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

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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 5th, 90th, and 95th percentiles (P5, 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 1 (NHANES1).

Results: The P85 and P95 for BMI and TSF were higher for Saudi adolescents than the NHANES1 and the difference was wider for P95. Conversely, there was a lower MAMC at P90 and P95 than the NHANES1 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 P95, which was misleading, since those adolescents showing similar body mass index had more fatness than the average reference population indicated by TSF at P95, and less muscle content on average than reference population indicated by MAMC at P95.

Conclusion: Overweight and obesity with increased body fat content and decreased 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 mature.


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 8% of them are found in developing countries. Although the world is facing a global epidemic of obesity,2 little attention has been given to the nutrition of adolescence and there is not much published information on the subject.3

The rapid economic growth and 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 Consequently, problems of overweight and obesity arose especially among the Saudi youth that was estimated to be around 27.5% among boys5 and 28.0% among girls.6 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.7 The development of obesity early in life may compound the risk factors for cardiovascular diseases more drastically than in a later phase in life.8,9 Also, overweight children are at higher risk for developing long-term chronic conditions including adult onset diabetes mellitus, orthopedic disorders and respiratory diagnoses.10-14 In adults, the pattern of fat has been associated with coronary heart disease and non-insulin dependent diabetes mellitus.15-18

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
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 m². 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. 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. Mid-arm muscle circumference (MAMC) was calculated in mm from the following equation:

\[ \text{MAMC (mm) = mid-arm circumference (mm) - } (3.14 \times \text{triceps skin fold (mm)}) \]

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, measurements were repeated. The two anthropometric measures were reasoned to be within acceptable limits. Introserver (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 ≥90% 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). D2

**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 P5, P55 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 P5, P55 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 P85 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 P85 curve was lower than the NHANES at P50 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 P85 curve. The BMI at P90 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 P30, 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 masses as well as adipose tissue. Additionally, the body mass index is moderately correlated with height during growth. In contrast, skin folds more closely reflect the amount of adipose tissue, but are subject to large measurement errors. 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. 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, Geurtsmaeker and Deitel found that the prevalence of obesity (P95th 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. Those findings indicate that increase in adipose tissue was accompanied by decrease in lean body mass. The similarity of our findings for BMI at P85 and P95, skin fold thickness at P50, P75 and P95, and mid-arm muscle circumference at P50, P90 and P95 suggest that adiposity (fatness) has increased and muscle mass has decreased. On the other hand, Saudi boys and girls showed an average similar body mass index indicated by BMI at P50, which was misleading since those adolescents showing similar body mass index had more fitness 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, no study has yet shown the difference in even fitness 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. 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 indoor sedentary activities are the norm.

A possible limitation of our study is the use of
NHNES I as reference population for comparison with
Saudi population values since the WH0 Expert Committee
recommended using provisionally the NCHS (National Center
for Health Statistics) reference. 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. 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. Applying the three
European BMI-for-age references curves also yielded
unrealistically high prevalence of thinness. 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 inaccurate correlation 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 an 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 risks of morbidity and mortality in adult life. Future studies on obesity in Saudi
adolescents should look at trends on obesity involving
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
to 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
increase in muscle mass over time even for those adolescent showing average body mass index.

References

1. WHO Working Group. Use and interpretation of anthropometric
2. Kuczm SA. Adolescent nutritional status in developing countries. Proc
Natl Acad Sci USA 1987;84:3211-3.
3. Mierwacki D, Elia LR, Hagen ML, Grummer-Straw L. Overweight and obesity in preschool children from developing
4. El-Hamri MA. Wargy AS. Relationship between obesity, overweight
5. Popkin SM. The nutrition transition in low-income countries: an
6. Al-Naimi AR, Alhaffar AA, Al-Harbi A. The pattern of growth
7. Ashour AM, Moustafa NA, Alzubaidy S, Zurni R. Nutritional
status of adolescent girls in the Eastern Province of Saudi Arabia.
9. Most A, Jooe PF, Dallal GE, Bieri CI, Diner WH. Long term
mortality and morbidity of overweight adolescents: a followup of the
1106-7.
13. Gidding SS, Bao W, Steffes WN, Berrnan CB. Effects of secular
trends to obesity on coronary risk factors in children in the Bogalusa
15. Guillemard M, Laplance L, Rouillon P, Lambert A. Physical activity,
obesity, and cardiovascular risk factor in children. The Belgian
Luxembourg Child Health Study. II. Obes Res 1997;5:549-54.
Nutr 1991;121(Suppl):1411S-1418.
17. Laplanc L, Bengsiris C, Penhart K, Rho Y, Jernsm L. Distribution of
adolescent female and male cardiovascular disease and death a 12-year follow-up of participants in the Population Study of
19. de Bruin NC, van Wijhe-van vik SCAM, Nagini T, Jonkman RE.
Deeptan HG, Visser IMA. Quantitative measurement of infant body
fat by anthropometry and total body electrical conductivity. Am J
21. Marais CC, Buhler JP, Macfarlin W. Reliability, reproducibility, and
precision of anthropometric measurements: the Second National
22. Most A, Dallal GE, Diner WH. Reference data for obesity and
23. Fina-Aguh A. New norms of upper arm fat and muscle mass for
24. Qinti SM, Leonard WR, Healawan VM. These limitation of the
25. Flagg RM, Hales WR, Landis JR. Similar trends in the United
27. Geurtszel SR, Diner WR Jr. Secular trends in body mass index in the