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Mini Review

Childhood obesity in Asia: the value of accurate body composition methodology

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Childhood obesity, a significant global public health problem, affects an increasing number of low- and middle-income countries, including in Asia. The obesity epidemic has been fuelled by the rapid nutrition and physical activity transition with the availability of more energy-dense nutrient-poor foods and lifestyles of many children dominated by physical inactivity. During the growing years the pace and quality of growth best quantified by a combination of anthropometric and body composition measures. However, where normative data are available, this has typically been collected on Caucasian children. To better define and characterise overweight and obesity in Asian children, and to monitor nutrition and physical activity interventions, there is a need to increase the use of standardized anthropometric and body composition methodologies. The current paper reports on initiatives facilitated by the International Atomic Energy Agency (IAEA) and outlines future research needs for the prevention and management of childhood obesity in Asia.

Key Words: childhood obesity, Asia, body composition, methodology, stable isotopes

INTRODUCTION

Childhood obesity is increasing at an alarming rate,¹ particularly in low- and middle-income countries and is acknowledged as a significant global public health problem.²⁻⁶ Global estimates in 2010 suggested that 35 million children were overweight or obese, with this figure likely to double by 2020.¹ The increasing international trend for overweight and obesity in childhood is occurring alongside an escalation in poor eating and physical activity behaviours. The epidemic of obesity in Asia has been fuelled by the rapid nutrition and physical activity transition being more commonly experienced. Energy-dense and often poor quality foods are more widely available and the typical lifestyle of many children is characterised by low levels of physical activity and a predisposition to inactive or sedentary behaviours.² Taken together, these changes mean that affected children have an increased risk of lifestyle-related, non-communicable diseases (NCDs) including type 2 diabetes,⁷ cardiovascular diseases and certain forms of cancer.⁵

Many Asian countries are experiencing the double burden of under- and overnutrition⁸ with consequent stress on health provision systems. Further, the prevalence of overweight and obesity increases along with a country's level of socio-economic transition, prevalence is generally higher in urban than in rural areas, and unlike many

parts of the developed world, more pronounced in higher socio-economic groups of the population.^{2,5}

The childhood years represent a major 'window of opportunity' and 'teachable moment' with respect to two of the key behavioural risk factors for NCDs, an unhealthy and energy-dense diet plus a lifestyle characterised by low levels of physical activity and an increase in sedentary behaviours. In Asia, the prevention and management of overweight and obesity, and the likelihood of unhealthy practices tracking through adolescence into adulthood if unchecked, has been exacerbated by a lack of quality data, capacity amongst health professionals and exemplar intervention approaches.

A better understanding of the quality of growth and maturation of Asian children and adolescents in the context of the burgeoning obesity problem could be gained with the utilization of appropriate body composition asse-

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ssment techniques.^{9,10} The more widespread use of standardized anthropometric and valid and reliable body composition approaches would also help to quantify changes as a function of growth and also diet and physical activity interventions.

This paper details emerging challenges in the region and references future research directions related to the prevention and management of childhood obesity. In particular, the paper references obesity-related initiatives supported by the IAEA and partner organisations. A major goal of these research and capacity building initiatives has been to contribute to the wider use of stable isotopes to progress the nutrition agenda in low- and middle-income countries, including the more systematic use of anthropometry and body composition assessment techniques.

A region in transition - impact on health

Many Asian countries are experiencing a socioeconomic and lifestyle transition due to a combination of globalisation and urbanization. Consistent with this economic and demographic transition is declining physical activity levels and increased sedentary behaviours. Whilst the prevalence of childhood overweight and obesity is increasing in many Asian countries, including India, Singapore, China, Malaysia and Vietnam,¹¹ rates of obesity and urbanization vary across the region. In addition to overweight and obesity, the activity trends and more energy-dense diets have contributed to poor metabolic and cardiovascular health in younger age groups.^{5,12,13} Sadly, the brunt of the impact of the epidemic of chronic NCDs in Asia is being borne by more disadvantaged populations.¹⁴

Anthropometry - an important but often misused marker of health

Anthropometric measurements have traditionally been used to characterize growth and maturation but have also been used, as is the case for the body mass index (BMI), as a 'criterion' for overweight and obesity. However, it is important to highlight that height and weight (and therefore BMI) are not measures of body composition, that is, they provide no information regarding the relative proportions of fat mass (FM) and fat-free mass (FFM).⁹ The differentiation between anthropometry and body composition in the context of the Asian child is critical given that (some) Asian children may differ in the relationship between level of body fat and metabolic risk, as evidenced in adults.¹⁴ Similarly, if body fatness in South Asians differs in amount and distribution from Caucasians, (or from other Asians), an inappropriate extension of anthropometric data may disadvantage some when using cut-offs developed in Caucasian populations.

Standardized anthropometry plus body composition assessment - a more valuable marker of health

Body fat level, and more importantly its regional distribution, is an acknowledged marker of health status yet detailed body composition of different populations is often not available. In adult Asian populations, particularly South Asians, higher total and central adiposity is seen at the same BMI when compared with Caucasians.¹² Such ethnic-specific differences in body fat

distribution may be related to ethnic differences in cardio-metabolic risk. For example, Nazare et al¹⁴ found that ethnicity significantly affects abdominal obesity with East Asians having the most deleterious fat distribution. The morphologic characteristics cited above have also been reported in young Asians^{15,16} making this population more susceptible to metabolic diseases and more recently, a range of cardio-metabolic risk factors have also been reported in normal-weight South Asian children.⁵

To address the challenges associated with unhealthy levels of adiposity in many Asian populations, there is an urgent need to advance our knowledge and understanding of physical growth changes of Asian children, in particular changes in adiposity during childhood and adolescence. The urgency is in large part associated with the knowledge that the cost of treating established obesity and related conditions is enormous with serious consequences for healthcare providers in the developed and the developing world.¹⁷⁻¹⁹

At a more fundamental level, the establishment of normative data on body size, shape and composition of Asian children from different locations is an important priority, particularly in the context of the current challenge of overweight and obesity and the burgeoning problem of type 2 diabetes. Ideally, such information should be available from birth and across the growing years. This would enable a better definition of healthy growth in this population and most importantly, to understand associations between growth during childhood and later health outcomes.

The lack of comprehensive data on the growth and development of Asian children contributes to the challenge of accurately documenting and then comparing physical characteristics of children from different locations. It is critical to establish reference data in populations of Asian children¹¹ such as age- and sex-specific BMI cut-offs for overweight and obesity. Reported prevalence of overweight and obesity depends on the definition used, for example whether from the International Obesity Taskforce (IOTF, 2000),²⁰ US Centres for Disease Control (CDC, 2000),²¹ or World Health Organisation (WHO, 2006).^{22,23} The IOTF BMI cut-offs for example may not be appropriate for Asian children and adolescents because they are mainly based on Caucasian populations and lower cut-offs have been reported as more appropriate for defining BMI-related health risk in Asian populations.²⁴ The actual prevalence of overweight and obesity may be significantly higher than reported in the published literature with even greater public health consequences.

A logical extension beyond the collection of anthropometric data is to better understand the relationship between BMI and percentage body fat (%BF) in this population. We recently addressed this issue in a large group of 8-10 year-old children (N=1039)⁹ encompassing a wide BMI range, recruited from China, Lebanon, Malaysia, The Philippines and Thailand. Body composition was determined using the criterion deuterium dilution technique to quantify total body water (TBW) and subsequently FFM, FM and %BF. Ethnic differences were found in the BMI-%BF relationship but varied by BMI. For example, %BF in Filipino boys was approximately 2% lower than Thai and Malay counterparts. In contrast,

Thai girls had approximately 2% higher %BF values than Chinese, Lebanese, Filipino and Malay girls at a given BMI. Compared with Caucasian children of the same age, Asian children had 3-6 units lower BMI at a given %BF.

In the context of various classification approaches, approximately one-third of the obese Asian children (%BF above 25% for boys and above 30% for girls) in our study were not identified using the WHO classification and more than half using the IOTF classification. In summary, a lack of understanding of ethnic differences in body size, proportion and fat distribution may contribute to misuse or misinterpretation of results obtained from anthropometric indices alone.²⁵ Results from the study by Liu et al⁹ confirmed the necessity to consider ethnic differences in body composition when developing BMI cut-points and other obesity criteria in Asian children.

Total body water (TBW) assessment by deuterium dilution technique

Quantification of TBW using the deuterium dilution technique enables the subsequent estimation of FFM and based on the two-compartment model, FM can be derived as the difference between body weight and FFM. The technique is suitable for both field settings and large-scale studies, is non-invasive and therefore suitable for more widespread use and the generation of normative data (see Table 1).

The technique involves the collection of biological samples (saliva or urine) in the field and subsequent analysis in a laboratory facility. The IAEA has made a significant contribution over many years to capacity building in the application of the deuterium dilution technique to quantify TBW in low- and middle-income countries, including in Asia. The IAEA has also helped to fund key initiatives associated with better understanding the relationship between body fat and metabolic risk in pre-adolescents and adolescents, and also the prevention and management of chronic disease in children and adolescents in the context of the epidemic of obesity and

type 2 diabetes. In addition, the Agency has contributed to increased access to Isotope Ratio Mass Spectrometers (IRMS) dedicated to nutrition applications and also Fourier transform infrared spectroscopy (FTIR) for analysis of deuterium enrichment in saliva. This support has contributed significantly to the more widespread use of stable isotopes to assess body composition in the region.

Bioelectrical impedance analysis (BIA)

Despite the relative simplicity of the technique and wide range of commercial devices available, BIA has been used and abused in the research context. Given the cost and technical challenges associated with the widespread use of the criterion measure of TBW assessment, the deuterium dilution technique, considerable attention has been paid to validation of BIA against the criterion measure. With the support of the IAEA and other agencies, some recent studies have assessed the validity of BIA for the estimation of TBW and FFM using the deuterium dilution technique as a reference in multi-ethnic samples of Asian children.¹⁰ We recruited 948 participants (492 boys and 456 girls) from five Asian countries, including China (East Asia), Lebanon (West Asia), Malaysia, Philippines and Thailand (South East Asia), and in each country participants in each gender and age group were randomly divided into two groups, a validation group (328 boys and 302 girls) and a cross-validation group (164 boys and 154 girls). To harmonize data collection across the five countries, the same equipment and technique, including deuterium oxide dilution approach was employed and all measurements were conducted following standardized operating procedures by trained investigators. The BIA prediction equations for TBW and FFM developed in the study are valid for use in Chinese, Lebanese, Malay, Filipino and Thai children aged 8-10 years across a wide BMI range (12.2-34.9 kg/m²). Our population-specific BIA prediction equation provides an appropriate tool for the accurate assessment of body composition among Asian children. It also provides the opportunity to compare obesity prevalence based on percent body fat rather than BMI using a relatively inexpensive, simple to use technique.

Conclusions and recommendations

In summary, the relationship between BMI and %BF differs by ethnicity among Asian children confirming that the widespread application of a single BMI cut-off point may not be appropriate to screen for health risks in all Asian children. Asian children have a higher %BF than Caucasian children at any given BMI - this also suggests that Asian children may be at higher risk of developing obesity-related health problems at lower BMI values. Because relatively little is known about ethnic variation in health risk across %BF ranges and there is no widely accepted classification of excess body fat among children, there is an urgent need to undertake further research to address the dose-response relationship between %BF and health risk in children and adolescents in different ethnic groups.^{9,10,26} Such work will also necessitate the systematic use of standardized anthropometric and body composition techniques, including stable isotope approaches, to

Table 1. Body composition reference techniques

Total body water (TBW)	Stable isotope dilution technique (deuterium or oxygen-18) is the criterion measure of TBW. Suitable for use in field settings and in large-scale studies.
Body density	Air Displacement Plethysmography (ADP, Pea Pod [®] and Bod Pod [®]). Commonly limited to use in laboratory settings.
Bone mineral content	Dual X-ray Absorptiometry (DXA). Typically limited to laboratory-based studies.
Additional approaches	
Bioelectrical impedance analysis (BIA)	Widely used but relevance based on quality of algorithm(s). Typically data collected on Caucasian populations.
Anthropometric measurements and prediction equations	Harmonized approaches needed and ethnic-specific equations.

establish more comprehensive normative data on Asian children and adolescents from different backgrounds.

An increase in education and training of health professionals and capacity building, ideally with the support of international, regional and local agencies is required to inform evidence-based health policy and practices in the region. There is also an urgent need for more aggressive intervention programs targeting diet and physical activity,¹¹ a major focus of which should be to institute intervention strategies to increase awareness and promote healthy lifestyles in schools.¹⁶

AUTHOR DISCLOSURES

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亚洲儿童肥胖：准确的体成分测量方法的价值

儿童肥胖是一个重要的全球性公共健康问题，影响到包括亚洲在内的越来越多的中低收入国家。快速的营养和体育活动的过渡，即更多的高能量密度低营养食物的摄入和许多孩子缺乏体力活动为主的生活方式更加助长了肥胖的流行。在发育期，体格测量和体成分测量相结合是定量生长发育速度和质量最好的方法。然而，可用的规范数据通常是在白人儿童中收集的。为了更好地定义和描述亚洲儿童的超重和肥胖，并监测营养和体育活动的干预措施，有必要增加使用标准化的体格测量和身体成分测量方法。本文报告了国际原子能总署（IAEA）的促进措施，并概述了未来亚洲在儿童肥胖的预防和管理方面的研究需求。

关键词：儿童肥胖、亚洲、体成分、方法、稳定同位素