COMPARISON BETWEEN BODY MASS INDEX, TRICEPS SKIN FOLD THICKNESS AND MID-ARM MUSCLE CIRCUMFERENCE IN SAUDI ADOLESCENTS

Bahaa Abalkhail, MD, DrPH; Sherine Shawky, MD, DrPH

Introduction: Adolescence is an important period in an individual's life. Overweight and obesity are fraught with several health problems even later in life. The objective of this study was to estimate the overweight, obesity, body fat and muscle content of Saudi adolescents as compared to a recognized reference population.
Subjects and Methods: Data were collected from a sample of Saudi adolescents in Jeddah from 42 boys' and 42 girls' schools during the month of April 2000. Data collection was done by personal interviews to collect sociodemographic factors and by direct measurement of weight, height, triceps skin fold thickness (TSF) and mid-arm circumference (MAC). The 50th, 85th, and 95th percentiles (P50, P85 and P95) for body mass index (BMI) and triceps skin fold thickness (TSF) were taken, then the 50th, 90th, and 95th percentiles (P50, P90 and P95) for the mid-arm muscle circumference (MAMC) were calculated. These measurements were compared with corresponding values of the National Health and Nutrition Examination Survey I (NHANES I).
Results: The P85 and P95 for BMI and TSF were higher for Saudi adolescents than the NHANES I and the difference was wider for P95. Conversely, there was a lower MAMC at P90 and P95 than the NHANES I reference population curves. The lower MAMC curves were less marked in girls than in boys. On the other hand, Saudi boys and girls showed on average similar body mass index indicated by BMI at P50, which was misleading, since those adolescents showing similar body mass index had more fatness than the average reference population indicated by TSF at P50, and less muscularity on average than reference population indicated by MAMC at P50.
Conclusion: Overweight and obesity with increased body fat content and decreased body muscle content appear to be widespread among Saudi adolescents even among those adolescents showing average body mass index. Public health interventions are required to improve quality of food, encourage physical activity and exercise, as well as correct the perception of appropriate body stature.
Ann Saudi Med 2002;22(5-6):324-328.

Key Words: Body mass index, triceps skin fold thickness, mid-arm muscle circumference, children, adolescents.

Adolescence is an important period in the individual's life. Adolescents represent around 20% of the global world's population and around 84% of them are found in developing countries.[1] Although the world is facing a global endemic of obesity,[2,3] little attention has been given to the nutrition of adolescence and there is not much published information on the subject.[2]

The rapid development in economy that took place in Saudi Arabia during the last decades resulted in the adoption of a sedentary lifestyle and consumption of high-fat and low-fiber diet.[4,5] Consequently, problems of overweight and obesity arose especially among the Saudi youth that was estimated to be around 27.5% among boys[6] and 28.0% among girls.[7] Obesity in adolescence is associated with several problems from which the most prevalent are the psychological consequences in youth and the persistence of obesity in adult life.[8] The development of obesity early in life may compound the risk factors for cardiovascular diseases more drastically than in a later phase in life.[5,9] Also, overweight children are at higher risk for developing long-term chronic conditions including adult onset diabetes mellitus, orthopedic disorders and respiratory diseases.[10-16] In adults, the pattern of fat has been associated with coronary heart disease and non-insulin dependent diabetes mellitus.[17,18]

For individual assessment of body composition, anthropometry is being replaced by more accurate but also more complicated methods. It however remains a valid tool for epidemiological studies of the body composition in large groups.[19] The aim of this study was to estimate overweight, obesity, body fatness and muscle content of Saudi adolescents by measuring body mass index, triceps

From the Department of Community Medicine and Primary Health Care, College of Medicine and Allied Health Sciences, King Abdulaziz University, Jeddah, Saudi Arabia.

Address reprint rests and correspondence to Dr. Abalkhail: Department of Community Medicine and Primary Health Care, Faculty of Medicine and Allied Health Sciences, King Abdulaziz University, PO Box 80205, Jeddah 21589, Saudi Arabia. E-mail: abalkhail60@hotmail.com.

Accepted for publication 06 July 2002. Received 14 January 2001.

FIGURE 1. Comparison of boys' body mass index (BMI) between Saudis (solid line and NANHES (dotted line) aged 10-19 years.

FIGURE 2. Comparison of boys' triceps skin fold thickness (TSF).

FIGURE 3. Comparison of girls' body mass index (BMI) between Saudis (solid line) and NHANES (dotted line) aged 10-19 years.

FIGURE 4. Comparison of girls' triceps skin fold thickness (mm).

skin fold and mid-arm muscle circumference, and to compare these measures to a recognized reference population, in a study which we believe has not been done before.

Subjects and Methods

Jeddah is one of the largest cities of the Kingdom of Saudi Arabia with a population of 2.1 million and about 690 governmental and 327 private schools for both sexes. The sample of the study was selected by stratified sampling technique with proportional allocation to the type of school (governmental or private) and educational level to choose 42 boys' schools and 42 girls' schools (the first, second, and third-grade were excluded for logistics reasons). One class from each educational level in the selected schools was chosen at random. All students in the selected class with Saudi nationality were considered. A participation rate or around 99.0% was attained. Only those in the age group of 10-19 years (both male and female) were considered for analysis.

Data Collection

Data were collected by structured questionnaire using medical students trained in interviewing skills, and directly supervised by the medical staff. The questionnaire included information on sociodemographic factors and direct measurements of body weight, height, triceps skin fold (TSF) thickness and mid-arm circumference (MAC). The weight was measured without shoes using a Seca (model 777) personal scale to the nearest 0.1 kg and the height was taken barefooted using standard measuring tape to the nearest 0.1 cm. The body mass index (BMI) was calculated as the weight in kg/height in m^2. TSF thickness was measured to the nearest millimeter with measurement taken over the triceps muscle halfway between the elbow and the acromial process of the scapula, with the skin fold parallel to the longitudinal axis of the upper arm.[20] MAC was measured to the nearest centimeter with a tape with the right arm hanging relaxed. The measurement was taken midway between the tip of the acromion and olecranon process.[21] Mid-arm muscle circumference (MAMC) was calculated in mm from the following equation:

MAMC (mm)=mid-arm circumference (mm)–[3.14x triceps skin fold (mm)].

The 50th percentile (P50), 85th percentile (P85), and 95th percentile (P95) for BMI and TSF were derived for each age- and gender-specific strata, while the 50th percentile (P50), 90th percentile (P90), and 95th percentile (P95) for MAMC were calculated for each age and gender-specific strata. Standardization procedures for the collection of TSF and MAC were undertaken during the 4th medical school year for male and female students in groups. After training of each group in class, measurement errors for the two anthropometric measures were reasoned to be within acceptable limits.[21] Intraobserver (test-retest) reliabilities (precision) for each student ranged from 91% to 100%. Interobserver reliabilities (accuracy) based on independent samples were 89% to 100% between the student and the principal investigator. During the fieldwork, a 10% random sample from the survey showed interobserver reliabilities were =99% for TSF and MAC, while intraobserver reliabilities were =97%.

Data entry and analyses were done using SPSS for Windows. The BMI, TSF and MAMC calculated percentiles curves were compared with the corresponding reference population curves of the National Health and Nutrition Examination Survey I (NHANES I).[22,23]

Results

A total of 2737 students of Saudi nationality were included in the study. They comprised 1344 males and 1393 females, with ages ranging from 10 to 19 years. As seen from Figure 1, the BMI at P85 and P95 curves were much higher for Saudi boys than the NHANES reference curves at all age groups, with the gap being wider for P95 curves. The BMI at P50 was similar for Saudi boys compared to the NHANES reference at all the age groups. Also, TSF at P50, P85 and P95 curves were much higher for Saudi boys at all age groups than the NHANES reference curves, and the difference between the curves was still wider for P95 than P85 (Figure 2). The Saudi boys' TSF at P85 curve was much higher than the NHANES reference TSF at P95 curve. On the other hand, the MAMC at P50, P90 and P95 curves were lower among Saudi boys at all age groups than the NHANES reference curves. The Saudi boys' MAMC at P95 curve was lower than the NHANES at P90 curve.

Similar to boys, the BMI at P85 and P95 curves were much higher for Saudi girls at all age groups than the NHANES reference curves (Figure 3) with the difference between curves being wider for P95. The Saudi girls' BMI at P85 curve was even higher than the NHANES reference BMI P95 curve. The BMI at P50 was similar for Saudi girls compared to the NHANES reference curves at all age groups. Also, TSF at P50, P85 and P95 curve was slightly higher than the NHANES curves at all age groups (Figure 4). The Saudi girls' TSF at P85 curve was slightly higher than the NHANES reference TSF P95 curve. The curves for

the MAMC at P50, P90 and P95 were lower for Saudi girls aged 10 to 17 years than the NHANES reference curves but for the 18-19 age groups the curves were similar.

Discussion

Although adipose tissue is probably the component of overweight that most confers an increased disease risk, most studies of overweight and obesity have focused solely on relative weight. The relative weight although easily obtained, reflects bone and muscle mass as well as adipose tissue. Additionally, the body mass index is moderately correlated with height during growth.[24] In contrast, skin folds more closely reflect the amount of adipose tissue, but are subject to large measurement errors.[25] Furthermore, because of the interrelationships among energy intake, growth, and fat storage, there may be more discordance between overweight and obesity among children than among adults. Griffiths et al.[26] found that <50% of boys with a weight-for-height value above the 90th percentile were also above the 75th percentile for triceps skin fold thickness. Also, using NHANES data, Gortmaker and Deitz[27] found that the prevalence of obesity (P85th percentile for triceps skin fold) among 12 to 17 year olds increased by 40% from 1960 to 1980, while the same population showed no change in the mean BMI over the same period.[28] These findings indicate that increase in adipose tissue was accompanied by decrease in lean body mass.[27] The similarity of our findings for BMI at P85 and P95, skin fold thickness at P50, P85 and P95, and mid-arm muscle circumference at P50, P90 and P95 suggest that adiposity (fatness) has increased and muscularity has decreased. On the other hand, Saudi boys and girls showed on average similar body mass index indicated by BMI at P50, which was misleading since those adolescents showing similar body mass index had more fatness than average reference population indicated by TSF at P50, and less muscularity on average than the reference population indicated by MAMC at P50.

Under-muscularity was more marked in boys than in girls, since boys at this age should normally be involved in more physical activities that build muscles. Although other surveys have pointed out the possible prevalence of overweight and obesity for both genders,[6,7] no study has yet shown this difference in over-fatness and under-muscularity among Saudi youth. The reduction in energy expenditure observed with modernization and other social changes have been previously documented to be associated with a more sedentary lifestyle in which motorized transportation, mechanized equipment and labor saving devices (at home and work) have become the norm.[8,29,30] A plausible hypothesis is that Saudi boys and girls have been affected by this modernization, but as boys require more muscular effort to build up their muscle content they were more affected not only by fat deposition but also by loss of muscle content than girls. In Saudi Arabia, foreigners perform most jobs requiring heavy muscular work. Moreover, there is no popular sport activity in the country and physical exercise activities in schools nearly do not exist, especially in girls' schools. Much of the physical education program at schools is devoted to team sports at the expense of aerobic activities. After school physical activity is also on the decline. More children are at home with no supervision as the number of households with all adults working outside the home increases. Television, video games, and other indoors sedentary activities are the norm.

A possible limitation of our study is the use of NHANES I as reference population for comparison with Saudi population values since the WHO Expert Committee recommend using provisionally the NCHS (National Center for Health Statistics) reference.[31] With the use of the NCHS reference, high prevalence of low BMI-for-age was reported for both stable and displaced populations in many developing countries.[2] A possible explanation for high estimates are the marked skewness of the NCHS age-specific distribution toward higher values compared with other well-nourished populations.[31] Applying the three European BMI-for-age reference curves also yielded unrealistically high prevalence of thinness.[32] On the contrary, we found higher BMI and TSF curves in both sexes in our study compared to the NHANES reference curves. This validates using the NHANES reference population as a reference standard.

In conclusion, our result shows that there is a problem of overweight and obesity in the Kingdom in addition to incorrect balance between body fat and muscle content resulting in over-fatness and under-muscularity among Saudi adolescents. Public health intervention aimed at adolescents should help improve dietary habits, encourage physical activity and correct the views on optimal body stature. In addition, there is a need for a systematic surveillance of growth indices over time, and identification of the pattern of fat distribution in Saudi adolescents in order to identify and treat obesity. Intervention to prevent adolescent obesity could prevent adult obesity, and accordingly reduce the risk of morbidity and mortality in adult life. Future studies on obesity in Saudi adolescents should look at trends on obesity that involve measuring body mass index, triceps skin fold thickness and mid-arm muscle circumference over time. Previous studies (unpublished data) done by the principal author showed that there has been a progressive increase in body mass index over time in Saudi adolescents, which was related mainly to increase in weight gain with no corresponding change in height measurements. This increase in BMI could also be related to increase in triceps skin fold thickness and decrease in muscle mass over time even for those adolescents showing average body mass index.

References

1. WHO Working Group. Use and interpretation of anthropometric indicators of nutritional status. Bull WHO 1986;64:929-41.
2. Kruz MK. Adolescent nutritional status in developing countries. Proc Nutr Soc 1996;55:321-31.
3. Martorell R, Khan LK, Huges ML, Grummer-Strawn LM. Overweight and obesity in preschool children from developing countries. Intern J Obesity 2000;24:959-67.
4. El-Hazmi MA, Warsy AS. Relationship between obesity, overweight and plasma lipid in Saudis. Saudi Med J 1999;20:512-25.
5. Popkin BM. The nutrition transition in low-income countries: an emerging crisis. Nutr Rev 1994;52:285-98.
6. Al-Nuaim AR, Bamgboye EA, Al-Herbish A. The pattern of growth and obesity in Saudi Arabian male school children. Int J Obes Relat Metab Disord 1996;20:1000-5.
7. Abuhussain NA, Musaiger AO, Nicholls PJ, Stevens R. Nutritional status of adolescent girls in the Eastern Province of Saudi Arabia. Nutr Health 1999;13:171-7.
8. Neutzling MB, Taddei JAAC, Rodrigues EM, Sigulem DM. Overweight and obesity in Brazilian adolescents. Int J Obes 2000; 24:869-74.
9. Must A, Jaques PF, Dallal GE, Bajema CJ, Dietz WH. Long term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922 to 1935. N Engl J Med 1992;27: 1350-5.
10. Aristimuno GG, Foster TA, Voors AW, Srinivasan SR, Berenson GS. Influence of persistent obesity in children on cardiovascular risk factors: the Bogalusa Heart Study. Circulation 1984;69:895-904.
11. Smoak CG, Burke GL, Webber 1S, Harsha DW, Srinivasan SR, Bereson GS. Relation of obesity to clustering of cardiovascular disease risk factors in children and young adults. The Bogalusa Heart Study. Am J Epidemio1 1987;125:364-72.
12. Lauer RM, Clarke WR. Childhood risk factors for high adult blood pressure: the Muscatine Study. Pediatrics 1989;84:633-41.
13. Gidding SS, Bao W, Srinivasan SR, Berenson GS. Effects of secular trends in obesity on coronary risk factors in children: the Bogalusa Heart Study. J Pediatr 1995;127:868-74.
14. Gidding SS, Leibel RL, Daniel S, Rosenbaum M, van Horn L, Marx GR. Understanding obesity in youth. Circulation 1996;94:3383-7.
15. Guillaume M, Lapidus L, Bjorntorp P, Lambert A. Physical activity, obesity, and cardiovascular risk factor in children. The Belgian Luxembourg Child Study II. Obes Res 1997;5:549-56.
16. Dietz WH. Childhood weight affects adult morbidity and mortality. J Nutr 1998;128(Suppl 2):411S-414S.
17. Lapidus L, Bengtsson C, Pennert K, Rybo E, Sjostrom L. Distribution of adipose tissue and risk of cardiovascular disease and death: a 12-year follow-up of participants in the Population Study of Women in Gothenburg, Sweden. BMJ 1984;289:1257-61.
18. Must A, Jacques PF, Dallal G, et al. Long-term morbidity and mortality of overweight adolescents. N Engl J Med 1992;327:1350-5.
19. de Bruin NC, van Velthoven KAM, Stijnen T, Juttmann RE, Degenhart HJ,Visser HKA. Quantitative assessment of infant body fat by anthropometry and total-body electrical conductivity. Am J Clin Nutr 1995;61:279-86.
20. Preliminary Findings of the First Health and Nutrition Examination Survey, United States, 1971-1972: Anthropometric and Clinical Findings. Rockville, MD: National Center for Health Statistics, 1975.
21. Marks GC, Habicht JP, Mueller WH. Reliability, dependability, and precision of anthropometric measurements: the Second National Health and Nutrition Examination Survey, 1976-1980. Am J Epidemiol 1989;130:578-87.
22. Must A, Dallal GE, Dietz WH. Reference data for obesity: 85th percentiles of body mass index (wt/ht2) and triceps skin fold thickness. Am J Clin Nutr 1991;53:839-46.
23. Frisancho A. New norms of upper limb fat and muscle areas for assessment of nutritional status. Am J Clin Nutr 1981;34:2540-5.
24. Garn SM, Leonard WR, Hawthorne VM. Three limitation of the body mass index. Am J Clin Nutr 1986;44:996-7.
25. Flegal KM, Harlan WR, Landis JR. Secular trends in the United States, 1960-80 (letter). Am J Epidemiol 1990;132:196-7.
26. Griffiths M, Rivers JPW, Hoinville EA. Obesity in boys: the distribution between fatness and heaviness. Hum Nutr Clin Nutr 1985;39:259-69.
27. Gortmaker SL, Dietz WH Jr. Secular trends in body mass index in the United States, 1960-1980 (letter). Am J Epidemiol 1990;132:194-5.
28. Harlan WR, Landis JR, Flegal KM, Davis CS, Miller ME. Secular trends in body mass in the United States, 1960-1980. Am J Epidemiol 1988;128:1065-74.
29. Centers for Disease Control. Vigorous physical activity among high school students, United States, 1990. MMWR 1992;41:33-5.
30. Diguiseppi C, Roberts I, Li L. Influence of changing travel patterns on child death rates from injury: trend analysis. BMJ 1997;314:710-3.
31. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. WHO Tech Rep 1995;854.
32. de Onis M, Dasgupta P, Saha S, Sengupta DM, Blossner M. The National Center for Health Statistics Reference and the growth of Indian adolescent boys. Am J Clin Nutr 2001;74:248-53.