Prevalence and risk factors for adolescents (13–17 years): overweight and obesity

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Increase in childhood overweight and obesity has become an important public-health problem in industrialized nations. The objective of the present study was to assess the prevalence of overweight and obesity as defined by the World Health Organization among school children in Guntur city, Andhra Pradesh, India, and identify its associated factors. A cross-sectional and institutional study adopting a multistage stratified random sampling technique with proportional allocation was carried out during 2006 on adolescents (13–17 yrs). The overall prevalence of overweight (85th percentile) among adolescents was 8.4% (95% confidence interval (CI): 6.9, 9.9) among girls and 6.9% (95% CI: 5.8, 8.0) among boys. Approximately 68% of the sample belonged to communities that are considered socially backward and about two-thirds of the mothers of adolescents did not have any nutritional knowledge. The prevalence of overweight and obesity (2.7%, $P < 0.001$) was significantly lower among adolescents who participated in household activities (≥ 2 h/day) and was highly significant among those who did not play any indoor games (6.6%, $P < 0.001$). Adolescents who bought lunch at school were at increased risk of being overweight and obese (95% CI: 1.441 and 1.19–1.64). Parents and schools provide opportunities for public-health initiatives for reducing childhood and adolescent overweight and obesity. This study confirms the findings of earlier studies carried out in the Western countries and emphasizes that regular physical exercise, doing household activities, regulated television viewing, and healthy eating behaviour could contribute to controlling overweight and obesity.

Keywords: Adolescents, obesity, overweight, physical activity, risk factors.

A FAT child used to be generally considered as a healthy child who is likely to survive the rigours of undernourishment and infection. But unlike the past, today obesity and overweight in childhood are considered as a major health-risk condition developed mainly due to malnutrition and improper lifestyle, which can lead to a number of health problems both in childhood and later in adulthood.

Overweight is associated with the onset of major chronic diseases leading to complications and also psychosocial problems in children and adults. The greater concern is that the risks of overweight during childhood will persist into adolescence and adulthood. Tackling the problem of the growing number of overweight individuals is a major challenge for most countries. Hence close monitoring of prevalence of overweight in children and adolescents and taking timely preventive measures will be an effective approach in dealing with the problem of obesity[1].

During the past two decades, the prevalence of obesity in children has risen greatly worldwide and this has become a major health problem in both developed and developing countries. Overweight and obesity during childhood are a matter of growing concern in India also. Most individuals develop their eating and activity patterns during childhood[2]. The transition in nutrition and lifestyle, e.g. popularity of fast foods, soft drinks, sedentary lifestyle, and lack of exercise, increased television watching and computer use are the common trends adopted by children today. These may be the causes for overweight seen in children of both rural and urban areas[1].

The subjects were adolescents (13–17 yrs) from Guntur, Andhra Pradesh (AP), India. Majority of the population are Hindus, Christians and Muslims. Other communities such as Jains and Sikhs are represented in smaller numbers. AP is one of the largest provinces of the Indian union, with a total population of ~ 76.2 million. Approximately 73% of the population lives in rural areas, subsisting mainly on agriculture. A total of 1240 students attend four schools in urban Guntur. A multistage stratified random sampling technique with proportional allocation was used.

Trained investigators measured standing height to the nearest 0.1 cm after the students had removed their shoes, and body weight to the nearest 0.1 kg on calibrated digital scales. Overweight and obesity were defined using the international body mass index (BMI) cut-off points established for children and youth[3]. These cut-off points are based on health-related adult definitions of overweight (≥ 25 kg/m^2) and obesity (≥ 30 kg/m^2), but are adjusted to specific age and sex categories for children[3].

Overweight and obesity and 95% confidence internal (CI) were calculated, according to age, sex, SES, ethnic group, type of school and physical activity level. Associations were assessed using χ^2 tests. Multiple logistic regression analysis was also carried out to examine associations between independent variables and overweight and obesity. For all statistical tests, $P < 0.05$ was taken as the significant level.

A total of 1240 adolescents (47.75% boys and 52.25% girls) in the age group of 13–17 yrs, with a mean age of 15.8 yrs, were studied. Approximately 68% of the sample belonged to communities that are considered socially backward. The mean income per month of parents was Rs 5797.70 ± 2832.18. The major occupation of the fathers was either business (31.85%) or service (45%). Approximately two-thirds of the mothers of adolescents did not have any nutritional knowledge (Table 1).

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Table 1. Selected socio-demographic characteristics of the study samples in Guntur city (n = 1240)

Demographic feature	Adolescents (13–17 yrs)	
	Number of students	Percentage
Adolescents		
Boys	592	47.75
Girls	648	52.25
Type of school		
Government	408	32.90
Private	832	67.10
Community		
Scheduled caste/tribes	306	24.68
Backward community	538	43.38
Others	396	31.94
Family income (Rs)		
<2000	176	14.2
2001–5000	198	15.9
5001–7000	355	28.6
7001–10000	405	32.7
> 10000	106	08.6
Socio-economic status		
Upper	148	11.93
Middle	768	61.94
Lower	324	26.13
Occupation		
Business	395	31.85
Service	558	45.00
Others	287	23.15
Nutritional knowledge of parents		
Aware	416	33.55
Not aware	824	66.45

The mean height of the adolescents was 136.85 ± 15.12 cm for boys and 131.72 ± 12.40 cm for girls, whereas the mean weight was 39.43 ± 16.06 kg for girls and 42.61 ± 15.32 kg for boys. The mean BMI of the adolescents was 19.21.

In general, the prevalence of overweight (≥ 85th percentile) among adolescents was 8.4% (95% CI: 6.9, 9.9). The prevalence of overweight was higher among girls (9.1%; 95% CI: 7.4, 10.8) than among boys (6.9%; 95% CI: 5.8, 8.0) (Table 2). The prevalence of overweight (≥ 85 percentile) among girls tended to increase from 7.6% at 13 yrs to 11.8% at 16 yrs and gradually decreased at 17 yrs (10.2%), whereas in the case of boys, it was the highest at the age of 16 yrs (9.2%) and decreased to 5.8% at the age of 17 yrs.

The prevalence of overweight and obesity (2.7%) was significantly lower among adolescents who participated in household activities ($P < 0.001$) than among the non-participants (20.6%). It was also significantly higher ($P < 0.001$) among adolescents who did not play any indoor games (6.6%) compared with those participating in various indoor games (2.4%). Similarly, overweight and obesity were marginally higher among adolescents who were not involved in physical activities such as walking, jogging and cycling (Table 3).

Among adolescents, 15.3% did not eat breakfast (Table 4). In a univariate analysis, these students were 1.5 times more likely to be overweight than those who usually ate breakfast. Missing lunch was also associated with an increased risk of excess body weight, but this risk was not statistically significant. Relative to those bringing lunch from home, students buying lunch at school were 41% more likely to be overweight (unadjusted odds ratio 1.41, 95% CI: 1.19–1.64). Increasing frequencies of eating supper together at home (family supper) and decreasing frequencies of eating supper in front of the television were associated with a decreased risk of overweight because dietary habits are interrelated. Thus, we considered these habits simultaneously and found that lunch pattern and frequency of family supper and supper in front of the television were determinants of body weight.

In this study, we have presented estimates on the prevalence of overweight and obesity in a preventative group of adolescent population in Guntur District, using individual weight, height measures to calculate BMI. The overall prevalence of overweight (≥ 85th percentile of BMI) among the urban adolescents studied (8.4%) was 14 times higher than that of their rural counterparts (0.6%) reported by the National Nutrition Monitoring Bureau surveys (NNMB) in 2002 (ref. 4). However, the prevalence was lower in this study compared to those carried out in Ludhiana, Pune, Delhi, Chennai[5]. The reason for the higher prevalence of overweight (26%) and obesity (7.4%) among the adolescent population studied in Delhi and Ludhiana might be because the subjects selected for these studies were affluent.

Several studies have reported the prevalence of overweight and obesity in school children applying different methods (85th and 95th percentile) as cut-off points. Data extracted from selected studies in individual Asian countries show prevalence ranging from 5% to 9% among several urban cities in Asia. Various reports in the 1990s have pointed out the prevalence of overweight (over 20%) and obesity (over 5%) among urban population groups.

A clear socio-economic gradient in the prevalence of overweight and obesity was observed in this study, which is consistent with other studies[6,7]. This could be due to several reasons related to obesity, encountered to a greater extent in the higher-income groups. Studies have reported that the rise in sedentary behaviours such as increased use of vehicular transport and decreased physical activity has led to increased prevalence of overweight and obesity.

Overweight and obesity were marginally higher in the pubertal age group, i.e. 13–15 yrs of age, as was observed in other studies in Delhi and Chennai[5], perhaps because

Table 2. Prevalence of obesity and overweight in adolescents in Guntur city (n = 1240)

Variable	Sub-variable	Percentage	Mean body mass index (BMI)	Overweight (≥ 85 to < 95th percentile)	Obese (≥ 95th percentile)	Over weight and above (≥85th percentile and 95% CI)
Mean age (yrs)	Pooled	15.8*	19.21 (18.8, 19.62)	6.8	1.6	8.4 (6.9, 9.9)
Adolescents	Boys	47.75	18.4 (18.2, 18.6)	5.4	1.5	6.9 (5.8, 8.0)
	Girls	52.25	19.5 (19.2, 19.8)	7.2	1.9	9.1 (7.4, 10.8)

Table 3. Activity-related risk factors for those overweight among adolescents (n = 1240)

Variable	Duration	n	Not overweight	P value
Participation in household activities (h/day)	None	542	79.4	< 0.001
	< 2	320	94.1	
	≥ 2	378	97.3	
Participation in indoor games (h/week)	None	639	93.4	< 0.001
	< 6	383	94.9	
	≥ 6	218	98.6	
Participation in outdoor games (h/week)	None	550	96.9	< 0.004
	< 6	228	90.3	
	≥ 6	462	95.2	
Walking (h/day)	None	712	92.6	< 0.008
	< 2	321	9.4	
	≥ 2	207	100.0	
Jogging (h/day)	None	1039	96.9	< 0.12
	< 2	176	94.9	
	≥ 2	25	100.0	
Cycling (h/day)	None	947	91.8	< 0.001
	< 2	188	93.4	
	≥ 2	105	100.0	

of increased adipose tissue and overall bodyweight in children during puberty. The prevalence of overweight and obesity was marginally less in the post-pubertal period (16–17 yrs). It has been reported earlier that the number of fat cells increases during periods of rapid growth up to 16 yrs of age, after which increased fat ordinarily accumulates by increasing the size of the fat cells already present[8].

The results revealed that regular physical activity was an important factor in reducing the prevalence of overweight and obesity. The prevalence was significantly lower in children who participated regularly in household chores ($P < 0.001$), played outdoor games and performed physical exercise. The diets of the children in the higher socio-economic group are known for their greater fat content, and the subjects are involved in more sedentary activities. These observations are consistent with results of previous studies[9]. In addition, the prevalence of overweight and obesity was higher among children involved in sedentary activities such as spending ≥ 3 h/day watching television[10]. Klesges *et al.*[11] also reported the effect of watching television on metabolic rate, and overweight and obesity in children. In urban areas, considering the safety of keeping children away from heavy traffic, parents feel more comfortable if their children play indoor games or watch television and, therefore, do not encourage them to participate in outdoor sports and games.

Freedman *et al.*[12] showed the adverse effects of overweight in their 17-yr follow-up study and reported that an early average increase of 0.5 kg/m^2 of BMI in children increases the risk for hypertension, dyslipidemia and type-2 diabetes a decade later. It is interesting to note that ~ 8% of adolescents perceived that they were overweight, which indicates that the self-reporting of obesity could also be a good indicator of the problem.

Although the prevalence values of childhood obesity in this study are lower than those of other studies from similar settings[13–17], the increasing trend of overweight and obesity in our study was significant. During a short span of 2 yrs, the proportion of overweight children increased significantly across all age groups and in both sexes. This was accompanied by an increasing trend in mean BMI values across all age groups. The increase was substantial

Table 4. Dietary-related risk factors for the overweight among adolescents (n = 1240)

Risk factor	No. of students		Adjusted odds ratio (95% CI)
	n	Percentage	
Breakfast			
Usually eat	1050	84.68	1
Do not eat	190	15.32	1.50 (1.06–2.13)
Lunch			
Bring from home	738	59.51	1
Eat at home	362	29.19	0.94 (0.77–1.14)
Buy at school	109	08.80	1.41 (1.19–1.64)
Do not eat	31	02.50	1.10 (0.64–1.89)
Family supper			
< Once/week	215	17.33	1
1–2 times/week	327	26.37	0.81 (0.63–1.03)
3–4 times/week	248	20.01	0.68 (0.52–0.88)
≥ 5 times/week	450	36.29	0.69 (0.57–0.84)
Supper in front of television			
< Once/week	131	10.56	1
1–2 times/week	349	28.14	1.07 (0.93–1.23)
3–4 times/week	263	21.21	1.22 (1.00–1.50)
≥ 5 times/week	497	40.09	1.44 (1.18–1.74)
Eating at fast-foods restaurants			
< Once/week	633	51.04	1
1–2 times/week	442	35.64	1.02 (0.90–1.16)
≥ 3 times/week	165	13.32	0.86 (0.57–1.12)

in private schools and not seen in government schools. Although urban schools had a higher proportion of overweight children, both urban and rural schools showed an upward trend in the 2-yr period[14].

Evidence from several national health surveys in Asia points to significant differences in prevalence of overweight and obesity among various countries[18–22]. Asian countries such as Taiwan and China have experienced rapid increase in the prevalence of childhood obesity[23,24]. Rapid economic growth has improved the nutritional, socio-economic and health status of many countries[25]. Obesity has increased markedly with this nutritional evolution in most Asian countries. A similar nutritional transition is under way in India as well[22].

The sedentary lifestyle of children and adolescents has been attributed mainly to television-viewing, computer games, internet, overemphasis on academic excellence, unscientific urban planning and ever-increasing automated transport[26].

The major conclusion drawn from the present study is that low levels of physical activity, watching television, and consuming junk food are associated with a higher prevalence of overweight. Thus, participation in household activities and regular physical exercise could help in lowering the prevalence of overweight. Therefore, the role of physical activity, games and sports should be emphasized, and facilities should be provided for outdoor games in schools, with compulsory hours for sports and games. There is an urgent need to educate the urban community on the aspects of healthy food habits and desired lifestyles to prevent overweight/obesity and its associated ill-effects.

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Osmotic adjustment in pollen grains: a measure of drought adaptation in sorghum?

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The immediate and most common response by the different organs of a plant to water stress is decrease in turgor. This may be partially or fully adjusted by accumulation of solutes. In the present study sorghum pollen grains were subjected to *in vitro* osmotic stress using polyethylene glycol (PEG). The change in size and shape of the pollen grains under osmotic stress was considered as a measure of osmotic adjustment (OA). The *in vitro* pollen response to osmotic stress with and without osmolyte and genotypic response to pollen OA vis-à-vis leaf OA was analysed in kharif and rabi sorghum genotypes. At 40% PEG (discriminative osmotic stress), the pollen grains of rabi genotypes retained their size, whereas the kharif genotypes showed shrinkage but responded to external supply of osmolyte. This indicates increased capacity of turgor adjustment in rabi genotypes compared to kharif genotypes. The increased capacity of turgor adjustment is referred to as intrinsic OA and the response to external supply of osmolyte as induced OA. The leaf OA was significantly high in rabi genotypes compared to kharif genotypes, indicating a close correspondence between intrinsic OA in pollen grains and high leaf OA. In addition the study indicates that OA is a drought-adaptive trait and could have evolved in the rabi genotypes by virtue of their regular exposure to moisture stress, and it could be induced in kharif genotypes.

Keywords: Drought adaptation, osmotic adjustment, pollen grain, sorghum.

MANY physiological mechanisms are adapted by crop plants to drought stress. Integration of these traits in breeding programmes is difficult due to complex or time-consuming protocols[1]. Osmotic adjustment (OA) is one of such mechanisms, which is routinely used to test the drought tolerance of the genotype[2]. It is normally estimated by Morgan's regression method[3], Ludlow's full turgor adjustment method[4] or rehydration method[5,6]. All the three methods require estimation of osmotic potential and relative water content with change in leaf water potential. As a result, this method is time-consuming and difficult for screening a large number of genotypes.

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