Original Article

# Prevalence and socioeconomic correlates of growth impairment among Saudi children and adolescents

Abdulrahman Al-Hussaini[1,2,3], Muhammad Salman Bashir[4], Musa Khormi[5], Wahid Alkhamis[6], Mona Alrajhi[7], Thana Halal[6]

[1]Division of Pediatric Gastroenterology, Children's Specialized Hospital, King Fahad Medical City, [2]College of Medicine, Alfaisal University, [3]Prince Abdullah bin Khalid Celiac Disease Research Chair, Department of Pediatrics, Faculty of Medicine, King Saud University, Riyadh, [4]Department of Biostatistics, Research Services Administration, Research Center at King Fahad Medical City, [5]Division of Pediatric Gastroenterology, Children's Hospital, King Saud Medical City, Riyadh, [6]Ministry of Health, School Health Administration, Riyadh, [7]Family Medicine Specialist, Geriatric Care and Osteoporosis Control Program Coordinator, Ministry of Health, Riyadh, Saudi Arabia

## Abstract

**Background:** Saudi Arabia has witnessed economic prosperity leading to changes in diet and lifestyle. Concurrent with these changes, the prevalence rates of overweight and obesity are rising. No recent data exist on the trends and pattern of growth impairment among Saudi children. We aimed to provide the most recent estimate of the prevalence of thinness and short stature among healthy school-aged children in Riyadh, Saudi Arabia, and to investigate the effect of parental socioeconomic status (SES) on growth impairment.

**Methods:** A cross-sectional study was conducted in 2015 among schoolchildren in Riyadh. A sample of 7931 children (67% girls) aged 6–16 years was randomly selected. Body mass index (BMI) z-score $<-2$ SD and height z-score $<-2$ SD, for age and sex, using the WHO reference 2007, defined thinness and short stature, respectively. To assess the impact of SES on growth, we categorized SES into 4 levels by incorporating 4 main indicators: parents' educational level, family income, type of residence, and parents' jobs.

**Results:** The prevalence of short stature was 15%, and the prevalence of thinness was 3.5%. Stratification of the thinness prevalence rate according to gender indicated that boys were significantly thinner than girls (4.7% versus 2.8%, $P = 0.048$). Short stature was significantly higher among children in the lower SES classes than among their counterparts in the higher SES classes. Parents of thin children were more likely to be less educated, have less income, live in apartments, and have a lower SES than parents of overweight and obese children.

**Conclusions:** The rate of thinness among Saudi children is low, similar to that in developed countries, and is significantly correlated with SES.

**Keywords:** Growth, Saudi Arabia, short stature, socioeconomic status, thinness, Riyadh

**Address for correspondence:** Dr. Abdulrahman Al-Hussaini, Associate Professor of Pediatrics, Consultant Pediatrician, Gastroenterologist and Hepatologist, Alfaisal University, Children's Specialized Hospital, King Fahad Medical City, P. O. Box 59046, Riyadh – 11525, Saudi Arabia.
E-mail: aa_alhussaini@yahoo.com

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## INTRODUCTION

Over the past 40 years, Saudi Arabia has witnessed significant economic prosperity, leading to complex changes in diet, lifestyle, and health patterns. Concurrent with these changes, the rates of overweight and obesity are rising among Saudi children.[1] Although a few studies have reported on the prevalence of pediatric growth faltering in Saudi Arabia at national and regional levels, they are either old[2,3] or small in sample size.[4] No recent data exist on the trends and patterns of undernutrition among Saudi children and adolescents. Undernutrition during childhood has been associated with adverse effects on school achievement, cognitive development, and general health.[5,6] Because of their implications on public health, up-to-date information on trends in growth impairment (i.e., short stature and thinness) is crucial for developing and evaluating the success of interventions to provide good nutrition and promote growth.

These facts prompted us to provide the most recent estimate of the prevalence of growth impairment among a large randomly selected study sample of apparently healthy school-aged children in Riyadh, and to investigate the effect of parental socioeconomic status (SES) on the rate of growth impairment.

## METHODS

### Study setting and design

This research project was an observational cross-sectional population-based study to determine the prevalence of thinness and short stature among apparently healthy school-aged children and adolescents (aged 6–16 years). The sample included both sexes attending primary and intermediate schools in Riyadh, Saudi Arabia, in 2015. Short stature was defined as a z-score of height for age and sex $<-2$ standard deviations (SD), and thinness/wasting was defined as a z-score of low body mass index (BMI) for age and sex $< -2$ SD. The World Health Organization's (WHO) 2007 growth standards and references were used to calculate short stature and thinness measures,[7] and Z-scores of weight, height, and BMI for students aged 5–18 years were determined using WHO Anthroplus software.[8]

### Study population

*Source population:* The details of the methodology of the celiac mass screening study, from which the study population for the present study was recruited, have been described elsewhere.[9] In brief, a total of 104 schools (61 primary schools and 43 intermediate schools; 53 schools for males and 51 schools for females) were randomly selected from the 5 "administrative" geographic regions of Riyadh (North, South, East, West, and Center) using a probability proportionate sampling procedure. Parents of 10046 students provided informed consent and agreed to participate in the study. The final sample consisted of 7931 students (mean age 11.22 ± 2.62 years; 4988 or 63% were female), who provided complete data for analysis. Riyadh is considered the most representative city in Saudi Arabia because of its high rate of immigration from different parts of the country and the demographic, ethnic, genetic, and dietary characteristics of its inhabitants, which are similar to populations in other regions of Saudi Arabia.

### Study procedures

#### *Anthropometric measurements*

Participants' weight and height were measured in the school by a trained team of doctors and nurses. Weight was measured with the students wearing light clothing and no shoes, using an electronic scale to the nearest 100 g. Height was measured using a wall-mounted stadiometer, with the children not wearing shoes. The measurements were recorded to the nearest 0.1 cm. BMI was calculated as the ratio of weight (kilograms) to the square of height (meters).

#### *Data collection*

A health advocator in each school distributed envelopes to all students. Each envelope contained the following: 1) a consent form and 2) a survey to collect demographic data and information on the presence of gastrointestinal (GI) symptoms, including abdominal pain and distension, diarrhea, constipation, vomiting, and SES. All students whose parents gave informed consent underwent measurement of growth parameters. Parental SES was measured by collecting data on 4 main indicators: parents' educational level, family income, type of residence, and parents' jobs. We used a scale of 1–20 as follows: educational level, 6 points; monthly family income 6 points; type of residence, 4 points; type of work, 4 points. In the Saudi community, we believe that the middle SES is much wider than the lower or high SES; therefore, we subcategorized the middle class into low middle and high middle classes. An overall score of $\leq 5$ from a maximum of 20 defined the low SES, 6–10 defined low middle SES, 11–15 defined high middle SES, and >15 defined high SES. Participants were categorized into 6 educational levels: postgraduate degree (6 points), university graduate (5 points), high school graduate (4 points), intermediate school graduate (3 points), primary school graduate (2 points), and illiterate (1 point). Monthly family income was graded as follows: >30000 Saudi riyals (SR) (6 points), 20000–30000 SR (5 points), 10000–20000 SR (4 points), 5000–10000 SR (3 points),

<5000 SR (2 points), and no income (1 point). Type of residence was categorized into 4 types: palace (4 points), villa (3 points), apartment (2 points), and small traditional house (1 point). Occupation of parents was classified as follows: Trader/businessman/professional (4 points), office clerk (3 points), worker (2 points), and unemployed (1 point). The term "professional" refers to a job that requires a higher education degree (such as a bachelor's degree, master's degree, or Ph.D.). "Worker" refers to a working-class person who performs service-oriented work or manual labor, while office clerk refers to an administrative job that involves sitting at a computer or desk. We considered the higher income occupation to refer to the occupation of parents regardless of whether it was the father or mother's job.

### Ethical considerations

This study was approved by the institutional review board in our hospital (number 11-066) and the Ministry of Education in Saudi Arabia. All study participants, or their legal guardians, provided informed written consent prior to study enrollment.

### Statistical analysis

All categorical variables, such as gender, father's education, family income, and occupation, are presented as numbers and percentages. Continuous variables such as age and socioeconomic score are expressed as the mean ± SD. Non-parametric tests were used when data were skewed. The Kolmogorov–Smirnov test was used to check the assumption of a normal distribution. Chi-square/Fisher's exact test was used according to whether the cell expected frequency was smaller than 5, and it was applied to determine the significant association between categorical variables. Multivariate logistic regression analysis by the backward elimination method was applied to determine the most significant risk factors/predictors, by using reference level short stature and low BMI. A two-tailed $P$ value less than 0.05 was considered statistically significant. All data were entered and analyzed using the statistical package SPSS 25 (SPSS Inc., Chicago, IL, USA).

## RESULTS

### Prevalence of growth faltering

Out of 7931 participants in the celiac mass screening study, a total of 2249 children were in the 6-to-9-year age group (28.5%) [48.1% males and 51.9% females]; 3885 children were in the 10-to-13-year age group (49.0%), and 1796 adolescents were in the 14-to-16-year age group (22.6%). One thousand one hundred and eighty-one children and adolescents had short stature (15%), and 274 were thin (3.5%) [Tables 1-5]. Stratification of the short stature prevalence rate according to age group, shown in Table 1, indicates that adolescents are more affected with short stature than children (16.6% versus 14.5%). Comparatively, young girls (6–9 years) had a higher prevalence of short stature than young boys (33% versus 21%, $P < 0.001$); however, male adolescents were shorter than female adolescents (29.3% versus 22.6%, $P = 0.009$). The differences for gender were not statistically significant among the 10-to-13-year-old age group. Overall, boys were significantly thinner than girls (4.7% versus 2.8%, $P = 0.048$). Stratification of the thinness prevalence rate according to age group, presented in Table 2, indicates a progressive decrease in the prevalence of thinness with advancing age, without significant differences between girls and boys.

### Comparison of short group versus normal stature group

Table 3 shows a comparison of the short and normal stature groups for the indicators of SES and the presence of GI symptoms. Short stature was significantly higher among children and adolescents in the lower SES classes than among their counterparts in the higher SES classes across all the SES indicators [Figure 1]. Parents of short children and adolescents had significantly lower income and education and were more likely to live in traditional houses and apartments than parents of children and adolescents with normal stature. The presence of GI symptoms was not different between the two groups.

### Comparison of the thin group, normal BMI group, and overweight/obese group

Apart from the significantly younger age and male

**Table 1: Prevalence of short stature based on age groups and gender**

| Age Group (year) | Total (*n*=7931) | Short (*n*=1181) Total (*n*=1181) | Males (*n*=475) | Females (*n*=706) | *P* |
|---|---|---|---|---|---|
| 6-16 years | 2943 males<br>4988 females | 14.9% | 16.1% % | 14.1% | 0.804 |
| 6-9 | 2250 (28.4%) | 230 (28.0%) | 99 (20.8%) | 231 (32.8%) | *<0.001 |
| 10-13 | 3885 (49.0%) | 552 (46.8%) | 237 (49.9%) | 315 (44.7%) | 0.075 |
| > 13 | 1795 (22.6%) | 298 (25.3%) | 139 (29.3%) | 159 (22.6%) | *0.009 |

**Table 2: Prevalence of thinness based on age groups and gender**

| Age Group (year) | Total (*n*=7931) | Thin (*n*=274) Total (*n*=274) | Males (*n*=140) | Females (*n*=134) | *P* |
|---|---|---|---|---|---|
| 6-16 years | 2943 males<br>4988 females | 3.45% | 4.75% | 2.68% | 0.048 |
| 6-9 | 2250 (28.4%) | 104 (4.6%) | 60 (42.9%) | 44 (32.8%) | 0.087 |
| 10-13 | 3885 (49.0%) | 119 (3.1%) | 54 (38.6%) | 65 (48.5%) | 0.097 |
| > 13 | 1796 (22.6%) | 51 (2.8%) | 26 (18.6%) | 25 (18.7%) | 0.986 |

**Table 3: Comparison of short stature group versus normal growth group**

| | | Short Stature (*n*=1181) | Normal Height (*n*=6645) | OR [95% C.I] | *P* |
|---|---|---|---|---|---|
| Age | Mean±SD | 11.38±2.65 | 11.22±2.60 | 0.977[0.954-0.998] | 0.052 |
| Gender | Male | 475 (40.2%) | 2425 (36.5%) | 1.171 [1.032-1.329] | *0.015 |
| | Female | 706 (59.8%) | 4220 (63.5%) | | |
| Father's Education | Illiterate | 110 (9.3%) | 468 (7.0%) | 1.356 [1.091-1.685] | *0.006 |
| | Primary | 232 (19.6%) | 916 (13.8%) | 1.529 [1.303-1.794] | *<0.001 |
| | Intermediate | 222 (18.8%) | 1007 (15.2%) | 1.296 [1.104-1.522] | *0.002 |
| | High School | 350 (29.6%) | 1941 (29.2%) | 1.021 [0.891-1.169] | 0.766 |
| | Bachelors | 201 (17.0%) | 1762 (26.5%) | 0.568 [0.484-0.668] | *<0.001 |
| | Masters/Doctorate | 51 (4.3%) | 439 (6.6%) | 0.638 [0.474-0.859] | *0.003 |
| Mother's Education | Illiterate | 214 (18.1%) | 785 (11.8%) | 1.652 [1.4-1.95] | *<0.001 |
| | Primary | 274 (23.2%) | 1073 (16.1%) | 1.569 [1.35-1.823] | *<0.001 |
| | Intermediate | 213 (18.0%) | 1080 (16.3%) | 1.134 [0.964-1.333] | 0.128 |
| | High School | 252 (21.3%) | 1683 (25.3%) | 0.8 [0.689-0.929] | *0.003 |
| | Bachelors | 208 (17.6%) | 1816 (27.3%) | 0.568 [0.485-0.667] | *<0.001 |
| | Masters/Doctorate | 6 (0.5%) | 89 (1.3%) | 0.376 [0.164-0.862] | *0.016 |
| Family Income | No Income | 89 (7.5%) | 313 (4.7%) | 1.649 [1.292-2.105] | *<0.001 |
| | < 5000 | 286 (24.2%) | 1244 (18.7%) | 1.387 [1.198-1.607] | *<0.001 |
| | 5000-10000 | 375 (31.8%) | 1879 (28.3%) | 1.18 [1.032-1.349] | *0.015 |
| | 10000-20000 | 250 (21.2%) | 1927 (29.0%) | 0.657 [0.566-0.763] | *<0.001 |
| | 20000-30000 | 60 (5.1%) | 653 (9.8%) | 0.491 [0.374-0.645] | *<0.001 |
| | > 30000 | 61 (5.2%) | 319 (4.8%) | 1.08 [0.815-1.431] | 0.591 |
| Occupation | Unemployed | 376 (31.8%) | 1721 (25.9%) | 1.336 [1.169-1.528] | *<0.001 |
| | Worker | 681 (57.7%) | 3827 (57.6%) | 1.003 [0.885-1.137] | 0.964 |
| | Office Clerk | 80 (6.8%) | 594 (8.9%) | 0.74 [0.581-0.943] | *0.015 |
| | Trader/Professional | 44 (3.7%) | 502 (7.6%) | 0.474 [0.346-0.649] | *<0.001 |
| Residence | Traditional house | 245 (20.7%) | 806 (12.1%) | 1.896 [1.618-2.223] | *<0.001 |
| | Apartment | 439 (37.2%) | 2120 (31.9%) | 1.263 [1.11-1.436] | *<0.001 |
| | Villa | 472 (40.0%) | 3580 (53.9%) | 0.57 [0.502-0.647] | *<0.001 |
| | Palace | 7 (0.6%) | 31 (0.5%) | 1.27 [0.559-2.896] | 0.565 |
| Socioeconomic Status (SES) | ≤ 5 (Low SES) | 71 (6.0%) | 252 (3.8%) | 1.62 [1.238-2.128] | *<0.001 |
| | 6–10 (Lower Middle SES) | 498 (42.2%) | 2056 (30.9%) | 1.63 [1.434-1.847] | *<0.001 |
| | 11–15 (Higher Middle SES) | 545 (46.1%) | 3711 (55.9%) | 0.68 [0.598-0.767] | *<0.001 |
| | > 15 (High SES) | 67 (5.7%) | 625 (9.4%) | 0.58 [0.447-0.751] | *<0.001 |
| SES score | Mean±SD | 10.55±3.22 | 11.57±3.26 | 1.098 [1.078-1.119] | *<0.001 |
| Abdominal Distension | Yes | 84 (7.1%) | 513 (7.7%) | 0.92 [0.72-1.163] | 0.469 |
| Diarrhea | Yes | 74 (6.3%) | 390 (5.9%) | 1.07 [0.829-1.386] | 0.595 |
| Constipation | Yes | 118 (10.0%) | 647 (9.7%) | 1.03 [0.837-1.265] | 0.786 |
| Abdominal Pain | Yes | 295 (25.0%) | 1733 (26.1%) | 0.94 [0.818-1.088] | 0.426 |
| Vomiting | Yes | 68 (5.8%) | 342 (5.1%) | 1.13 [0.861-1.472] | 0.385 |

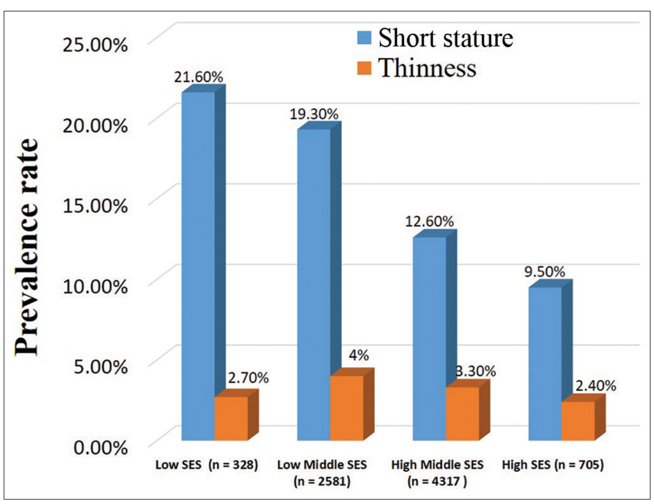


**Figure 1:** Prevalence of short stature and thinness based on the socioeconomic status

predominance in the thin group compared to the normal BMI group, the two groups did not differ in the SES indicators and scores [Table 4]. However, on further subanalysis and comparison of the thin group versus the overweight and obese group (2504 children and adolescents, 31.5%), some differences became more prominent between the two groups. Notably, parents of thin children and adolescents were more likely to be less educated, have less income, live in apartments, and have a lower SES, than parents of overweight and obese children [Table 5]. Additionally, thin children and adolescents had a significantly higher frequency of GI symptoms than their counterparts in the normal BMI group and overweight/obese group.

## DISCUSSION

Our study presents a snapshot of the current undernutrition status among school-aged children and adolescents in a representative sample of Riyadh and makes a number

**Table 4: Comparison of thin group versus normal body mass index group**

| | | Thin (*n*=274) | Normal BMI (*n*=6218) | OR [95% C.I] | *P* |
|---|---|---|---|---|---|
| Age | Mean±SD | 10.62±2.970 | 11.18±2.616 | 1.091 [1.041-1.143] | *0.002 |
| Gender | Male | 140 (51.1%) | 2264 (36.4%) | 1.825 [1.432-2.325] | *<0.001 |
| | Female | 134 (48.9%) | 3954 (63.6%) | | |
| Father's Education | Illiterate | 28 (10.2%) | 464 (7.5%) | 1.411 [0.944-2.11] | 0.092 |
| | Primary | 40 (14.6%) | 916 (14.7%) | 0.989 [0.702-1.394] | 0.952 |
| | Intermediate | 40 (14.6%) | 988 (15.9%) | 0.905 [0.643-1.274] | 0.567 |
| | High School | 92 (33.6%) | 1795 (28.9%) | 1.246 [0.964-1.61] | 0.093 |
| | Bachelors | 58 (21.2%) | 1555 (25.0%) | 0.805 [0.599-1.082] | 0.150 |
| | Masters/Doctorate | 12 (4.4%) | 399 (6.4%) | 0.668 [0.371-1.202] | 0.175 |
| Mother's Education | Illiterate | 38 (13.9%) | 828 (13.3%) | 1.048 [0.738-1.488] | 0.792 |
| | Primary | 56 (20.4%) | 1077 (17.3%) | 1.226 [0.908-1.657] | 0.183 |
| | Intermediate | 42 (15.3%) | 1040 (16.7%) | 0.901 [0.645-1.26] | 0.544 |
| | High School | 71 (25.9%) | 1487 (23.9%) | 1.113 [0.844-1.467] | 0.449 |
| | Bachelors | 64 (23.4%) | 1603 (25.8%) | 0.877 [0.659-1.167] | 0.369 |
| | Masters/Doctorate | 2 (0.7%) | 77 (1.2%) | 0.586 [0.143-2.4] | 0.453 |
| Family Income | No Income | 20 (7.3%) | 303 (4.9%) | 1.537 [0.961-2.458] | 0.071 |
| | < 5000 | 53 (19.3%) | 1249 (20.1%) | 0.954 [0.702-1.296] | 0.763 |
| | 5000-10000 | 90 (32.8%) | 1819 (29.3%) | 1.183 [0.914-1.531] | 0.201 |
| | 10000-20000 | 69 (25.2%) | 1717 (27.6%) | 0.882 [0.668-1.166] | 0.378 |
| | 20000-30000 | 18 (6.6%) | 537 (8.6%) | 0.744 [0.457-1.209] | 0.231 |
| | > 30000 | 13 (4.7%) | 293 (4.7%) | 1.007 [0.57-1.78] | 0.980 |
| Occupation | Unemployed | 73 (26.6%) | 1684 (27.1%) | 0.978 [0.744-1.286] | 0.872 |
| | Worker | 168 (61.3%) | 3588 (57.7%) | 1.162 [0.906-1.489] | 0.236 |
| | Office Clerk | 25 (9.1%) | 529 (8.5%) | 1.08 [0.709-1.645] | 0.721 |
| | Trader/Professional | 8 (2.9%) | 416 (6.7%) | 0.419 [0.206-0.853] | *0.013 |
| Residence | Traditional house | 37 (13.5%) | 850 (13.7%) | 0.986 [0.692-1.405] | 0.937 |
| | Apartment | 106 (38.7%) | 2094 (33.7%) | 1.243 [0.969-1.594] | 0.086 |
| | Villa | 129 (47.1%) | 3146 (50.6%) | 0.87 [0.682-1.107] | 0.255 |
| | Palace | 0 (0.0%) | 28 (0.5%) | — | 0.266 |
| Socioeconomic status (SES) | <=5 (Low SES) | 9 (3.3%) | 248 (4.0%) | 0.82 [0.416-1.608] | 0.559 |
| | 6-10 (Lower Middle SES) | 103 (37.6%) | 2085 (33.5%) | 1.19 [0.93-1.533] | 0.164 |
| | 11-15 (Higher Middle SES) | 145 (52.9%) | 3352 (53.9%) | 0.96 [0.754-1.225] | 0.748 |
| | > 15 (High SES) | 17 (6.2%) | 532 (8.6%) | 0.71 [0.429-1.164] | 0.171 |
| SES score | Mean±SD | 11.08±3.133 | 11.36±3.254 | 1.037 [0.999-1.077] | 0.059 |
| Abdominal Distension | Yes | 20 (7.3%) | 415 (6.7%) | 1.1 [0.691-1.755] | 0.685 |
| Diarrhea | Yes | 14 (5.1%) | 366 (5.9%) | 0.86 [0.498-1.489] | 0.592 |
| Constipation | Yes | 35 (12.8%) | 616 (9.9%) | 1.33 [0.925-1.917] | 0.122 |
| Abdominal Pain | Yes | 89 (32.5%) | 1611 (25.9%) | 1.38 [1.062-1.783] | *0.015 |
| Vomiting | Yes | 23 (8.4%) | 290 (4.7%) | 1.87 [1.203-2.917] | *0.005 |

of important observations. First, the prevalence of thinness among Saudi children and adolescents (3.6%) is comparable to that in developed countries (3%–6%).[10,11] However, the prevalence of short stature (15%) puts Saudi Arabia in an intermediate position between developed and developing countries.[12,13] Second, significant differences were observed for SES variables between short versus normal stature children and adolescents, and thin versus overweight/obese children and adolescents, indicating that undernutrition is more prevalent among individuals with lower SES.

The WHO has defined the double burden of malnutrition as the simultaneous existence of a high rate of undernutrition along with a high rate of overweight and obesity in any population.[10] The cutoffs used to define a high prevalence of undernutrition are thinness >20% and stunting/short stature >30% and overweight/obesity in children and adults of more than 30%.[11] The double burden of malnutrition is especially prevalent in low- and middle-income countries such as sub-Saharan Africa, North Africa, and South and East Asia, driven by rapid dietary changes characterized by increased consumption of low-cost ultra-processed unhealthy foods and beverages.[11] The WHO has categorized Middle Eastern countries into countries in "early nutrition transition" characterized by moderate levels of overweight, obesity, and undernutrition. These countries include Egypt, Jordan, Lebanon, Libyan Arab Jamahiriya, Morocco, Palestine, and the Syrian Arab Republic. Other countries in "advanced nutrition transition" include the Arabian Gulf countries, which have high levels of overweight and obesity and moderate levels of undernutrition.[14] A third category constitutes countries with significant undernutrition, widespread micronutrient deficiencies, and emerging overweight and obesity in certain socioeconomic subgroups; countries in this category include Yemen, Iraq, and

**Table 5: Comparison of thin group versus overweight + obese group**

| | | Thin (BMI < - 2 z-score) (*n*=274) | Overweight + Obese (BMI > +1 z-score) (*n*=2504) | OR [95% C.I] | *P* |
|---|---|---|---|---|---|
| Gender | Male | 140 (51.1%) | 895 (35.7%) | 1.878 [1.462-2.413] | *<0.001 |
| | Female | 134 (48.9%) | 1609 (64.3%) | | |
| Father's Education | Illiterate | 28 (10.2%) | 159 (6.3%) | 1.679 [1.1-2.562] | *0.015 |
| | Primary | 40 (14.6%) | 333 (13.3%) | 1.114 [0.782-1.589] | 0.549 |
| | Intermediate | 40 (14.6%) | 375 (15.0%) | 0.97 [0.682-1.381] | 0.868 |
| | High School | 92 (33.6%) | 751 (30.0%) | 1.18 [0.905-1.538] | 0.220 |
| | Bachelors | 58 (21.2%) | 671 (26.8%) | 0.734 [0.542-0.993] | *0.044 |
| | Masters/Doctorate | 12 (4.4%) | 173 (6.9%) | 0.617 [0.339-1.123] | 0.111 |
| Mother's Education | Illiterate | 38 (13.9%) | 254 (10.1%) | 1.426 [0.989-2.057] | 0.056 |
| | Primary | 56 (20.4%) | 386 (15.4%) | 1.41 [1.031-1.928] | *0.031 |
| | Intermediate | 42 (15.3%) | 411 (16.4%) | 0.922 [0.653-1.302] | 0.644 |
| | High School | 71 (25.9%) | 678 (27.1%) | 0.942 [0.709-1.252] | 0.680 |
| | Bachelors | 64 (23.4%) | 689 (27.5%) | 0.803 [0.599-1.076] | 0.142 |
| | Masters/Doctorate | 2 (0.7%) | 36 (1.4%) | 0.504 [0.121- 2.105] | 0.338 |
| Family Income | No Income | 20 (7.3%) | 134 (5.4%) | 1.393 [0.855- 2.267] | 0.181 |
| | < 5000 | 53 (19.3%) | 434 (17.3%) | 1.144 [0.833-1.571] | 0.406 |
| | 5000-10000 | 90 (32.8%) | 671 (26.8%) | 1.336 [1.023-1.745] | *0.033 |
| | 10000-20000 | 69 (25.2%) | 762 (30.4%) | 0.769 [0.578-1.024] | 0.072 |
| | 20000-30000 | 18 (6.6%) | 249 (9.9%) | 0.637 [0.388-1.045] | 0.072 |
| | > 30000 | 13 (4.7%) | 144 (5.8%) | 0.816 [0.456-1.461] | 0.493 |
| Occupation | Unemployed | 73 (26.6%) | 630 (25.2%) | 1.08 [0.814-1.433] | 0.592 |
| | Worker | 168 (61.3%) | 1426 (56.9%) | 1.198 [0.928-1.547] | 0.165 |
| | Office Clerk | 25 (9.1%) | 232 (9.3%) | 0.983 [0.638-1.516] | 0.939 |
| | Trader/Professional | 8 (2.9%) | 216 (8.6%) | 0.319 [0.156- 0.653] | *0.001 |
| Residence | Traditional house | 37 (13.5%) | 309 (12.3%) | 1.109 [0.769-1.6] | 0.580 |
| | Apartment | 106 (38.7%) | 714 (28.5%) | 1.582 [1.222-2.048] | *<0.001 |
| | Villa | 129 (47.1%) | 1419 (56.7%) | 0.68 [0.53-0.873] | *0.002 |
| | Palace | 0 (0.0%) | 17 (0.7%) | — | 0.171 |
| Socioeconomic status (SES) | ≤5 (Low SES) | 9 (3.3%) | 108 (4.3%) | 0.75 [0.377-1.505] | 0.421 |
| | 6-10 (Lower Middle SES) | 103 (37.6%) | 703 (28.1%) | 1.54 [1.19-2] | *0.001 |
| | 11-15 (Higher Middle SES) | 145 (52.9%) | 1435 (57.3%) | 0.84 [0.652-1.075] | 0.164 |
| | > 15 (High SES) | 17 (6.2%) | 258 (10.3%) | 0.58 [0.347-0.957] | *0.031 |
| Abdominal Distension | Yes | 20 (7.3%) | 257 (10.3%) | 0.69 [0.429-1.105] | 0.120 |
| Diarrhea | Yes | 14 (5.1%) | 150 (6.0%) | 0.85 [0.481-1.483] | 0.557 |
| Constipation | Yes | 35 (12.8%) | 212 (8.5%) | 1.58 [1.081-2.319] | *0.017 |
| Abdominal Pain | Yes | 89 (32.5%) | 616 (24.6%) | 1.47 [1.127-1.929] | *0.001 |
| Vomiting | Yes | 23 (8.4%) | 152 (6.1%) | 1.42 [0.897-2.24] | 0.133 |

Palestine (Gaza). In Saudi Arabia, data on growth patterns among children and adolescents (aged 6–18) are scarce. In 2004, El Mouzan *et al.*,[15] using the WHO child growth standards, reported a prevalence of wasting in 12.7% and stunting in 13.7% of a national sample of Saudi children younger than 5 years of age. The authors concluded that undernutrition among young children in Saudi Arabia is intermediate, between socioeconomically developed and developing countries. In 2017, Alshammari *et al.*[4] reported a prevalence rate of thinness in 6.9%, short stature in 5.7%, and overweight and obesity in 32% of 1107 children and adolescents (aged 5–18) from the Hail region. In a previous report on the same population as the present study, we determined that the prevalence rate of obesity in Riyadh increased from 12.7% in 2006[16] to 18.2% in 2015 (combined overweight and obesity = 31.6%),[1] a rate that is similar to the obesity rate in the U.S. pediatric population.[17] The low prevalence of thinness (3.6% and 6.9%) and high rate of overweight and obesity (>30%) in two major cities (Riyadh and Hail) indicate that there is a rightward shift in the right tail of the BMI distribution associated with the obesity epidemic in Saudi Arabia, similar to that of developed countries. While thinness could be a marker of malnutrition, thin children are not necessarily undernourished. The clinical value of thinness is complicated by genetic and biologic factors across different populations, which lead to changes in body composition with growth, and differences in timing and pace of growth spurt and sexual maturation.[18,19] The increased frequency of GI symptoms among thin children in this study should be interpreted with caution. In any celiac mass screening study in the general population, it is likely that parents of symptomatic children become more interested in participating, which might lead to unavoidable selection bias.

While few children were classified as thin, a considerably higher number of children in our study were short (15%). Attained height is the result of genetic factors, environmental and sociocultural conditions, and nutrition during the growth period. Short stature or stunting is largely attributed to chronic undernutrition; however, the key contributing factors vary from one country to another. In some low-income countries, parasitic infections contribute to growth stunting by causing loss of appetite, diarrhea, and malabsorption.[20,21] In Saudi Arabia, we believe that familial/genetic causes contribute to a more significant proportion of short stature than undernutrition does. In a retrospective review of 110 Saudi children and adolescents with short stature, referred to a tertiary care-based pediatric endocrine clinic from 1990 to 2009, 57 patients (51.8%) were found to have genetic short stature, while endocrine and nutritional causes were diagnosed in the remaining 53 patients (48.2%).[22] In contrast, familial short stature was a minor cause of short stature (<5%) in a large case series with subjects from other countries.[23,24] The high rate of consanguineous marriages in Saudi Arabia (up to 50%–60%) could explain the high rate of familial short stature.[25] Furthermore, several developing countries (e.g. Jordan, Cameron, Pakistan, Palestine) with much lower economic development and living standards than Saudi Arabia scored lower prevalence rates of short stature (5%–10%),[23,24,26] which further supports our assumption that undernutrition is not the major player leading to short stature among Saudi children and adolescents. Thus, we acknowledge the negative impact of low SES on the growth of a subgroup of socioeconomically disadvantaged children with subsequent nutritional deprivation and poor environmental conditions, as evidenced by the statistically significant differences in socioeconomic indices between short- versus normal-stature children and adolescents, and thin versus overweight/obese children and adolescents. Further research is needed to investigate the underlying causes of short stature among Saudi children and adolescents to identify preventable or modifiable etiologies.

While the obesity epidemic in Saudi Arabia is receiving considerable attention from researchers, health officials, and the media in terms of both policy and practice, our study is timely, shifting the focus from overnutrition in the Saudi community to undernutrition. Our study identified children and adolescents in the low SES category as a subgroup vulnerable to developing undernutrition. It is very important to prevent these vulnerable populations from undernutrition during childhood and adolescence, the critical periods of growth and development, that could have long-term implications for adult health. Undernutrition among schoolchildren has been associated with poor cognition and school achievement, learning difficulties, and behavioral problems, compared with matched controls.[27] Malnutrition is the fundamental cause of morbidity and mortality among children.[28] Adoption of effective measures to improve SES in this vulnerable group can be the most cost-effective way of preventing growth faltering and associated adverse health outcomes.[29]

Our study has several limitations. The cross-sectional nature of our study precluded any inference on the causality between variables. The study sample was not a national sample, which makes it difficult to generalize the results to the whole country and does not represent the rural community in Saudi Arabia. However, these data from the largest Saudi city are representative of the Saudi urban setting and can be compared to prevalence data recorded in other urban cities in other countries. The strengths of this study were the random stratifying sampling methodology and the large general pediatric population that was divided into 4 socioeconomic categories to study the socioeconomic variables that correlate with growth to identify groups vulnerable to malnutrition. The study has merits in providing updated data on the prevalence of growth patterns among Saudi children and adolescents.

The Saudi community's significant economic prosperity and increased living standards over the past 30 to 40 years has led to a shift toward BMI distribution associated with the obesity epidemic and a decline in undernutrition to levels similar to those in developed countries. These growth patterns are correlated with SES.

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## Conflicts of interest

There are no conflicts of interest.

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