The Role of Lifestyle Behaviors in Early Childhood Obesity: Insights from Pre-School Populations

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Abstract: *Aim*: Childhood obesity is an escalating global health concern. Identifying modifiable risk factors is crucial to inform effective prevention strategies. This study explored lifestyle behaviors, including chrono-nutrition and sedentary behaviors, associated with overweight/obesity among Saudi pre-school children.

Methods: This cross-sectional study of 450 children aged 3-6 years from 20 pre-schools assessed chrono-nutrition, sedentary, and sleep behaviors through questionnaires filled by parents/guardians. Height, weight, and skinfold thickness were measured. BMI was calculated using International Obesity Task Force classifications for children aged 2-18.

Results: Overweight/obesity prevalence in preschoolers was 22.67%. Weight, skinfold, and body fat percentage were significantly higher among the overweight/obese group ($p<0.001$). A significant association ($p=0.009$) was observed between sleeping time and BMI. However, insignificant associations were observed between BMI and chrono-nutrition or physical activity. Logistic regression analysis revealed that evening (OR=0.142, 95%CI: 0.024-0.834, $p=0.031$) and irregular screen time (OR=0.162, 95%CI: 0.036-0.730, $p=0.018$) as well as more than two hours of napping (OR=0.268, 95%CI: 0.073-0.987, $p=0.048$) were associated with lower odds of overweight or obesity status.

Conclusions: Selected lifestyle behaviors exhibited significant associations with lower overweight/obesity among preschoolers. Future studies on pre-school children's lifestyle behaviors are warranted to enhance preventive health education and health promotion among young children.

Keywords: Obesity, overweight, pre-school, lifestyle, chrono-nutrition.

1. INTRODUCTION

Childhood obesity has emerged as a public health issue in both developed and developing countries [1]. In 2022, around 37 million children under 5 years of age will be overweight [2], and in 2025, the number of overweight or obese infants and young children globally is expected to reach 70 million [3]. This statistic is alarming and underscores the need for targeted interventions to address obesity in this age group.

Obesity in children can lead to adverse health consequences, including hypertension, diabetes, heart disease, musculoskeletal disorders, and even certain types of cancer [4]. In addition, it exposes them to psychological and social problems, including depression, low self-confidence, suicidal thoughts, bullying, and negative consequences on cognitive development that may reduce their quality of life [5]. Further, childhood obesity often persists into adulthood [6]. Therefore, the pre-school years are crucial for obesity prevention, as this stage lays the foundation for lifestyle and general health. Research on the etiology of obesity is still very active, as multiple factors such as genetics, environment, lifestyle, and physiological factors that often interact with each other contribute to obesity [7].

As Saudi Arabia's economy has flourished over the past decades, lifestyles have changed dramatically, and urbanization has accelerated. The lifestyle changes [8] could explain the recent increase in obesity prevalence in Saudi Arabia. This modern lifestyle alters the regularity and time of food intake in ways that can disrupt the body's natural circadian rhythm. Chrono-nutrition is an emerging field that concerns the relationship between the body’s circadian rhythms and dietary intake [9].

It is well-recognized that high physical activity in early childhood is related to improved health status

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[10]. Modern lifestyle is also characterized by sedentary behaviors. Various studies have shown a rising trend in body mass index (BMI) and a high prevalence of sedentary behaviors among school children and adolescents [11,12]. Furthermore, sleep deprivation among children affects their behavior, learning, and school performance, as well as their mood and emotions [13]. Over 71% of Saudi school children did not attain the recommended sufficient sleep duration at night, and insufficient sleep was associated with infrequent breakfast and several important socio-demographic and lifestyle behaviors [14].

It is important to identify the lifestyle behaviors associated with childhood overweight and obesity in Saudi Arabia to design and implement an intervention that aims to reduce the burden of excess body weight in early childhood. In the present study, we examined the association of chrono-nutrition, sedentary, and sleep behaviors with overweight/obesity among randomly selected Saudi preschool children.

2. MATERIALS AND METHODS

2.1. Design and Population

This descriptive cross-sectional study was conducted among pre-school children aged 3 to 6 years in Riyadh City, Saudi Arabia. A representative random sample was selected from pre-schools using a multistage stratified cluster random sampling technique. A total of 20 public and private schools were randomly selected from four geographical areas (east, west, north, and south) within the city of Riyadh. Three private and three public schools from each of the east and west areas and two private and two public schools from each of the north and south regions were selected. Sixty classes were randomly chosen from different sections of KG1-KG2-KG3. A consent form and a survey questionnaire were sent to the parents/guardians of the children. All Saudi children, boys and girls aged 3-6 years old, were eligible for inclusion in the study, except if they had a chronic medical condition.

2.2. Sample Size Estimation

The estimated total sample size was determined to be 420 students. It was calculated while assuming a population proportion that yields the maximum possible sample size required (P = 0.50), with a confidence level of 95% and a margin of error of 5%. Figure **1** presents the steps involved in sampling participants.

2.3. Study Questionnaire

Data were collected through a questionnaire designed by the research team members. A pilot study (result not reported in the study) was conducted to confirm the questionnaire's reliability and validity and evaluate the participants' understanding of the questions. To ensure the content validity of the questionnaire, a panel of experts in the field was asked to give their views as regards the clarity of questionnaire phrases. The final questionnaire was approved after reviewing the phrases and conducting adequate modifications. The questionnaire was delivered and collected through collaboration with the school teachers. The questionnaire consisted of sections addressing demographic characteristics, chrono-nutrition, sedentary behavior, and sleep patterns.

2.3.1. Demographic Characteristics

This section consisted of demographics-related questions, including the child's age and sex, parents' age and education level, whether parents are overweight or obese, and family income.

2.3.2. Chrono-Nutrition

Eating habits and food choices were assessed using a specifically designed self-reported questionnaire filled out by the children's parents/ guardians. The questionnaire asked parents/guardians to answer based on the child's habitual dietary habits. It consisted of questions about the number of meals the child usually has throughout the day, the frequency and time of the meals, and the snacking and fast-food habits.

2.3.3. Sedentary Behavior

Time spent on activities that require moving and screen time were considered as indicators of being physically active or inactive. Screen time was recorded as the time spent watching television (TV), videos, using a phone, and playing electronic games.

2.3.4. Sleep Behavior

Night-time sleep duration, an indicator of sleep habit, was assessed by recording bedtime, the duration (hours) of sleep, and the duration of nap. According to the National Sleep Foundation Guidelines for children 3 to 5 years old, insufficient sleep (short sleep) is sleeping less than 9 hours per night [15].

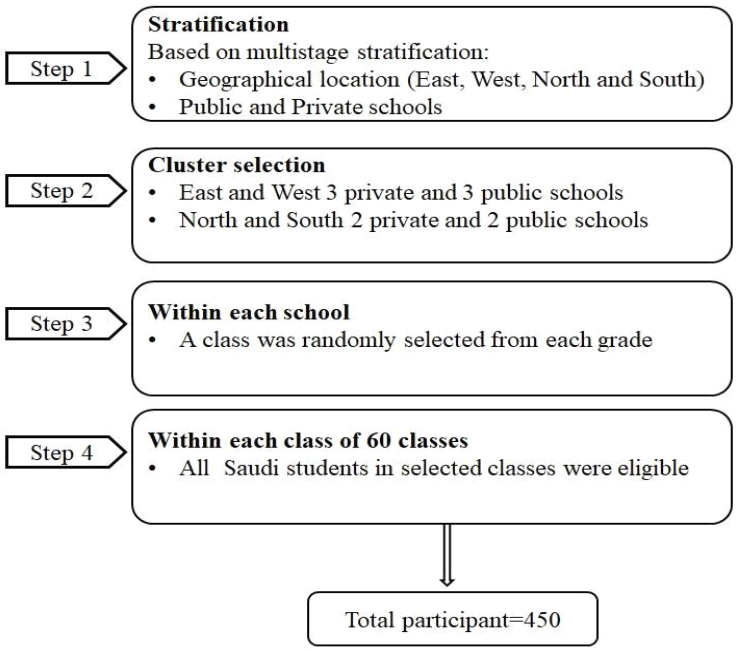

Figure 1: Steps involved in sampling of participants.

2.3.5. Anthropometric Measurement

A trained investigator took anthropometric measurements while participants wore light clothing without shoes. Bodyweight was measured to the nearest 100 g using portable scales (Innotech-Australia). A stadiometer measured the student's height in centimeters (cm). Skinfold thickness was assessed using a skinfold caliper (Lange, USA) on the right side of the body (triceps and sub scapular folds). Body fat percent was then calculated using a prediction equation specific for children [16]. BMI was calculated using weight in kg over squared height, and the classification of overweight and obesity was based on "The International Obesity Task Force" for children aged 2 to 18 years [17].

2.4. Statistical Analysis

Data were checked and analyzed using the IBM-SPSS program, version 24 (Chicago, IL, USA). Descriptive statistics were obtained for all variables and reported as means and standard deviations (SD) or frequency and percentage (%). Differences in anthropometric measures were tested between girls and boys using independent t-tests. Non-parametric data were tested using a chi-square test to identify the differences between boys and girls. Chrono-nutrition, sedentary behavior, and sleep behavior of participants relative to BMI were tested using a chi-square test. Logistic regression analysis, adjusted for age and sex, was used to test the association of selected chrono-nutrition, sleep, and screen variables with overweight/obese vs non-overweight/non-obese among the preschoolers. The level of significance was set at $\leq$0.05 levels.

3. RESULTS

3.1. Characteristics of the Participants

Table **1** shows the anthropometric and demographic characteristics of the participating children based on sex and BMI. A total number of 450 children (241 girls and 209 boys) participated in the study, and their ages ranged between 3 and 6 years, with a mean age of 4.70 years. There were no significant differences between boys and girls in body weight and subscapular skinfold. On the other hand, the triceps skinfold and body fat percentage were significantly higher in girls than boys (p=0.020 and p=0.001, respectively). The height of the boys, however, was significantly higher than that of the girls (p=0.008). Based on BMI, there were no significant differences between the two groups in age and height, but body weight (p<0.001), triceps skinfold (P<0.001), subscapular skinfold (p<0.001), and body fat% (P<0.001) were significantly higher in overweight/obese as compared with their non-overweight/non-obese participants.

Regarding demographics, most parents (mothers and fathers) aged 30 to 39 years. Also, most parents have a bachelor's degree. About 63% of the parents reported that they were neither overweight nor obese,

Table 1: Anthropometric and Demographic Characteristics of the Participating Children Based on Sex and BMI (N=450)

Variables	Total (N=450)	Sex		*p*-value	BMI		*p*-value
		Girls (n=241; 53.6%)	Boys (n=209; 46.4%)		Non-overweight /non-obese (n=348, 77.33%)	Overweight/obese (n=102, 22.67%)	
Age (years)	4.70±0.81	4.71±0.80	4.70±0.83	0.936	4.72±0.80	4.65±0.85	0.49
Body weight (kg)	18.57±3.55	18.37±3.13	18.79±3.91	0.208	17.44±2.09	22.44±4.61	< 0.001
Height (cm)	105.94±6.05	105.42±6.03	106.54±6.02	0.008	105.81±5.79	106.39±6.88	0.39
Triceps skinfold (mm)	9.57±3.06	9.88±2.91	9.21±3.19	0.020	8.66±2.16	12.67±3.60	< 0.001
Subscapular skinfold mm)	5.96±2.82	6.16±2.64	5.72±3.00	0.106	5.08±1.36	8.95±4.16	< 0.001
Body fat%	17.41±5.52	18.19±5.49	16.50±5.41	0.001	15.86±4.29	22.67±5.96	< 0.001
Mother's age (years)							
<30	110(24.4)	56(50.9)	54(49.1)	0.696	84 (76.4)	26 (23.6)	0.93
30-39	268(59.5)	148(55.2)	120(44.8)		205(76.5)	63(23.5)	
40-49	72(16.0)	37(51.4)	35(48.6)		55(76.4)	17(23.6)	
Father's age(years)							
<30	16(3.5)	11(68.8)	5(31.2)	0.389	11(68.8)	5(31.3)	0.41
30-39	235(52.2)	130(55.3)	105(44.7)		178(75.7)	57(24.3)	
40-49	166(36.8)	85(51.2)	81(48.8)		126(75.9)	40(24.1)	
≥ 50	33(7.3)	15(45.5)	18(54.5)		29(87.9)	4(12.1)	
Mother's education level							
Less than high school	38(8.4)	19(50.0)	19(50.0)	0.861	30(85.7)	5(14.3)	0.35
High school	98(21.7)	51(52.0)	47(48.0)		71(72.4)	27(27.6)	
Bachelor's degree	275(61.1)	148(53.8)	127(46.2)		215(77.3)	63 (22.7)	
Postgraduate	39(8.6)	23(59.0)	16(41.0)		32(82.1)	7(17.9)	
Father's education level							
Less than high school	28 (6.2)	10 (35.7)	18 (64.3)	0.220	24(85.7)	4(14.3)	0.63
High school	107 (23.8)	61 (75.0)	46(43.0)		84(78.5)	23(21.5)	
Bachelor's degree	254 (56.4)	139(54.7)	115(45.3)		195(76.8)	59(23.2)	
Postgraduate	61(13.6)	31(50.8)	30(49.2)		45(73.8)	16(26.2)	
Are any of the parents overweight / obese?							
Non	283(62.9)	144(50.9)	139(49.1)	0.423	220(77.7)	63(22.3)	0.664
Mother	60(13.3)	33(55.0)	27(45.0)		49(81.7)	11(18.3)	
Father	53(11.8)	33(62.3)	20(37.7)		40(75.5)	30(24.5)	
Both mother and father	54(12)	31(57.4)	23(42.6)		39(72.2)	15(27.8)	
Family's monthly income (SAR)							
Less than 10000 (LIG)	163(38.7)	86(52.8)	77(47.2)	0.70	122(74.8)	41(25.2)	0.69
10000 – 20000 (MIG)	176(41.8)	99(56.3)	77(43.7)		137(77.8)	39(22.2)	
More than 20000 (HIG)	82(19.5)	42(51.2)	40(48.8)		65(79.3)	17(20.7)	

Data are presented as mean ± Standard Deviation (SD) for continuous variables and frequency and percentage (%) for categorical variables; * p-value significant <0.05; p-value tested by Chi-square test or an exact probability test (for small frequencies) for categorical data and unpaired t-test for continuous data; BMI: Body mass index; SAR: Saudi Riyal; LIG: lower income group; MIG: middle-income group; HIG: higher income group.

while 13.3% of mothers, 11.8% of fathers, and 12% of both parents reported being overweight/obese. Furthermore, approximately 42% of the families fell into the category of middle-income group (MIG) with monthly earnings ranging from 10,000 to 20,000 SR, while 38.7% had an income below 10,000 SR, indicating a low-income group (LIG) status. Family's monthly income for most participants in non-overweight/non-obese falls in the range of 10,000-20,000 SR (MIG), while over-weight/obese groups had family income less than 10,000 SR (LIG). No significant associations ($p \geq 0.05$) have been observed in descriptive characteristics, BMI, or sex of the participants relative to parents' age, education level, number of siblings in the family, or the family's monthly income.

3.2. Chrono-nutrition

As shown in Table **2**, there were no significant ($p=0.889$) differences in the number of meals consumed between the two groups. Almost half (50.9%) of the participants reported that they regularly consume breakfast before going to school, and more than 40% of participants eat their lunch and dinner regularly, with an insignificant ($p \geq 0.05$) difference between the two groups. Similarly, most (72.7%) of participants reported consuming their lunch before 3 pm and dinner (56.6%) between 7-9 pm. The present study observed that the majority (82.6%) of the children eat meals prepared outside the home once or twice weekly, and around 59% of parents believe breakfast to be the most important meal for their children.

3.3. Sedentary Behavior

Table **3** depicts sedentary behavior relative to overweight/obesity status. It has been observed that, on average, participants spend around 2.6 hours in front of a screen daily, with insignificant differences between the two groups. Around 43.1% spent their time on-screen during the afternoon, while 40.7% didn't report any regular screen watching. Nearly 25% of participants always eat while watching TV, while almost 62% of participants only eat sometimes while watching the screen. About half of the participants spend one hour or less on activities that require movement, while 24.0% reported not engaging in any activity. No significant ($p \geq 0.05$) association was observed between BMI and the use of electronic devices or lifestyle activities that require movement.

3.4. Sleep Behavior

Table **4** shows the sleep behavior of the participants across over weight/obesity status. The average sleep duration was 8.4 hours, with an insignificant difference between the two groups. Nearly 43% of the participants slept between 8:00 and 9:00 pm, and a significant association was found between BMI and sleeping time ($p=0.009$). Further, 60% of the participants took a nap, and 47.8% reported taking a nap for at least 1-2 hours, with no significant association noted between BMI and napping time.

Table 5 shows the logistic regression analysis results adjusted for age and sex, chrono-nutrition, screen, sleep, and physical activity relative to overweight/obesity versus non-overweight/non-obesity. The odds of being overweight/obese were lower if the child watched the screen in the evening (aOR = 0.142, p = 0.031) or at no regular time (aOR = 0.162, p = 0.018) than those who watched the screen in the morning. In addition, napping for more than 2 hours was associated with lower odds of being overweight or obese (aOR = 0.268, p = 0.048) than napping for less than one hour.

4. DISCUSSION

The present study examined Saudi preschoolers' lifestyle behaviors, including chrono-nutrition, sedentary lifestyle, and sleeping behaviors, and their associations with overweight or obesity status. The findings showed that overweight/obesity prevalence among preschoolers was 22.67%. A significant association ($p=0.009$) was observed between sleeping time and BMI. However, insignificant associations were observed between BMI and chrono-nutrition or physical activity. Logistic regression analysis revealed that evening and irregular screen time, as well as more than 2 hours of napping, were associated with lower odds of being overweight or obesity status.

Obesity and physical inactivity in young children represent an important public health issue. The combined prevalence of overweight and obesity in Saudi preschoolers in the current study was 22.7%. A systematic review of 21 studies conducted in Saudi Arabia between 2006 and 2023, involving 63,512 participants aged 2 to 19 years, revealed a concerning prevalence of overweight (5%-29%) and obesity (3.8%-49.7%) among children based on CDC criteria, highlighting a growing public health concern [18]. The prevalence of obesity reported almost two decades

Table 2: Chrono-Nutrition of the Participants Relative to Overweight/Obesity Status (N=450)

Variables	Total (N=450)	BMI		*p*-value
		Non-overweight/ non-obese (n=348)	Overweight/obese (n=102)	
How many main meals does your child eat during the day?	2.84±0.684	2.83±0.680	2.84±0.700	0.889
Does your child eat breakfast before going to school?				
Rare	151(33.5)	122(80.8)	29(19.2)	0.365
Often	70(15.6)	55(78.6)	15(21.4)	
Regular	229(50.9)	171(74.7)	58(25.3)	
How often does your child eat his lunch?				
Regular	204(45.3)	153(75)	51(25)	0.366
Often	154(34.3)	125(81.2)	29(18.8)	
Rare	92(20.4)	70(76.1)	22(23.9)	
When does your child usually eat his lunch?				
Before 3 pm	327(72.7)	255(78.0)	72(22.0)	0.253
3-5 pm	104(23.1)	76(73.1)	28(26.9)	
After 5 pm	19(4.2)	17(89.5)	2(10.5)	
How often does your child eat his dinner?				
Regular	185(41.1)	139(75.1)	46(24.9)	0.640
Often	154(34.2)	122(79.2)	32(20.8)	
Rare	111(24.7)	87(78.4)	24(21.6)	
When does your child usually eat his dinner?				
Before 7 pm	147(32.7)	109(74.1)	38(25.9)	0.385
7-9 pm	255(56.6)	199(78.0)	56(22.0)	
After 9 pm	48(10.7)	40(83.3)	8(16.7)	
Does your child eat snacks between the main meals?				
Always	121(26.9)	94(77.7)	27(22.3)	0.787
Often	125(27.8)	94(75.2)	31(24.8)	
Sometimes	195(43.3)	152(77.9)	43(22.1)	
Never	9(2.0)	8(88.9)	1(11.1)	
How many times does your child eat meals prepared outside the home weekly?				
Never	25(5.6)	23(92.0)	2(8.0)	0.229
1-2	371(82.6)	283(76.3)	89(23.7)	
3-4	50(11.1)	39(78.0)	11(22.0)	
5 or more	3(0.7)	3(100)	0(0)	
Which meal is the most important for your child, in your opinion?				
Breakfast	264(58.7)	148(56.1)	116(43.9)	
Lunch	161(35.8)	78(48.4)	83(51.6)	0.250
Dinner	25(5.5)	15(60)	10(40.0)	

Data are presented as mean ± Standard Deviation (SD) for continuous variables and frequency and percentage (%) for categorical variables; Chi Squares tests of the proportions for significant differences between obese/overweight and normal participants; p-value significant <0.05.

Table 3: Sedentary Behaviors of Children Relative to Overweight/Obesity Status (N=450)

Variables	Total (N=450)	BMI		*p*-value
		Non-overweight/ non-obese (n=348)	Overweight/ obese (n=102)	
How many hours does your child usually spend in front of the screen* daily?	2.59±1.123	2.60±1.170	2.58±0.948	0.843
What time of the day does your child spend their time on the screens?				
Morning	33(7.3)	24(72.7)	9(27.3)	0.897
Afternoon	194(43.1)	151(77.8)	43(22.2)	
Evening	40(8.9)	32(80.0)	8(20)	
Irregular	183(40.7)	141(77.0)	42(23.0)	
Does your child eat while watching the screen?				
Never	62(13.7)	51(82.3)	11(17.7)	0.588
Sometimes	277(61.6)	213(76.9)	64(23.1)	
Always	111(24.7)	84(75.7)	27(24.3)	
How many hours does your child spend on activities that require moving (other than what is given to him at school)				
Non	108(24.0)	87(80.6)	21(19.4)	0.484
1 hour or less	214(47.6)	168(78.5)	46(21.5)	
1-2 hours	111(24.6)	81(73.0)	30(27.0)	
2 hours or more	17(3.8)	12(70.6)	5(29.4)	

Data are presented as mean ± Standard Deviation (SD) for continuous variables and frequency and percentage (%) for categorical variables; Chi Squares tests of the proportions for significant difference between obese/overweight and normal participants; p-value significant <0.05; Screen* (TV, phone, tablet, or laptop)

Table 4: Sleep Behavior of children Relative to Overweight/Obesity Status (N=450)

Variables		BMI		*p*-value
	Total (N=450)	Non-overweight /non-obese (n=348)	Overweight/obese (n=102)	
How many hours does your child sleep at night?	8.424±1.19	8.46±1.21	8.29±1.11	0.207
What time does your child usually go to sleep?				0.009
7 pm or before	113(25.1)	89(78.8)	24(21.2)	
8-9 pm	192(42.7)	136(70.8)	56(29.2)	
10 pm and after	145(32.2)	123(84.8)	22(15.2)	
Does your child take a nap during the day?				0.232
No	180(40.0)	134(74.4)	46(25.6)	
Yes	270(60.0)	214(79.3)	56(20.7)	
If yes, how many hours does your child spend napping?				
Less than 1 hour	95(35.2)	71(74.7)	24(25.3)	0.070
1-2 hours	129(47.8)	101(78.3)	28(21.7)	
More than 2 hours	46(17.0)	42(91.3)	4(8.7)	

Data are presented as mean ± Standard Deviation (SD) for continuous variables and frequency and percentage (%) for categorical variables; Chi Squares tests of the proportions for significant difference between obese/overweight and normal participants; p-value significant <0.05.

Table 5: Logistic Regression Analysis Results Adjusted for Age and Sex for Chrono-Nutrition, Sedentary, and Sleep Behaviors Relative to Overweight /Obesity Status

Variables	Overweight /obese versus non-overweight/non-obese			
	B	aOR	95% CI	*p*-value
Does your child eat breakfast before going to school? (ref. rare)		1.00		
Often	0.300	1.350	0.450-4.049	0.593
Regular	0.740	2.097	0.930-4.724	0.074
How often does your child eat his lunch? (ref. regular)		1.00		
Often	-0.380	0.684	0.308-1.520	0.351
Rare	-0.015	0.985	0.386-2.513	0.975
When does your child usually eat his lunch? (ref. before 3)		1.00		
3:00-5:00 pm	0.252	1.287	0.589-2.812	0.528
After 5 pm.	-1.162	0.313	0.031-3.196	0.327
How often does your child eat his dinner? (ref. regular)				
Often	-0.137	0.872	0.376-2.023	0.749
Rare	0.007	1.007	0.383-2.648	0.989
When does your child usually eat his dinner? (ref. before 7:00 pm)		1.00		
7:00-9:00 pm	-0.326	0.722	0.272-1.919	0.514
After 9:00 pm	-0.286	0.751	0.183-3.082	0.691
Which meal is the most important for your child, in your opinion? (ref. breakfast)				
Lunch	-0.030	0.970	0.455-2.070	0.938
Dinner	-0.924	0.397	0.068-2.301	0.303
How many times does your child eat meals prepared outside the home weekly? (ref.never)		1.00		
1-2 times	1.599	4.947	0.533-45.939	0.160
3-4 times	1.956	7.070	0.644-77.596	0.110
Does your child eat snacks between the main meals? (ref. always)		1.00		
Often	-0.60	0.942	0.357-2.482	0.903
Sometimes	0.187	1.206	0.490-2.969	0.684
Never	-0.186	0.830	0.032-21.613	0.911
How many main meals does your child eat during the day?	-0.379	0.685	0.392-1.196	0.183
How many hours does your child spend on activities that require moving (other than what is given to him at school) (ref. none)		1.00		
1 hour or less	0.159	1.172	0.477-2.880	0.729
1-2 hours or less	0.206	1.229	0.423-3.567	0.704
2 hours or more	0.138	1.148	0.149-8.876	0.895
Hours spent in front of the screen daily	-0.153	0.858	0.625-1.177	0.342
What time of the day does your child spend on the screens (ref. morning)				
Afternoon	-1.502	0.223	0.049-1.021	0.053
Evening	-1.954	0.142	0.024-0.834	0.031
Irregular	-1.819	0.162	0.036-0.730	0.018
Does your child eat while watching the screen? (ref. never)		1.00		
Sometimes	0.388	1.475	0.449-4845	0.522
Always	0.300	1.349	0.356-5.119	0.660

(Table 5). Continued

Variables	Overweight /obese versus non-overweight/non-obese			
	B	**aOR**	**95% CI**	***p*-value**
How many hours does your child sleep at night?	0.10	1.010	0.550-1.857	0.974
What time does your child usually go to sleep? (ref. 7 pm or before)		1.00		1.00
8-9 pm	0.715	2.045	0.485-8.629	0.330
10 pm and after	0.299	1.348	0.145-12.534	0.793
How many hours does your child spend napping? (ref. less than 1 hour)		1.00		
1-2 hours	-0.069	0.933	0.445-1.954	0.854
More than 2 hours	-1.315	0.268	0.073-0.987	0.048

B- unstandardized regression coefficient; aOR- adjusted odd ratio; (95% CI) - 95% confidence interval; ref.- reference group.

Ago among preschoolers from Jeddah using the skinfold equation [19] was 10.8%. El Mouzan *et al*. [20] studied the prevalence of overweight and obesity in Saudi children and adolescents using BMI. They reported regional variations of 21.0% in the Central, 13.4% in the Southwest, and 20.1% in the northern regions. In a recent report, the prevalence of obesity was higher among boys (10.4%) than girls (8.3%), with the overall reported prevalence among children aged 2-6 years as 12.3% [21], which is lower than the prevalence reported in the present study, while the prevalence of overall obesity reported in Canadian preschoolers were 25.6% [22]. The body fat percentage for boys and girls differs significantly, with girls having a higher percentage than boys among those participants. This agrees with the results reported previously on Saudi pre-school [19] and the findings from the current study.

Several physiological processes, including nutrition, are regulated by the circadian rhythm. Chrono-nutrition is the relationship between food intake and circadian clock [23]. In the present era, modern lifestyle habits, including irregular eating schedules, meal skipping, and prolonged sedentary behavior, often lead to a vicious cycle that disrupts circadian rhythms and contributes to obesity [24]. It has been observed that most of the participants consumed breakfast, lunch, and dinner regularly. Also, most of them reported consuming lunch before 3 pm and dinner between 7-9 pm. Peripheral circadian rhythms can be upset by meal timing [25], and poor nutrition—including irregular eating schedules—can interfere with homeostasis, impacting insulin sensitivity, glucose metabolism, and leptin release, raising the risk of obesity and diabetes [26]. Since breakfast minimizes the consumption of high-energy snacks, Niklas *et al.* [27] suggest that eating breakfast regularly can reduce body weight since it reduces fat content in the diet, as the children who eat breakfast consume greater amounts of grains, fruits, and dairy products.

The present study observed that most parents/guardians were highly educated, which may influence preschoolers' dietary intake and food preferences. In a study conducted in Belgium, a lower dietary adequacy in children of mothers with low and medium levels of education has been noted [28]. Contrary to this, some studies have mentioned that the level of parents' education was positively associated with obesity in their children, which may be due to mothers' lack of knowledge about balanced diets and healthy eating habits [29, 30]. In agreement with the result obtained in the present study, the dietary pattern was not found to be associated with overweight/obesity in Chinese preschoolers [31]. The consumption of snacks has been shown to increase caloric intake, but no association between snacking and weight gain was noted previously [32]. However, a study that analyzed published papers for children aged 2-18 from January 2004 to 2014 found that snacking influences the diet intake of children but is not an independent factor contributing to weight gain [33]. Other studies have reported that snacking was negatively associated with fatness and reduced the risk of overweight and abdominal obesity [34,35]. The possible explanation for the inconsistent results might be the snacking patterns and the types of foods and beverages consumed as snacks.

Sedentary behavior was not associated with overweight/obesity in the current study except for evening and irregular screen timing, which indicated a lower likelihood of being obese or overweight than morning screen time. Morning screen time has a greater impact on obesity risk due to its adverse

influence on physical activity and eating habits. Beginning the day with screen time can reduce the possibilities of early engagement in physical activity. Physical activity is vital in preventing childhood and adolescent overweight and obesity and lowering the risk of adult obesity [36]. The other reason might be the unhealthy food and beverage advertising on television, which greatly impacts children's food preferences, choices, and consumption, with a higher intake of advertised products not only during screen time but also at other times of the day. Jensen *et al*. [37] have reported that children who ate meals on-screen were more likely to consume breakfast cereals, desserts/sweets, milk, and yogurt than when they ate off-screen, leading to higher calorie consumption, particularly among those distracted during meals.

Furthermore, Pate *et al.* [38] found no association among young children but reported a positive association between sedentary time and BMI in older children and adolescents. In a study, TV viewing and physical activity were the only significant predictors of BMI among children aged 3-6 years [39]. Excess screen time not only reduces physical activity but also stimulates food intake and overconsumption, especially of snack foods, leading to a reduction in resting metabolic rate, which is, in turn, responsible for the diminution of total energy expenditure and enhancing positive caloric balance. Therefore, encouraging children to spend less time watching TV is an important strategy to be less sedentary.

In the present study, the average sleep duration for overweight/obese (8.29 hours) participants was slightly less than non-overweight/non-obese participants (8.46 hours), with a mean of 8.42 hours for all participants. Elsewhere, it has been reported that children sleeping for 8 hours or less were 2.2 times more likely to be overweight/obese [40]. In our study, napping for more than 2 hours is significantly associated with lower odds of being obese or overweight. While daytime napping has been related to cognitive and mood benefits [41], its relationship with obesity is unclear, with research yielding contradictory results, including links with both higher [42] and lower obesity risk [43] or even a potential inverse relationship between daytime napping and the risk of obesity [44]. A study on Iranian adults has shown that daytime napping is linked to an increased risk of overweight/obesity in short sleepers. However, among subjects with longer sleep duration, it is not associated with an increased risk of becoming overweight or obese [45]. The difference in the results might be most likely due to differences in study design and methodology, and further study with a larger sample size is required to address this difference.

The present study found no significant relation between demographic characteristics and BMI. Children from higher-income families tend to be more likely to become overweight. Families with higher incomes can afford several meals daily, dine out, have food delivered to their homes, and have snacks more often [46]. Another study conducted in Jeddah, Saudi Arabia, reported that the prevalence of overweight and obesity in obese children between 3 and 18 years was higher with high educational levels of both parents as well as with high family income [47]. In contrast, a study conducted in the United States found that children from low-income families are more prone to become obese [48]. This may be due to differences in the definitions of obesity and indicators of socioeconomic status used.

5. LIMITATIONS

This study had several limitations. The results are not generalizable to all Saudi students because data were collected from one urban area. Rural children may have different lifestyles than the children in the cities. Objective measures did not verify the self-reported sleep duration and physical activity data. Also, recall bias might be of concern, as some responses require remembering. Some results were marginally significant, so a large sample size is recommended for a more appropriate result.

6. CONCLUSION

The global rise in obesity in preschoolers presents a growing public health crisis, emphasizing the need for coordinated and comprehensive strategies to address the issue effectively. The present study, which investigated the relationship between chrono-nutrition, sedentary behavior, and sleep patterns with overweight and obesity in a randomly selected sample of Saudi pre-school children, suggests that chrono-nutrition minimally impacts BMI in this age group. The findings suggest that the timing of screen use may also influence children's weight status, emphasizing the need to manage screen time as part of effective strategies to prevent childhood obesity. Future studies on pre-school children's lifestyle behaviors are warranted to enhance preventive health education and health promotion.

ETHICS APPROVAL STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of ABC **(**Ref. No. KSU-HE-19-189).

INFORMED CONSENT STATEMENT

The study objectives were explained to the parents/guardians of all children, and written consent was obtained from them. They were informed that they could contact the investigator if they had questions or would like to withdraw their child from the study. In addition, permission to conduct this research in schools was obtained from the Ministry of Education and the principals of the selected schools.

DATA AVAILABILITY STATEMENT

The authors confirm that the article's data supporting this study's findings are available. Raw data supporting this study's findings are available from the corresponding author upon reasonable request**.**

COMPETING INTERESTS

The authors declare that there is no competing interest to disclose.

AUTHORS' CONTRIBUTIONS

MHA and NAA designed the study, MHA and WSA contributed to the analysis design. WSA performed the formal analysis and provided methodological insights. SA and MHA drafted the initial manuscript; HAA, HMA, and FFA reviewed the final manuscript. All authors read, revised, and approved the final manuscript for submission. SA was responsible for submitting the manuscript.

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