Body mass index in Saudi Arabian children and adolescents: a national reference and comparison with international standards

Abdullah S. Al Herbish, a Mohammed I. El Mouzan, a Abdullah A. Al Salloum, a Mansour M. Al Qureshi, b Ahmed A. Al Omar, b Peter J. Foster, c Tatjana Kecojevic c

From the a Department of Pediatrics, King Saud University, b Ministry of Health, Riyadh, Saudi Arabia, c School of Mathematics, Manchester University, United Kingdom

Correspondence: Abdullah S. Al Herbish, MD • 2965 Abdulaziz Aba Husain Street-Al Morsalat, Riyadh 12461-6591, Saudi Arabia • T: +966-55-525-3313 F: +966-1-463-3582 • asalherbish@yahoo.com / vppa_office@drsulaimanalhabib.com • Accepted for publication June 2009


BACKGROUND AND OBJECTIVES: Because there are no reference standards for body mass index (BMI) in Saudi children, we established BMI reference percentiles for normal Saudi Arabian children and adolescents and compared them with international standards.

SUBJECTS AND METHODS: Data from a stratified multistage probability sample were collected from the 13 health regions in Saudi Arabia, as part of a nationwide health profile survey of Saudi Arabian children and adolescents conducted to establish normal physical growth references. Selected households were visited by a trained team. Weight and length/height were measured and recorded following the WHO recommended procedures using the same equipment, which were subjected to both calibration and intra/interobserver variations.

RESULTS: Survey of 11 874 eligible households yielded 35 275 full-term and healthy children and adolescents who were subjected to anthropometric measurements. Four BMI curves were produced, from birth to 36 months and 2 to 19 years for girls and boys. The 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th, and 97th percentiles were produced and compared with the WHO and CDC BMI charts. In the higher percentiles, the Saudi children differed from Western counterparts, indicating that Saudi children have equal or higher BMIs.

CONCLUSION: The BMI curves reflect statistically representative BMI values for Saudi Arabian children and adolescents.
anthropometric techniques using a well-tested design and calibrated equipment at frequent intervals. Sample selection was based on the most recent population census at the start of the study with the assistance of the general directorate of statistics, Ministry of Planning in Saudi Arabia. 

Taking an average and perhaps a conservative Saudi family size of 3 children, 14,000 households will theoretically yield a sample size of 42,000 children and adolescents (0-19 years of age). This was enough to produce a valid and representative result with a standard error of less than 5%. Households were randomly selected using a stratified multistage probability sampling procedure. The details of the selected households (location, name of the family head, and other information) were provided by the above mentioned general directorate of statistics. 

As an important prerequisite for this project, a pilot study was performed in Buraidah City targeting 70 households. This succeeded in testing the procedure starting from training teams to locating the households to collection of the data. Minor modifications were done in the procedure and some difficulties and unexpected obstacles were overcome. The questionnaire in its final version contained three major parts: first, the demographic data of all family members and their medical history; second, physical examination; and third, the measurements after assuring eligibility criteria comprised the following: Saudi family with children and/or adolescents, born at term and free of chronic illnesses based on the history and the physical examination.

At least two investigators actively participated in training the teams in the 13 health directorate all over Saudi Arabia. These investigators remained in constant communication with the team heads to solve any unexpected difficulties. Furthermore, they were responsible for reviewing all completed questionnaires sent to the project headquarters in Riyadh before data entry was initiated. The techniques of measurement were done as per WHO recommendations. 

This included measuring the child’s length (for <2 years old) with two observers with the child in supine position on a flat surface stadiometer with a fixed head and sliding feet ends, or standing height (for >2 years old) performed by one observer following the recommended standards. Length and height measurement was recorded to the nearest 0.1 cm. The weight was performed with minimal clothing and recorded to the nearest 0.1 kg. The equipment was standardized in that two to three new sets were purchased specifically for the project per directorate. This equipment was easily calibrated, repaired, carried, and moved around. Reliability and accuracy was further assured by following the intra- and inter-observer variations done randomly in 1% of the sample. This was randomly performed on the 1st and the 15th household, respectively, by doing the measurement twice. All data were double-checked, multiple frequency tables were scrutinized, and statistical techniques were used to detect deficiencies and inaccuracies. The date were entered utilizing Epi info 2002 CDC, US, software program published by the CDC. 

Birth date which was recorded from the birth certificate or the Saudi national identification card was converted from Hegira to Gregorian and the decimal age was calculated. A published software was used. The lambda, mu, sigma (LMS) method proposed by Cole and Green was utilized for curve construction, smoothing of weight and height and the calculated BMI \([\text{wt (kg)} / (\text{L or Ht m}^2)]\) against age for both boys and girls.

**RESULTS**

Of the 14,000 targeted households, 11,874 (84.8%) were found eligible as the remaining were either vacant or occupied by families who were non-Saudis or had non-eligible children. However, this number of households yielded 35,279 eligible full-term and healthy children and adolescents for measurements. The sample was well distributed per region indicat-

<table>
<thead>
<tr>
<th>Region</th>
<th>Eligible children no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makkah Al Mokarramah</td>
<td>6430 (18.1)</td>
</tr>
<tr>
<td>Riyadh</td>
<td>6395 (18.0)</td>
</tr>
<tr>
<td>Eastern Province</td>
<td>3810 (11.1)</td>
</tr>
<tr>
<td>Aseer</td>
<td>3459 (9.9)</td>
</tr>
<tr>
<td>Al Jouf</td>
<td>2347 (6.6)</td>
</tr>
<tr>
<td>Najran</td>
<td>2241 (6.3)</td>
</tr>
<tr>
<td>Al Madina Al Monawarah</td>
<td>2123 (6.0)</td>
</tr>
<tr>
<td>Northern Borders</td>
<td>2044 (5.8)</td>
</tr>
<tr>
<td>Hail</td>
<td>1945 (5.5)</td>
</tr>
<tr>
<td>Gizan</td>
<td>1613 (4.7)</td>
</tr>
<tr>
<td>Qassim</td>
<td>1293 (3.7)</td>
</tr>
<tr>
<td>Al Baha</td>
<td>884 (2.5)</td>
</tr>
<tr>
<td>Tabuk</td>
<td>715 (2.0)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>35,279 (100)</td>
</tr>
</tbody>
</table>
ing good representation (Table 1). The female to male ratio was almost equal (49.5% were females and 50.6% males). Four BMI curves were created: 0-36 month and 2-19 years for both females and males. Ten percentiles were formed similar to the CDC 2000 growth curves. These were the 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th, and 97th percentile. The 85th percentile was included for its important value as a cut-off point for definition of overweight. These curves are shown in Figures 1, 2, 3, and 4.
BMI IN SAUDI CHILDREN

Figure 5. BMI for girls from birth to 60 months: comparison with WHO.

Figure 6. BMI for boys from birth to 60 months: comparison with WHO.

Figure 7. BMI for girls from age 2 to 19 years: comparison with CDC.

Figure 8. BMI for boys from age 2 to 19 years: comparison with CDC.

an attempt to make a comparison between the present study curves and other internationally available curves, we overlapped the present curves with the WHO and the CDC 2000 available curves for the 0-60 months and the 2-19 years of age, respectively (Figures 5, 6, 7, and 8).

DISCUSSION
Establishing norms for every community has become a necessity. Growth charts for Saudi children and adolescents have finally been established for use in the assessment of both healthy and diseased children. An important parameter of growth is BMI. This has been
BMI IN SAUDI CHILDREN

useful in the assessment of physical growth in children and in the definition of obesity, both in children and adults. Furthermore, BMI has been found to correlate very well with other long-term health parameters, e.g. blood pressure. Among the various tools to assess overweight and obesity, BMI has therefore become more frequently used during the last few decades. BMI is affected by ethnicity. It is therefore necessary to establish BMI for children and adolescents for the Saudi community where obesity has become prevalent in both children and adults. This is due perhaps to changes in the lifestyle of the Saudi community. Weight and BMI have shown a continuous increase over the decades. Al Hazzaa demonstrated rising trends in BMI, body fatness, central obesity, and prevalence of obesity among Saudi school boys over the last two decades.

In establishing any normal value, it is very pertinent to compare these values to what is available internationally. In this study, we have overlapped the calculated BMI for the children and adolescents included in the study with the available WHO (young) and the CDC (old) BMIs. It is very interesting to note that higher percentiles show a difference, illustrating that Saudi children may be equal or even more in BMI compared to their western counterparts. This coincides with the fact that BMIs over the last two decades have been increasing. This phenomena have also been noticed in other communities such as the US and Australia and some neighboring countries (such as Kuwait and Bahrain). The sex differences noted in the present study depict that female children and adolescents may have higher BMI values compared to males is in line with the reports of Al Shehri et al. The lower percentiles, however, were less than the WHO and CDC counterparts, particularly beyond six months of age.

We believe that the present study is quite representative for Saudi children and adolescents as it has followed a multi-stage probability random sampling procedure, which is known to be the strongest design to select a representative sample of any population. Furthermore, the methodology of case finding, accurate equipment, and accurate measurements with strong intra- and interobserver variation observations further augment the strength of the representation. Therefore, we highly recommend that these BMI curves be used for reference purposes for Saudi children and adolescents and perhaps for other neighboring countries. These curves should be referred to for assessment of healthy children and children suffering from chronic illness in order to monitor normal growth, an important goal for a proper long-term care and management. Children with specific disorders such as chromosomal anomalies should have their own curves. This has fortunately been established for some children such as Saudi children with trisomy 21.

Acknowledgment

The authors would like to thank the teams who participated in the field work, and Cecile Singson Sael and Pia Miguel for typing the manuscript.
REFERENCES
1. Quetelet LAJ. Physique Sociale. Vol 2. Brus-
sels: C Muquardt; 1869.
2. Kamp J. Ein Korperspropti Onsegesetz zur beurteilung der langegewichtstund – abweicher populations – altergruppe. Munchener Medizi-
nische Wochenschrift 1921;68:976-8.
3. WHO multicenter growth reference group. As-
seessment of differences in linear growth among population in the WHO multicenter growth refer-
4. Kuczmarski RJ, Ogden CL, Guo SS, Grum-
methods and development. Vital Health Stat 11 
2002;246:1-190.
5. Lynch J, Wang XL, Wilcken DE. Body mass 
index in Australian children: recent changes 
6. Al-Hazzaa H, Al-Nakeeb Y, Olayan A. Norma-
tive values of physical fitness in Saudi youth 15-
25 years. Riyadh Educational Research Center, 
King Saud University; 1988.
7. Al-Sekait M, Al Nasser A, Bamgboye E. The 
growth patterns of school children in Saudi Ara-
8. Al Nuaim AR, Bamgboye EA, Al Herbish A. 
The pattern of growth and obesity in Saudi Ara-
bian male school children. Int J Obesity 
1996;20:1000-5.
9. Magbool GM. Body mass index of Saudi chil-
dren ages six to 16 years from the Eastern prov-
10. Waterlow JC, Bazina R, Keller W, Lane WK, 
Nichman MZ, Tanner JM. The presentation and 
use of height and weight data for comparing the 
nutritional status of groups of children un-
der age of 10 years. Bull World Health Organ 
11. Population characteristics in the Kingdom of 
Saudi Arabia. Demographic survey. Central 
Department of Statistics (Population and Vital 
Statistics), Riyadh, KSA: Ministry of Planning; 
12. Jelliffe DB. The assessment of nutritional 
status of the community. WHOG, 1986, Mono-
graph No. 53.
13. The center for disease control and preven-
tion. The Epinfo Nutrition Program. Nutstat 2002; 
gov/epinfo/.
centile curves: the LMS method and penalized 
15. El-Mouzan MI, Al-Herbish AS, Al-Salloum 
AA, Qurachi MM, Al Omar AA. Growth charts for 
Saudi children and adolescents. Saudi Med 
16. Guillaume M. Defining obesity in child-
1999;70:1265-30S.
17. Lauer RM, Clarke WR, Mahoney LT, Witt J. 
Childhood predictors for high adult blood pres-
18. Al-Hazaa HM. Prevalence and trends in 
obesity among school boys in central Saudi Ar-
19. El Hazmi MA, Warsy AS. The prevalence of 
obesity and overweight in 1-18 years old Saudi 
20. Al-Shahri MA, Mostafa GA, Al-Belban K, 
Hamdi A, Almabari M, Altrabolsi H, et al. Stan-
dards of growth and obesity for Saudi children 
(ages 3-18 years) living at high altitudes. West 
21. Al Hazaa HM. Rising trends in BMI of 
Saudi adolescents: evidence from three national cross sectional studies. Asia Pac J Clin Nutr 
22. Al-Isa AN, Thalib L. Body mass index of Ku-
waiti children 3-9 years reference percentile and 
23. Musaiger AO, Gregory WB. Profile of body 
composition of school children (6-18 y) in Bah-
24. Al Husain M. Body mass index for Saudi 
2003;92:1482-5.