Adiposity and physical activity levels among preschool children in Jeddah, Saudi Arabia

Hazzaa M. Al-Hazzaa, PhD, FACSM, Amani A. Al-Rasheedi, PhD.

ABSTRACT

Objective: To assess the levels of adiposity and physical activity among Saudi preschool children from Jeddah.

Methods: Participants included 224 Saudi preschool children, randomly selected from public and private preschools in Jeddah during April and May of 2006, using a multistage stratified sampling technique. Measurements included weight, height, body mass index, triceps and subscapular skinfolds, fat percentage, fat mass (FM), fat-free mass (FFM), FM index (FMI) and FFM index (FFMI), time spent watching television and physical activity levels using electronic pedometer for 3 continuous days during weekdays.

Results: The fat content averaged 20.6% of body weight, while the prevalence of obesity was 10.8%. There were significant gender differences in fat percentage, FM, FFM, FMI, and FFMI. The mean value for pedometer-determined steps counts for the preschool children was 6773.2 steps per day. Boys were significantly more active than girls. Only 22.4% of the preschool children had 10000 steps or more per day. There were no significant age differences in skinfolds measurements, fat percentage, FMI, FFMI, central obesity or daily steps counts. Television viewing time increased by 22.5% from age 4 to age 6. Compared to non-obese, obese preschool children were significantly heavier, taller and had higher values for all adiposity indices and television viewing time.

Conclusion: A considerable proportion of Saudi preschool children is obese and even a greater proportion is physically inactive. Obesity and physical inactivity represent major risks for a number of non-communicable diseases, and an early intervention is most appropriate.

Saudi Med J 2007; Vol. 28 (5): 766-773

From the Exercise Physiology Laboratory (Al-Hazzaa), King Saud University, Riyadh and the Department of Nutrition and Food Science (Al-Rasheedi), College of Home Economic and Art Education, Jeddah, Kingdom of Saudi Arabia.

Received 29th August 2006. Accepted 12th December 2006.

Address correspondence and reprint request to: Prof. Hazzaa M. Al-Hazzaa, Director, Exercise Physiology Laboratory, King Saud University, PO Box 9792, Riyadh 11423, Kingdom of Saudi Arabia. Fax. +966 (1) 4674852. E-mail: halhazzaa@hotmail.com

Childhood obesity is a global epidemic and the rising trends in overweight and obesity are well documented in both developed and developing countries.[1-3] Obesity in childhood carries potentially long-term effects on cardiovascular and metabolic diseases.[4,5] In addition, childhood obesity often persists into adulthood.[6] Among older children, obesity was shown to be an important predictor of adult obesity, regardless of parental obesity.[7] Thus, the preschool years may be a critical period for obesity prevention as indicated by the association of adiposity rebound and obesity in later years.[8]

Obesity is simply a result of an imbalance between energy intake and expenditure, and by far the most variable contributor of total energy expenditure is physical activity.[9] Recent recommendations from expert panelists convened by the Centers for Disease Control and Prevention (CDC) called for the characterization of the relationship between physical activity and obesity in preschool-age children.[10] Theoretically, the establishment of appropriate physical activity habits in early childhood should translate into positive health consequences later in life. Evidence is now accumulating that an increase in physical activity in early childhood period is associated with improved health status.[11,12] In addition, higher levels of physical activity during periods of early childhood and childhood (4-11 years) lead to the acquisition of less body fat by the time of early adolescence.[13] On the other hand, it is believed that reduced physical activity level is contributing to the rise in childhood overweight and obesity seen in recent years.[14]

In Saudi Arabia, where an enormous lifestyle transformation has occurred in recent decades, several local studies reported a rising trend in body mass index (BMI) and a high prevalence of physical inactivity among school children and adolescents.[15-17] However, information on physical activity levels of Saudi preschool children is lacking. Additionally, early studies on overweight and obesity among young children were based solely on the assessment of BMI. [18,19] However, BMI has a poor sensitivity to screen for overweight

young children.[20] Therefore, the objectives of the present study were to assess the levels of adiposity using both BMI and skinfolds measurements and to measure daily physical activity levels among randomly selected Saudi preschool children from Jeddah.

Methods. This cross-sectional study was conducted during the April and May of 2006 in the city of Jeddah, Saudi Arabia. Participants consisted of 224 Saudi preschool children (109 boys and 115 girls) randomly selected from public and private preschools using a multistage stratified sampling technique. This represents a response rate of approximately 75% of the selected sample size. The number of Saudi boys drawn from each of the public and private schools was proportional to the total number of Saudi boys in each category. The age of the selected children ranged from 3.4-6.4 years. Permission to conduct the study was secured from the directorate office of educational research in the Ministry of Education, Jeddah branch. Written consent was also obtained from each child's parent. The study was conducted in full accordance with the internationally agreed ethical principles in conducting medical research.

Body weight was measured without shoes to the nearest 0.1 kg using Seca digital scale (Seca, Germany). Standing height was measured barefooted to the nearest 0.1 cm using a calibrated measuring rod (Seca Road Rod). In addition, triceps and subscapular skinfolds thicknesses were measured on the right side of the body using Lange skinfolds caliper. Body fat percent was then calculated using a prediction equation specific for children and youth.[21] Obesity was defined as body fat content that equals or exceeds 25% and 30% of total body weight for boys and girls, respectively.[22]

Habitual physical activity was measured using electronic pedometer (Digi-walker) for 3 continuous days during weekdays. Three days measurements were shown to provide a reliable estimate of daily step counts (intraclass correlation coefficient of 0.80).[23] Pedometers are simple and inexpensive body-worn motion sensors that are increasingly used for objective assessment of physical activity behaviors. The type of pedometer used in the present study was recently found to be valid for measuring steps.[24] The instrument does not interfere with the child's normal daily activity. The pedometer was attached securely to the right hip of the child. Families were instructed to make sure that the pedometer stays on place at all times except during sleeping and bathing. In addition, parents were asked in a separate questionnaire to provide an estimate of the amount of time that a child spends watching television (TV) per day.

Data entry and statistical analysis were performed using the Statistical Package for the Social Science program, version 10 (Chicago, IL). Results are expressed as means and standard deviations. Differences between boys and girls in all anthropometric measures, steps counts and TV viewing time were tested using independent t-tests. Differences between age groups (4-, 5-, and 6-year old) in all variables were tested using one-way analysis of variance with Scheffe post hoc test. Furthermore, 2-factor analysis of variance was used to test for age and gender interactions in physical activity and body fat indexes. The level of significant was set at 0.05 levels. In addition to body fat percentage, fat mass (FM) and fat-free mass (FFM), we calculated FM index (FMI = FM/height^2) and FFM index (FFMI = FFM/height^2) that are normalized for body stature.[25] Thus, FMI and FFMI are both discrete and adjusted for body size.

Results. **Table 1** presents the descriptive characteristics of the preschool children grouped by gender. Boys represented approximately 49% of the total sample. Estimated fat content for the whole sample averaged 20.6% of body weight. The prevalence of obesity in the whole sample was 10.8% (9.2% in boys and 11.5% in girls). The mean value for pedometer-determined steps counts for the preschool children was 6773.2 steps per day. Only 22.4% of the preschool children had 10000 steps or more per day (27.1% of boys and 18.6% of girls). There were even smaller proportions of boys (10.2%) and girls (4.0%) who achieved 15000 steps or more per day. There were no significant differences between boys and girls in chronological age, body weight, height, BMI, sum of skinfolds or TV viewing time. However, there were significant (p<0.05) gender differences in fat percentage, FM, FFM, FMI, FFMI, and steps counts per day.

Table 2 displays the characteristics of the sample grouped by age categories. The number of preschool children in the sample increases from age 4 to age 6. Those increases may very well reflect the actual numbers of children enrolled in the preschools. Older children, in general, are more likely to be enrolled in preschool compared with younger children. As shown in **Table 2**, values of body weight, height, fat mass, and fat-free mass across the age groups were all significantly (p=0.000) different. However, there were no significant differences between age groups in skinfolds measurements, percentage of fat, FMI, FFMI, or steps counts per day. Furthermore, judging from subscapular to triceps ratio, central obesity did not significantly change from younger (93%) to older (92.2%) children. Television viewing time increased steadily from 136.5 min/day at age 4 to reach a high of 167.2 min/day at age 6. This significant rise (p=0.018) represents an increase of 22.5% in sedentary behavior among preschool children.

Table 1 - Descriptive characteristics of the sample grouped by gender (means and standard deviations).

Variable	All	Boys	Girls	*P*-value*
Number of participants	224	109	115	
Age (years)	5.19 ± 0.85	5.21 ± 0.83	5.17 ± 0.87	0.745
Body weight (kg)	18.97 ± 4.3	19.0 ± 3.7	18.9 ± 4.8	0.904
Body height (cm)	109 ± 6.8	109.7 ± 5.9	108.3 ± 7.5	0.104
Body mass index (kg/m^2)	15.8 ± 2.3	15.7 ± 2.2	15.9 ± 2.3	0.420
Triceps skinfold (mm)	10.2 ± 3.6	9.8 ± 3.3	10.5 ± 3.8	0.101
Subscapular skinfold (mm)	9.3 ± 3.7	8.9 ± 3.7	9.8 ± 3.8	0.081
Sum of 2 skinfolds (mm)	19.5 ± 7.1	18.6 ± 6.7	20.3 ± 7.4	0.090
Subscapular/triceps ratio (%)	92.1 ± 16.1	90.6 ± 17.5	93.5 ± 14.5	0.171
Fat percent (%)	20.6 ± 6.1	17.7 ± 5.7	23.4 ± 5.1	0.000
Fat mass (kg)	4.1 ± 2.1	3.5 ± 1.9	4.6 ± 2.2	0.000
Fat free mass (kg)	14.9 ± 2.6	15.5 ± 2.3	14.3 ± 2.8	0.001
Fat mass index (kg/m^2)	3.4 ± 1.5	2.9 ± 1.4	3.8 ± 1.4	0.000
Fat-free mass index (kg/m^2)	12.5 ± 1.2	12.8 ± 1.2	12.1 ± 1.2	0.000
Steps count per day	6773.2 ± 5301.6	7814.1 ± 5301.5	5954.3 ± 5190.7	0.043
TV viewing (min/day)	154.8 ± 66.1	162.4 ± 69.9	147.7 ± 61.7	0.095

*Levels of significance for the gender differences based on independent t-tests.

Table 2 - Descriptive characteristics of the sample grouped by age (means and standard deviations).

Variable	Age (years)			*P*-value
	4	5	6	
Number of participants	51	70	103	
Age (years)	3.94 ± 0.29	4.97 ± 0.26	5.97 ± 0.23	0.000
Body weight (kg)	12.2 ± 3.1	18.8 ± 3.4	20.5 ± 4.6	0.000
Body height (cm)	101.6 ± 5.2	108.5 ± 4.8	112.9 ± 5.5	0.000
Body mass index (kg/m^2)	15.6 ± 1.7	15.9 ± 2.1	15.9 ± 2.6	0.622
Triceps skinfold (mm)	9.6 ± 3.1	10.3 ± 3.4	10.3 ± 3.9	0.433
Subscapular skinfold (mm)	8.8 ± 2.7	9.4 ± 3.6	9.6 ± 4.3	0.485
Sum of 2 skinfolds (mm)	18.4 ± 5.7	19.6 ± 6.8	19.9 ± 7.9	0.451
Subscapular/triceps ratio (%)	93 ± 12.3	91.2 ± 13.5	92.2 ± 19.2	0.821
Fat percent (%)	19.9 ± 5.1	21 ± 5.9	20.6 ± 6.6	0.576
Fat mass (kg)	3.3 ± 1.4	4.1 ± 1.8	4.4 ± 2.5	0.006
Fat-free mass (kg)	12.9 ± 2.1	14.7 ± 2.1	16 ± 2.5	0.000
Fat mass index (kg/m^2)	3.1 ± 1.1	3.4 ± 1.4	3.4 ± 1.7	0.493
Fat-free mass index (kg/m^2)	12.4 ± 1.1	12.5 ± 1.2	12.5 ± 1.3	0.890
Steps counts per day	7933.4 ± 8152.6	6947.4 ± 5698.6	6431.5 ± 4310.5	0.604
TV viewing (min/day)	136.5 ± 70.1	150 ± 52.8	167.2 ± 70.1	0.018

*Levels of significance for the age differences based on one-way ANOVA tests.

Table 3 shows the anthropometric measures, steps counts per day and TV viewing time in obese and non-obese preschool children. There were no significant differences between obese and non-obese in age (p=0.151), central obesity (p=0.136) or steps counts per day (p=0.109). However, compared to non-obese, obese preschool children were significantly (<0.001) heavier, taller and had higher values for BMI, skinfolds, fat percent, FM, FFM, FMI and FFMI. Obese children also spent significantly (0.001) more time watching TV (197.5 ± 89.3 min/day) than their non-obese peers (150.0 ± 60.9 min/day). The descriptive characteristics of the active and inactive preschool children are displayed in **Table 4**. The cut-off steps counts for classifying children as obese is 10000 steps or more per day. Based on the above cut scores, approximately 78% of the whole sample was considered inactive. Active children accumulated on the average 14611 steps per day, whereas inactive children averaged approximately 4512 steps per day. As shown in **Table 4**, there was no significant difference between active and inactive preschool children in any of the measured anthropometric and body composition variables. In addition, inactive children spent almost similar time watching TV (168 ± 71.2 min/day) as did active children (159.8 ± 62.9 min/day).

Two-way analysis of variance revealed no significant interactions between gender and age categories in fat percent (p=0.106), BMI (p=0.067), FMI (p=0.069), FFMI (p=0.194) or activity levels (p=0.135). Accordingly, we examined the main effects for the above mentioned variables. **Figure 1** depicts values for body fat percent and BMI relative to age in the preschool boys and girls. Fat percent showed significant differences (p<0.01) between boys and girls across all age groups. However, values of BMI for boys and girls were not significantly different from each other at any age categories. Moreover, **Figure 2** presents FMI and FFMI values relative to age in boys and girls. As clearly illustrated in that figure, the differences in FMI between boys and girls were significant (p<0.01) at age 5 and 6 but not at age 4. For FFMI, however, the differences between the 2 genders were significant (p<0.01) at age 4 and 5 but not at age 6.

Discussion. The present investigation reports for the first time on the levels of objectively measured physical activity for Saudi preschool children. Previous local studies, however, were confined to data from school-aged boys.[15,16] Our study also presents for the first time adiposity data for Saudi preschool children based on skinfolds measurements. Earlier prevalence

Table 3 - Anthropometric measurements, steps counts and television viewing in obese and non-obese preschool children. Data are mean ± standard deviation.

Variable	Obese*	Non-obese	*P*-value**
Percentage of the total sample	10.8	89.2	
Age (years)	5.4 ± 0.78	5.2 ± 0.85	0.151
Body weight (kg)	26.6 ± 5.6	18 ± 3.0	0.000
Body height (cm)	115.2 ± 6.0	108.2 ± 6.5	0.000
Body mass index (kg/m^2)	19.9 ± 2.8	15.3 ± 1.6	0.000
Triceps skinfold (mm)	17.6 ± 3.4	9.2 ± 2.3	0.000
Subscapular skinfold (mm)	16.8 ± 4.1	8.4 ± 2.5	0.000
Sum of 2 skinfolds (mm)	34.4 ± 6.6	17.7 ± 4.6	0.000
Subscapular/triceps ratio (%)	96.7 ± 19.3	91.5 ± 15.6	0.136
Fat percent (%)	31.2 ± 3.5	19.3 ± 5.0	0.000
Fat mass (kg)	8.4 ± 2.7	3.5 ± 1.2	0.000
Fat-free mass (kg)	18.2 ± 3	14.5 ± 2.3	0.000
Fat mass index (kg/m^2)	6.3 ± 1.5	3.0 ± 0.98	0.000
Fat-free mass index (kg/m^2)	13.6 ± 1.4	12.3 ± 1.1	0.000
Steps counts per day	5374.6 ± 3753.6	7064.5 ± 5494.6	0.109
TV viewing (min/day)	197.5 ± 89.3	150 ± 60.9	0.001

* Fat percent ≥25% of body weight for boys and ≥30% of body weight for girls.
** Levels of significance for the differences between obese and non-obese (independent t-tests).

reports solely estimated overweight and obesity from BMI.[18,19] Our findings indicate that the prevalence of adiposity and physical inactivity among Saudi preschool children were approximately 11% and 78%, respectively. Nowadays, obesity and physical inactivity in young children represent an important public health issue.[10,26] This is due to the fact that adiposity rebound (the lowest inflection point of BMI during childhood) typically occurs between 4 and 6 years of age. Evidence indicates that an early adiposity rebound predicts an increased obesity in adulthood.[8] Moreover, adiposity rebound was shown to occur at a later age for the most active children, thus, reducing their risk of obesity later in life.[13]

Using the International age- and sex-specific child BMI cut-off values to define overweight and obesity,[27] we calculated the combined prevalence of overweight and obesity in this study to be 19.2% in boys and 22.6% in girls. These prevalence rates were higher than what was reported in an earlier study for young Saudis of comparable age group.[19] However, the mean BMI values in the present study were similar to those local BMI norms reported recently for Saudi children aged 4, 5, and 6 years.[18] Furthermore, our findings on adiposity of the preschoolers were in line with numerous other studies that reported increased adiposity in preschool children.[1-3,28] Among preschool children aged 2-5 years from the United States, the prevalence of overweight was reported to be 10.1% and an additional 10.7% were at risk for becoming overweight.[3] The overall prevalence of overweight and obesity among Canadian preschool children was estimated to be 25.6%.[1] In addition, 23% of 5-7 year-old German children were considered overweight or obese.[28]

Measuring free-living physical activity in young children is technically challenging. Direct comparison of our finding on physical activity levels with those of other studies[29-32] is difficult, due to the differences in methods of physical activity assessments. However, children, in general, are thought to have a sedentary lifestyle at an early age.[14,33] In addition, time spent in moderate to vigorous physical activity in young Scottish children were reported to be 2% and 4% of all monitored hours at age 3 and 5, respectively.[32] The National Association for Sport and Physical Education of the United States has recently released physical activity guidelines for children attending preschools.[33] The guidelines indicate that preschool-aged children should engage in at least 2 hours of exercise a day. Half of these 2 hours in structured physical activity and the reminder in unstructured, free-play settings.[33] Opportunities for physical activity may be what young children really need to increase their levels of activity. However, in major cities like Jeddah, parents would

Table 4 - Anthropometric measurements, steps counts and TV viewing in active and inactive preschool children. Data are mean ± standard deviation.

Variable	Active*	Inactive	*P*-value**
Percentage of the total sample	22.4	77.6	
Age (years)	5.4 ± 0.84	5.4 ± 0.68	0.795
Body weight (kg)	19.5 ± 3.2	19.8 ± 4.7	0.644
Body height (cm)	110.1 ± 5.7	110.5 ± 5.7	0.706
Body mass index (kg/m^2)	16.1 ± 2.1	16.1 ± 2.5	0.961
Triceps skinfold (mm)	10.5 ± 3.6	10.5 ± 3.8	0.975
Subscapular skinfold (mm)	9.9 ± 3.1	9.6 ± 4.2	0.738
Sum of 2 skinfolds (mm)	20.4 ± 6.5	20.1 ± 7.8	0.854
Subscapular/triceps ratio (%)	95.1 ± 15	91.1 ± 17.3	0.219
Fat percent (%)	21.2 ± 5.8	21.3 ± 6.5	0.985
Fat mass (kg)	4.3 ± 1.7	4.4 ± 2.4	0.664
Fat-free mass (kg)	15.2 ± 2.0	15.4 ± 2.7	0.744
Fat mass index (kg/m^2)	3.5 ± 1.3	3.5 ± 1.6	0.850
Fat-free mass index (kg/m^2)	12.6 ± 1.2	12.5 ± 1.3	0.896
Steps counts per day	14611 ± 4797.7	4512.3 ± 2599.8	0.000
TV viewing (min/day)	168 ± 71.2	159.8 ± 62.9	0.543

*Active ≥10000 steps per day and inactive <10000 steps per day.
** Levels of significance for the differences between active and inactive (independent t-tests).

rather have their children stay home and watch TV than play outside home unattended. In addition, increased proportions of Saudi school children are now being driven by car to schools.[34] Walking to and from school can boost the child's energy expenditure and contribute to energy balance. Reducing the time spent watching TV is another strategy that can offer the opportunities for children to be less sedentary. However, active preschool children in our study did not differ significantly from inactive peers in time spent watching TV.

The findings that boys in the present study were more active than girls are consistent with many previous studies.[29-32,35] Not only do boys engage in greater amount of physical activity, they also tend to engage in higher intensity activity than girls do.[36] Age may also interact with gender to produce different physical activity patterns in children. Reilly et al[32] found a gender difference at age 5 years but not at 3 years of age. In our study, age and gender did not show any significant interaction in many variables including physical activity. Furthermore, our results indicated that physical activity levels in the preschool children did not show any significant differences across age. However, contrary to our findings, Pate et al[31] reported that 4- and 5-year-old boys and girls spent more time in sedentary activity compared with 3-year-old children. In addition, the amount of time spent in light activities was the greatest among 3-year-old children, followed by 4-year-old and then by 5-year-old.[31] Other studies had also found an age difference in physical activity levels. [30,35]

Although there was a tendency for the non-obese preschool children in the present study to have higher steps counts per day than obese peers (7064.5 versus 5374.6 steps counts), the difference did not reach a statistical significance (p=0.109). Elsewhere, it was reported that overweight preschool children had lower

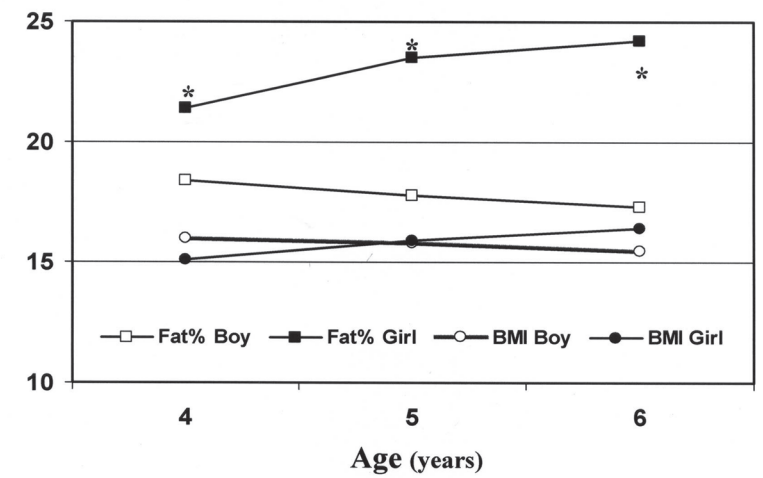

Figure 1 - Fat percent (Fat%) and body mass index (BMI) across age in preschool boys and girls. (*significant differences between boys and girls at <0.01 level).

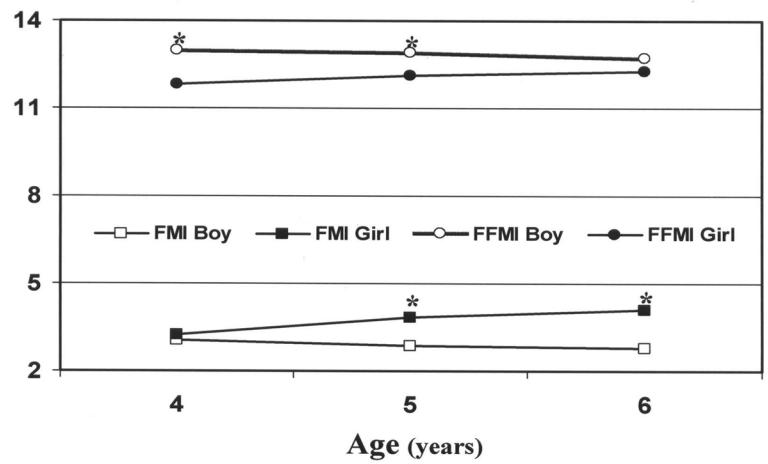

Figure 2 - Fat mass index (FMI) and fat-free mass index (FFMI) across age in preschool boys and girls. (*significant differences between boys and girls at <0.01 level).

physical activity levels than non-obese children.[37] Furthermore, Davies et al[38] found that high level of fat percentage was associated with low physical activity levels. Low activity was also related to a higher BMI among girls.[12] The relationship between physical activity and adiposity may be affected by the levels of exercise intensity. Pate and coworkers[31] reported that child's BMI was related to their vigorous but not to moderately vigorous levels of physical activity. In the present study, we used electronic pedometers for physical activity assessment. Although they are valid and reliable,[23,24] pedometers do not distinguish physical activity intensities during free-living assessment as accelerometers do. Perhaps, this may have weakened the relationships between fat percentage and steps counts.

Body fat percentage in the present study did not change significantly with age (p=0.576). However, FM and FFM increased significantly (p<0.001) with advancing age. Those increases in FM and FFM with advancing age reflect the association of the 2 variables with body weight. However, when FM and FFM were normalized to body size as previously recommended,[25] the differences across age groups disappeared. Indeed, the correlation coefficients between stature and each of FM and FFM in the present study were 0.83 and 0.50, respectively. In contrast, the relationships between stature and each of FMI and FFMI were much lower, reaching 0.29 and 0.22, respectively. Factors that promote an increase in energy intake or a reduction in energy expenditure can lead to obesity.[9] At preschool age, both dietary intake and physical activity were shown to be strongly influenced by parents and preschool policies.[39] In the present study, variation in adiposity due to preschool was significant (p=0.033). However, no significant (p=0.709) differences were seen in physical activity levels due to school that the child attends.

Our findings indicated that obese preschool children spent significantly more time watching TV than non-obese did. Increased TV viewing time not only comes at the expenses of time spent on physical activity, but also heightens the children's exposure to food advertising on TV. A longitudinal study conducted on 3-7 year-old children showed that physical activity and TV viewing were the only significant predictors of BMI among these young children.[40] Moreover, TV viewing time was shown to be associated with increased BMI and higher prevalence of overweight.[28] It is of interest to indicate though, that recent research suggests that efforts to decrease time spent in sedentary activities resulted in weight loss among obese children.[41]

In conclusion, the present investigation reveals that a considerable proportion of Saudi preschool children is obese and that the prevalence of physical inactivity among those young children is very high. Obesity and physical inactivity represent major risks for a number of noncommunicable diseases, and an early intervention would be most appropriate. Efforts aimed on combating childhood obesity and physical inactivity must include education, research and intervention. Furthermore, policy makers, health care providers, educators, and parents should all be involved in such efforts.

References

1. Canning P, Courage M, Frizzell L. Prevalence of overweight and obesity in a provincial population of Canadian preschool children. ***Can Med Assoc J*** 2004; 171: 240-242.
2. de Onis M, Blossner M. Prevalence and trends of overweight among preschool children in developing countries. ***Am J Clin Nutr*** 2000; 72: 1032-1039.
3. Ogden C, Flegal K, Carroll M, Johnson C. Prevalence and trends in overweight among US children and adolescents, 1999-2000. ***JAMA*** 2002; 288: 1728-1732.
4. Speiser P, Rudolf M, Anhalt H, Camacho-Hubner C, Chiarelli F, Eliakim A, et al. Consensus statement: childhood obesity. ***J Clin Endocrinol Metab*** 2005; 90: 1871-1887.
5. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. Report of WHO Consultation on Obesity. Geneva, Switzerland: WHO, 2000.
6. Guo S, Wu W, Chumlea W, Roche A. Predicting overweight and obesity in adulthood from body mass index values in childhood and adolescence. ***Am J Clin Nutr*** 2002; 76: 653-658.
7. Whitaker R, Wright J, Pepe M, Seidel K, Dietz W. Predicting obesity in young adulthood from childhood and parental obesity. ***N Engl J Med*** 1997; 337: 869-873.
8. Whitaker R, Pepe M, Wright J, Seidel K, Dietz W. Early adiposity rebound and the risk of adult obesity. ***Pediatrics*** 1998; 101: e105.
9. Delany J. Role of energy expenditure in the development of pediatric obesity. ***Am J Clin Nutr*** 1998; 68: s950-s955.
10. Fulton J, Burgeson C, Perry G, Sherry B, Galuska D, Alexander M, et al. Assessment of physical activity and sedentary behavior in preschool-age children: Priorities for research. ***Pediatric Exercise Science*** 2001; 13: 113-126.
11. Binkley T, Specker B. Increased periosteal circumference remains present 12 months after an exercise intervention in preschool children. ***Bone*** 2004; 35: 1983-1388.
12. Saakslahti A, Numminen P, Varstala V, Helenius H, Tammi A, Viikari J, et al. Physical activity as a preventive measure for coronary heart disease risk factors in early childhood. ***Scand J Med Sci Sports*** 2004; 14: 143-149.
13. Moore L, DiGao A, Bradlee M, Cupples L, Sundarajan-Ramamurti A, Proctor M, et al. Does early physical activity predict body fat change throughout childhood? ***Prev Med*** 2003; 37: 10-17.
14. U.S. Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA: Centers for Disease Control and Prevention (CDC), National Centers for Chronic Disease Prevention and Health Promotion, 1996.
15. Al-Hazzaa H. Physical activity, fitness and fatness among Saudi children and adolescents: implications for cardiovascular health. ***Saudi Med J*** 2002; 23: 144-150.
16. Al-Hazzaa H. Prevalence of physical inactivity in Saudi Arabia: A brief review. ***East Mediterr Health J*** 2004; 10: 663-670.

17. Al-Hazzaa H. Rising trends in BMI of the Saudi adolescents: Evidences from three national cross-sectional studies. ***Asia Pac J Clin Nutr*** 2007; 16: (in press).
18. Al-Mazrou Y, Al-Amoud M, El-Gizouli S, Khoja T, Al-Turki K, Tantawi N, et al. Comparison of growth standards between Saudi and American Children aged 0-5 years. ***Saudi Med J*** 2003; 24: 598-602.
19. El-Hazmi M, Warsy A. A comparative study of prevalence of overweight and obesity in children in different province of Saudi Arabia. ***J Trop Pediatr*** 2002; 48: 172-177.
20. Mast M, Langnase K, Labitzke K, Bruse U, Preuss U, Muller M. Use of BMI as a measure of overweight and obesity in field study on 5-7 year old children. ***Eur J Nutr*** 2002; 41: 61-67.
21. Slaughter M, Lohman T, Boileau R, Horswill C, Stillman R, VanLoan M, et al. Skinfold equations for estimation of body fatness in children and youth. ***Human Biology*** 1988; 60: 709-723.
22. Lohman, T. Advances in Body Composition assessment. Champaign (IL): Human Kinetics; 1992.
23. Tudor-Locke C, Burkett L, Reis J, Ainsworth B, Macera C, Wilson D. How many days of pedometer monitoring predict weekly physical activity? ***Prev Med*** 2005; 40: 293-298.
24. Courter S, Schneider P, Karabulut M, Bassett D Jr. Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. ***Med Sci Sports Exerc*** 2003; 35: 1455-1460.
25. VanItallie T, Yang M, Hemsfield S, Funk R, Boileau R. Height-normalized indices of body's fat-free mass and fat mass: Potentially useful indicators of nutritional status. ***Am J Clin Nutr*** 1990; 52: 953-959.
26. American Academy of Pediatrics, Committee on Sports Medicine and Fitness and Committee on School Health. Organized sports for children and preadolescents. ***Pediatrics*** 2001; 107: 1459-1462.
27. Cole T, Bellizzi M, Flegal K, Dietz W. Establishing a standard definition of child overweight and obesity worldwide: International survey. ***BMJ*** 2000; 320: 1-6.
28. Muller M, Koertzinger I, Mast M, Langase K, Grund A. Physical activity and diet in 5 to 7 years old children. ***Public Health Nutr*** 1999; 2: 443-444.
29. Finn K, Johannsen N, Specker B. Factors associated with physical activity in preschool children. ***J Pediatr*** 2002; 140: 81-85.
30. Jackson, D, Reilly J, Kelly L, Montgomery C, Grant S, Paton J. Objectively measured physical activity in representative sample of 3-to 4- year-old children. ***Obes Res*** 2003; 11: 420-425.
31. Pate R, Pfeiffer K, Trost S, Ziegler P, Dowda M. Physical activity among children attending preschools. ***Pediatrics*** 2004; 114: 1258-1263.
32. Reilly J, Jackson D, Montgomery C, Kelly L, Slater C, Grant S, et al. Total energy expenditure and physical activity in young Scottish children: mixed longitudinal study. ***Lancet*** 2004; 363: 211-212.
33. National Association for Sport and Physical Education (NASPE). Active Start: A Statement of Physical Activity Guidelines for Children Birth to Five Years. Reston, VA: National Association for Sport and Physical Education Publication; 2002.
34. Al-Hazzaa H. How much load do Saudi school children carry over their shoulders? ***Saudi Med J*** 2006; 27: 1567-1571.
35. Louie L, Chan L. The use of pedometry to evaluate the physical activity levels among preschool children in Hong Kong. ***Early Child Dev Care*** 2003; 173: 97-107.
36. McKenzie T, Sallis J, Nader P, Broyles S, Nelson J. Anglo-and Mexican-American preschoolers at home and at recess: activity patterns and environmental influences. ***J Dev Behav Pediatr*** 1992; 13: 173-180.
37. Trost S, Sirard J, Dowda M, Pfeiffer K, Pate R. Physical activity in overweight and nonoverweight preschool children. ***Int J Obes*** 2003; 27: 834-839.
38. Davies p, Gregory J, White A. Physical activity and body fatness in preschool children. ***Int J Obes*** 1995; 19: 6-10.
39. Dowda M, Pate R, Trost S, Almeida M, Sirard J. Influences of preschool policies and practices on children's physical activity. ***J Community Health*** 2004; 29: 183-196.
40. Jago R, Baranowski T, Baranowski J, Thompson D, Greave K. BMI from 3-6 y of age is predicted by TV viewing and physical activity, not diet. ***Int J Obes*** 2005; 29: 557-564.
41. Epstein L, Valoski A, Vara L, McCurley J, Winicwski L, Kalarchian M, et al. Effects of decreasing sedentary behavior on weight change in obese children. ***Health Psychol*** 1995; 14: 109-115.