

Lifestyle-Related Determinants of Obesity Among Omani Children

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أنماط الحياة المحددة للسمنة بين الأطفال العمانيين

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ABSTRACT: Objectives: This study aimed to examine the relationship between body mass index (BMI) z-scores and lifestyle-related factors including nutrition, physical activity, screen time and time spent sleeping in 6–10-year-old Omani children. **Methods:** This cross-sectional study included mother-child dyads that were recruited from five provinces in Oman. Children's BMI measurements and questionnaires on nutrition intake, physical activity, screen time and time spent sleeping and a single-day dietary recall were collected. **Results:** A total of 197 dyads were included in this study. The children's mean age was 7.7 ± 1.6 years and 53% were female. In this study, 17.4% of the children were classified as overweight or obese. No significant relationship was found between the children's BMI z-scores and nutrition intake, moderate-to-vigorous physical activity time or screen time ($P \geq 0.05$). Increased time spent sleeping at night was positively associated with childhood obesity ($P < 0.05$). **Conclusion:** The relationship between obesity and caloric intake, physical activity and screen time among children younger than 10 years seems to be moderated by certain factors that need to be investigated. Qualitative studies and questionnaires that are culturally sensitive are therefore needed.

Keywords: Children; Pediatric Obesity; Diet, Food, and Nutrition; Physical Activity; Screen Time; Sleep; Oman.

المخلص: الهدف: هدفت هذه الدراسة إلى اختبار العلاقة بين الدرجات المعيارية لمؤشر كتلة الجسم والعوامل المتعلقة بنمط الحياة بما في ذلك التغذية والنشاط البدني ومدة الجلوس أمام الشاشة والوقت الذي يتم قضاؤه في النوم عند الأطفال العمانيين في عمر 6–10 سنوات. **الطريقة:** تضمنت هذه الدراسة المقطعية تناهيات من أم وطفل من خمس ولايات في سلطنة عُمان. تم جمع قياسات مؤشر كتلة الجسم للأطفال واستبيانات حول التغذية والنشاط البدني ومدة الجلوس أمام الشاشة والوقت الذي يقضيه الطفل في النوم واسترجاع النظام الغذائي للطفل ليوم واحد. **النتائج:** تم تضمين ما مجموعه 197 تناهيات في هذه الدراسة. كان متوسط عمر الأطفال 7.7 ± 1.6 سنة وكانت نسبة الإناث 53%. تم تصنيف 17.4% من الأطفال على أنهم يعانون من زيادة الوزن أو السمنة في هذه الدراسة. لم يتم العثور على علاقة ذات دلالة إحصائية بين الدرجات المعيارية لمؤشر كتلة جسم الأطفال وتناول الغذاء أو مدة النشاط البدني المعتدل إلى القوي أو مدة الجلوس أمام الشاشة ($P \geq 0.05$). ارتبطت الزيادة في الوقت الذي يتم قضاؤه في النوم ليلاً ارتباطاً إيجابياً بسمنة الأطفال ($P < 0.05$). الخلاصة: يبدو أن العلاقة بين السمنة وتناول السعرات الحرارية والنشاط البدني ومدة الجلوس أمام الشاشة بين الأطفال الذين تقل أعمارهم عن 10 سنوات تتأثر ببعض العوامل الأخرى التي تحتاج إلى دراسة. ولذلك، هناك حاجة إلى بحوث نوعية واستبيانات تراعي الاعتبارات الثقافية.

الكلمات المفتاحية: أطفال؛ سمنة الأطفال؛ النظام الغذائي والغذاء والتغذية؛ نشاط بدني؛ وقت أمام الشاشة؛ نوم؛ عُمان.

ADVANCES IN KNOWLEDGE

- The relationships between obesity and caloric intake, time spent in moderate-to-vigorous physical activity and screen time among children younger than 10 years old are generally statistically weak, probably due to moderating factors.
- In Oman, childhood obesity is associated with increased time spent sleeping.
- This study is the first to examine lifestyle-related determinants of obesity among Omani children aged 6–10 years.

APPLICATION TO PATIENT CARE

- Children should have regular health check-ups which include weight and height measurements.
- Awareness of healthy nutrition intake needs to be emphasised for children and their families.
- A movement towards preventing and treating obesity among children needs to be initiated in Oman.

CHILDHOOD OBESITY IS A GLOBAL PUBLIC health concern. The worldwide prevalence of childhood obesity doubled from 1980–2013.¹ In Oman from 2012–2018, the rate of overweight and obesity increased from 3.5% to 4.2% among children in the first grade (i.e. 6–7 years), from 12.8% to 15% among children in the seventh grade (i.e. 12–13 years)

and from 12.5% to 16.7% among children in the tenth grade (i.e. 15–16 years).^{2,3} In 2016, 32.3% of Omani children aged 5–19 years old were overweight.⁴

Childhood obesity increases children's risk of developing prediabetes, type two diabetes and cardiovascular disease later in life.⁵ Children with obesity are also vulnerable to peer neglect and

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rejection, attention-deficit hyperactivity disorder, anxiety and depression.^{6,7}

Obesity is a complex health problem; it has genetic attributes that are influenced by environmental factors.⁸ These environmental factors contributing to obesity are partly explained by the imbalance between energy intake and energy expenditure.⁹ When there is high energy intake and low energy expenditure, the resultant extra energy is stored in the body as adipose tissue.¹⁰

In Oman, research of childhood obesity is limited. A recent study found that 9–10-year-old Omani children with obesity had generally but not significantly ($P > 0.05$) lower physical fitness levels compared to their non-obese counterparts.¹¹ No other study from Oman was found upon a search of the literature. It is well reported, nevertheless, that children with obesity have higher energy intake, lower physical activity levels and higher sedentary time (e.g. screen time) when compared to non-obese children.^{12,13} Findings from Gulf Cooperation Council (GCC) countries, excluding Oman, contain inconsistent findings in regards to the association between childhood obesity and nutrition, physical activity and screen time.¹⁴ Uncertainty persists about the influence of nutrition and physical activity patterns on childhood obesity, particularly in Oman.

Middle childhood (i.e. 6–10 years) is an excellent age to deliver obesity-related programmes. Healthy behaviours learned during middle childhood have more potential to support sustainable changes.¹⁵ Prior to health promotion programmes, it is essential to understand the contributing factors to the obesity problem. Therefore, this study aimed to examine the relationship between BMI z-scores and nutrition, physical activity, screen time and time spent sleeping in 6–10-year-old children in Oman.

Methods

Using a cross-sectional research design, data were collected from December 11, 2017, to January 24, 2018. Participants consisted of mother-child dyads and were recruited on a volunteer basis from five public schools, seven non-governmental community centres and six home visits in five Omani provinces (Al-Seeb, Bowsher, Bidbid, Nizwa and Ibra). Mothers who were Omani, aged 18 years or older and possessed the ability to speak, read and write in Arabic were included. Omani children who were between 6–10 years old, had no chronic illness that restricted nutrition or physical activity and had no sibling(s) in the study were included. Based on similar factors' correlation findings from other studies', calculations

generated from the G-power programme resulted in a required minimum sample size for children-mother dyads of 193. This calculation resulted in an 80% power to detect a correlation as small as $r = 0.2$ or a Cohen's d of 0.41.

Invitation messages were distributed to mothers through WhatsApp Messenger (Facebook. Inc., Mountain View, California, USA) and letters were distributed to mothers via their children at school. Trained and supervised research assistants collected all data. Children's anthropometric measurements were taken and mothers completed an Arabic-language questionnaire for their children regarding nutrition, physical activity, screen time and time spent sleeping. In addition, a single-day dietary recall for children was collected.

Children's weights were measured using a Seca 877 Class III scale (Seca GmbH & Co. KG, Hamburg, Germany) to the nearest 0.1 kg. Height was measured with a Seca 213 portable stadiometer (Seca GmbH & Co. KG) to the nearest 0.1 cm. Both height and weight were measured twice and averaged. The children's BMI z-scores were calculated by computer and organised according to the World Health Organization growth charts for children aged 5–19 years: severely thin was defined as a z-score of less than -3 , thin was defined as a z-score between -3 to -2 , normal growth was defined as a z-score between -2 to 1 , overweight was defined as a z-score between 1 to 2 and obese was defined as a z-score of greater than 2 .¹⁶

The mothers completed a questionnaire adapted from the Fish Feeding Study (FFS).¹⁷ The FFS questionnaire was developed in Arabic by a team of researchers from the Department of Food Science and Nutrition, College of Agricultural and Marine Sciences, Sultan Qaboos University, Muscat, Oman and tested for content validity, reliability (83%) and reproducibility among 100 Omani children age 6–10 years old (unpublished data). For this study, the FFS questionnaire was modified slightly: four items related to fish and salt intake were removed and one item relating to the number of hours slept per day was added. Permission to modify the tool was obtained from its developers.

Mothers were also asked about their children's frequency of consumption of 22 different foods. The answer options were "daily", "weekly", "monthly", "occasionally" or "never". For the analysis, those options were categorised into "more frequent", representing daily or weekly, and "less frequent" reflecting monthly, occasionally or never. Physical activity was examined by asking about the frequency and duration of nine different moderate-to-vigorous physical activities (MVPA) the child completed in a week (e.g. riding

Table 1: Omani children’s body mass index z-score means for frequency of consumption of soft and sugary drinks, addition of fat or butter, moderate-to-vigorous physical activity, screen time and time spent sleeping (N = 197)

Variable	n*	Mean BMI z-score ± SD	P value
Frequency of soft drink and sugary drink consumption			0.01
Daily or weekly	104	-0.45 ± 1.37	
Monthly, occasionally or never	91	0.08 ± 1.51	
Frequency of addition of fat/butter			0.02
Daily or weekly	131	-0.38 ± 1.48	
Monthly, occasionally or never	59	0.15 ± 1.41	
MVPA in minutes/day			0.99
≥60	76	-0.22 ± 1.46	
<60	108	-0.22 ± 1.52	
Screen time in minutes/day			0.99
≤120	156	-0.21 ± 1.50	
>120	30	-0.22 ± 1.51	
Time spent sleeping at night in hours/day			0.12
<9	49	-0.50 ± 1.39	
≥9	147	-0.12 ± 1.49	

BMI = body mass index; SD = standard deviation; MVPA = moderate-to-vigorous physical activity.

* The number of participants in each variable add up to 195, 190, 184, 186 and 196, respectively, instead of 197 for each variable, due to missing data.

a bicycle, jumping rope, etc.). Mothers were also asked about the frequency and duration of their children’s activities involving screen time during a week, including watching television or videos, playing video games and using computers. Questions about MVPA and screen time involved either “yes” or “no” answers as well as how many times per week the child engaged in the activity and the duration in minutes of each activity. Sleep was examined by asking mothers about their child’s number of night-time sleep hours over a 24-hour period. The mothers could choose “less than nine hours,” “nine to eleven hours” or “more than eleven hours,” which were based on the USA’s National Sleep Foundation’s categories for the number of night-time sleep hours for children aged 6–11 years.¹⁸

For single-day dietary recall, the researchers used the Automated Self-Administered 24-hour (ASA24) Dietary Assessment Tool (2016) developed by the United States National Cancer Institute which includes detailed questions about food preparation and portion sizes.¹⁹ The ASA24 has adequate face validity

Table 2: Omani children’s weight status and frequency of consumption of soft and sugary drinks, moderate-to-vigorous physical activity, screen time and time spent sleeping (N = 197)

Variable	n (%)*		Chi-square test	P value
	Normal or underweight	Overweight or obese		
Frequency of soft drink and sugary drink consumption			3.772	0.052
Daily or weekly	91 (87.5)	13 (12.5)		
Monthly, occasionally or never	70 (77)	21 (23)		
MVPA in minutes/day			0.02	0.89
≥60	62 (81.6)	14 (18.4)		
<60	89 (82.4)	19 (17.6)		
Screen time in minutes/day			0.07	0.79
≤120	128 (82.1)	28 (17.9)		
>120	24 (80)	6 (20)		
Time spent sleeping at night in hours/day			3.843	0.052[†]
<9	45 (91.8)	4 (8.2)		
≥9	117 (79.6)	30 (20.4)		

MVPA = moderate-to-vigorous physical activity

*The number of participants in each variable add up to 195, 184, 186 and 196, respectively, instead of 197 for each variable, due to missing data. [†]Using Fisher’s exact test due to small cell count.

for estimates of energy, nutrients and different food groups consumed.¹⁹ A previous study showed that 80% of items consumed were correctly reported in the ASA24.²⁰ Bilingual English/Arabic research assistants with backgrounds in nutrition science conducted the interviews with the children’s mothers.²¹ This approach addressed challenges related to English language proficiency and Internet access.²²

Univariate analysis was used to examine each of the study variables by looking at descriptive statistics including mean ± standard deviation, range for continuous variables and frequency tables for categorical/dichotomous variables. Several statistical tests including correlation, independent t-test, chi-square test, multiple linear regression and binary logistic regression were used to analyse the relationships between the study variables. Multiple linear regression was used to predict the children’s BMI z-scores from a single-day nutrition intake. To avoid collinearity, three separate models were built. The children’s BMI z-scores were calculated based on energy intake, macronutrients (i.e. protein, fat, carbohydrates) and main food groups (i.e. grains, fruits, vegetables, protein and dairy) controlling for age and gender. Additionally, a logistic regression model was run with the children’s weight status as

Table 3: Coefficient-based model of physical activity pattern predictors on Omani children's weight status

Variable*	Unstandardised β	SE	P value	Exp(B)	95% CI for Exp(B)	
					Lower	Upper
MVPA time	-0.00	0.00	0.26	0.996	0.99	1.00
Screen time	-0.00	0.00	0.21	1.00	0.998	1.01
Sleep time	-1.19	0.58	0.04	0.31	0.10	0.94

SE = standard error; CI = confidence interval; MVPA = moderate-to-vigorous physical activity. *Weight status reference group was constituted of children identified as overweight or obese. MVPA time and screen time were continuous variables. The sleep time reference group was constituted of children achieving less than nine hours of sleep a night.

the outcome and single-day nutrition intake as the predictor. Three models were built based on energy, macronutrients and main food groups consumed. Multiple linear regression was also used to predict the children's BMI z-scores from the 22 foods on the FFS. Also, binary logistic regression was run with the children's weight status as an outcome, and the 22 foods' frequency of intake as predictors. Additionally, multiple linear regression was used to predict the children's BMI z-scores from MVPA time, screen time and time spent sleeping as well as after controlling for age and gender. Statistical Package for the Social Sciences (SPSS), Version 25 (IBM, Corp., Armonk, New York, USA) was used for the statistical tests. A P value of <0.05 was considered statistically significant.

Approval for this study was obtained from the Institutional Review Board at the University of North Carolina at Chapel Hill (IRB Study number 17-2785) and the research ethical committee at the Technical Office for Research and Development at the Ministry of Education (MOE) in Oman. The risks and benefits of participating in this study were explained in Arabic to the mothers and children and all questions were answered before the mothers were asked to give consent for their and their child's participation or the children were asked to assent to their own participation.

Results

A total of 197 dyads were included in the final study analyses. Of the 204 dyads who consented to participate, four dyads were not eligible according to the inclusion criteria and the electronic questionnaire data for three other dyads were categorised as lost, most likely due to incomplete submission. The mean age of the children was 7.7 ± 1.6 years and the majority of the children were female (53%). A total of 17.4% of the children were classified as overweight or obese and 5.6% were classified as thin or severely thin.

Children's energy intake ranged from 613–3,736 kcal/day (mean = $1,770 \pm 563.5$ kcal/day), while their mean protein and carbohydrate intakes were $65.0 \pm$

26.6 and 250.2 ± 87.0 g/day, respectively. The children's mean daily fat intake was 58.6 ± 23.7 g and their mean grain intake was 7.6 ± 3.9 ounces/day. The study demonstrated that 81% of the children consumed refined grains daily and only 35% of the children consumed whole grains daily.

The mean daily intake of fruit was 1.4 ± 1.2 cups, while the mean intake of vegetables was 1.5 ± 1.1 cups per day. The majority of children (80%) consumed dairy daily and 60% of children consumed fast food either rarely or never. Nearly half of the children (46.4%) consumed soft or sugary drinks rarely or never. For the single-day dietary recall, 92.4% of mothers reported that it was the usual pattern of their children's daily dietary intake.

Children's mean daily MVPA was 61.4 ± 63.7 minutes. Children's mean daily screen time was 63.0 ± 68.6 minutes per day and the majority of the children (75%) complied with the National Sleep Foundation

Table 4: Coefficient-based models of single-day nutrition intake predictors on Omani children's body mass index z-scores

Model*	Unstandardised β	SE	P value
Energy in kcal	-1.04×10^{-5}	0.00	0.96
Macronutrients			
Protein in g	0.01	0.01	0.17
Fat in g	0.00	0.01	0.85
Carbohydrates in g	-0.00	0.00	0.27
Food groups			
Grains in oz	0.03	0.03	0.37
Fruits in cup	-0.03	0.09	0.72
Vegetables in cup	0.08	0.10	0.41
Protein-based foods in oz	0.03	0.04	0.49
Dairy in cup	0.03	0.11	0.76

SE = standard error; kcal = kilocalories; g = grams; oz = ounces.

*Separate models were run for energy, macronutrients (i.e. protein, fat and carbohydrates) and food groups (i.e. grains, fruits, vegetables, protein-based foods and dairy); children's ages and genders were statistically controlled.

Table 5: Coefficient-based models of single day nutrition intake predictors on Omani children's weight status

Model*	Unstandardised β	SE	P value	Exp(B)	95% CI for Exp(B)	
					Lower	Upper
Energy in kcal	0.00	0.00	0.29	1.00	0.999	1.00
Macronutrients						
Protein in g	-0.00	0.01	0.72	0.997	0.98	1.01
Fat in g	0.01	0.01	0.50	1.01	0.99	1.03
Carbohydrates in g	-0.00	0.00	0.19	0.996	0.99	1.00
Food groups						
Grains in oz	-0.02	0.05	0.76	0.98	0.89	1.09
Fruits in cup	0.05	0.15	0.75	1.05	0.78	1.42
Vegetables in cup	0.16	0.17	0.33	1.18	0.85	1.62
Protein-based foods in oz	-0.03	0.07	0.71	0.97	0.85	1.12
Dairy in cup	-0.10	0.21	0.65	0.91	0.61	1.37

SE = standard error; CI = confidence interval; kcal = kilocalories; g = grams; oz = ounces.

*Weight status reference group was overweight or obesity; separate models were run for energy, macronutrients (i.e. protein, fat, carbohydrates) and food groups (i.e. grains, fruits, vegetables, protein-based foods and dairy); children's age and gender were statistically controlled.

recommendations of at least nine hours of sleep per night for those aged 6–11 years.

The children's BMI z-scores were not significantly correlated with the single-day intake of total energy, protein, total fat, carbohydrate, grains, fruits, vegetables, protein food or dairy ($r = -0.04$ – 0.08 ; $P \geq 0.05$ each) [No table for correlation analysis]. With regression analysis, no significant predictor of BMI z-scores was found ($P \geq 0.05$) [Table 4]. No significant nutrition intake predictor was found for the children's weight status either ($P \geq 0.05$ each) [Table 5].

The mean BMI z-scores for the children reported to consume soft drinks or sugary drinks more frequently were significantly ($P = 0.01$) lower compared to children who were reported to consume soft or sugary drinks less frequently [Table 1]. Likewise, the mean BMI z-scores among the children who had fat or butter added to their food more frequently were significantly ($P = 0.02$) lower than the mean BMI z-scores of the children who had fat or butter added less frequently [Table 1]. The relationships between each of the other 20 food types and children's BMI z-scores and weight status were found not to be significant. Multiple linear regression showed that none of the 22 items was a significant predictor of the children's BMI z-scores or weight status ($P \geq 0.05$).

The children's BMI z-scores were not significantly associated with time spent engaged in MVPA ($r = -0.04$; $P \geq 0.05$). Similarly, the mean BMI z-score was not significantly different between the children reported to engage in MVPA for 60 minutes or more per day compared to the children reported to engage

in MVPA less than 60 minutes per day [Table 1]. A chi-square test analysis indicated no significant association between MVPA (stated as a dichotomous variable) and children's weight status [Table 2]. The children's BMI z-scores were not significantly associated with daily screen time ($r = 0.06$; $P \geq 0.05$) irrespective of duration [Table 1]. No significant associations were detected between screen time and weight status [Table 2].

Mean BMI z-scores were not significantly different between children reported to sleep less than nine hours per night compared to children reported to sleep nine hours or more per night [Table 1]. Children's weight status was also not significantly associated with the time spent sleeping ($P = 0.52$) [Table 2]. Multiple linear regression indicated that MVPA time, screen time and time spent sleeping were not significant predictors of children's BMI z-scores [Table 6]. However, binary logistic regression (with the children's weight status as an outcome) suggested that sleeping less than nine hours per night was

Table 6: Coefficient-based models of physical activity pattern predictors on Omani children's body mass index z-scores

Variable*	Unstandardised β	SE	P value
MVPA time	-0.00	0.00	0.43
Screen time	0.00	0.00	0.22
Sleep time	0.39	0.27	0.15

SE = standard error; MVPA = moderate-to-vigorous physical activity.

*The outcome was considered body mass index z-score; MVPA time and screen time were considered continuous variables; the sleep reference group had at least nine hours sleep each night.

significantly associated with decreased odds of being overweight or obese ($P = 0.04$) [Table 3].

Discussion

The study aimed to assess the relationship between BMI z-scores and nutrition, physical activity, screen time and time spent sleeping in Omani children. Analyses suggest no significant relationship between total energy or macronutrient intake and children's BMI z-scores. In a previous study, an increase in total energy intake was linked to an increase in body weight.¹² The relationship between energy intake and overweight and obesity, however, relies in part on energy expenditure.⁹ This relationship may explain why researchers in a previous study reported no significant association between energy intake and body composition while others found that energy and carbohydrate intake were significantly ($P < 0.05$) associated with children's BMI.^{23,24}

The current study also found that total grain intake per day and whole grain or other grain-intake frequency had no significant relationship with BMI z-scores. Different influences of whole grains and refined grains on obesity have been documented previously in the literature.^{25–27} Whole-grain intake was found to be inversely related to BMI and obesity among children 6–18 years old ($P < 0.05$) according to a large study conducted in the USA.²⁵ Another study found that reducing white bread consumption versus reducing whole-grain bread consumption was associated with a lower increase in weight.²⁶ However, another study showed similar findings to the current study, indicating no significant relationship between total grain intake and obesity in children.²⁷

Fast food intake has also been linked to obesity.¹² However, in the current study, fast food intake was low, most likely because the children were too young to eat outside of their homes with friends.²⁸ This behaviour might explain the lack of a significant relationship between the frequency of fast food intake and the children's BMI z-scores in the current study. Further research is needed to clarify the nature of home-prepared food and its relationship to obesity, especially because societal changes in the GCC countries imply that home-prepared food is becoming more calorie dense.

In the present study, mean BMI z-scores were significantly ($P < 0.05$) higher among children who had fat or butter added to their food less frequently (i.e. monthly, occasionally or never) compared to children who had fat or butter added to their food more frequently (i.e. daily or weekly). However, during data collection, mothers revealed that they

preferred to use homemade or natural fat (e.g. ghee) extracted from milk. Previous research has shown that trans-fatty acids are linked to obesity, in contrast to natural fats which have not been found to have such an association.²⁹ A systematic literature review found no supporting evidence indicating a significant relationship between dairy fat or high-fat dairy foods and obesity.³⁰

Interestingly, the current study showed that mean BMI z-scores were higher among children who were reported to consume soft drinks or sugary drinks less frequently compared to those who consumed them more frequently. The frequency of soft drink or sugary drink intake, however, was not a significant predictor of children's weight status in this study. Similar findings have been reported in other GCC countries. One study reported a significant negative relationship between soft drinks or sugary drinks and childhood obesity, while another reported no significant relationship.^{31,32} In Oman, sugary drink portion sizes are usually small (6–8 ounces), which could partly explain its non-significant relationship with obesity; especially in light of the fact that acceptable juice intake for children older than seven years is eight ounces a day.³³ Children who consume sugary drinks as a daily snack may get full easily and eat less or skip main meals that are more calorie dense. It is important to note that the data collected were subjective and reported by mothers who may not necessarily be aware of all items consumed by their children throughout the day, including soft drinks or sugary drinks. Further investigation is needed to clarify the risk of consuming soft drinks and sugary drinks on obesity in Oman.

In this study, MVPA time was not significantly associated with children's BMI z-scores. One study from the GCC supports these findings, documenting no significant ($P > 0.05$) relationship between physical activity and BMI.³² However, another study conducted in the GCC suggested that low levels of physical activity were associated with childhood obesity.³¹ Participants in the current study demonstrated an acceptable daily level of MVPA as children's mean daily MVPA was 61.4 ± 63.7 minutes. Nevertheless, objective measurement tools such as accelerometers should be considered in future research.

This study found that screen time was not significantly associated with children's BMI z-scores. Similarly, no significant relationship between screen time and childhood obesity has been reported in other GCC-based studies.^{31,34} However, a GCC-based study reported that mean BMI was significantly ($P < 0.05$) higher among children and adolescents engaged in more than two hours of screen time per day compared to those engaging in less than an hour

per day.³⁵ In the current study, the majority of children had healthy screen time behaviour (i.e. less than two hours of screen time per day), which may indicate that the relationship between screen time and childhood obesity is moderated by age or other environmental factors.

In this study, sleeping at least nine hours per night was significantly associated with increased odds of children becoming overweight or obese. In general, short sleep duration in children has been linked to obesity.³⁶ Other mechanisms, including dietary intake, time of eating and obesogenic dietary behaviours have been linked to sleep and obesity.³⁵ These mechanisms need to be investigated from a cultural perspective to further understand the relationship between sleep and obesity among Omani children.

The nutrition intake and physical activity measures used in this study were unable to establish a statistically positive relationship to childhood obesity in Omani children. It is worth noting that genetic factors play a role in the relationship between environmental factors and obesity.³⁷ A strong positive relationship ($P = 0.001$) between maternal BMI and childhood obesity has been reported in Oman.³⁸ Children who did not inherit the obesity-associated genes may practice unhealthy nutritional behaviours yet have a normal body weight.

This study was subject to certain limitations. The study was cross-sectional with a relatively small sample size that was selected using convenience sampling from urban and suburban communities, which limits the generalisability of the study's findings. Also, child nutrition and physical activity pattern instruments provided only subjective data as these data were self-reported by mothers, which could have added bias. Due to feasibility issues, dietary recall reporting was limited to a single day of data collection. A question at the end of the dietary recall interview, however, asked mothers whether the child's nutrition intake of that day was usual, more than usual or less than usual. The majority of mothers (92.4%) answered that the intake was as usual.

Conclusion

This study demonstrated that childhood obesity is a complex health problem that needs to be examined at different levels. This study provides primary data that can be used for future childhood obesity research in Oman. Future research in Oman can be directed toward designing culturally tailored assessment tools to better capture significantly associative factors. Investing in school-based health programmes would

promote general child health and control childhood obesity in Oman.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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