Childhood overweight and obesity have increased dramatically since 1990. A recently published analysis of 450 nationally representative cross-sectional surveys from 144 countries showed that 43 million children (35 million in developing countries) are estimated to be overweight and obese, while 92 million are at risk of overweight [1].

Body mass index (BMI) is widely used to assess overweight and obesity, and standard cutoff values are now widely accepted for adults as well as children [2]. A major shortcoming of BMI is that it provides excess weight relative to height, not excess body fat, so it cannot differentiate between a muscular body and fatty body. The interpretation of BMI among children and adolescents has additional problems [3]. Skinfold thickness and bioelectric impedance, give variable results and thus are a less preferred approach. Recently, dual energy X-rays absorptiometry (DXA) has gained wider acceptability as a research tool for evaluation of body composition as it provides precise body composition analysis with a low radiation dose [4,5], is reproducible, and able to detect small changes in body composition in both, adults and children [6]. It is increasingly being used as a criterion or reference for comparison with other body composition measurement techniques [7-10] and is highly correlated with bioelectric impedance analysis (BIA), skinfold thickness, and underwater weighing [11-14].

It is now well established that adult Asian subjects have higher levels of body fat than European subjects with comparable BMI values which has led to a revision of WHO recommendations for appropriate BMI cut-off levels in Asian populations [15]. Similar differences in total body fat have also been seen in Asian children and adolescents residing in western countries [16,17]. One of the major limitations of these studies is very small sample size of Asian-Indian subjects. However, absence of population based reference data makes it difficult to
define cutoffs for excess body fat especially in Asian-Indian children and adolescents.

There have been few earlier studies aimed at defining reference intervals of percentage body fat in Asian-Indian children and adolescents. However, these studies had limitations of either a small sample size or use of skin fold thickness for calculation of percentage body fat [18,19] and none of them used DXA. We, therefore, undertook this study to develop-age and sex-specific reference distribution of body fat in apparently healthy children in the age group of 7-17 years in Northern India and to assess agreement between obesity (defined by BMI) and excess body fat (assessed by DXA).

**METHODS**

This cross sectional study was part of health survey of Delhi school children. Details have been published previously [20]. Brief history and tailored clinical examination related to anthropometry was carried out in 1640 children (825 boys; 815 girls) aged 7-17 years. Subjects suffering from any systemic disease (including diabetes and hypothyroidism) or on any chronic treatment for more than one month were not recruited for DXA. All subjects were transported to the study center for body fat assessment by DXA. Body weight was measured to the nearest 0.1 kg using digital weighing machine (EQUINOX Digital weighing machine, Model EB6171) and height was measured with wall mounted stadiometer (Model WS045, Narang Medical Limited, Delhi). BMI was calculated by weight (in Kg) divided by square of height (in meter). Overweight and obesity were defined by using cutoff provided by International Obesity Task Force (IOTF, 2). The study protocol was approved by the institutional ethics committee of Institute of Nuclear Medicine and Allied Sciences (INMAS). Administrative approval was taken from school authorities, written informed consent from parents / guardians, while verbal assent was taken from the children who participated in the study. Since the number of subjects in 5-year and 18-year age group was small (12 and 16, respectively), they were not included in the final analysis.

**Dual energy X-rays absorptiometry**: Whole body DXA scans were performed using GE Lunar Prodigy scanner (software version 2.20; General Electric Medical Systems, Madison, WI, USA). Measurements were taken with the subject supine on the scanning table, beginning at the top of the head and moving in a rectilinear pattern down the body to the feet. The coefficient of variation of the scanner (on the basis of two consecutive scans of 15 adult subjects) was 0.44% for total fat mass. Similarly, whole body phantom was also scanned daily before subject evaluation and remained stable during study period. However, in view of additional radiation exposure, the reproducibility of these scans was not assessed among children.

There are no generally acceptable percentage cutoffs for body fat to define overweight and obesity in children. Even among adults, World Health Organization concluded that “there is no agreement about cutoff points for the percentage of body fat to constitute obesity” [14, 21]. In absence of any universal acceptance, we adopted two approaches for defining excess body fat. In the first approach ('Prevalence matching' approach or Method A, 22), we formed three categories of body fatness (normal, moderate and elevated body fat) which correspond to the three BMI categories (normal, overweight and obese as defined by IOTF cutoffs). Within each age and sex group, percentage body fat cutoffs were chosen in a way that the number of children with elevated, moderate and normal body fat would equal the number of children who had BMI in the obese, overweight and normal BMI categories. If there is perfect correlation between BMI and percentage body fat, it would result in perfect matching of three body fat categories with the three BMI categories.

The second approach (Method B), was based on use of 85th and 95th centile cut-offs for defining excess body fat as suggested [14]. We used these two cutoffs from our data set to define excess body fat. Subjects with percentage body fat < 85th centile were considered as having normal body fat, those with percentage body fat between 85-95th centile as having moderate body fat and individuals with body fat > 95th centile were considered as having elevated body fat.

We then looked for agreement between body fat categories (normal, moderate and elevated body fat, generated by both methods) and BMI categories (normal BMI, overweight BMI and obese BMI). We also compared percentage body fat data from our study with available similar (age and sex matched) two data sets from US population.

**Statistical analysis**: Analysis was performed using STATA 9.0 (College Station Road, TX, USA). Descriptive statistics were calculated as mean and standard deviations. An age specific distribution of percentage body fat was calculated separately for boys and girls. A p value of <0.05 was considered as statistically significant. Student t test for independent samples was used to compare difference in means between boys and girls. Age related reference centile curves were generated using LMS Program version 1.28 [23]. Fleiss’ kappa was used for assessing the reliability of agreement.