Original Article

Activity energy expenditure, screen time and dietary habits relative to gender among Saudi youth: interactions of gender with obesity status and selected personal behaviours

Hazzaa M Al-Hazzaa PhD, FACSM, FECSS, Nada M Albawardi MPH

Lifestyle and Health Research Center, Health Sciences Research Center, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia

Background and Objectives: Lifestyle-related risks are linked to several non-communicable diseases, with enormous global mortality and economic cost. Women in Saudi Arabia are faced with high prevalence of obesity, inactivity and sedentary behaviours. This study examined the interaction effects of gender with obesity status and lifestyle behaviours among Saudi adolescents. **Methods and Study Design:** A total of 2888 adolescents (1500 females) aged 15-19 years were randomly selected from secondary schools in three major cities in Saudi Arabia, using a multistage stratified cluster sampling technique. Weight, height and waist circumference were measured and physical activity (PA), screen time, sleep duration and dietary habits were assessed using a validated questionnaire. ANCOVA and multivariate tests were used while controlling for age. **Results:** A number of lifestyle behaviours displayed significant gender effects, with some selected variables having multiple interaction effects. Total activity energy expenditure and sum of vigorous-intensity PA showed significant interaction effects between gender and obesity status, whereas sum of moderate activity energy expenditure, non-leisure-time PA and sleep duration exhibited significant interaction effects between gender and screen time. Vegetable intake showed significant three-way interaction effects between gender, waist/height ratio and screen time. **Conclusions:** The presence of several lifestyle behavioural risks, including physical inactivity, sedentary behaviours and some dietary habits was confirmed. The high inactivity level and screen time represents a double burden on the health of young Saudi females. Future studies must address the psycho-social, cultural and environmental determinants associated with healthy lifestyle relative to gender and initiate novel interventions to reduce sedentary behaviour.

Key Words: dietary habits, gender differences, obesity, physical activity, sedentary behaviour

INTRODUCTION

Lifestyle-related risk factors have been shown to be linked to several non-communicable diseases (NCDs), with immense global mortality and economic cost.[1] Indeed, physical inactivity, high screen time, insufficient sleep and unhealthy eating habits are well established modifiable risk factors for non-communicable diseases.[2] Significant associations are frequently observed between childhood overweight or obesity and physical inactivity, unhealthy eating habits,[3,4] insufficient physical activity or high sedentary behaviors.[5,6] On the other hand, health-enhancing behaviours including increased level of physical activity, reduced screen time, sufficient sleep and adequate intake of breakfast, fruits and vegetables are recommended as part of adolescents' healthy lifestyle behaviors.[7]

Findings from a recent national survey showed that overweight plus obesity (BMI >25 kg/m^2) prevalence among Saudi youth 15-24 years old is considerably high, reaching 54.1% and 51.6% for young males and females, respectively.[8] Due to the high prevalence of obesity and physical inactivity, Saudi women appear to be at high risk of cardiovascular disease.[9] In addition, a recent local study involving young to middle-age women, has shown that predictors of long-term cardiometabolic risk among Saudi women were significantly different from that of men.[10] The study also found that the best discriminators of long-term cardiometabolic risk among Saudi women were body mass index, waist circumference and lipid accumulation product, whereas the best predictors for men were the visceral adiposity index, conicity index and mid-arm muscular area.[10]

Recent research involving Saudi adolescents indicates that the majority do not meet the recommended guidelines of at least 60 minutes of daily moderate- to vigorous-intensity physical activity.[5,11] Sedentary behaviours

Corresponding Author: Prof Hazzaa M Al-Hazzaa, Lifestyle and Health Research Center, Health Science Research Center, Princess Nourah bint Abdulrahman University, PO Box 93216, Riyadh, 11673, Saudi Arabia.
Tel: 966503200419
Email: halhazzaa@hotmail.com
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among Saudi youth were also shown to be high.[5] In addition, Saudi adolescents tend to have unfavorable dietary habits, such as low intakes of breakfast, fruit and vegetables.[5,12] It was clear from the above mentioned studies that females appeared consistently at more risk of physical inactivity, sedentary behaviours and breakfast skipping than males.[5,11] It is interesting to note that earlier research conducted on Saudi adolescents showed contrasting results relative to gender. Male adolescents in private schools, but not females, had higher odds of being overweight or obese than those in public schools.[3] In addition, Saudi males in public schools were more active than in private schools, whereas the opposite was true for females.[5] Moreover, exercise timing and physical activity patterns seem to be somewhat different relative to gender. Males exercise in public spaces, while females workout mostly at home.[11] Also, the reasons reported for being active appeared to be quite different between male and female adolescents, as most males engage in physical activity for health and recreation whereas females were mostly active for the purpose of weight loss.[11]

Elsewhere, contrasting findings have been reported regarding gender differences in health-compromising behaviours, as one study indicated that Greek males were involved in more health risk behaviours than females.[13] Brazilian adolescents exhibited gender differences in risk behaviours associated with non-communicable diseases, with girls showing higher insufficient physical activity and boys reporting lower intakes of fruit and vegetables.[14] Further, gender differences in several lifestyle behaviours were also noted among Turkish adolescents.[15] Thus, it is unclear how such lifestyle behaviours as physical activity and screen use among adolescents can be influenced by gender status when other lifestyle habits like dietary habits or sleep are taken into consideration. In a secondary analysis to the Arab Teens Lifestyle Study data set from Saudi Arabia, the present article reported on the physical activity levels, screen time, sleep duration and dietary habits among Saudi male and female youth between the ages of 15 and 19 years. The objective of the present study was to examine the interaction effects of gender with obesity status, activity energy expenditure, sleep duration and selected dietary habits among Saudi youth.

METHODS

Study design and participants

This is a cross sectional study involving healthy students who were randomly selected from both public and private secondary schools in three major cities (Riyadh, Jeddah and AL-Khobar) in Saudi Arabia. The study was part of the Arab Teens Lifestyle Study (ATLS). ATLS is a school-based cross-sectional multicenter collaborative study, involving secondary students 15-19 year-olds.[16] The needed sample size was calculated while assuming a population proportion of 0.50 (which yields the maximum possible sample size required) with a 95% confidence level while the degree of accuracy (the amount of allowed error) was set at 0.05. The random selection of the sample was based on a multistage stratified cluster sampling technique. Detailed selection procedures can be found elsewhere.[5] Briefly, a systematic random sampling procedure was used at the first stage to select the schools, as schools were stratified into boys and girls secondary schools, with further stratification into public and private schools. The selection of private to public schools was proportional to students' population size. Eight schools (four from the boys' schools and four from the girls' schools) were randomly selected from each of the four geographical areas in each city (i.e., east, west north and south). At the second stage, classes were selected from each grade (from grades 10, 11 and 12th level) in each school using a simple random sampling design. Thus, we selected at least 24 classes in each city (12 each from the boys and girls schools).

The study protocol and procedures were approved by the Research Center, College of Education, King Saud University and they conformed to the provisions of Declaration of Helsinki. In addition, approvals from schools were obtained as well as consents from students and parents (for minors).

Body weight and height measurements were performed in the morning by a trained researcher. Body weight was measured to the nearest 100 grams with the subject wearing minimal clothing and without shoes using calibrated portable scales (Seca, Germany). Height was measured to the nearest centimeter by a calibrated measuring rod with the subject in a full standing position and not wearing shoes. Body mass index (BMI) was calculated as weight in kilograms over the height squared in meters. The International Obesity Task Force (IOTF) age- and sex-specific BMI cutoff values were used to determine overweight and obesity among adolescents 17 years or younger.[17] For participants aged 18-19 years old, adult cutoff standards for defining overweight (BMI=25-29.9 kg/m^2) and obesity (BMI=30+ kg/m^2) were used. In addition, waist circumference (WC) was measured horizontally at navel level to the nearest 0.1 cm employing a non-stretchable measuring tape. Waist height ratio (WHtR) was then calculated as the ratio between WC in cm and height in cm. A WHtR cut-off score of 0.50 was used to identify abdominal obesity among adolescents irrespective of gender.[18]

Assessments of lifestyle factors

Physical activity

The ATLS questionnaire was used to collect lifestyle variables.[5,16] The questionnaire was previously shown to be a reliable and valid instrument for assessing physical activity and other lifestyle habits in a group of youth from 14-25 years of age.[19,20] Students answered all of the questions at school after a brief introduction and description of the study objectives and contents of the questionnaire by one of the research assistants. The average time for filling the questionnaire ranged from 20 to 25 minutes.

The physical activity section of the questionnaire gathers information on the frequency, duration and intensity of light-, moderate- and vigorous-intensity physical activities during a usual week. The physical activity included in the questionnaire were transport, household, fitness and sports-related activities. Each activity was given metabolic-equivalent (MET) value using the compendium of physical activity,[21] and youth compendium of physical activity.[22] To assess the adolescent's levels of physical activity, we calculated the total activity energy expendi-

ture in METs-minutes per week and the METs-minutes per week spent in each of the moderate- and vigorous-intensity physical activity. Physical activity was also categorized into two levels (active or inactive) based on total activity energy expenditures above or below 1680 METs-minutes per week (this represents 60 min per day multiplied by 7 days per week and then multiplied by 4 METs).

Sedentary behaviours and sleep duration

The questionnaire includes questions designed to asses typical time in hours spent per day on sitting activities, including television (TV) viewing, video games, and recreational use of computer and internet during week days and weekends. The adolescents also recorded their typical sleep duration as average hours slept on weekdays and weekends. For total screen viewing time cut-off values, we used above or below 3 hours per day and for sleep duration we calculated sufficient and insufficient sleep duration as above or below 8 hours per night.[23]

Dietary habits

The questionnaire also included specific questions related to frequency intakes of set of dietary habits during a usual week. Such dietary habits included both healthy and unhealthy foods. More specifically, the participants were asked to report how many times per week they consume breakfast, vegetables (cooked and uncooked), fruits, milk/dairy products, sugar-sweetened drinks (including soft drinks), fast foods, donuts/cakes, and sweets and chocolates. The answers to choose from ranged from zero intake to 7 days per week (every day).

Data and statistical analysis

The data was entered into a coded SPSS data entry sheet, checked, cleaned and analyzed using IBM SPSS software, version 22. Descriptive statistics were calculated and presented as means and standard deviations (SD) or frequencies and proportions. Cross tabulations were performed for abdominal obesity (waist to height ratio), screen time, sleep duration and selected dietary habits stratified by gender and physical activity levels. Two-way analysis of covariance (ANCOVA) tests, while controlling for the effect of age, were used to examine the differences in selected lifestyle variables stratified by gender, school type and obesity status, based on BMI. Further, multivariate analyses of variance tests were used to test differences in activity energy expenditure, dietary habits and sleep duration stratified by gender, waist to height ratio category (above or below 0.50) and sedentary behaviours category (above or below 3 hours of screen time per day), while controlling for age. The level of significance was set at $p<0.05$.

RESULTS

The number of participants included in the present study was 2888 adolescents (1500 females). The means (SD) for age of males and females were 16.7 (1.1) and 16.5 (1.0) years, respectively. Males have significantly ($p\leq0.001$) greater body weight (mean (SD)=70.0 (20.5) kg than females (58.0 (15.5) kg). Body mass index was also significantly ($p\leq0.001$) higher in males than in females (24.6 (6.7) versus 23.6 (6.1)). The proportion of adolescents having waist to height ratio above 0.50 was 33.1%, with significant ($p=0.001$) differences between boys (36.0%) and girls (30.3%). Table 1 presents the results of cross tabulation for cut-off values of abdominal obesity (based on waist to height ratio), screen time, sleep duration and selected dietary habits stratified by gender and physical activity levels. There are significant differences in proportions between active and inactive males, but not in females, relative to abdominal obesity category ($p=0.014$), French fries/potato chips intake ($p=0.003$), cake/donuts intake ($p=0.034$) and sweets/chocolates intake ($p=0.011$). On the other hand, females showed significantly ($p=0.014$) different proportions between active and inactive group relative to the screen time cut-off scores. Both male and female adolescents exhibited significant differences in the proportions of cut-off values for breakfast, fruit, vegetables and dairy intake relative to activity category. However, gender did not show a significant difference in sleep duration relative to activity level.

Results of two-way ANCOVA tests for selected lifestyle variables stratified by gender and school type, while controlling for the effect of age, are shown in Table 2. Total activity energy expenditure, sum of vigorous-intensity activity, sleep duration, French fries/potato chips intake and sweets or chocolates intake all showed significant interactions effects between gender and school type, while fast food intake exhibited a significant main effect of school type. Table 3 presents the results of two-way ANCOVA tests for activity energy expenditure and screen time stratified by gender and obesity status (based on BMI cut-offs), while controlling for the effect of age. Only total activity energy expenditure and sum of vigorous-intensity physical activity showed significant interaction effects between gender and obesity status, whereas sum of moderate-intensity activity indicated significant gender effects.

Table 4 presents results of multivariate analyses of variance tests for activity energy expenditure, dietary habits and sleep duration stratified by gender, waist to height ratio category and screen time category, while controlling for the effect of age. Total activity energy expenditure, sum of vigorous activity energy expenditure and leisure-time physical activity showed significant interactions effects between gender and waist to height ratio, whereas sum of moderate activity energy expenditure, non-leisure-time physical activity and sleep duration exhibited significant interaction effects between gender and screen time. However, vegetable intake showed significant three-way interaction effects between gender, waist to height ratio and screen time. Similarly, Table 5 displays the results of multivariate analyses of variance for dietary habits and sleep duration stratified by gender, activity levels and screen time category, while controlling for the effects of age. Vegetables intake showed significant interaction effects of gender by screen time, whereas sugar-sweetened drink intake exhibited significant multiple interaction effects related to gender by activity, gender by screen time and activity by screen time. Sleep duration showed significant interaction effects for gender by activity levels.

Table 1. Cross tabulation (%) for abdominal obesity (waist to height ratio), screen time, sleep duration and selected dietary habits stratified by gender and physical activity levels (above or below 1680 METs-min/week, for active or inactive, respectively)

Variable	Gender	Cut-off value	Activity level		*p*-value
			Active	Inactive	
Waist to height ratio	Male	<0.50	68.7	60.8	0.014
		0.50+	33.3	39.2	
	Female	<0.50	71.3	69.2	0.267
		0.50+	28.7	30.8	
Screen time (hours/day)	Male	≤3	30.3	30.2	0.506
		>3	69.7	69.8	
	Female	≤3	21.6	17.1	0.042
		>3	78.4	82.9	
Sleep duration (hours/day)	Male	≤8	32.0	30.9	0.357
		8+	68.0	69.1	
	Female	≤8	32.7	29.3	0.135
		8+	67.3	70.7	
Breakfast intake	Male	Daily	31.2	25.3	0.009
		Non-daily	68.8	74.7	
	Female	Daily	26.3	19.1	0.003
		Non-daily	73.7	80.9	
Vegetables intake	Male	Daily	28.5	16.7	<0.001
		Non-daily	71.5	83.3	
	Female	Daily	32.4	19.7	<0.001
		Non-daily	67.6	80.3	
Fruit intake	Male	Daily	19.6	11.8	<0.001
		Non-daily	80.4	88.2	
	Female	Daily	16.2	8.2	<0.001
		Non-daily	83.8	91.8	
Milk/dairy product intake	Male	Daily	39.9	24.8	<0.001
		Non-daily	60.1	75.1	
	Female	Daily	30.0	23.8	0.015
		Non-daily	70.0	76.2	
Sugar-sweetened drink intake (day/week)	Male	<4 days/week	31.8	33.7	0.243
		4+ days/week	68.2	66.3	
	Female	<4 days/week	44.7	42.1	0.218
		4+ days/week	55.3	57.9	
Fast food intake (day/week)	Male	<4 days/week	68.6	71.8	0.108
		4+ days/week	31.4	28.2	
	Female	<4 days/week	76.9	74.8	0.243
		4+ days/week	23.1	25.2	
French fries/potato chips intake (day/week)	Male	<4 days/week	71.3	77.9	0.003
		4+ days/week	28.7	22.1	
	Female	<4 days/week	68.1	69.6	0.335
		4+ days/week	31.9	30.4	
Cake, donut or biscuits intake (day/week)	Male	<4 days/week	73.2	77.6	0.034
		4+ days/week	26.8	22.4	
	Female	<4 days/week	69.5	71.5	0.257
		4+ days/week	30.5	28.5	
Sweets or chocolate intake (day/week)	Male	<4 days/week	59.9	66.0	0.011
		4+ days/week	40.1	34.0	
	Female	<4 days/week	45.2	47.9	0.214
		4+ days/week	54.8	52.1	

DISCUSSION

Previous data investigating the interaction effects of gender with concurrent obesity and selected lifestyle habits are remarkably very limited. In the present research, we studied activity energy expenditure, screen time, sleep duration and selected dietary habits among Saudi male and female youth between the ages of 15 and 19 years, with a focus on the interaction effects of gender with obesity status, activity level, sleep, screen time and selected dietary habits. Using two-way ANCOVA and multivariate analyses of variance tests, while controlling for the effect of age, we have observed several significant interaction effects between gender, activity levels, screen time, obesity status and some selected dietary habits. In general, the examined lifestyle behaviors in the present study displayed a tendency toward significant gender effects with some selected variables having multiple interaction effects.

The present study showed that total activity energy expenditure, sum of vigorous-intensity activity, sleep duration, and some selected unhealthy dietary intakes exhibited significant interaction effects between gender and

Table 2. Two-way ANCOVA tests for selected lifestyle variables stratified by gender and school type, while controlling for the effect of age (data are mean and SD)

Variable	Gender	School type		*p*-value
		Public	Private	
Total activity energy expenditure (METs- min/week)	Male	3099±3035	2889±2563	Gender: 0.097
	Female	1130±1291	1432±1727	School type: 0.944
				Gender x school type: 0.006
Sum of vigorous-intensity activity (METs-min/week)	Male	2197±2443	1997±1997	Gender: 0.091
	Female	497±776	714±1104	School type: 0.972
				Gender x school type: 0.004
Sum of moderate-intensity activity (METs-min/week)	Male	998±1103	1008±1037	Gender: 0.105
	Female	729±825	814±989	School type: 0.471
				Gender x school type: 0.367
Total screen time (hour/day)	Male	5.2±3.2	5.6±3.3	Gender: 0.122
	Female	6.6±3.6	6.6±3.4	School type: 0.587
				Gender x school type: 0.119
Sleep duration (hour/day)	Male	7.1±1.6	7.2±1.5	Gender: 0.854
	Female	7.3±1.7	7.1±1.7	School type: 0.579
				Gender x school type: 0.049
Breakfast intake (day/week)	Male	3.8±2.6	3.5±2.7	Gender: 0.188
	Female	3.3±2.6	3.3±2.6	School type: 0.455
				Gender x school type: 0.253
Vegetables intake (day/week)	Male	3.6±2.4	3.8±2.5	Gender: 0.297
	Female	3.6±2.4	3.7±2.4	School type: 0.260
				Gender x school type: 0.537
Fruit intake (day/week)	Male	3.2±2.2	3.3±2.4	Gender: 0.053
	Female	2.5±2.1	2.7±2.2	School type: 0.295
				Gender x school type: 0.485
Milk/dairy products intake (day/week)	Male	4.3±2.5	4.3±2.4	Gender: 0.078
	Female	3.6±2.6	3.8±2.5	School type: 0.448
				Gender x school type: 0.439
Sugar-sweetened drink intake (day/week)	Male	4.8±2.5	4.7±2.3	Gender: 0.128
	Female	4.3±2.3	4.0±2.3	School type: 0.322
				Gender x school type: 0.272
Fast food intake (day/week)	Male	2.8±2.0	3.0±1.9	Gender: <0.001
	Female	2.6±1.8	2.7±1.8	School type: <0.001
				Gender x school type: 0.966
French fries/potato chips intake (day/week)	Male	2.4±2.1	2.8±2.1	Gender: 0.461
	Female	2.9±2.0	2.8±2.0	School type: 0.633
				Gender x school type: 0.007
Cake, donut or biscuits intake (day/week)	Male	2.5±2.1	2.5±2.0	Gender: 0.136
	Female	2.8±2.1	2.7±2.0	School type: 0.838
				Gender x school type: 0.484
Sweets or chocolates intake (day/week)	Male	2.9±2.3	3.3±2.3	Gender: 0.277
	Female	4.0±2.3	3.7±2.3	School type: 0.955
				Gender x school type: <0.001

Table 3. Two-way ANCOVA tests for activity energy expenditure and screen time stratified by gender and obesity status (based on BMI), while controlling for the effect of age (data are mean and SD)

Variable	Gender	Obesity status		*p*-value
		Non-overweight/ non-obese	Overweight/ Obese	
Total activity energy expenditure (METs- min/week)	Male	3242±3082	2792±2683	Gender: 0.089
	Female	1198±1420	1250±1456	Obesity level: 0.575
				Gender x obesity level: 0.003
Sum of vigorous-intensity activity (METs-min/week)	Male	2371±2493	1853±2.86	Gender: 0.100
	Female	567±917	542±823	Obesity level: 0.472
				Gender x obesity level: <0.001
Sum of moderate-intensity activity (METs-min/week)	Male	975±1.69	1037±1111	Gender: 0.015
	Female	725±835	808±944	Obesity level: 0.093
				Gender x obesity level: 0.787
Total screen time (hour/day)	Male	5.25±3.2	5.41±3.3	Gender: 0.051
	Female	6.6±3.5	6.55±3.6	Obesity level: 0.692
				Gender x obesity level: 0.427

Table 4. Multivariate analyses of activity energy expenditure, dietary habits and sleep duration stratified by gender, waist to height ratio category (above or below 0.50) and sedentary behaviours category (above or below 3 hours of screen time per day), while controlling for age

Variable	Screen time	Male		Female		*p*-value for between subjects effects
		Waist/height ratio		Waist/height ratio		
		<0.50	0.50+	<0.50	0.50+	
Total activity energy expenditure (METs-min/week)	Low	3629 ±3189	2600 ±2725	1617 ±1802	1641 ±1893	Gender: <0.001 WHR: 0.02 Screen time: 0.291 Gender x WHR: 0.04 Gender x screen time: 0.082 WHR x screen time: 0.324 Gender x WHR x screen time: 0.124
	High	3403 ±2997	2998 ±2691	1349 ±1444	1271 ±1238	
Sum of METs-min/week vigorous activity	Low	2664 ±2626	1712 ±2151	773 ±1163	685 ±1127	Gender: >0.001 WHR: <0.001 Screen time: 0.346 Gender x WHIR: 0.001 Gender x screen time: 0.381 WHR x screen time: 0.186 Gender x WHR x screen time: 0.129
	High	2393 ±2404	1980 ±2091	623 ±962	521 ±674	
Sum of METs-min/week moderate activity	Low	965 ±1068	887 ±1072	844 ±925	956 ±1004	Gender: 0.002 WHR: 0.714 Screen time: 0.434 Gender x WHR: 0.304 Gender x screen time: 0.012 WHR x screen time: 0.939 Gender x WHR x screen time: 0.384
	High	1009 ±1078	1017 ±1092	726 ±838	750 ±855	
Leisure-time physical activity (min/week)	Low	427 ±413	293 ±352	129 ±213	134 ±215	Gender: <0.001 WHR: 0.005 Screen time: 0.905 Gender x WHR: 0.010 Gender x screen time: 0.124 WHR x screen time: 0.222 Gender x WHR x screen time: 0.056
	High	403 ±391	370 ±373	117 ±182	105 ±163	
Non-leisure-time physical activity (min/week)	Low	162 ±172	150 ±154	201 ±235	214 ±203	Gender: 0.001 WHR: 0.700 Screen time: 0.003 Gender x WHR: 0.215 Gender x screen time: 0.034 WHR x screen time: 0.694 Gender x WHR x screen time: 0.956
	High	157 ±171	139 ±151	158 ±201	162 ±177	
Breakfast intake (day/week)	Low	3.86 ±2.7	3.19 ±2.6	3.63 ±2.6	2.98 ±2.6	Gender: 0.001 WHR: <0.001 Screen time: 0.642 Gender x WHR: 0.534 Gender x screen time: 0.137 WHR x screen time: 0.731 Gender x WHR x screen time: 0.494
	High	3.97 ±2.7	3.61 ±2.7	3.53 ±2.6	2.83 ±2.5	
Vegetables intake (day/week)	Low	3.77 ±2.4	3.32 ±2.2	3.99 ±2.5	4.22 ±2.4	Gender: 0.294 WHR: 0.272 Screen time: 0.520 Gender x WHR: <0.501 Gender x screen time: 0.501 WHR x screen time: 0.708 Gender x WHR x screen time: 0.033
	High	3.88 ±2.4	3.88 ±2.4	3.80 ±2.3	3.46 ±2.3	
Fruit intake (day/week)	Low	3.48 ±2.3	3.01 ±2.2	3.78 ±2.2	3.69 ±2.0	Gender: <0.001 WHR: 0.360 Screen time: 0.763 Gender x WHR: <0.588 Gender x screen time: 0.232 WHR x screen time: 0.161 Gender x WHR x screen time: 0.251
	High	3.29 ±2.2	3.42 ±2.3	3.58 ±2.1	3.58 ±2.1	

Data are mean and SD. *p*-values for multivariate tests: age: <0.001; gender: <0.001; waist to height ratio (WHtR): <0.001; screen time: <0.001; Gender x waist/height ratio: 0.123; Gender x screen time: 0.004; waist/height ratio x screen time: 0.858; Gender x waist/height ratio x screen time: 0.388.

Table 4. Multivariate analyses of activity energy expenditure, dietary habits and sleep duration stratified by gender, waist to height ratio category (above or below 0.50) and sedentary behaviours category (above or below 3 hours of screen time per day), while controlling for age (cont.)

Variable	Screen time	Male		Female		*p*-value for between subjects effects
		Waist/height ratio		Waist/height ratio		
		<0.50	0.50+	<0.50	0.50+	
Milk/dairy products intake (day/week)	Low	4.49±2.4	3.80±2.5	3.81±2.5	3.71±2.6	Gender: <0.001 WHR: 0.010 Screen time: 0.655 Gender x WHR: 0.209 Gender x screen time: 0.157 WHR x screen time: 0.639 Gender x WHR x screen time: 0.263
	High	4.52±2.4	4.24±2.4	3.76±2.5	3.52±2.5	
Sugar-sweetened drink intake (day/week)	Low	4.29±2.5	4.12±2.4	3.67±2.4	3.66±2.3	Gender: : <0.001 WHR: 0.105 Screen time: <0.001 Gender x WHR: 0.788 Gender x screen time: 0.448 WHR x screen time: 0.488 Gender x WHR x screen time: 0.654
	High	5.10±2.2	4.85±2.3	4.41±2.3	4.11±2.3	
Fast food intake (day/week)	Low	2.58±1.9	2.33±1.7	1.83±1.4	1.76±1.6	Gender: <0.001 WHR: 0.123 Screen time: <0.001 Gender x WHR: 0.608 Gender x screen time: 0.111 WHR x screen time: 0.808 Gender x WHR x screen time: 0.619
	High	3.19±2.0	3.06±2.0	2.83±1.8	2.70±1.9	
French fries/potato chips intake (day/week)	Low	2.14±2.0	2.23±1.9	2.36±1.9	2.04±1.7	Gender: 0.175 WHR: 0.120 Screen time: <0.001 Gender x WHR: 0.115 Gender x screen time: 0.277 WHR x screen time: 0.784 Gender x WHR x screen time: 0.630
	High	2.70±2.1	2.62±2.1	3.05±2.0	2.75±2.0	
Cake, donut or biscuits intake (day/week)	Low	2.18±1.9	2.08±1.8	2.36±1.9	2.31±1.9	Gender: 0.055 WHR: 0.080 Screen time: <0.001 Gender x WHR: 0.723 Gender x screen time: 0.804 WHR x screen time: 0.367 Gender x WHR x screen time: 0.525
	High	2.70±2.1	2.52±2.1	2.96±2.1	2.58±1.9	
Sweets or chocolates intake (day/week)	Low	2.73±2.3	2.27±2.0	3.35±2.2	3.04±2.2	Gender: <0.001 WHR: <0.001 Screen time: <0.001 Gender x WHR: 0.422 Gender x screen time: 0.859 WHR x screen time: 0.595 Gender x WHR x screen time: 0.139
	High	3.35±2.3	3.10±2.3	4.35±2.3	3.59±2.1	
Sleep duration (hour/day)	Low	6.95±1.6	6.98±1.5	6.68±1.9	6.57±1.8	Gender: 0.136 WHR: 0.198 Screen time: <0.001 Gender x WHR: 0.258 Gender x screen time: 0.004 WHR x screen time: 0.345 Gender x WHR x screen time: 0.823
	High	7.18±1.5	7.11±1.5	7.42±1.5	7.13±1.8	

Data are mean and SD. *p*-values for multivariate tests: age: <0.001; gender: <0.001; waist to height ratio (WHtR): <0.001; screen time: <0.001; Gender x waist/height ratio: 0.123; Gender x screen time: 0.004; waist/height ratio x screen time: 0.858; Gender x waist/height ratio x screen time: 0.388.

school type. This may be explained by the fact that private but not public schools offer leisure-time physical activity, which will naturally include some vigorous-intensity activities. Furthermore, private schools in Saudi Arabia are more likely to allow the sale of French fries/potato chips and candy/chocolates than do public schools, due to more regulated canteen sales in public schools. The total activity energy expenditure and sum of vigorous-intensity physical activity in the current research also exhibited significant interaction effects between gender and obesity status. Active males but not females showed reduced waist to height ratio compared with less active males. These findings may indicate the generally reduced physical activity levels among Saudi females. With high levels of physical inactivity among female adolescents, there is less heterogeneity in activity energy

Table 5. Multivariate analyses of dietary habits and sleep duration stratified by gender, activity levels (above or below activity energy expenditure of 1680 METs-min/week) and screen time (above or below 3 hours of screen time per day), while controlling for age

Variable	Screen time	Male		Female		*p*-value for between subjects effects
		Active	Inactive	Active	Inactive	
Breakfast intake (day/week)	Low	3.74±2.7	3.38±2.7	3.65±2.6	3.24±2.6	Gender: 0.045 Activity: 0.005
	High	3.98±2.7	3.56±2.6	3.61±2.7	3.24±2.6	Screen time: 0.488 Gender x activity: 0.929 Gender x screen time: 0.356 Activity x screen time: 0.971 Gender x activity x screen time: 0.887
Vegetables intake (day/week)	Low	4.00±2.3	2.92±2.2	4.3±2.4	4.01±2.5	Gender: 0.0002 Activity: <0.001
	High	4.11±2.4	3.44±2.3	4.2±2.4	3.42±2.3	Screen time: 0.901 Gender x activity: 0.210 Gender x screen time: 0.004 Activity x screen time: 0.821 Gender x activity x screen time: 0.065
Fruit intake (day/week)	Low	3.66±2.3	2.61±2.1	3.45±2.3	2.47±2.1	Gender: <0.001 Activity: <0.001
	High	3.64±2.3	2.88±2.2	3.21±2.2	2.32±2.0	Screen time: 0.910 Gender x activity: 0.971 Gender x screen time: 0.198 Activity x screen time: 0.512 Gender x activity x screen time: 0.482
Milk/dairy products intake (day/week)	Low	4.76±2.4 ±2.4	3.30±2.4 ±2.4	4.33±2.6 ±2.6	3.56±2.5 ±2.5	Gender: 0.005 Activity: <0.001
	High	4.68±2.3 ±2.3	4.06±2.4 ±2.4	4.03±2.5 ±2.5	3.57±2.5 ±2.5	Screen time: <0.001 Gender x activity: 0.823 Gender x screen time: 0.469 Activity x screen time: 0.661 Gender x activity x screen time: 0.074
Sugar-sweetened drink intake (day/week)	Low	4.09±2.6	4.30±2.5	3.78±2.4	3.63±2.3	Gender: <0.001 Activity: 0.769
	High	5.14±2.2	4.84±2.2	4.25±2.4	4.41±2.3	Screen time: 0.001 Gender x activity: <0.001 Gender x screen time: 0.011 Activity x screen time: 0.004 Gender x activity x screen time: 0.087
Fast food intake (day/week)	Low	2.63±1.9	2.27±1.8	2.17±1.6	1.67±1.4	Gender: < 0.001 Activity: 0.003
	High	3.25±2.0	2.94±1.9	2.74±1.8	2.83±1.9	Screen time: < 0.001 Gender x activity: 0.450 Gender x screen time: 0.237 Activity x screen time: 0.092 Gender x activity x screen time: 0.138
French fries/ potato chips intake (day/week)	Low	2.45±2.1	1.98±1.7	2.48±2.0	2.14±1.7	Gender: 0.003 Activity: 0.001
	High	2.91±2.2	2.35	3.08±2.1	2.94±2.0	Screen time: <0.001 Gender x activity: 0.378 Gender x screen time: 0.353 Activity x screen time: 0.825 Gender x activity x screen time: 0.202
Cake, donut or biscuits intake (day/week)	Low	2.19±1.8	1.91±1.7	2.58±2.1	2.23±1.8	Gender: 0.003 Activity: 0.027
	High	2.72±2.1	2.52±2.1	2.89±2.1	2.82±2.1	Screen time: <0.001 Gender x activity: 0.857 Gender x screen time: 0.565 Activity x screen time: 0386 Gender x activity x screen time: 0.603

Data are mean and SD. *p*-values for multivariate tests: age: <0.001; gender: <0.001; activity: <0.001; screen time: <0.001; gender x activity: 0.755; gender x screen time: 0.032; activity x screen time: 0.087; gender x activity x screen time: 0.294.

expenditure and consequently less likelihood of associations with other variables. In addition, the current study finding showed that several parameters of activity energy expenditure, including vigorous physical activity, display significant interaction effects between gender and waist to height ratio, whereas the sum of moderate activity energy

Table 5. Multivariate analyses of dietary habits and sleep duration stratified by gender, activity levels (above or below activity energy expenditure of 1680 METs-min/week) and screen time (above or below 3 hours of screen time per day), while controlling for age (cont.)

Variable	Screen time	Male		Female		*p*-value for between subjects effects
		Active	Inactive	Active	Inactive	
Sweets or chocolates intake (day/week)	Low	2.86±2.3	2.11±1.9	3.50±2.3	3.15±2.2	Gender: <0.001 Activity: 0.003
	High	3.37±2.3	3.16±2.3	4.18±2.3	4.12±2.3	Screen time: 0.001 Gender x activity: 0.257 Gender x screen time: 0.848 Activity x screen time: 0.068 Gender x activity x screen time: 0.557
Sleep duration (hour/day)	Low	6.88±1.6	7.00±1.7	6.65±1.8	6.63±1.9	Gender: 0.116 Activity: 0.112
	High	7.14±1.5	7.23±1.5	7.12±1.8	7.42±1.6	Screen time: <0.001 Gender x activity: <0.001 Gender x screen time: 0.875 Activity x screen time: 0.375 Gender x activity x screen time: 0.290

Data are mean and SD. *p*-values for multivariate tests: age: <0.001; gender: <0.001; activity: <0.001; screen time: <0.001; gender x activity: 0.755; gender x screen time: 0.032; activity x screen time: 0.087; gender x activity x screen time: 0.294.

expenditure, exhibited significant interaction effects between gender and screen time. This is noteworthy as recent findings involving 1 million men and women indicated that there was a reduced risk of mortality during follow-up in those participants who sat for more than 8 hours per day but exhibited high levels of activity energy expenditure per week, however, this protection was removed with just moderate level of physical activity.[24]

The current findings also indicated that vegetable intake exhibited significant multiple interaction effects between gender, waist to height ratio, physical activity and screen time. Vegetable consumption also showed significant interaction effects related to gender by screen time, whereas sugar-sweetened drink intake significantly exhibited multiple interaction effects associated with gender by activity, gender by screen time and activity by screen time. Our findings may be partly explained by the fact that some young Saudi females are reported to be quite concerned about their body weight and shape.[25] Indeed, previous research have shown that dietary habits and physical activity to be strongly influenced by gender attitudes and behaviors.[26] Gender differences in dietary intakes and eating behaviours have been previously reported in Chinese students.[27] Further, a study conducted on 1,500 Indian adolescents indicated that female adolescents in rural schools had the least positive dietary habits and a limited engagement in sport activities.[28] Contrasting findings among male and female American students have been reported, as statistically significant gender by physical activity or fruit intake effects were observed during the transition out of high school; physical activity reduction for males at the transition point, while a decrease was found in fruit intake for males and females during the same transitional period.[29]

Similar to our findings, Brazilian adolescents exhibited gender differences in risk behaviours associated with noncommunicable diseases, as girls showed higher insufficient physical activity and boys presented with lower intakes of fruit and vegetables.[14] Likewise, most Kuwaiti adolescents, especially girls, do not engage in sufficient physical activity, spend more time on screen related activities and have unhealthy dietary habits.[30] Further, previous research on Portuguese youth have shown that girls, especially during late childhood and adolescence, have lower total activity level compared with boys.[31] Turkish high school females were found to be less active, consumed breakfast less frequently and chocolate more often than males, however they reported less total screen time, lower carbonated beverage intake and higher consumption of fruits and vegetables.[15] While, some previous research observed greater physical activity among young males compared to females,[32-34] boys from the United States more likely than girls to meet physical activity guidelines.[7] Other studies showed there were insignificant lifestyle differences between the adolescent males and females.[35,36]

Ethnic and cultural factors may have contributed to the gender differences observed in physical activity and sedentary behaviors.[37] In general, the reported physical activity level for the majority of Arab females has usually been shown to be much lower than those of males.[38,39] Possible reasons that may lead Saudi female adolescents to be less active than males may be that females have typically limited opportunities to participate in physical activity compared with males, both inside and outside school. In addition, many families may not openly encourage females to take part in outdoor sports and physical activity for cultural reasons. The unfavourable lifestyle-related factors that were observed among Saudi female adolescents in the present study highlight the need for gender and culturally tailored specific interventions to improve their health behaviours. A recent positive step in addressing this problem has been the development of school physical education programs for girls beginning in 2017. Schools may be an ideal target for offering healthy lifestyle education and physical activity promotional programs for young Saudi females as recent research has provided evidence for the effectiveness of school-based health promotion programs for improving certain health outcomes.[40]

Gender differences in participation in overall and strenuous physical activity appear to be largely related to club membership enrollment and withdrawal from organized sport programs.[41] Other studies have found encouragement and support, or sport and exercise related beliefs to be significant factors[41] for participation. Factors that were drawn from experiences with organized sports and sports clubs elsewhere, however, cannot be applied to female's sports participation in Saudi Arabia as there are currently few publicly available health clubs or fitness centers that meet the needs of the average Saudi girls. Private female fitness centers, though growing in number, are fairly limited and have very expensive membership fees beyond the income of the average family. The Saudi Sport Authority, however, is now working diligently to expand the opportunities for girls to take part in sports by organizing many sporting activities that are culturally appropriate for young Saudi females.

Strength and limitations

The strengths of the present study include the use of a large and representative sample of Saudi adolescents from three major cities in the country. The questionnaire that was used in the study is a validated and comprehensive physical activity questionnaire utilizing all domains of physical activity. Among the limitations of the current study is the cross-sectional design, which precludes us from implying causal relationship between the selected variables. Also, physical activity and sedentary behaviours were assessed with questionnaires, which have lower validity and reliability than objective measures. However, the ATLS questionnaire has been validated and well tested in previous research,[5,20] and is now widely used in several studies involving Arab youth populations.[37,42-46] Another limitation is that, data was not collected regarding the socio-environmental influences on girls' youth behaviour, which may have provided additional explanation of the relationships of gender with lifestyle factors. Finally, sleep morningness versus eveningness among the adolescent participants may have influenced lifestyle factors, as findings from a study involving Japanese junior high school children showed that those with morning preference compared with evening type were associated with higher sleep drive and better sleep-wake parameters and lifestyle habits.[47]

Conclusion

The findings from the present study, which was conducted on a large and representative sample of Saudi youth, confirmed the presence of several unhealthy lifestyle behaviour risks, including physical inactivity, sedentary behaviour and several dietary habits. A high prevalence of inactivity and screen time represents a double burden on the future health of young Saudi females. In addition, the study found a number of significant interaction effects between gender and each of activity levels, screen time, dietary habits and obesity status. In general, the examined lifestyle behaviours in the present study displayed tendencies toward significant gender effects with some selected variables having shown multiple interaction effects. The promotion of healthy lifestyles including increasing physical activity, reducing screen time and improving dietary habits should be a national public health priority. Future studies need to address the psycho-social, cultural and environmental determinants associated with healthy lifestyle habits among youth in Saudi Arabia with further interventional research aiming to evaluate novel programs to prevent and reduce sedentary lifestyle habits and improve the future health of Saudi youth.

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AUTHOR DISCLOSURES

The authors declare that they have no competing interests.

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