramount importance.

There are many ways of measuring childhood obesity, but no commonly accepted standard has yet emerged.[5] Since obesity is, by definition, excess body fatness, it should ideally be defined on the basis of body fatness measure.[6] Reference methods of measurement such as dual-energy X-ray absorptiometry (DEXA) and hydrodensitometry require the use of sophisticated apparatus and techniques, which are beyond the scope of most clinical practice and impractical for use in epidemiological studies. A simple and less time-consuming

*Correspondence: WPC Fu, 73 Meyer Road, ♯10-03, Singapore 437898, Singapore.
E-mail: crosanz@singnet.com.sg
Received 9 November 2002; revised 24 March 2003; accepted 24 April 2003

method of measuring body composition is leg-to-leg bioelectrical impedance analysis (BIA). It has good correlation with DEXA[7] and has been validated for use in population-based studies to estimate body composition, from which percentage body fat (PBF) is then derived.[7,8]

Surrogate measures that calculate an excess of body weight to height are more commonly used in assessing childhood obesity. One such measure is percentage-weight-for-height (PWH), which measures an individual's weight as a function of his desirable weight. This method is based on population-specific reference values and has been used in Singapore for the screening of obesity in children since 1984 with 10-yearly revisions.[9] Another measure is the body mass index (BMI), a simple and convenient proxy measure of obesity that has been recommended for paediatric use.[10]

Recently, the International Obesity Task Force (IOTF), using data from six international countries, including Singapore, proposed age- and gender-specific BMI cutoff values for childhood overweight and obesity.[11] Currently, the IOTF-BMI cutoff values are recommended for use in international comparisons of obesity prevalence.[11] To our knowledge, only one study conducted in a Caucasian population has assessed the use of IOTF-BMI to define childhood obesity for clinical practice and epidemiology.[12] This study suggested that the IOTF-BMI cutoffs may be associated with low sensitivity, which can result in failure to identify the obese child. Little is known however about the applicability of the IOTF-BMI as a screening tool for Asian populations. Furthermore, the relation between BMI and body composition varies widely between populations,[13,14] and Asians have been found to have lower BMI compared to Caucasians for the same body fat content.[15,16] Hence, the use of international cutoff points to define obesity in different populations may not be appropriate.[13,14]

We therefore aim to explore the relation between BMI, PWH and PBF in Singaporean Chinese children, and to assess the applicability of the IOTF-BMI cutoff values as a screening tool for childhood obesity in Singapore, compared to the current population-specific cutoff values using PWH.

Methods

Subjects

Our study was conducted among 623 Chinese subjects (321 males and 302 females) aged 6–11 y. They were sampled from a study population of 1567 pupils in one primary school in Singapore, and satisfied the inclusion criteria of ethnic Chinese who were Singapore citizens or permanent residents. Proportionate stratification by academic level, being a good surrogate for age, was first applied, followed by random sampling by individual in each level. The sampling fraction was 40% (629 pupils), calculated from the anticipated population proportion of obesity of 16% ($\pm$3%), based on the prevalence rate in the school last year. The response rate was 100%. Two pupils were transferred out of the school before our study commenced and four pupils were excluded from analysis as they were more than 11 y old. This gave rise to the final 623 subjects.

Measurements

Anthropometric and body composition measurements were performed by trained investigators. Subjects had height measured to the nearest 0.1 cm using a metal measuring tape calibrated perpendicularly against a flat vertical wall by a spirit rule. All measurements were taken by a single investigator, using only one measuring tape. Correct posture of the subjects was ensured by maintaining the Frankfort plane and parallax error was reduced by using a set square to take the height from the same side (right) of all subjects.

The TANITA® Body Composition Analyser (TBF-300, TANITA, Tokyo, Japan), which incorporates both a weighing scale and a leg-to-leg bioelectrical impedance analyser, was used to measure weight (kg) and PBF to the nearest one decimal place. Subjects were dressed in light sports attire and had their bladders emptied first to minimize measurement errors. Age, gender and height were entered manually and both the soles of the subjects and the metal sole plates of the machine were cleaned with a dry cloth. The subjects were then asked to stand barefoot on the metal sole plates, with heels placed on the posterior plates and balls of the feet on the anterior plates. All had their hands by their sides and were facing forward when the readings were taken by the analyser. Body weight and PBF estimated using the standard built-in prediction equations for children were displayed by the machine and printed out.

BMI was calculated using the formula (weight in kg)/(height in m)^2 and obesity was defined using IOTF cutoff values determined by Cole *et al*[11] where it passed through a BMI of 30 kg/m^2 at age 18 y. PWH was calculated by expressing the measured body weight as a percentage of the mid-point of desirable weight for a child of that gender aged 6–18 y, as recommended in the weight-for-height reference tables used by the School Health Service of Singapore.[9,17] These reference tables, first devised in 1983, are updated 10-yearly — this current study is based on the 1993 growth charts for Singapore students aged 6–18 y.[17] Subjects were considered to be obese if their PWH measures were equal to or more than 120%.[9,17]

Definition of obesity

Obesity should ideally be assessed based on measurement of body fat. TANITA® analyser is convenient and validated in measuring body composition in children.[7,8,18] In our study, PBF was calculated from the built-in prediction equation in the TANITA® analyser, which was validated in a study involving Chinese children in Hong Kong aged 7–18 y.[8]

In our study, we define obese children as those above the 95th percentile of PBF for each age- and gender-specific group in our sample. Although this statistical definition is arguably arbitrary, it is a conventional cutoff point which is consistent with other practices in paediatrics,[19] and has been employed in previous studies carried out by Reilly *et al*.[12] In addition, other studies showed that the precise definition of excessive PBF did not influence final conclusions regarding the overall sensitivity and specificity of the obesity indices examined.[12,20]

Statistical analysis

The data collected were entered into Microsoft© Excel 2000 and checked for accuracy. Data analysis was made using the software Statistical Package for Social Sciences (SPSS) for Windows (version 11.0).

The strength of association among the different indices of obesity was assessed using Spearman's correlation coefficient. Age- and gender-specific prevalence rates of obesity were determined using both IOTF-BMI and local PWH cutoff values.

Simple linear regression was used to compare BMI against PBF for each age- and gender-specific group. The PBF value corresponding to each BMI cutoff value as defined by the IOTF was then derived from the regression equations. The same was repeated to derive PBF values corresponding to the PWH cutoff values for each age- and gender-specific group.

Age- and gender-specific 95th percentiles of PBF were calculated. The sensitivity and specificity of the IOTF-BMI cutoff values and the local PWH cutoff values for obesity were determined using the 95th percentiles of PBF as the reference standard. χ^2 tests were used to determine if there were significant differences in sensitivity and specificity between genders for each index. A *P*-value of <0.05 was considered statistically significant.

Results

Subject characteristics

Table 1 details physical characteristics of the subjects in this study. The number of boys and girls in the sample were comparable (321 boys, 302 girls). The overall mean height (boys 131.7 cm, girls 131.4 cm) and weight (boys 30.8 kg, girls 29.8 kg) were similar between boys and girls. Overall, while there was little difference in the mean PWH (boys 98.8%, girls 98.7%) between genders, boys had a higher mean BMI (boys 17.3 kg/m^2, girls 16.8 kg/m^2) as well as a higher mean PBF (boys 18.7%, girls 16.6%) than girls. The mean PBF was higher in boys than in girls from age 6 to 9 y. However, from age 10 to 11 y, girls had higher age-specific mean PBF than boys.

Correlation among the different indices of obesity

BMI, PWH and PBF correlated well with one another, with the strongest correlation between BMI and PBF ($r = 0.87$, $P < 0.01$). The correlation coefficient between PWH and PBF was 0.76 ($P < 0.01$), and that between BMI and PWH was 0.83 ($P < 0.01$). Compared to boys, girls showed better correlation between BMI and PBF (boys $r = 0.76$, girls $r = 0.97$), as well as between PWH and PBF (boys $r = 0.74$, girls $r = 0.78$). However, the correlation between BMI and PWH was better in boys ($r = 0.86$) than in girls ($r = 0.79$).

Prevalence rates of obesity

The prevalence rate (95% CI) of obesity in our sample was 16.4(13.5,19.3)% ($n = 102$) when PWH cutoff values were used, but was lower at 6.9(4.9,8.9)% ($n = 43$) when the IOTF-BMI cutoff values were used. Table 2 shows the age- and

Table 1 Mean (s.d.) values of height, weight, PWH, BMI and PBF values among 6–11 y old Singaporean Chinese children by age and gender

Age (y)	n	*Height (cm) Mean (s.d.)*	*Weight (kg) Mean (s.d.)*	*PWH (%) Mean (s.d.)*	*BMI (kg/m^2) Mean (s.d.)*	*PBF(%) Mean (s.d.)*
Boys						
6	55	118.9 (4.9)	22.4 (5.2)	99.5 (16.9)	15.8 (2.7)	16.7 (5.9)
7	58	123.8 (5.0)	25.3 (5.7)	99.1 (16.5)	16.4 (2.8)	18.1 (5.3)
8	58	129.4 (6.1)	27.8 (5.8)	96.2(16.1)	16.5 (2.7)	17.0 (5.5)
9	55	134.8 (5.2)	33.6 (8.5)	101.6 (19.8)	18.3 (3.7)	21.5 (8.4)
10	44	140.9 (6.0)	37.9 (10.2)	100.7 (21.2)	18.9 (4.3)	19.4 (7.0)
11	51	146.4 (8.4)	40.3 (9.2)	95.9 (15.6)	18.7 (3.1)	19.9 (6.8)
Total	321	131.7 (11.1)	30.8 (9.8)	98.8 (17.7)	17.3 (3.4)	18.7 (6.7)
Girls						
6	55	115.8 (4.3)	20.9 (3.9)	102.2 (15.5)	15.5 (2.3)	13.8 (5.7)
7	61	123.8 (5.4)	23.7 (4.2)	97.1 (12.8)	15.4 (2.0)	14.2 (4.7)
8	49	128.7 (5.7)	27.7 (6.1)	101.0 (18.5)	16.7 (3.0)	16.4 (6.5)
9	50	135.0 (5.9)	30.2 (6.2)	95.2 (14.3)	16.5 (2.5)	16.5 (5.9)
10	49	143.4 (8.5)	39.7 (12.1)	101.7 (21.7)	19.0 (4.2)	20.4 (8.5)
11	38	149.3 (7.2)	41.5 (9.6)	94.2 (17.5)	18.5 (3.4)	20.3 (7.0)
Total	302	131.4 (12.7)	29.8 (10.4)	98.7 (16.9)	16.8 (3.2)	16.6 (6.8)

PWH = percentage-weight-for-height; BMI = body mass index; PBF = percentage body fat estimated by BIA using TANITA® analyzer.

Table 2 Prevalence rates of obesity among 6–11 y old Singaporean Chinese children by age and gender

Age (y)	n	*Obese by PWH (%)*[a]	*Obese by BMI (%)*[b]
Boys			
6	55	12.7	7.3
7	58	20.7	10.3
8	58	15.5	5.2
9	55	27.3	14.5
10	44	20.5	13.6
11	51	11.8	3.9
Total	321	18.1	9.0
(95% CI)		(13.9,22.3)	(5.9,12.2)
Girls			
6	55	16.4	5.5
7	61	6.6	3.3
8	49	18.4	4.1
9	50	8.0	2.0
10	49	28.6	10.2
11	38	10.5	2.6
Total	302	14.6	4.6
(95% CI)		(10.6,18.5)	(2.3,6.9)

[a]Obese by PWH is defined as body weight ⩾120% of ideal body weight.
[b]Obese by BMI as defined by the IOTF cutoff values for obesity.

gender-specific prevalence rates of obesity. The prevalence rate of obesity was higher in boys than in girls whether IOTF-BMI (boys 9.0%, girls 4.6%) or PWH (boys 18.1%, girls 14.6%) cutoff values were used. Compared to the PWH cutoff values, the IOTF-BMI cutoff values gave lower prevalence rates across all age groups (6–11 y) in both boys and girls.

Corresponding PBF values

Figures 1 and 2 show the PBF values corresponding to the IOTF-BMI and PWH cutoff values for obesity, in boys and girls, respectively. The IOTF-BMI cutoff values gave higher corresponding PBF values across all age groups (6–11 y) in both boys and girls, compared to PWH cutoff values.

Sensitivity and specificity

Taking children in the top 5% of PBF distribution in each age- and gender-specific group as true positives, the overall sensitivity of the IOTF-BMI definition of obesity was 75.0%, while that of the local PWH definition was higher at 91.7%. On the other hand, the overall specificity of the IOTF-BMI definition of obesity was 95.8%, while that of the local PWH definition was lower at 86.6%.

Table 3 shows the sensitivity and specificity of the two definitions of obesity by gender. Using the IOTF-BMI definition of obesity, there was a lower ($P = 0.35$) sensitivity in girls (66.7%) than in boys (83.3%), with little difference ($P = 0.01$) in specificity between girls (97.9%) and boys (93.9%). In contrast, there were no significant ($P > 0.05$) differences in both sensitivity and specificity between girls and boys when the local PWH definition of obesity was used.

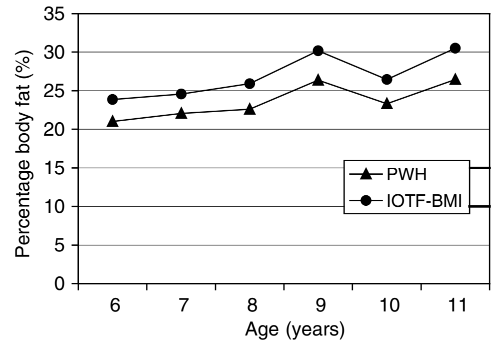

Figure 1

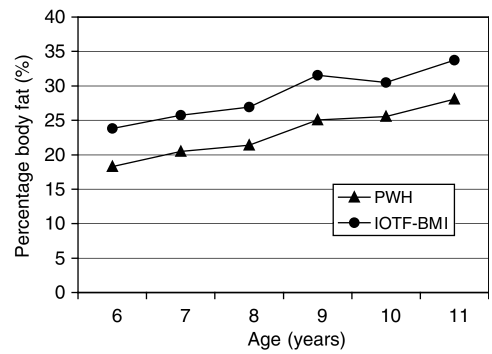

Figure 2

Table 3 Sensitivity and specificity of PWH and IOTF-BMI definitions of obesity

	n	*Sensitivity (%)*	*Specificity (%)*
PWH[a]			
Boys	321	91.7	84.8
Girls	302	91.7	88.6
Total	623	91.7	86.6
IOTF-BMI[b]			
Boys	321	83.3	93.9
Girls	302	66.7	97.9
Total	623	75.0	95.8

[a]Obese by PWH is defined as body weight ⩾120% of ideal body weight.
[b]Obese by BMI as defined by the IOTF cutoff values for obesity.

Discussion

The results of this community-based study showed that BMI and PWH are good indicators of body fatness in Singaporean Chinese children for both genders and across all ages and can be used to identify childhood obesity.

However, it was noted that PWH and IOTF-BMI cutoff values gave vastly different prevalence rates. Likewise, previous studies have shown that the prevalence rate of obesity is influenced by the reference data used and the obesity indicator adopted.[5,21] In our study, the prevalence rate of obesity using IOTF-BMI cutoff values was much lower at 6.9% than that for PWH at 16.4%. Other recent studies also reported a lower prevalence rate when using IOTF-BMI as compared to other definitions.[12,22,23]

Ideally, a screening tool should have both high sensitivity and specificity,[24] and these are important considerations in choosing the definition used for the detection of childhood obesity in population-based screening programmes. High sensitivity is necessary to avoid failure of identifying obese children, so that intervention and treatment can be instituted early, thus preventing the long-term consequences associated with childhood obesity.[1,4] On the other hand, high specificity of the screening tool ensures that nonobese children are not misclassified as obese, which may otherwise lead to unnecessary treatment and psychosocial implications of stigmatization.[19] While the latter concerns are not trivial, failure to identify the obese child may have more serious consequences than misclassification since it results in an increase in adult morbidity and mortality.[1,2,4] The low long-term success rate and high social cost associated with the treatment of diseases linked to childhood obesity, such as cardiovascular disease and type II diabetes mellitus,[25] support the need for early intervention and treatment of childhood obesity. Hence, high sensitivity may be a more important consideration than specificity in choosing an appropriate screening tool for childhood obesity.

Our study showed that while both IOTF-BMI and PWH had high specificity (95.8 and 86.6%, respectively), IOTF-BMI had much lower sensitivity (75.0%) than PWH (91.7%). This would explain the lower obesity prevalence rates obtained using IOTF-BMI as compared to PWH. To our knowledge, only one other study has investigated the sensitivity and specificity of the IOTF-BMI — they also found IOTF-BMI to have low sensitivity.[12] As such, an international definition such as the IOTF-BMI cutoff values may be unsuitable when used as a screening tool for childhood obesity in Singapore, since it potentially fails to adequately identify all obese children and substantially underestimates obesity prevalence. Population-specific measures such as the local PWH cutoff values, on the other hand, probably better reflect the true prevalence of obesity among Singapore children.

In addition to having high sensitivity, PWH cutoff values were also able to identify obese children with lower PBF. Our results showed that the PBF values corresponding to the PWH cutoffs were consistently lower than those corresponding to the IOTF-BMI cutoffs for both genders and across all ages. This is important in obesity screening as it allows clinicians and health promoters to address the growing problem of childhood obesity at an earlier stage, where intervention or treatment may reduce the potential long-term consequences.

There are other concerns about using international definitions for screening purposes. In deriving the international cutoff values for the IOTF-BMI,[11] the reference population used had taken into account major Western populations, but lacked adequate representation from Asia and other parts of the world. Although Singapore was represented in this study, the centile curve for Singapore showed a notably higher BMI, in both sexes aged 6–18 y, than that of all the other countries.[11] This may mean that the average of the centiles, used to derive the IOTF cutoffs, is not an accurate reflection of the Singapore paediatric population. Another concern in using the IOTF-BMI for screening purposes is that the relation between BMI and body composition varies widely between populations and ethnic groups.[13–16] This could partly account for the disparity we observed in obesity prevalence obtained using the IOTF-BMI as compared with PWH. While international cutoff points may be useful for the comparison of obesity prevalence in epidemiological studies, they may not be appropriate for assessing obesity in population-specific screening programmes.[13,14] As such, we find insufficient evidence to support the use of international definitions like IOTF-BMI, over the current practice of using local PWH cutoff values in the screening for childhood obesity in Singapore.

We acknowledge that there are certain limitations in our study. Firstly, PWH and BMI are intrinsically different in the way they identify obesity, and this may contribute to the disparity observed in the prevalence obtained using the two methods. However, we believe that the influence of this is small and that the large difference in sensitivity between the PWH and IOTF-BMI cutoffs is likely to be a more significant factor. Secondly, there is currently no established definition or level of childhood obesity that has been identified to reflect increased health risk.[5] While we cannot be certain that PWH specifically identifies obese children with lower health risks, it is the only population-specific standard for which reference values have been identified locally. Until such time when local population-specific cutoff values based on health risks are available, we recommend that the use of local PWH cutoff values for screening of childhood obesity in Singapore be continued.

Conclusion

This study showed that BMI and PWH correlate well with one another and are good indicators of body fatness in Singaporean Chinese children. However, IOTF-BMI cutoff values gave much lower obesity prevalence rates than PWH cutoff values. In addition, IOTF-BMI had much lower sensitivity compared to PWH in identifying obese children and thus potentially underestimates obesity prevalence. As such, its use as a screening tool for childhood obesity in Singapore is limited. Population-specific cutoff values may be more appropriate than international cutoff values for use in population-based screening programmes. We recommend that our current practice of using PWH cutoff values, derived from local population studies, be continued as part of the screening programme for obesity in Singaporean Chinese children. Future efforts should be targeted towards defining population- and ethnic-specific cutoff values for childhood obesity that are based on increased health risks.

Acknowledgements

The work described in this paper would not have been possible without the generosity and support of Mr Lee Chin Chuan, member of Hong Wen School's Management Committee 2000, the principal, Mr Ngoh Choon Ho, teachers, staff, pupils and parents of Hong Wen School. We are extremely grateful to all the members of our Community Health Project 2002 group, who have helped us immensely in collecting the information for this study. We thank A/Professor Ng Tze Pin, A/Professor Ho Ting Fei, Dr Lee Yung Seng, A/P Loke Kah Yin and S/N Betty Kek of the Department of Paediatrics, National University Hospital, for their invaluable guidance throughout our project. Our questions on percentage weight for height standards and age-adjusted body mass index were kindly addressed by Dr Uma Rajan, former director of the School Health Service, and Dr Tim J Cole, professor of medical statistics, Department of Epidemiology and Public Health, Institute of Child Health, London.

References

1 Must A, Strauss RS. Risks and consequences of childhood and adolescent obesity. *Int J Obes Relat Metab Disord* 1999; **23**: S2–S11.
2 Deckelbaum RJ, Williams CL. Childhood obesity: the health issue. *Obes Res* 2001; **9**: 239S–243S.
3 Guo SS, Roche AF, Chumlea WC, Gardner JD, Siervogel RM. The predictive value of childhood body mass index values for overweight at age 35 y. *Am J Clin Nutr* 1994; **59**: 810–819.
4 Freedman DS, Khan LK, Dietz WH, Srinivasan SR, Berenson GS. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa Heart Study. *Pediatrics* 2001; **108**: 712–718.
5 Guillaume M. Defining obesity in childhood: current practice. *Am J Clin Nutr* 1999; **70**: 126S–130S.
6 Reilly JJ. Assessment of body composition in infants and children. *Nutrition* 1998; **14**: 821–825.
7 Tyrrell VJ, Richards G, Hofman P, Gillies GF, Robinson E, Cutfield WS. Foot-to-foot bioelectrical impedance analysis: a valuable tool for the measurement of body composition in children. *Int J Obes Relat Metab Disord* 2001; **25**: 273–278.
8 Sung RY, Lau P, Yu CW, Lam PK, Nelson EA. Measurement of body fat using leg to leg bioimpedance. *Arch Dis Child* 2001; **85**: 263–267.
9 Ho TF. Eleventh Haridas memorial lecture. Childhood obesity in Singapore primary school children: epidemiological review and anthropometric evaluation. *J Singapore Paediatr Soc* 1985; **27**(Suppl 1): 5–40.
10 Dietz WH, Bellizzi MC. Introduction: the use of body mass index to assess obesity in children. *Am J Clin Nutr* 1999; **70**: 123S–125S.
11 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; **320**: 1–6.
12 Reilly JJ, Dorosty AR, Emmett PM, Avon. Longitudinal Study of Pregnancy and Childhood Study Team. Identification of the obese child: adequacy of the body mass index for clinical practice and epidemiology. *Int J Obes Relat Metab Disord* 2000; **24**: 1623–1627.
13 Deurenberg P, Deurenberg-Yap M. Differences in body-composition assumptions across ethnic groups: practical consequences. *Curr Opin Clin Nutr Metab Care* 2001; **4**: 377–383.
14 Deurenberg P. Universal cut-off BMI points for obesity are not appropriate. *Br J Nutr* 2001; **85**: 135–136.
15 Deurenberg-Yap M, Schmidt G, van Staveren WA, Deurenberg P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. *Int J Obes Relat Metab Disord* 2000; **24**: 1011–1017.
16 Ko GT, Tang J, Chan JC, Sung R, Wu MM, Wai HP, Chen R. Lower BMI cut-off value to define obesity in Hong Kong Chinese: an analysis based on body fat assessment by bioelectrical impedance. *Br J Nutr* 2001; **85**: 239–242.
17 School Health Services. School Health Service Report 1996.
18 Jebb SA, Cole TJ, Doman D, Murgatroyd PR, Prentice AM. Evaluation of the novel Tanita body-fat analyser to measure body composition by comparison with a four-compartment model. *Br J Nutr* 2000; **83**: 115–122.
19 Barlow SE, Dietz WH. Obesity evaluation and treatment: expert committee recommendations. *Paediatrics* 1998; **102**: e29.
20 Schaefer F, George M, Wuhl E, Scharer K. Body mass index and percentage fat mass in healthy German schoolchildren and adolescents. *Int J Obes Relat Metab Disord* 1998; **22**: 461–469.
21 Luciano A, Bressan F, Bolognani M, Castellarin A, Zoppi G. Childhood obesity: different definition criteria, different prevalence rate. *Minerva Pediatr* 2001; **53**: 537–541.
22 Kain J, Uauy R, Vio F, Albala C. Trends in overweight and obesity prevalence in Chilean children: comparison of three definitions. *Eur J Clin Nutr* 2002; **56**: 200–204.
23 Chinn S, Rona RJ. International definitions of overweight and obesity for children: a lasting solution? *Ann Hum Biol* 2002; **29**: 306–313.
24 Hennekens CH, Buring JE. *Epidemiology in medicine*. Boston, MA Little, Brown and Company, 1987.
25 Barba G, Giacco R, Clemente G, Venezia A, Russo P, Grimaldi C, Siani A. The BRAVO project: screening for childhood obesity in a primary school setting. *Nutr Metab Cardiovasc Dis* 2001; **11**: 103–108.