Original Article

The association between physical activity and overweight and obesity in a population of children at high and low altitudes in Southwestern Saudi Arabia

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ABSTRACT

Objective: To assess the relationship between overweight and obesity and physical activity in Saudi children born and permanently domiciled at high and low altitudes in Southwestern Saudi Arabia. **Subjects and Methods:** A cross-sectional study of 145 healthy Saudi children aged 10–15 years who were born and lived permanently at high altitude (3000–3100 m) and 154 healthy Saudi children of comparable age who were born and lived permanently at a relatively low altitude (500 m) was conducted. For each subject selected, body weight and body height were measured using an Avery beam weighing scale and a stadiometer, respectively. Body mass index (BMI) was calculated using the equation BMI = (weight [kg]/height [m^2]). Physical activity scores were determined using International Physical Activity Questionnaire-Short Form-A. Resting radial pulse rate (beat/minutes) was determined clinically. **Results:** Physical activity was significantly and inversely associated with overweight and obesity in boys at both high (χ^2 = 15.8, P < 0.001) and low (χ^2 = 14.7, P < 0.001) altitudes, but there was no clear trend for girls at either altitude. The lack of association between physical activity and overweight and obesity in girls was attributed to the low and homogeneous level of physical activity. **Conclusion:** Physical activity should be encouraged as a strategy for weight reduction in the overweight and the obese and the prevention of overweight and obesity in Saudi children at high and low altitudes.

Key words: Activity score, altitude, body mass index

INTRODUCTION

Childhood overweight and obesity have become a worldwide epidemic with significant medical, psychosocial, and economic consequences.[1,2] The prevalence of childhood overweight and obesity is increasing rapidly worldwide,[2] and there is mounting concern on the need for their early prevention and treatment. Overweight and obesity in childhood tend to persist into adulthood[3] and are associated with increased adult mortality and morbidity.[4,5]

Several studies that investigated childhood overweight and obesity in Saudi Arabia have found that lifestyle transformation (physical activity, leisure, and modernization) and a change in nutrition related to changing economic, social, and health factors have largely contributed to the

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increase in the prevalence of overweight and obesity observed in Saudi children and youth.[6-11]

Southwestern Saudi Arabia is characterized by areas of high and low altitude. The general impression is that overweight and obesity are unusual among highland children worldwide.[12,13] However, a fairly recent report indicated that overweight and obesity are the major problems among local children of Southwestern highlands of Saudi Arabia.[14-16] It was suggested that the difference in the rate of overweight and obesity between Saudi highland and lowland children could be related to the difference in physical activity levels since race, socioeconomic conditions, and dietary habits appeared to be similar in the two communities.[8] In general, the relationship between childhood overweight and obesity and physical activity is complex. In the previous prospective studies, physical activity level was inversely related to childhood overweight and obesity.[17,18] However, other studies of the same nature[19,20] have failed to show any significant relationship.

The aim of the present study was to describe the distribution of physical activity and its relationship to childhood overweight and obesity in high and low altitude populations of children in Southwestern Saudi Arabia where both environmental and population genotype differ from other studied areas.

SUBJECTS AND METHODS

This cross-sectional study was carried out in high and low altitude areas of the Aseer Province in Southwestern part of the Kingdom of Saudi Arabia. Three villages – Alsoda, Alsoga, and Tabab – located at 3000–3150 m above the sea level were selected for the study. For comparison, Alraish and Al-Khatarish villages located at a relatively low altitude of 500 m above the sea level were selected. The weather of Alsoda, Alsoga, and Tabab is cold and rainy in winter and dry with moderate temperatures in summer. Winter in Al-Khatarish and Alraish is rainy with relatively moderate temperatures and summer is dry and hot. The permanent residents in the two areas are rural populations who have many modern facilities (electricity, clean water supply, cars, etc.,) but who still maintain their basic dietary and social habits. Meat, chicken, and rice constitute the major dietary items for people living in the two areas. Primary health care in Aseer Province is provided through a wide network of primary health care centers. Secondary and tertiary care services in the province are provided through a network of well-staffed hospitals.

Data were collected from 145 healthy subjects aged 10–15 years who were born and bred at a high altitude (about 93% of the total population aged 10–15 years registered in Alsoda, Alsoga, and Tabab health centers) and 154 healthy subjects of comparable age who were also born and permanently domiciled at low altitudes (about 94% of the total population aged 10–15 years registered in Al-Khatarish and Alraish health centers). Subjects were selected on the basis of their acceptance or their parents' acceptance of the invitation by the medical practitioners and the local people working in the health centers to participate. Each child was first given a detailed clinical examination. Children in whom pathology was detected by clinical examination (chronic renal, respiratory, cardiovascular, and gastrointestinal) and those children who were not born and who did not have permanent residence in the designated study areas were excluded from this study.

To determine the level of physical activity of children at this age, the International Physical Activity Questionnaire-Short Form-A (IPAQ-SF-A) was used. The IPAQ-SF-A form was translated into Arabic and distributed 1 week before the clinical examination. The form was completed by the child, checked by the parents, and rechecked by the researchers and/or the medical practitioners in the health centers. The form comprised seven questions covering all types of physical activity. The IPAQ-SF-A assesses physical activity undertaken across a comprehensive set of domains including leisure time, domestic and gardening (yard) activities, and work-related and transport-related activities. Only the physical activity lasting more than 10 min without rest breaks and within the last 7 days was estimated. During the study, the average number of hours for which the respondent remained seated daily was noted. However, the questions on "sitting" were developed as separate indicators and not as part of the summed physical activity score. Physical activities were classified into three categories: Vigorous, moderate, and walking. Vigorous activity was physical activity that caused a high increase in breathing and/or heart rate such as carrying or lifting heavy loads, digging, running, playing football, or construction work. Moderate physical activity caused small increases in breathing and/or heart rate, for example, carrying a light load, cycling, swimming, and playing volleyball. All types of walking were included in the walking category. For each specific type of activity, the frequency (measured in days per week) and duration (time per day) were recorded. Physical activities were calculated in metabolic equivalent (MET). MET is the ratio of a person's working metabolic rate relative to the resting metabolic rate. One MET is defined as the energy cost of sitting quietly and is equivalent to a caloric consumption of 1 kcal/kg/h. Vigorous activity was given 8 METs, moderate 4 METs, and walking 3.3 METs.[21] FFor each activity the score was calculated by multiplying its METs x frequency (days per week) x duration (time per minutes). The subject's overall physical activity using IPAQ-SF-A (total physical activity MET-minutes/week)

was sum of total (walking + moderate + vigorous) MET-min/week scores. Using these values, three levels of physical activity were identified:

- High physical activity: The two criteria for classification as "high" are vigorous-intensity activity on at least 3 days achieving a minimum total physical activity of at least 1500 MET-min/week or 7 or more days of any combination of walking and moderate-intensity or vigorous-intensity activities achieving a minimum total physical activity of at least 3000 MET-min/week
- Moderate physical activity: The pattern of activity is to be classified as "moderate" in any of the following criteria: 3 or more days of vigorous-intensity activity of at least 20 min per day or 5 or more days of moderate-intensity activity and/or walking of at least 30 min per day or 5 or more days of any combination of walking and moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 600 MET-min/week
- Low physical activity: Those individuals who did not meet criteria for high or moderate were considered to have a "low" physical activity level.

For each subject at high and low altitudes, body weight was measured and recorded using an Avery beam weighing scale to the nearest 0.1 kg. Subjects were weighed partly dressed and a correction of 0.5 kg was made for clothing. Standing height was measured and recorded to the nearest 0.5 cm with a stadiometer (without shoes). The age of the child was calculated from birth certificate and body mass index (BMI) was computed from the weight and height (BMI = weight [kg]/height [m^2]). Overweight and obesity were defined as a BMI > 85% according to age- and gender-specific percentiles for BMI from the WHO-NCHS reference population.[22]

Statistical analysis

The collected data were compiled and fed into IBM computer. SPSS version 20 (IBM Corp., Armonk, NY) was used for standard statistical analysis. Descriptive data were presented as mean and ± standard deviation or percentages. The Student's *t*-test and *Z*-test were used to compare the two means and two percentages, respectively. Spearman's correlation coefficient was used to test for association between activity scores and BMI. Chi-square test was used to test for the association between overweight and obesity and the levels of physical activity. $P < 0.05$ was considered statistically significant.

RESULTS

Table 1 shows the distribution of weight, height, BMI, activity scores, and prevalence of overweight and obesity by altitude and sex. At both high and low altitudes, the ratio of boys: girls was 2:1. There were no significant differences in the mean ages between boys and girls at high altitude and their respective groups at low altitude ($P < 0.76$ for both). This was true for the entire group and the two subgroups. The overall prevalence of overweight and obesity was significantly higher among highland children (39.3%) than among lowland children (24.0%) ($P < 0.004$). This was true for both boys (37% at high altitude and 23.9% at low altitude, $P < 0.04$) and girls (44.4% at high altitude and 24.4% at low altitude, $P < 0.05$). There were no significant differences in the prevalence of overweight and obesity between the two sexes at the same altitude ($P < 0.39$ for highlanders and < 0.94 for lowlanders). At both high and low altitudes, boys reported significantly more activity than girls ($P < 0.001$ for both). When the two sexes were compared at different altitudes, lowland boys reported significantly more activity than highland boys ($P < 0.001$) while there was no significant difference in the level of activity between highland and lowland girls ($P < 0.5$).

Table 2 shows the number and percentage of subjects in the three activity levels by altitude and sex. None of the lowland and highland girls interviewed was highly active. For boys of the same age, the proportion of subjects who belonged to the high activity group was significantly greater in lowlanders (21.1%) than highlanders (10%) ($P < 0.03$). There were no significant differences in the percentages of subjects who belonged to the moderate activity level between boys and girls at high altitude and their counterparts at low altitude.

Table 1: The distribution of weight, height, BMI, activity scores and prevalence of overweight and obesity by sex

	High altitude		Low altitude	
	Boys	Girls	Boys	Girls
Number of subjects	100	45	109	45
Age (10-15 years)	12.6±1.6	12.6±1.4	12.5±1.6	12.1±1.3
Weight (kg)	44.8±15.7	42.3±11.3	40.8±12.9	39.4±11.5
Height (cm)	144.9±12.4	144.6±8.9	141.4±11.1	139.3±11.2
BMI (kg/m^2)	21.1±5.8	20.0±4.2	20.1±5.1	20.2±5.1
Activity score (MET-minutes/week)	1504.4±1011.9	212.0±202.9	2352.8±1303.5***	189.1±155.0
% of overweight and obesity	37.0**	44.4*	23.9	24.4

* $P<0.05$, ** $P<0.04$, *** $P<0.001$

The proportion of boys whose activity level was low was significantly greater in the group at high altitude than that at low altitude ($P < 0.001$) while no significant difference was found between the proportions of girls in the low activity group at high and low altitudes.

Significant negative correlations between activity scores and BMI were observed in highland and lowland boys and girls ($r^2 = -0.47$, $P < 0.001$; $r^2 = -0.63$, $P < 0.001$ for high altitude boys and girls, respectively; $r^2 = -0.52$, $P < 0.001$ and $r^2 = -0.35$, $P < 0.02$ for low altitude boys and girls, respectively).

Analyses were performed separately for boys and girls to test for the association between physical activity and overweight and obesity. For highland and lowland boys, physical activity was inversely related to overweight and obesity [Table 3]. In both highland and lowland boys, the proportion of overweight and obese was lowest in the highly active group and highest in the least active group. No significant association was observed between physical activity and overweight and obesity for either highland or lowland girls although the highest proportion of overweight and obese was in the least active group and the lowest was in the moderately active group [Table 3].

DISCUSSION

The present study demonstrated that the level of physical activity was inversely and significantly associated with overweight and obesity in boys aged 10–15 years at both high and low altitudes, but there was no clear trend for girls of the same age at either altitude. We selected the short form IPAQ-SF-A instrument, out of various methods available, as a measure of physical activity because it is short, reproducible, easy to administer in surveys and provides a reliable estimation for a range of physical activity domains. More importantly, the method was acceptable to the respondents at both high and low altitudes. In addition, the IPAQ-SF-A has been used in a series of international and national studies[21,23] and has widely accepted reliabilities.[21] In this study, the validity of the IPAQ-SF-A was indirectly tested by comparing activity scores with resting pulse rate which was found to be inversely and significantly related to activity score ($r^2 = -0.154$, $P < 0.008$). The relationship of pulse rate and physical activity levels is shown graphically in Figure 1.

Out of various indices, we selected BMI as an indicator of overweight and obesity because BMI is easy to derive and applies to all populations without any need for a reference

Table 2: Distribution of physical activity levels by altitude and sex

	High altitude		Low altitude	
	Boys *N* (%)	Girls *N* (%)	Boys *N* (%)	Girls *N* (%)
Low activity	20 (20.0)	43 (95.6)	3 (2.8)	44 (97.8)
Moderate activity	70 (70.0)	2 (4.4)	83 (76.1)	1 (2.2)
High activity	10 (10.0)	0 (0.0)	23 (21.1)	0 (0.0)

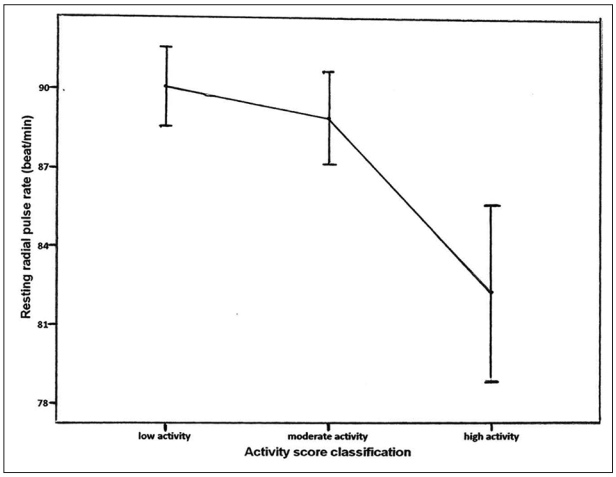

Figure 1: The relationship between physical activity levels and resting redial pulse rate. The vertical bars represent the standard deviations

Table 3: The prevalence of overweight and obesity according to the level of physical activity

	Boys		Girls	
	Number (*n*) in each activity level	Overweight and obese in each activity level *N* (%)	No. in each activity level	Overweight and obese in each activity level *N* (%)
High landers				
Low activity	20	15 (75.0)	43	20 (46.5)
Moderate activity	70	20 (28.6)	2	0 (0.0)
High activity	10	2 (20.0)	0	0 (0.0)
		χ^2=15.8, P<0.001		χ^2=1.7, P<0.19
Low landers				
Low activity	3	3 (100.0)	44	11 (25.0)
Moderate activity	83	22 (26.5)	1	0 (0.0)
High activity	23	1 (4.3)	0	0 (0.0)
		χ^2=14.7, P<0.001		χ^2=0.33, P<0.57

population. Furthermore, the BMI is highly correlated with other estimates of fatness.[24]

In this study, most of the high activity comprised soccer, games, and running. The low level of physical activity observed in girls, especially those at low altitude, may be related to sociocultural factors. Girls of this age tend to spend most of their time indoors watching television and playing computer games, and they are usually taken to school by car. The low levels of physical activity observed in highland boys compared to boys at low altitude may be mainly the result of the environment. Because of the cold weather at high altitude and the topography of the area, highland boys tend to spend most of their time indoors whereas lowland boys tend to be more active. They spend more time outdoors on farms rearing goats and sheep.

The negative association between physical activity and overweight and obesity in both high and low altitudes boys was consistent with previous studies in the field.[7,25] However, other studies reported no relationship.[19,20] This disparity may be the result of problems associated with the methods used to evaluate physical activity.

The BMI of both highland and lowland girls showed significant negative correlation with the activity score. However, no significant association was observed between the level of physical activity and overweight and obesity in either highland or lowland girls although the proportions of overweight and obesity were higher in the low activity group and lowest in the moderate activity group. This may be because this population of girls was homogenous with regard to physical activity, which had little or no apparent effect on overweight and obesity in individuals.

CONCLUSION

It is obvious that childhood overweight and obesity are a serious public problem with adverse effects on health and longevity. In view of the significant association between physical activity and overweight and obesity, at least in high and lowland boys, health education programs that encourage physical activity as means of preventing overweight and obesity and as strategy for weight reduction in overweight and obese children will certainly be justifiable.

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Conflicts of interest
There are no conflicts of interest.

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