Physical activity, fitness and fatness among Saudi children and adolescents

Implications for cardiovascular health

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ABSTRACT

During recent years, the Kingdom of Saudi Arabia has witnessed a tremendous development at an astounding rate. The standard of living rises and mechanization has been apparent in all aspects of people's life. As industrialization and modernization progress, a number of changes in physical activity and eating habits are likely to occur. Indeed, physical inactivity and sedentary living with associated low level of physical fitness are increasingly becoming prevalent in the Saudi society. These lifestyle changes undoubtedly carry unfavorable consequences on health outcomes of the Saudi population. This paper reviews the status of physical activity among Saudi children and adolescents and discusses its implications to cardiovascular health and fitness. From the available evidences, it appears that most Saudi children and adolescents do not meet the minimal weekly requirement of moderate to vigorous physical activity necessary for effectively functioning cardiorespiratory system. Furthermore, active Saudi boys tend to have favorable levels of serum triglycerides and high density liproteins-cholesterol compared with inactive boys. Sixteen percent of Saudi schoolboys are considered obese (fat content is above 25% of body mass). Body fat percent of Saudi boys seems to have increased over the past decade. Body fatness correlated significantly with several coronary artery disease risk factors. Based on the available evidences, promotion of physical activity among Saudi children and adolescents appears warranted and national policy encouraging active living is also needed.

Keywords: Physical activity, fitness, fatness, obesity, cardiovascular health, children, adolescents, exercise.

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It is now well recognized that physical inactivity and sedentary living habits represent an independent risk factor for lifestyle-related diseases, and that physical activity reduces an individual's risk of both cardiovascular disease and all-cause mortality.[1-4] Recently, a number of consensus statements and governmental reports have further emphasized the importance of regular physical activity to the health and well being of people at all ages.[5-9] However, 2 important recent documents on physical activity and health merit mentioning briefly, namely the United States of America (USA) Surgeon General Report[8] and "Healthy People 2010" document.[9] On July of 1996, the USA Department of Health and Human Services released the first Surgeon General's Report on physical activity and health.[8] The report is considered a milestone in the USA public health policy. It emphasized the significance of physical activity to human health and general well being. The other report, the "Healthy People 2010" document, was launched in early 2000, by the Center for Disease Control and Prevention (CDC). In that report, 10 leading health indicators (LHI) were identified. The LHI reflect the major public health concerns in the USA, and highlight the importance of health promotion and disease

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prevention. Physical activity, not surprisingly, came as the first LHI, followed by obesity, in the recently released "Healthy People 2010" report. Furthermore, World Health Organization (WHO) has recognized physical inactivity as a major threat to worldwide population health.[10] The WHO recommended possible goals and priority actions for countries to promote active living by the year 2001. Included in these actions is an assessment of physical activity level among various sectors of the population.

During recent years, the Kingdom of Saudi Arabia has witnessed a tremendous development at astounding rate. The standard of living rises and mechanization has been apparent in all aspects of people's life. As industrialization and modernization progress, a number of changes in physical activity and eating habits are likely to occur. Indeed, physical inactivity and sedentary living with associated low level of physical fitness are increasingly becoming prevalent in Saudi society.[11] In addition, with satellite television and increased reliance on computer and telecommunication technology, further reduction in physical activity is projected in the coming years. The impact of these lifestyle changes on societal health is very considerable. In fact, these changes were thought to be responsible for the epidemic of non-communicable diseases along with their complications in the region.[12]

This paper, therefore, reviews the current level of physical activity among Saudi children and adolescents and discusses its implications to cardiovascular health and fitness. The data that is presented in this review comes mostly from a collection of studies made on groups of Saudi children and adolescents, and was carried out in our laboratory during the past 10 years.[13-20] Additional unpublished data on physical activity and pediatric health are also presented in this review. It is hoped that this paper will ultimately stimulate some interests and encourage future research in the area of physical activity epidemiology in the Kingdom of Saudi Arabia.

The status of physical activity among Saudi children and adolescents. It is important that we define physical activity before examining its status among Saudi children and adolescents. Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure above the basal level.[21] Our ability to relate physical activity to health indicators depends on accurate, precise and dependable measures. Physical activity is commonly measured through mechanical/electronic or physiological measurements.[22] It is widely recognized that children and youth need regular physical activity for normal growth and development, and maintenance of good health and fitness.[8,15,23-27] Recommendations from major consensus statements regarding physical activity and children and adolescent's health call for regularly sustained

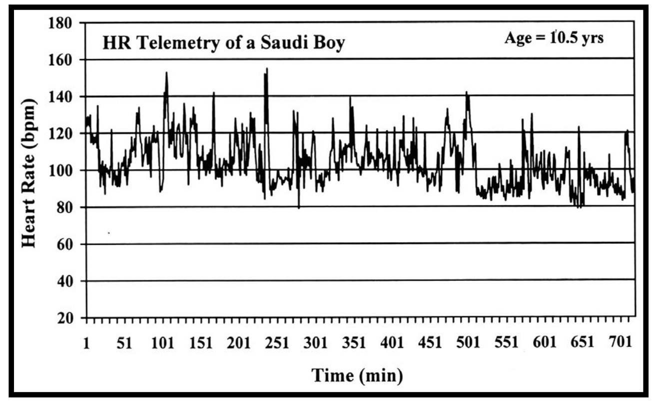

Figure 1 - Minute by minute heart rate telemetry for 12 hours in a Saudi boy. HR-heart rate, yrs-years, min-minute, bpm - beats per minute.

physical activity of moderate to vigorous intensity in most (if not all) days of the week.[1,6-9,26,27] In addition, the USA Surgeon General Report emphasized the importance of promoting active lifestyle among the youth.[8] However, the status of physical activity worldwide is not bright, according to WHO report.[10] The WHO, alerting to the reduction in physical activity habits among world population, stated that 60% of the world population is not active, with inactivity being higher among girls and women. The report adds that physical activity declines significantly with age during adolescence, and that poor urban areas have the worse overall inactivity trend.[10]

During the last decade, we conducted a series of research studies aimed on assessing the level of physical activity among Saudi children and adolescents with special reference to cardiovascular health and fitness.[13,14,16-20] For physical activity assessment, we used all-day heart rate telemetry measurements. Heart rate data were stored and then retrieved and analyzed at a later time. **Figure 1** presents a minute by minute heart rate tracing for 12 hours in a typical Saudi boy. As clearly seen in **Figure 1,** daily heart rate was averaging 105 bpm. Heart rate rarely exceeded 140 bpm in that boy, which corresponds to a moderate intensity level of physical activity in children.

The results of heart rate telemetry of Saudi boys during after school time indicated that Saudi boys spent on the average limited time on activities that raise the heart rate above 159 bpm (9.6 minutes) or above heart rate at ventilatory threshold (14.6 minutes).[16,18] These 2 levels of activities are considered vigorous and somewhat vigorous. It was also shown that Saudi boys spent just over 29 minutes on activities that raised heart rate to above 139 bpm.[16,18] Such level is considered a moderate level of physical activity. Sixteen percent of the children never exceeded a heart rate level of 159 bpm during the whole day period, and only 15% of the

Table 1 - Prevalence of selected coronary artery disease (CAD) risk factors in Saudi boys.

Risk factor	Cut-off value	Age (yr)	Prevalence (%)
Total cholesterol (mmol.L^{-1})			
Rafii et al 1994	>4.97[a]	5-7	10
	>4.91[a]	10-14	10
	>4.4[b]	5-14	>25
Al-Nozha et al	>4.47[c]	5<10	25
	>4.60[c]	10<15	25
Al-Hazzaa et al 1993	>5.2[d]	7-12	22.9
	>4.8[e]	7-12	40.8
	>4.4[b]	7-12	59.8
Triglycerides (mmol.L^{-1})			
Al-Hazzaa et al 1993	>1.4[f]	7-12	26.4
Al-Nozha et al	>1.57[c]	5<10	25
	>1.67[c]	10<15	25
HDL-Cholesterol (mmol.L^{-1})			
Al-Hazzaa et al 1993	<0.96[b]	7-12	4
LDL-Cholesterol (mmol.L^{-1})	>3.4[b]	7-12	17.4
Al-Hazzaa et al 1993	>2.9[b]	7-12	41.3
Blood pressure (mmHg)			
Al-Hazzaa et al 1993	>120/80[g]	7-12	4.2
	>125/85[g]	10-12	4.2
Al-Nozha et al 1997	>120/80[g]	6-9	11.8
	>125/85[g]	10-13	5.4
	>135/90[g]	14-17	5.4
Body fat percent (%)			
Al-Hazzaa et al 1993	>25%[h]	7-12	15.6
Physical inactivity			
Al-Hazzaa & Sulaiman 1993	<30 min. at HR> 139 bpm[i]	7-12	57.1

a=age and sex adjusted 90th percentile as reported by authors
b=borderline level, based on AAP policy statement on cholesterol in childhood.
c=age and sex adjusted 75th percentile as reported by authors
d=high level of cholesterol, based on AAP policy statement on cholesterol in childhood
e=90th Percentile as recommended by National Institute of Health
f=95th percentile from Lipid Research Clinics Population Studies Data Book, as recommended by Kwiterovich
g=age adjusted 90th percentile from the Report of the Second Task Force on Blood Pressure Control in Children, 1987
h=cut-off value for definition of obesity
i=based on the recommended amount (30 minutes or more) of moderate level of daily physical activity for children and adolescents
HR-heart rate, BPM=beats per minute, yr=year, HDL=high density lipoproteins, LDL=low density lipoproteins

boys spent 20 minutes or more at heart rate above 159 bpm.[11,16] In addition, 57% of the boys had less than 30 minutes of daily moderate physical activity (at HR> 139 bpm).[11,16] Both levels of moderate (HR>139 bpm) and vigorous (HR>159 bpm) physical activities among Saudi boys are considerably lower than those levels reported for children from other countries.[28-30] In the year 1999, 65% of adolescents in the USA were reporting vigorous physical activity 3 or more days per week for 20 minutes or more.[9]

Correlation analysis of childrens activity levels during physical education lesson with activity levels outside school time reveals a significant correlation coefficient ($r = 0.48$; $p < 0.05$).[14,16] This means that boys who were active during physical education class were likely to be active during outside school time, and vice versa. In another analysis of our physical activity data,[20] for a group of 40 prepubescent brothers (8.5±1.0 versus 10.8±1.0 years, for the younger and older brothers), we found a heritability coefficient of 0.52 ($p<0.01$) in the percentage of time spent at heart rate above 159 bpm. However, the heritability coefficient was lower for moderate level of physical activity ($r= 0.28$). These findings indicate that vigorous physical activity exhibits familial resemblance in prepubescent boys.

Physical activity and cardiovascular health. Regular physical activity has long been regarded as an important part of a healthy lifestyle. Recent evidence has strongly reconfirmed this relationship between physical activity and a wide range of physical and mental health benefits.[1-8,23,25,26] Physical inactivity and sedentary living habits, on the other hand, have been linked to a number of chronic diseases including coronary artery disease (CAD), hypertension, diabetes mellitus, osteoporosis, colon cancer, anxiety and depression.[3,5-8] In the following sections, I will review some evidences on the prevalence of CAD risk factors and obesity among Saudi children and adolescents, and discuss the associations between physical activity and these health indicators. I must indicate, however, that an elaborate discussion of CAD risk factors in pediatric population is beyond the scope of this paper.

Physical activity and coronary artery disease risk factors in Saudi children. The interests in studying children's physical activity relative to cardiovascular health stem from the fact that diseases such as CAD and obesity, for which inactivity is a likely risk factor, have their origin in childhood.[31-36] Further, CAD risk factors were shown to track from childhood to adulthood.[33,37] This makes prevention of lifestyle-related diseases at early age the "best buy in public health."[38]

As presented in **Table 1,** a number of CAD risk factors were shown to exist in Saudi pediatric population.[17,18,39-41] Studies from our laboratory[17,18] indicated that out of 220 Saudi boys from Riyadh city, 22.9% exceeded total cholesterol level of 5.2 mmol.L^{-1}, 26.4% had triglycerides level above 1.4 mmol.L^{-1}, 17.4% had LDL-cholesterol level above 3.4 mmol.L^{-1}, 4% had HDL-cholesterol level below .096 mmol.L^{-1}, 16% were considered obese (fat % was above 25% of body mass), and 4.2% of the boys had high systolic and diastolic blood pressure (based on age-specific cut-off values).[42] Other local studies had shown some degrees of CAD prevalence ranging from 5% to 25% for total cholesterol,[40,41] above 25% for triglycerides,[40] and from 5.4% to 11.8% for hypertension.[39]

Physical inactivity appears to associate with some CAD risk factors in Saudi children. As seen in **Table 2,** CAD risk factors were more present in the least active Saudi boys compared with the most active counter parts.[15] When the percentage of children who exceeded certain recommended cut-off values[43-45] of blood lipids were considered relative to activity levels, there was a clear reduction in risk with increased activity level.[18] The proportion of active versus inactive boys who exhibited unfavorable levels of total cholesterol, triglycerides, HDL-C and LDL-C were 22.7 versus 26%, 9.1 versus 48%, 0.0 versus 4.3%, and 8.7 versus 21.7%.[18]

Physical activity and obesity among Saudi children and adolescents. The prevalence of pediatric obesity is increasing rapidly worldwide.[46-49] Overweight in youth is associated with overweight in adulthood.[50] Furthermore, obesity is associated with several CAD risk factors, including hyperlipidemia, hyperinsulinemia, hypertension, and early atherosclerosis.[31-33,51-53] Because of public health importance, childhood obesity should be closely monitored. Obesity in this paper is defined as body fat content exceeding 25% of total body mass.[54] Cited data on the prevalence of obesity among Saudi children and adolescents is, therefore, restricted to those studies in which fat percent was measured or estimated from skinfold thicknesses.[19,55] Fat content exceeding 25% of body mass in male (a level of 30% in female) was shown to be associated with higher risk for CAD in children.[53] On the other hand, the wide acceptability of body mass index (BMI) as a measure of obesity in adults does not necessarily extend to children. This is due to the effect of age on the height in children.[56] Body mass index, while easily measured, is more a measure of overweight than of adiposity. Using growth data from 1200 Saudi boys 6-14 years of age,[55] we were able to demonstrate that while BMI was increasing from 11 to 13 years body fat content was not.[57] A recent report comparing BMI cut-off values with body fat percent in prepubertal children found that although high BMI cut-off points had high specificity, the sensitivity was poor.[58] Similar findings were reported by Malina et al,[59] in adolescents 9-19 years. In addition, a recent study using receiver operating characteristics (ROC) analysis assessed the usefulness of BMI, triceps skinfold thickness and upper arm girth for screening for obesity in adolescents 10-15 years. Obesity was defined as equal or above 25% and 30% of body fat (using DEXA) for boys and girls. Their findings showed that triceps skinfold thickness gave significantly the best results for obesity screening in adolescents.[60]

Table 2 - Coronary artery disease (CAD) risk factors in Saudi boys 7-12 years, according to physical activity level (mean ± standard deviation).

Risk factor	Most active N=45	Least active N=46
Age (years)	9.65 ± 1.5	9.60 ± 1.4
Time spent at HR>159 bpm (min)	17.28 ± 7.5**	2.21 ± 0.86
Total cholesterol (mmol.L^{-1})	4.68 ± 0.74	4.60 ± 0.82
Triglycerides (mmol.L^{-1})	1.09 ± 0.45*	1.35 ± 0.61
HDL-Cholesterol (mmol.L^{-1})	1.43 ± 0.29*	1.28 ± 0.28
LDL-Cholesterol (mmol.L^{-1})	2.59 ± 0.82	2.68 ± 0.74
HDL-C/Total cholesterol (%)	30.7 ± 8.2	27.8 ± 7.3
Systolic blood pressure (mmHg)	98.6 ± 11.4	101.6 ± 11.2
Diastolic blood pressure (mmHg)	58.6 ± 6.9	60.6 ± 7.4

Subjects were matched for body mass and fat percent.
Physical activity levels were based on the percent of daily time spent at heart rate (HR) above 159 bpm, measured by continuous HR telemtry (most active = above 50th percentile, and least active, = below 50th percentile).
* $p<0.05$ (2-tailed test); ** $p<0.01$ (2-tailed test).
Data is from Al-Hazzaa, N=number, HR-heart rate, HDL=higher density lipoproteins, LDL=lower lipoproteins

Cross sectional studies conducted in Riyadh city indicate that 16% of Saudi school boys are classified as obese (that is body fat content equal or above 25 % of body mass).[15,17-19] **Figure 2** presents mean body fat percent across age for Saudi children 7-12 years. Body fat percent seems to have increased over the past decade. Moreover, longitudinal analysis of a group of Saudi boys (n=20) living in Riyadh indicated that fat percent had increased over a four-year period from 15.4% to 20.7% (unpublished data). What is more striking in this data is that the percentage of boys who exceeded body fat content of 25% of body mass (obesity cut off value) was alarmingly increasing. The proportion of obese boys increased from zero percent at age 8.6 years (when they were first tested in 1992) to 30% at age 13.2 years (when they were tested again in 1996). Values of the 95th percentiles of triceps skinfold thickness for Saudi boys from 3 local studies[19,40,55] were compared with the 95th percentile values of the USA National Health and Nutrition Examination Survey (NHANES)[61] and presented in **Figure 3.** Except for one local study,[55] in which data was collected more than 10 years ago, values of triceps skinfold thickness of Saudi boys exceeded those of the NHANES, indicating a higher prevalence of obesity

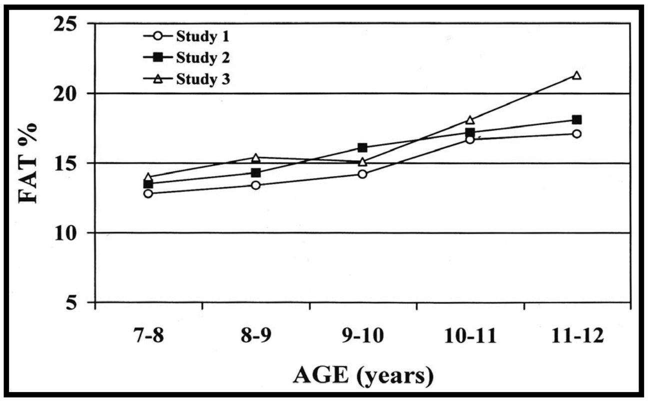

Figure 2 - Cross-sectional data from 3 studies assessed body composition in Saudi boys living in Riyadh. Data are from Al-Hazzaa, 1990[55] (study 1), Al-Hazzaa, 1992[13] (study 2) and Al-Hazzaa, 1994[19] (study 3).

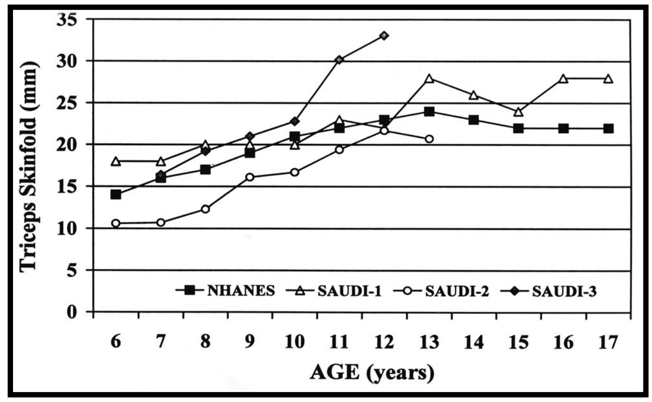

Figure 3 - Values of 95th percentiles of triceps skinfold thickness for Saudi boys reported in 3 studies. Data was compared with the 95th percentile values of the United States National Health and Nutrition Examination Survey (NHANES), reported in reference 61. Data for Saudi-1 from reference 40, Saudi-2 from reference 55 and Saudi-3 from reference 19.

among Saudi children and adolescents compared with the American youth.

The increase in obesity prevalence among Saudi children and adolescents reflects a population shift toward positive energy balance. Dietary intake and physical activity represent the modifiable aspect of the energy balance equation. Calorically dense foods are increasingly becoming accessible for Saudi children and adolescents. In addition, physical exertion has been systematically engineered out of most daily tasks of Saudi children and adolescents. Children are now transported to and from school, especially in urban areas of the Kingdom. Television viewing, videos and computer games are also contributing immensely to inactivity. Excessive television viewing may encourage both sloth and gluttony, and was shown to be an important determinant of obesity in children and adolescents elsewhere.[62]

As shown in **Table 3,** obese Saudi boys have higher systolic and diastolic blood pressure, higher triglycerides, lower cardiorespiratory fitness, lower HDL-cholesterol, and lower HDL-C/total cholesterol ratio. In addition, body fatness in Saudi children, as indicated in **Table 4,** correlated positively with triglyceride levels and systolic and diastolic blood pressure, and negatively with HDL-cholesterol and HDL-C/total cholesterol ratio.[17] The correlation

Table 3 - Characteristics of obese (fat > 25%) versus non obese (fat <25%) Saudi boys, while contolling for age (mean ± standard deviation).

Variable	Obese N=33	Non obese N=179
Age (years)	10.2 ± 1.4	9.4 ± 1.5*
Body mass (kg)	46.1 ± 11.4	28.2 ± 5.8**
Body height (cm)	140.2 ± 8.5	131.4 ± 8.8**
Fat content (%)	33.4 ± 6.2	13.5 ± 3.8**
BMI (kg.m^{-2})	23.2 ± 4.0	16.2 ± 2.0**
VO2max (ml. kg.$^{-1}$min^{-1})	41.9 ± 3.4	49.5 ± 5.6**
Systolic blood pressure (mmHg)	109.1 ± 9.4	98.2 ± 10.4**
Diastolic blood pressure (mmHg)	66.1 ± 7.2	58.4 ± 6.6**
Total cholesterol (mmol.L^{-1})	4.72 ± 0.92	4.62 ± 0.78
Triglycerides (mmol.L^{-1})	1.55 ± 0.72	1.13 ± 0.52**
HDL-Cholesterol (mmol.L^{-1})	1.26 ± 0.26	1.43 ± 0.30*
LDL-Cholesterol (mmol.L^{-1})	2.71 ± 0.96	2.67 ± 0.75
HDL-C/total cholesterol (%)	27.6 ± 8.1	31.2 ± 7.5*

.VO2max=maximal oxygen uptake, BMI=body mass index, *=p<0.05, **p<0.01 (using ANCOVA=analysis of covariance, with age as covariate), HDL=higher density lipoproteins, LDL=lower density lipoproteins

Table 4 - Correlation coefficeints of fatness (fat percent) with coronary artery disease (CAD) risk factors in Saudi boys 7 to 12 years.

Variable	r
Total cholesterol	0.05
Triglycerides	0.25**
HDL-Cholesterol	-0.24**
LDL-Cholesterol	0.05
HDL-C/Total cholesterol	-0.22**
Systolic blood pressure	0.46**

Data are from Al-Hazzaa, 1993, **p<0.01, r=Pearson correlation coefficient, HDL-higher density lipoproteins, LDL-lower density lipoproteins

Table 5 - Correlation coefficients of fatness (fat percent) with fitness and physical activity indices in Saudi boys 7 to 13 years.

Variable	r
VO_2max (ml.kg.$^{-1}$min^{-1})	-0.58**
1000 meter run time	0.55**
Activity level during PE[a]	-0.32*

VO_2=maximal oxygen uptake, [a]=measured by heart rate telemetry physical education (PE) classes, * p<0.05, ** p<0.01, Data is from Al-Hazza, 1995 and Al-Hazzaa, 1994 r=Pearson correlation coefficient

coefficients were strongest with systolic and diastolic blood pressure. Body fatness, as shown in **Table 5,** also exhibited significantly inverse relationships with indices of cardiorespiratory fitness and physical activity level at school.[14,19]

In conclusion, from the available heart rate telemetry studies, it appears that most of Saudi children and adolescents do not meet the minimal weekly requirement of moderate to vigorous physical activity necessary for effectively functioning cardiorespiratory system. Active Saudi boys exhibited more favorable levels of serum triglycerides and HDL-cholesterol compared with inactive boys. Moreover, 16% of Saudi school children are considered obese (body fat content is above 25% of body mass). Body fat percent in Saudi boys appears to have increased over the past decade. Body fatness correlated significantly with several CAD risk factors. Based on the available evidence, promotion of physical activity among Saudi children and adolescents, including an aggressive educational campaign, appears warranted. National policy encouraging active living is also needed. Medical communities and primary health care providers have an important role to play in physical activity promotion by providing routine assessment and counseling on physical activity and fitness for their patients. Furthermore, studies with nationally represented samples of Saudi children and adolescents are urgently needed to address the issue of physical activity, fitness, fatness and cardiovascular health.

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