# PREVALENCE OF OBESITY AND BODY COMPOSITION IN HONG KONG SCHOOL CHILDREN

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The objective of this study was to determine the prevalence of obesity among Hong Kong school children and to identify differences in the percent of body fat as measured by skinfold and bioimpedance methods. A total of 1275 boys and 1153 girls aged 6–13 years from six Hong Kong primary schools were recruited. Weight, height and body composition, including skinfold, arm-to-leg bioimpedance (BIO), and leg-to-leg bioimpedance (TANITA), were measured for each participant. Pearson's correlation was calculated for the skinfold method and the two bioimpedance methods. ANOVA was used to determine the mean differences in skinfold and bioimpedance methods by age and gender. The prevalence of overweight and obesity was 12.8% and 3.6%, respectively. Overall, boys had higher proportions of overweight and obesity than girls. The correlation of skinfold and bioimpedance measurements on percent of body fat was high for all girls (coefficient $r$ ranging from 0.75 to 0.99, $p=0.05$ to $p<0.01$), and high for boys with normal weight ($r$ ranging from 0.53 to 0.79, $p=0.17$ to $p<0.01$), but low for overweight and obese boys ($r$ ranging from –0.02 to 0.22). The mean difference was significantly greater among younger age groups, except for the normal weight girls. Further investigation on why boys have a higher prevalence of overweight and obesity is warranted. More reliable measurement tools also need to be employed.

**Keywords:** bioelectrical impedance, body composition, children, obesity

## Introduction

Over the past 20 years, there has been a marked increase in the prevalence of overweight and obesity among children in Hong Kong, thought to be related in part to a fast-growing economy (Lee et al. 2000; Woo et al. 1999; Leung et al. 1998a; Janus 1997; Leung et al. 1996; Leung 1995; Leung et al. 1995a & b). Childhood obesity is recognized as a major public health problem in Hong Kong because obesity in early life is associated with several risk factors leading to coronary heart disease, diabetes, cancer, and other chronic diseases and conditions in adult life (Must & Struss 1999; Dietz 1998; Guldan et al. 1998; Bao et al. 1997; Whitaker et al. 1997). To better understand the patterns and trends of obesity in school children, researchers in Hong Kong have carried out several studies in the last decade.

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Most of these studies defined obesity through a weight-for-height ratio, with obesity defined as a ratio 120% greater than a local reference (e.g. a median of weight-for-height calculated from Hong Kong Children Growth data). The findings showed that the prevalence of obesity increased after the age of 5 years and peaked at age 11 years, with 11.3% for boys and 8.9% for girls aged 3–18 years and 13.4% for boys and 10.5% for girls between the ages of 6 and 18 years (Sung et al. 2001; Cole et al. 2000; Leung et al. 1998a; Leung 1995).

Using weight-for-height ratio to define obesity and overweight is problematic because the reference can change with the population median, so comparisons over time and across populations are not consistent. If the population weight increases over time, the prevalence of obesity will be underestimated (Sung et al. 2001; Cole et al. 2000). To overcome these measurement limitations, two alternatives have received increasing attention from Hong Kong researchers: (1) using the International Obesity Task Force (IOTF) reference; and (2) using body composition to differentiate fat from fat-free weight (Cole et al. 2000; Wagner & Heyward 1999).

The IOTF reference for overweight and obesity in children has several advantages. These include that it is developed from sex-specific body mass index (BMI) age curves that pass through a BMI of 25 for overweight and 30 for obesity at age 18 years, that it is based on data from six countries (including Hong Kong), and that it allows comparison of study findings with those from adult populations as well as the same age groups across countries (Cole et al. 2000).

Body composition is a reliable alternative to define overweight and obesity, especially among children, because of the static nature of height during childhood and varying ages and degrees of maturity (Deurenberg-Yap et al. 2000; Deurenberg et al. 1999; Gutierrez-Fisac et al. 1999; Rosner et al. 1998; Suprasongsin et al. 1995; Goran et al. 1993). Among the techniques available for body composition evaluation, bioelectrical impedance analysis (BIA) has the advantages of being portable, rapid, noninvasive, and with easy operating features when compared to the traditional method of skinfold measurement (Cable et al. 2001; Ellis 1996; Gutin et al. 1996; Houtkooper et al. 1996). Few studies in Hong Kong children, however, have body composition measured by BIA (Sung et al. 2001; Chan et al. 1998; Eston et al. 1993). None have compared the difference in body composition measured by the skinfold and bioimpedance methods among children who are normal weight, overweight, or obese.

The aims of the present study were to: (1) determine the prevalence of overweight and obesity in Hong Kong school children using the IOTF reference; and (2) identify the difference in the percent of body fat as measured by skinfold and bioimpedance among Hong Kong school children.

## Methods

### *Subjects*

A total of 2428 school children (1275 boys, 1153 girls), aged 6–13 years from six primary schools located in Kowloon and New Territories school districts in Hong Kong, China, were recruited to participate in the study. The participation rate was 90%. Study schools reflected the distribution of school types from rural and urban districts and the socioeconomic mix in the study population was largely representative of the local population.

### *Procedure*

The principals of six primary schools located in Kowloon and New Territories school districts agreed to participate. Written parental consent and verbal assent from the students were obtained for all participants. The consent form and protocol were approved by the internal research grant committee of The Hong Kong Institute of Education prior to the study.

A research team followed specific study guidelines to collect information at each school. Demographic information including weight, height, and four measures of body composition were collected between February and June of 1999. The measures of body composition included skinfold as well as three bioelectrical impedance devices, namely the arm-to-leg BIA system (BIO), leg-to-leg BIA system (TANITA), and hand-to-hand BIA system (OMRON). All the body composition data measured by skinfold and bioelectrical impedance devices were collected at the school within a 3-hour period on the same day. Measurements from the OMRON formula are not included in this analysis because the formula is problematic for children under 10 years of age.

Before data collection, all participants were instructed to avoid exercise for a minimum of 12 hours prior to testing and advised to be normally hydrated and in a post-absorptive state (at least 4 hours) before the testing time. All anthropometric measurements (weight, height, skinfold thickness) were performed by the same researcher, who had previously demonstrated a test–retest reliability of $R > 0.90$ for each site (triceps and subscapular).

***Measurement***

Body height was measured barefoot with a wall-mounted stadiometer to the nearest 0.1 cm. Body weight was measured to the nearest 0.1 kg in light indoor clothing, without shoes, using a digital scale (Seca, Hamburg, Germany). From weight and height, BMI was calculated as weight (kg) divided by height squared ($m^2$). Overweight and obesity status were determined by the IOTF reference. The mid-year value was used for each age group (e.g. 7.5 for the 7.0–8.0 age group) (Cole et al. 2000).

Triceps and subscapular skinfolds were measured in triplicate with a Harpenden skinfold caliper (Herefordshire, UK) to the nearest 0.2 mm, on the left side of the body (Lohman 1992). If the reading differed by more than 1 mm, another reading was taken and the mean was recorded. The triceps skinfold thickness was determined midway between the acromion and olecranon processes at the posterior surface of the left arm; the subscapular skinfold 1 cm caudally and medially to the right scapular angle. The two skinfold measurements were summed and the total was used in the prediction of percent of body fat (Lohman 1992).

Arm-to-leg BIA system (BIO), or total body resistance and reactance, was measured with a bioelectrical impedance analyzer (Biodynamics Body Composition Analyzer, Model BIA-310E, Seattle, Washington, USA), using a standardized protocol. Whole body impedance was measured at a fixed signal frequency of 50 kHz. Two signal introducing electrodes were placed just below the phalangeal-metacarpal joint in the middle of the dorsal side of the right hand and just below the transverse (metatarsal) arch on the superior side of the right foot. Two detecting electrodes were placed between the styloid processes of the radius and ulna and between the medial and lateral malleoli of the ankle. During the measurement, participants were supine with the legs apart so that their thighs were not touching. Two measures were taken per participant, with the average value being used in the analysis.

The leg-to-leg BIA system (TANITA) (Tanita Model TBF-531, Tanita Corp., Tokyo, Japan) utilizes metal foot pad electrodes. Subjects step on the device with bare feet, similar to a bathroom scale. Unlike BIO, where electrical resistance is measured across the entire body (arm-to-leg), this device measures resistance across the lower extremity. Values for percent body fat as well as body weight are displayed. Prior to having subjects step onto the metal electrodes, the soles and heels of each participant's feet were cleaned with alcohol to ensure good contact. Two measures were taken for each participant, with the average value being used in the analysis.

Because the two bioimpedance methods were highly correlated (see results section), only the BIO measurement was used in comparison to the skinfold method in examining the discrepancy of percent of body fat measured. Difference in the percent of body fat was calculated as the percent of body fat measured by skinfold minus the percent of body fat measured by BIO, divided by the percent of body fat measured by BIO, then multiplied by 100.

***Data analysis***

The number and proportions of overweight and obese children among the participants were determined using the IOTF reference, stratified by gender. Pearson's correlation coefficients of the percent of body fat measured by the skinfold method and the two bioimpedance methods were calculated for boys and girls with normal weight, overweight, and obesity. The mean differences in the percent of body fat measured by the skinfold method and the BIO method were identified between gender, among different age groups for normal weight, overweight, and obese children, using ANOVA. The analyses were conducted using SAS version 9.00 (SAS 2002).

## Results

***Characteristics of the study population***

Of a total of 2428 study participants, 52.5% were boys and 47.5% were girls. Boys and girls had similar age

**Table 1.** Characteristics of study participants ($n = 2428$)*

| | Boys ($n = 1275$) | Girls ($n = 1153$) |
|---|---|---|
| Age (yr) | 9.2 ± 1.8 (6–13) | 9.2 ± 1.9 (6–13) |
| Height (cm) | 133.4 ± 11.7 (97.0–169.7) | 134.1 ± 12.1 (105.5–164.3) |
| Weight (kg) | 31.8 ± 10.4 (14.0–84.4) | 31.0 ± 9.3 (15.1–73.0) |
| Body mass index (kg/m$^2$) | 17.4 ± 3.3 (12.1–31.4) | 16.9 ± 2.8 (11.7–29.1) |

*Data are presented as mean ± standard deviation (range).

**Table 2.** Number and percent of overweight and obese children by age and sex ($n = 2428$)

| | *N* | Body mass index | | Obesity status* | |
|---|---|---|---|---|---|
| | | Median | Mean | Overweight, *n* (%) | Obese, *n* (%) |
| Boys | | | | | |
| All | 1275 | 16.6 | 17.4 | 181 (14.2) | 64 (5.0) |
| 6 | 92 | 15.6 | 15.9 | 11 (12.0) | 2 (2.2) |
| 7 | 203 | 15.2 | 15.7 | 22 (10.8) | 6 (3.0) |
| 8 | 203 | 15.8 | 16.5 | 21 (10.3) | 12 (5.9) |
| 9 | 183 | 16.5 | 17.3 | 24 (13.1) | 10 (5.5) |
| 10 | 234 | 17.0 | 18.1 | 38 (16.2) | 17 (7.3) |
| 11 | 239 | 18.8 | 19.3 | 51 (21.3) | 13 (5.4) |
| 12 | 96 | 17.5 | 18.6 | 11 (11.5) | 4 (4.2) |
| 13 | 25 | 17.9 | 18.1 | 3 (12.0) | 0 (0.0) |
| Girls | | | | | |
| All | 1153 | 16.2 | 16.9 | 130 (11.3) | 24 (2.1) |
| 6 | 104 | 15.0 | 15.6 | 12 (11.5) | 4 (3.9) |
| 7 | 161 | 15.1 | 15.5 | 15 (9.3) | 3 (1.9) |
| 8 | 171 | 15.5 | 16.2 | 17 (9.9) | 8 (4.7) |
| 9 | 185 | 16.5 | 16.8 | 21 (11.4) | 3 (1.6) |
| 10 | 213 | 16.5 | 17.1 | 25 (11.7) | 3 (1.4) |
| 11 | 184 | 17.9 | 18.2 | 29 (15.8) | 1 (0.5) |
| 12 | 97 | 17.2 | 18.0 | 7 (7.2) | 2 (2.1) |
| 13 | 38 | 17.7 | 18.4 | 4 (10.5) | 0 (0.0) |

*Obesity status as defined by International Obesity Task Force reference.

and height distributions. Boys weighed slightly more than girls ($p = 0.46$), and boys' BMI was higher than girls' ($p < 0.001$) (Table 1).

### *Prevalence of overweight and obesity*

The IOTF reference was used to define overweight and obesity status among study participants. Table 2 presents the mean and median of BMI, as well as the number and proportions of overweight and obese children among the study participants. Overall, 311 (12.8%) children in this study were classified as overweight and 88 (3.6%) children were classified as obese. Boys had higher proportions of overweight and obesity than girls, with 14.2% *vs.* 11.3% for overweight and 5.0% *vs.* 2.1% for obesity, respectively. Subgroup analysis showed that boys had higher proportions of overweight and obesity than girls in almost all age groups, with the exception of obesity among girls at age 6 years. The highest proportion of overweight was observed at age 11–12 years for both boys and girls. The peak in obesity prevalence was observed at age 10–11 years for boys and 8–9 years for girls.

### *Correlations of skinfold, BIO and TANITA*

Table 3 presents the correlations of percent of body fat measured by skinfold, BIO and TANITA. A significantly high correlation was found between the two bioimpedance measures for both boys and girls in normal weight, overweight, and obese groups, with Pearson's correlation coefficients of 0.90–0.96 ($p < 0.01$).

**Table 3.** Correlations of skinfold and two bioelectrical impedance analysis measures on percent body fat in boys and girls aged 6–13 years ($n = 2428$)

| | BIO | | TANITA | |
|---|---|---|---|---|
| | Boys | Girls | Boys | Girls |
| Skinfold | | | | |
| Normal weight | 0.5304 | 0.9952* | 0.7911† | 0.9762* |
| Overweight | 0.0646 | 0.9411* | 0.2203 | 0.8190† |
| Obese | −0.0252 | 0.9115* | 0.0871 | 0.7451 |
| BIO | | | | |
| Normal weight | 1.00 | 1.00 | 0.9118* | 0.9634* |
| Overweight | 1.00 | 1.00 | 0.9412* | 0.9364* |
| Obese | 1.00 | 1.00 | 0.8977* | 0.9234* |

*$p < 0.01$; †$p < 0.05$.

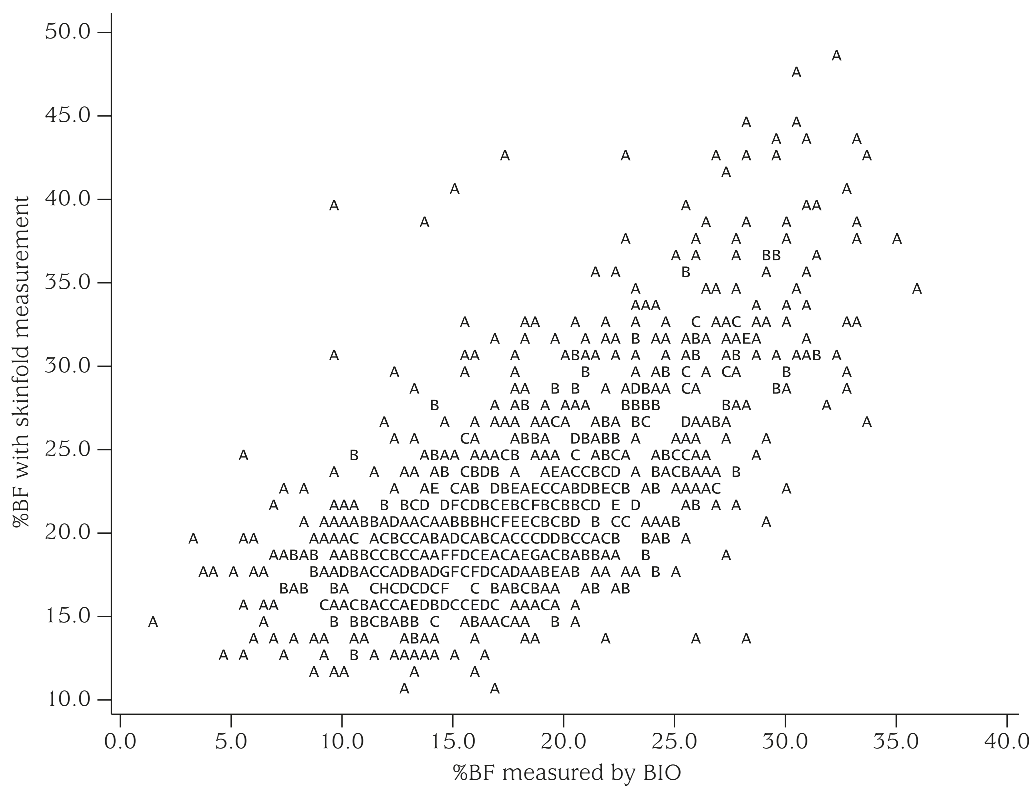


**Fig. 1** Correlation of percent body fat (%BF) measured by skinfold and BIO for normal weight boys.

The correlations between skinfold and bioimpedance measures were high for girls in normal weight, overweight, and obese groups, with the coefficient $r$ ranging from 0.75 to 0.99 ($p = 0.05$ to $p < 0.01$). The correlations between skinfold and bioimpedance measures were also high for boys with normal weight ($r = 0.53$, $p = 0.17$ and $r = 0.79$, $p = 0.02$), though the correlation between skinfold measure and BIO measure was not statistically significant. However, for boys who were overweight or obese, the two measurements were statistically unrelated ($r = -0.02$ to 0.22).

Figure 1 to Figure 6 display the correlations between skinfold measures and BIO measures for normal weight, overweight, and obese boys and girls.

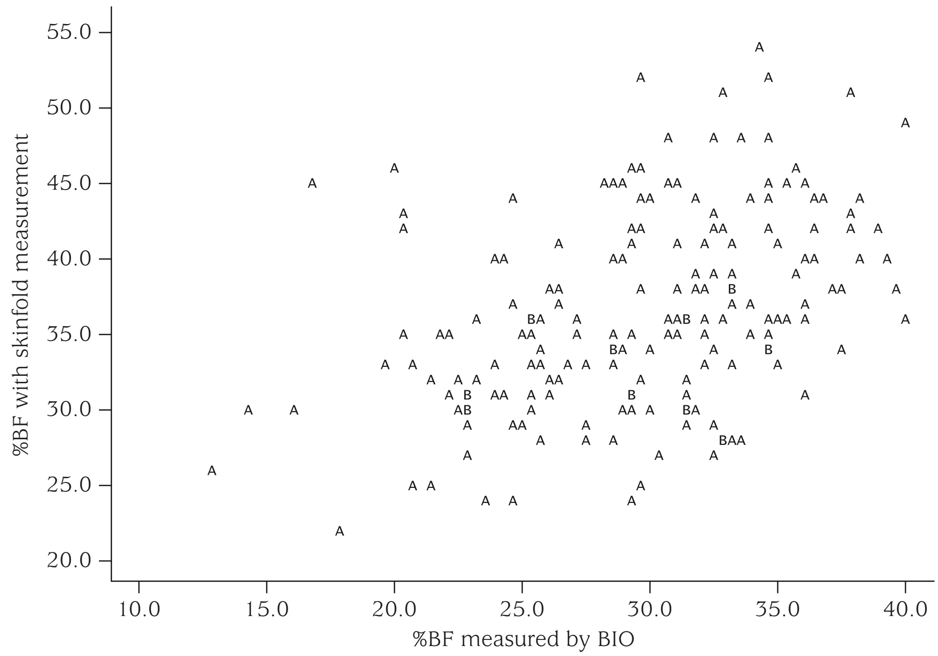


**Fig. 2** Correlation of percent body fat (%BF) measured by skinfold and BIO for overweight boys.

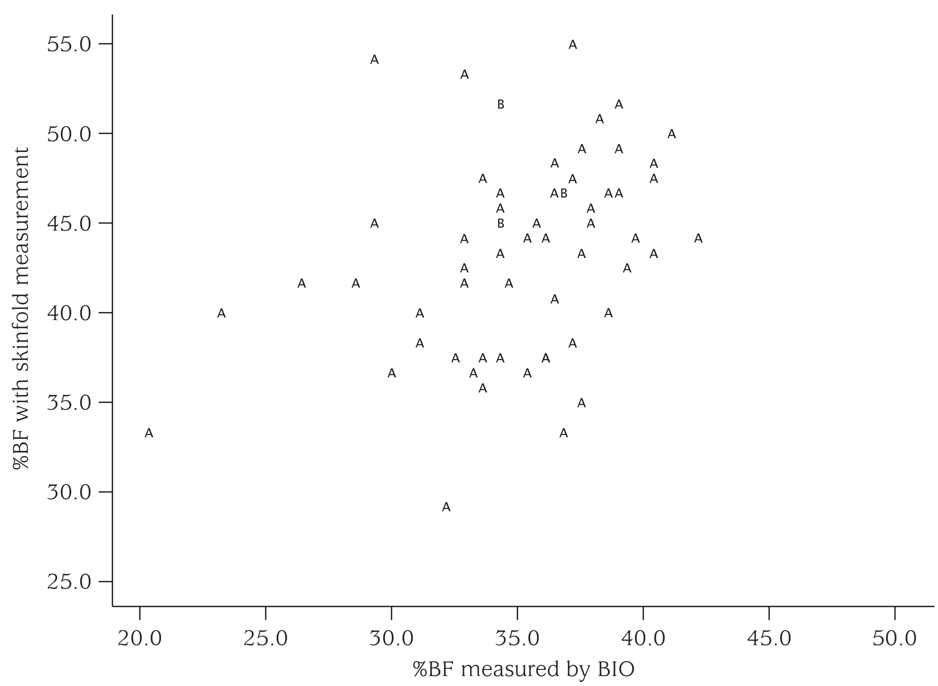


**Fig. 3** Correlation of percent body fat (%BF) measured by skinfold and BIO for obese boys.

***Difference in percent of body fat measured by skinfold and bioimpedance***

Because the two bioimpedance methods were highly correlated, only the BIO measurements were used for comparison with the skinfold method in examining the discrepancy of percent of body fat measured. Comparisons were made by gender and age (Table 4). The positive values of mean difference observed in Table 4 indicate that the skinfold method yielded a relatively higher percent of body fat than BIO for boys and girls

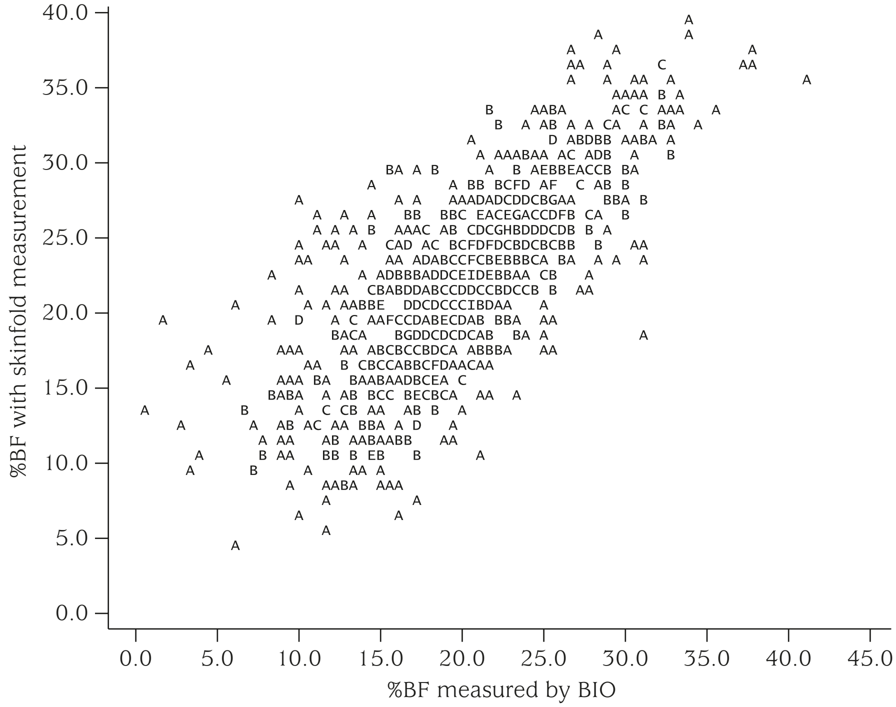


**Fig. 4** Correlation of percent body fat (%BF) measured by skinfold and BIO for normal weight girls.

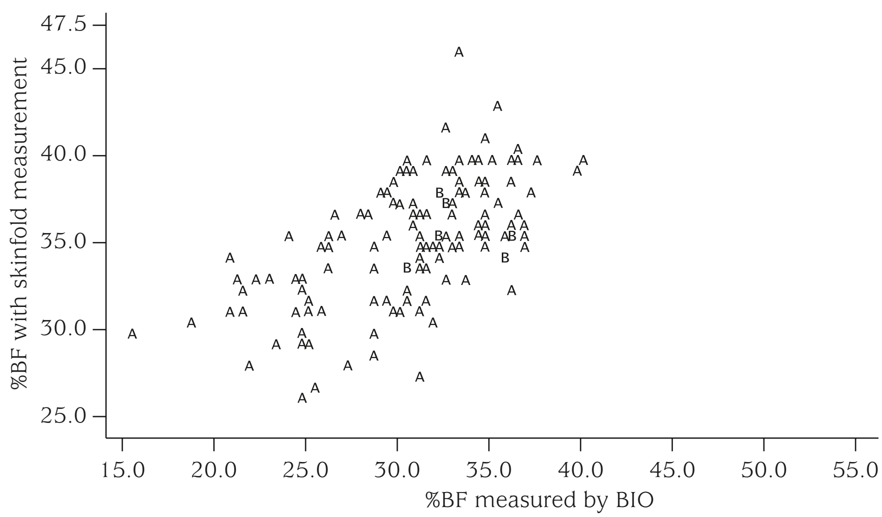


**Fig. 5** Correlation of percent body fat (%BF) measured by skinfold and BIO for overweight girls.

in almost all age and weight groups. After adjusting for age, the discrepancy between measures was significantly larger for boys than girls in all weight categories. Among boys of normal weight, overweight, and obese, mean differences of the two measures were greater at younger ages than older ages. Such an age difference was also observed among overweight and obese girls, but not among normal weight girls.

## Discussion

### *Prevalence of overweight and obesity among Hong Kong school children*

The prevalence of overweight and obesity found in our study population was 12.8% and 3.6%, respectively, according to IOTF cut-off points. These proportions are higher than previous findings from the 1993 Hong Kong

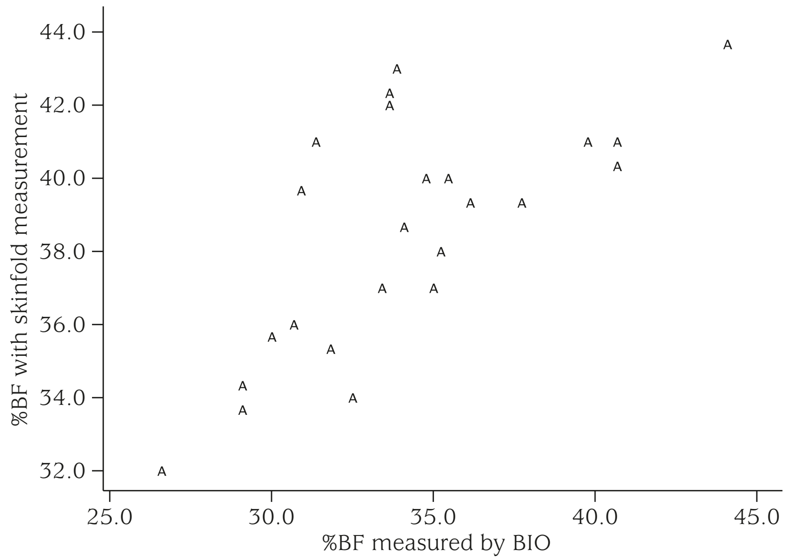


**Fig. 6** Correlation of percent body fat (%BF) measured by skinfold and BIO for obese girls.

**Table 4.** Mean difference in percent body fat measured by skinfold and BIO in boys and girls aged 6–13 years ($n = 2428$)

| | Normal | | Overweight | | Obese | |
|---|---|---|---|---|---|---|
| | *n* | Mean ± SD | *n* | Mean ± SD | *n* | Mean ± SD |
| Boys | | | | | | |
| 6 | 79 | 57.6 ± 42.4 | 11 | 47.7 ± 19.3 | 2 | 62.1 ± 11.4 |
| 7 | 175 | 63.0 ± 90.2 | 22 | 60.1 ± 40.6 | 6 | 38.2 ± 23.2 |
| 8 | 170 | 38.1 ± 39.8 | 21 | 30.7 ± 24.9 | 12 | 29.0 ± 19.8 |
| 9 | 149 | 29.8 ± 43.9 | 24 | 33.8 ± 19.0 | 10 | 32.1 ± 17.5 |
| 10 | 179 | 16.4 ± 26.4 | 38 | 17.3 ± 18.3 | 17 | 24.8 ± 12.0 |
| 11 | 175 | 13.7 ± 25.9 | 51 | 14.3 ± 18.4 | 13 | 13.9 ± 12.6 |
| 12 | 81 | 14.6 ± 27.1 | 11 | 2.8 ± 12.4 | 4 | –3.1 ± 6.7 |
| 13 | 22 | 23.7 ± 70.5 | 3 | –3.4 ± 9.0 | 0 | – |
| *p* for age difference in boys* | | < 0.0001 | | < 0.0001 | | < 0.0001 |
| Girls | | | | | | |
| 6 | 88 | 17.1 ± 131.4 | 12 | 29.0 ± 27.1 | 4 | 15.2 ± 8.9 |
| 7 | 143 | 6.4 ± 34.5 | 15 | 20.8 ± 19.4 | 3 | 20.6 ± 5.7 |
| 8 | 146 | 15.7 ± 51.5 | 17 | 22.8 ± 14.8 | 8 | 20.0 ± 7.3 |
| 9 | 161 | 30.1 ± 153.4 | 21 | 17.8 ± 11.7 | 3 | 5.2 ± 6.9 |
| 10 | 185 | 15.9 ± 27.5 | 25 | 15.1 ± 14.7 | 3 | 7.0 ± 2.5 |
| 11 | 154 | 26.8 ± 35.2 | 29 | 12.6 ± 14.7 | 1 | –0.9 |
| 12 | 88 | 24.9 ± 33.5 | 7 | 9.2 ± 11.1 | 2 | 2.6 ± 2.4 |
| 13 | 34 | 22.5 ± 23.7 | 4 | 9.6 ± 10.1 | 0 | – |
| *p* for age difference in girls* | | 0.0808 | | 0.0003 | | 0.0021 |
| *p* for gender difference† | | < 0.0001 | | < 0.0001 | | < 0.0001 |

*ANOVA; †ANOVA, adjusted for age.

National Growth Survey, which used the same criteria applied to 11,797 children from birth to 18 years of age, and identified 10.2% of children as overweight and 2.6% as obese (Rowlands et al. 2002). Higher proportions of overweight and obese children could be the result of increased high dietary fat intake, lack of physical activity, and the increasingly sedentary lifestyle of Hong Kong children (Johns & Ha 1999; Guldan et al. 1998; Leung et al. 1998b; Macfarlane 1997; Wong & Macfarlane 1997; McManus & Armstrong 1996).

### *Age and gender differences in the prevalence of overweight and obesity*

Leung and colleagues reported that the prevalence of obesity gradually increased after the age of 5 years and reached a peak at the age of 11 years for boys and 8 years for girls (Leung et al. 1995b). Consistent with their findings, we found that the prevalence of overweight increased after the age of 6 years and peaked at 11–12 years for both boys and girls. We also found that the highest proportion of obesity was at age 10–11 years for boys and 8–9 years for girls. The age difference in the prevalence of overweight and obesity found in this study may be related to body changes during puberty. A previous study reported that the mean age of puberty was 13 years for Hong Kong boys and 10.6 years for girls (Leung et al. 1996). The reduced proportion of overweight observed after age 12 in boys in this study may be related to puberty-induced changes in fat accumulation (Schaefer et al. 1998).

A higher proportion of overweight and obesity was found among boys than girls at all ages, with the exception of obese girls at age 6. These findings are similar to those reported by Sung and colleagues (Sung et al. 2001), but different from Ogle and colleagues who found that boys are generally leaner than girls from ages 4 to 26 years (Ogle et al. 1995). The reason for increased overweight and obesity among boys in this sample is unknown. Since the present study did not investigate other variables that may have contributed to the gender difference in overweight and obesity in this population, such as dietary intake, physical activity, or family history of obesity, additional studies are warranted to examine why boys are more likely to be overweight and obese, compared to similar aged girls, and why peak overweight appears at age 11–12 years. Special consideration should also be given to developing and implementing effective intervention strategies targeted at preventing obesity among school boys (Janz et al. 1999).

### *Mean difference in percent of body fat*

Although the skinfold method is considered to be appropriate for school aged children, and has been traditionally used in Hong Kong, there are criticisms regarding use of skinfold techniques for measuring body composition in young children (Rowlands et al. 2002; Chan et al. 1998; Eston et al. 1993). These include the necessity for subjects to be partially disrobed during data collection, the requirement of a well-trained and experienced technician to get accurate measurements, and the proficiency needed to obtain precise and valid skinfold measurements (Lohman et al. 1997).

Several studies conducted in Hong Kong in recent years have used bioimpedance to measure body composition in children, and concluded that bioimpedance is a reliable and accurate method of body composition measurement (Sung et al. 2001; Chan et al. 1998; Eston et al. 1993). Our findings revealed that the two bioimpedance measurements were highly correlated, suggesting that use of either bioimpedance measure could lead to a consistent estimation of percent body fat.

Chan and colleagues compared body composition measured by magnetic resonance imaging, skinfold, and BIO in 19 obese and non-obese children aged 8 to 12 years (Chan et al. 1998). They found that the correlations of total body fat and percent of body fat measured by the BIO and skinfold methods were relatively low. Our findings, however, found high correlations between skinfold and the two bioimpedance measures for all sampled girls and for boys of normal weight, but low correlations for overweight and obese boys. We also found that the discrepancies between the skinfold and BIO measures were large for boys and children at younger ages. These differences in percent of body fat measurement are probably due, in part, to the difference in fat distribution between boys and girls at different ages. He and colleagues studied sex and race differences in fat distribution among multiethnic children before and during puberty (He et al. 2004). They found that differences in fat distribution were evident in Asian boys and girls before and during puberty. Their findings, along with the findings from this study, suggest that the fat at each skinfold site may have different patterns of growth for boys and girls during their childhood and adolescence. While such differences could be of less concern for bioimpedance methods, the skinfold measurement should be used with caution when applied to children, especially for those at younger ages.

Although this study has limited generalizability to all Hong Kong children, to our knowledge, this is the first study that included a large number of Hong Kong school children to examine body composition using two bioimpedance measures. Findings from this study will provide empirical data for future intervention strategies to prevent overweight and obesity in this population.

## Conclusion

Childhood overweight and obesity is emerging as a major public health problem in Asian countries (Chia & Wang 2003; Ding et al. 1998; Leung et al. 1996). Because childhood obesity frequently tracks into adulthood, prevention of obesity in early years could lead to a reduction in the prevalence of adult obesity. The findings of this research provide a profile of percent of body fat for normal weight, overweight, and obesity among Hong Kong school children. Further studies are needed to determine why boys have a higher prevalence of overweight and obesity than girls, and to identify the contributing factors for this increase. In addition, more reliable measurement tools should be employed to accurately assess the rate of overweight and obesity in children, especially for those at younger ages.

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