

# The Physical Activity and Sleep Duration on the Risk of Obesity Among School Children

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## To cite this article:

Azrimaidaliza, Aurora Andari Amelia, Denas Symond. The Physical Activity and Sleep Duration on the Risk of Obesity Among School Children. *World Journal of Public Health*. Vol. 8, No. 2, 2023, pp. 113-119. doi: 10.11648/j.wjph.20230802.21

Received: March 15, 2023; Accepted: April 13, 2023; Published: April 27, 2023

**Abstract:** Obesity in school-aged children can be caused by lack of physical exercise and sleep. This study aims to determine the relationship between causal factors and risk and to analyze the confounding variables. Materials and Methods: Case-control design was implemented in two elementary schools Negeri 30 and Kartika I-10. The total sample is 76 students consisting of 38 cases and 38 controls. Secondary data were obtained from a list of elementary school students in each school being analyzed, while primary data were obtained through measurements and interviews. Data processing was performed using univariate, bivariate, and multivariate analysis. Results: Respondents in the case group engaged in more passive physical activity (78.9 %), and sleep duration was less than 76.3%. Obesity among school-aged children included physical activity (odds ratio [OR], 6.43; CI95% 2.32 to 17.85;  $p < 0.001$ ) and sleep duration (OR=4.43; CI95% 1.65 to 11.89;  $p$ -value =0.002). A Multivariate test found that calorie, protein, and fat intake were factors that confounded physical activity and sleep duration. There was a significant relationship between physical activity level (OR=6.43; CI95% 2.32 to 17.85;  $p < 0.001$ ) and duration of sleep (OR=4.43; CI95% 1.65 to 11.89;  $p = 0.002$ ) with the risk of obesity among school children. Conclusion: This study shows that energy, protein, and fat intake are confounding variables of physical activity and obesity risk. Then, energy and fat intake are variables that interfere with sleep duration and the risk of obesity.

**Keywords:** Children, Obesity, Physical Activity, Sleep Duration

## 1. Introduction

Nowadays, Indonesia is not only facing the problems of undernutrition but also overnutrition and obesity. Obesity has a higher risk of more severe health problems due to various complications and increased mortality risk [1]. There is a tendency for the younger age groups to suffer from obesity. In 2010, around 80% of overweight and obese children came from developing countries [2, 3].

Based on a Report by Indonesia Basic Health Research or called Riskesdas 2010 showed that the problem of obesity among children aged 6-12 years was still high at 9.2% or still above 5.0%. In 2013, the obesity rate among children aged 5-12 was nearly identical to that of 2010 at 8.8%. Especially in West Sumatra Province, the prevalence of obesity increased from 3.8% in 2010 to 7.7% in 2013 (8.9%).

The results of observation from the Provincial Health

Office of West Sumatra in 2015 found that the prevalence of obesity in elementary school-age children was 1.2%, while in Padang City, it was 2.9% [4]. In the same year, Padang City Health Office explained that the working area of Andalas Community Health Center in Padang had the largest prevalence of obesity among elementary school-age children 6.1%. Two elementary schools that had the highest prevalence of obesity in the working area of Andalas Community Health Center were Padang City Elementary School (SDN) 30 at 20.8% and Kartika I-10 Primary School (SD) at 16.4% [5].

Obesity can increase the occurrence of metabolic and degenerative diseases in the future [6]. Changes in lifestyle, eating habits, trends in sedentary activities, changes in work patterns, and advances in transportation are factors that trigger

obesity in urban areas [1, 7, 8]. In addition to food and lifestyle factors, the knowledge factors of nutrition and sleep habits are part of the behavioural component. These risk factors are influenced by the environment, socioeconomic, and culture [9].

Some studies showed there is an association between levels of physical activity with incidence of obesity. Pramono's research proved that mild physical activity increased obesity risk by 5.1 times more than the contribution of snacks were more than 300 kcal/day by only increased 3.2 times [9]. Research by Lugowska (2022) also explained that children with high physical activity were significantly more likely to change body mass categories from initial overweight to healthy weight compared to standard physical activity [10].

The risk factors for obesity that are reportedly also closely related to food intake are sleep duration. Whiting (2021) shows that lack of sleep will impact the quality of person's physical activity, which increases energy consumption a risk factor for obesity [11]. Lack of sleep (2-4 hours a day) can cause leptin levels to decrease by 18% and ghrelin levels to increase by 28%, which can increase the appetite by 23-24%.

Research conducted on children in China has shown a relationship between the length of sleep and the increase in BMI, which boys with a longer period of daily sleep ( $> 9$  h/d) had higher BMI levels, while girls with a shorter period of daily sleep ( $< 8$  h/d) had higher BMI [12]. In another research conducted in Australia, 22.3% of children aged 5-12 years have a short slept duration ( $< 10$  hours). Children who have short sleep duration ( $< 10$  hours) compared to children who get enough sleep with sufficient duration ( $\geq 10$  hours), have 2.61 times greater is of experiencing excess weight [1].

The preliminary study results related to the picture of obesity, length of sleep, and physical activity carried out in early January 2017 obtained as many as 19.9% of students in grades 4.5 and 6 were obese at SDN 30 and SD Kartika I-10 Padang. Other information obtained, 63.3% of students in the past week had a length of sleep  $< 10$  hours, and 76.7% of students classified as having less physical activity. Based on this, it is essential to know the relationship between level of physical activity and duration of sleep with obesity risk among elementary school-age children in the working area of Andalas Public Health Center, Padang City in 2017.

## 2. Methods

### 2.1. Study Area

The observational analytic was used in the study with a case-control approach which ran from January to July 2017. The research location was chosen purposively so that SD Negeri 30 and Kartika I-10 were assigned to the working area of the Andalas Health Center, Padang City, as the research location. Due to the highest incidence of obesity. The population in the study was all 4th, 5th, and 6th-grade students of elementary school 30 and Kartika I-10 Padang. The study

sample was determined based on the case and control inclusion criteria as follows: being willing to be a respondent by signing the informed consent form, being in good health, and being able to communicate well.

### 2.2. Sample

In contrast, the exclusion criteria for this study were the students who were not present at the time of data collection for 3 consecutive times. The sample size was determined using the case-control (matched) formula, the confidence level ( $Z1-\alpha$ ) is 95%, and the power of the test ( $Z1-\beta$ ) is 80% and calculated a drop out of 10% so that the sample was 76 students with 38 cases and 38 controls. This matched case controls with age, sex, and place of school. Then the research sample was taken by simple random sampling so that each sample had the same opportunity to be taken as a sample.

The collected data included the students' nutritional status, physical activity, and sleep duration. Nutritional status data were collected by weighing the body using a digital scale with a precision level of 0.1 kg, and height was measured using a microtoise with a precision level of 0.1 cm. Furthermore, the nutritional status assessment was based on the Central for Disease Control and Prevention (CDC) in 2000. If a person's Nutritional status was  $\geq 95$  percentile, they were categorized obese, and if the nutritional status was  $< 95$  percentile, categorized as not obese. Student physical activity data were collected using the Physical Activity Questionnaire for Children (PAQ-C) instrument and sleep duration data using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. Physical activity data were grouped into nonactive physical activity if the score was  $< 2.5$  PAQ-C and active physical activity if the score was  $\geq 2.5$  PAQ-C. Then the sleep duration was categorized into: 1) the duration of sleep was less if the length of sleep was less than 10 hours, and the duration of sleep was sufficient if the length of sleep was more or same as 10 hours. The Semi-Quantitative Food Frequency Questionnaire was used in interviews to obtain data on dietary intake, a potential confounding variable in the present investigation (SQ-FFQ). During the interview, we referred to the Health Ministry of Indonesia's food photo books to help the respondent's memory so that the data were expected to match the actual picture.

The Nutrition Program Study, Public Health Faculty, Andalas University, and Padang Health Institution approved this study. Before collecting the data using the questionnaires, the respondent was asked for permission and signed the informed consent form. This research also got permission from the principal of elementary schools and school teachers. The time of collecting data was carried out after study time or did not interfere with study time.

### 2.3. Statistical Analysis

Data analysis included univariate, bivariate, and multivariate analysis using a computer program of Statistical Package for the Social Sciences (SPSS). Univariate analysis

was performed by frequency distribution test, then bivariate analysis was conducted to determine the relationship between physical activity and sleep duration with childhood obesity risk. A Chi-square test with a significance level of 0.05 and 95% confidence interval was used to show the relationship between variables. While to determine the risk of physical activity and sleep duration as causes of childhood obesity is estimated by the Odds Ratio (OR). The interpretation of the value of the Odds Ratio (OR) is if the OR value  $> 1$  is a risk factor if the OR value is 1, then it is not a risk factor, and if OR  $< 1$  is a protective factor (reducing the incidence of disease). Then multivariate analysis was carried out by multiple logistic regression tests to estimate the relationship between physical activity and length of sleep with obesity after controlled energy intake, carbohydrate intake, protein intake, and fat intake validly. The modelling used in this study is a risk factor model to validate the relationship of one primary variable with the dependent variable by controlling several confounding variables. A confounding variable is said to be a confounding variable if the p-value  $< 0.05$  and the amount of risk is known from the Prevalence Odds Ratio (POR) value.

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**Table 2.** A score of Physical Activity and Sleep Duration of Primary School Children in the Working Area Andalas Health Centre.

Variables	Case			Control		
	Mean	$\pm$ SD	Min-Max	Mean	$\pm$ SD	Min-Max
Physical activity score	2.13	0.33	1.7 - 2.9	2.51	0.40	1.7 - 3.5
Sleep duration (hours)	8.79	1.19	7-12	9.50	1.01	7 - 11

Based on Table 2, the average score of obese children's physical activity ( $2.13 \pm 0.33$  per day) is slightly lower than non-obese children ( $2.51 \pm 0.40$  per day). Then it was also

### 3. Results

#### 3.1. Characteristics of Elementary School Children

Characteristics of elementary school children, including age and sex, can be seen in table 1 below;

**Table 1.** Distribution of Frequency of School Children based on Age and Gender in the Andalas Health Center Work Area.

Variables	Case		Control	
	f	%	f	%
Age (year)				
9	1	2.6	1	2.6
10	7	18.4	7	18.4
11	11	28.9	11	28.9
12	19	50.0	19	50.0
Total	38	100	38	100
Gender				
Boy	22	57.9	22	57.9
Girl	16	42.1	16	42.1
Total	38	100	38	100

Based on Table 1, the largest percentage of the sample was aged 12 years (50%), and the smallest percentage was aged 9 years (2.6%) in the case and control group. We also got the information that more than half samples in the case group and control group were male gender (57.9%). Then the average physical activity score and sample sleep duration can be seen in Table 2 below;

known that the average sleep duration of obese children ( $8.79$  hours  $\pm 1.19$  per day) was slightly lower than non-obese children ( $9.50$  hours  $\pm 1.01$  per day).

**Table 3.** The Association of Physical Activity and Sleep Duration with Obesity Risk of School Children.

Variables	Obesity				Total		P-Value*)	OR (95%CI)
	Case		Control					
	f	%	f	%	f	%		
Physical activity								
Nonactive	30	78.9	14	36.8	44	57.9	<0.001	6.43 (2.32 to 17.85)
Active	8	21.1	24	63.2	32	42.1		
Total	38	100	38	100	76	100		
Sleep duration								
Less	29	76.3	16	42.1	45	59.2	0.002	4.43 (1.65 to 11.89)
Enough	9	23.7	22	57.9	31	40.8		
Total	38	100	38	100	76	100		

\*)chi-square

#### 3.2. Physical Activity and Sleep Duration with Obesity Risk Among School Children

In the following analysis, physical activity is grouped into 2 categories: 1) active and 2) nonactive. While children's sleep

duration is grouped into less and sufficient categories of sleep duration. Then bivariate analysis was performed by Chi-square test, which can be seen in Table 3;

The results of the analysis show that obese children (cases) have a greater percentage of inactivity (78.9%) than non-obese children (controls) have a greater percentage of

active (63.2%). After being tested statistically, it was found that physical activity was significantly associated with the risk of childhood obesity ( $p$ -value  $< 0.001$ ; OR = 6.43; 95%CI 2.32 with 17.85). Based on OR, values indicate that nonactive children have a risk of 6.43 times higher for being obese compared with active children. Sleep duration obtained obese, children (cases) have a greater percentage of sleep duration (76.3%) compared with non-obese children (controls) who have a greater percentage of sufficient sleep duration (57.9%). The results of the statistical tests significantly indicate a relationship between sleep duration and obesity risk in school children ( $p$ -value = 0.002; OR = 4.43; 95%CI 1.65 with 11.89). Based on OR, the values showed that the children with sleep

duration were less at risk of 4.43 times being obese than children with sufficient sleep duration.

### 3.3. Physical Activity and Sleep Duration on Obesity Risk After Controlling Food Intake

Multivariate analysis with Multiple Logistic Regression tests was conducted to determine the role of other factors (confounding factors), energy, carbohydrate, protein, and fat intake on physical activity and sleep duration at the risk of obesity in elementary school children. The results of the multivariate analysis can be seen in Table 4;

**Table 4.** Multivariate analysis of Physical Activity and Sleep Duration on Obesity Risk after Controlling Confounding Variable.

	POR	95% CI	p- value*
Multivariate analysis of Physical Activity and Obesity Risk after Controlling Food Intake			
First model			
Physical activity	22.96	3.72 to 141.61	0.001
Energy intake	11.15	1.39 to 89.69	0.023
Protein intake	5.57	1.13 to 27.36	0.035
Carbohydrate intake	0.90	0.12 to 6.89	0.921
Fat intake	7.80	1.48 to 41.13	0.015
Last model			
Physical activity	22.97	3.73 to 141.67	0.001
Energy intake	10.40	2.22 to 48.71	0.003
Protein intake	5.62	1.16 to 27.33	0.032
Fat intake	7.88	1.51 to 41.09	0.014
Multivariate analysis of Sleep Duration and Obesity Risk after Controlling Food Intake			
First model			
Sleep duration	2.07	0.58 to 7.37	0.263
Energy intake	10.85	1.81 to 65.13	0.009
Protein intake	2.19	0.59 to 8.15	0.241
Carbohydrate intake	0.85	0.13 to 5.42	0.866
Fat intake	3.10	0.78 to 12.25	0.107
Last model			
Sleep duration	2.26	0.69 to 7.87	0.201
Energy intake	12.33	3.59 to 42.38	$\leq 0.001$
Fat intake	2.90	0.78 to 10.82	0.113

\*) Regression logistics test

The results of multiple logistic regression analysis in Table 4 show that energy, protein, and fat intake are confounding variables affecting the relationship between physical activity and the risk of obesity among school children. Based on the POR value, school children with nonactive physical activity have a 22.97 times greater risk of being obese after controlling by energy intake, protein intake, and fat intake variables than school children with active physical activity. Then, energy intake and fat intake are confounding variables that affect the relationship between sleep duration with the risk of obesity in school children. Based on the POR value, children with less sleep duration have a risk of 2.26 times obesity after being controlled by energy and fat intake variables.

## 4. Discussions

### 4.1. Characteristics of School Children

The results found that half of the school children involved as samples were obese at 12 years old (50%), and more than

half were male. This finding is similar to Era and Rachmalia (2017), who found that half of the obese school children were at the age of 10-12 years (52.8%), and more than half were male (59.1%).

Theoretically, it can be explained that weight gain starts at 5-7 years, during puberty or early menarche adolescence, especially among adolescent girls. During childhood, total body fat increased by 16% in women and 13% in men. When entering early adolescence, men have higher muscle mass than women.

### 4.2. Physical Activity

School children's physical activity is measured using PAQ-C, which is intended to explore the information about activities that are usually done by children daily. Based on the univariate analysis results, the average physical activity score of obese school children or a case group (2.134 per day) is lower than the average physical activity score of school children who are not obese or in the control group (2.508 per

day). Then after physical activity is grouped into active and nonactive categories, most school children have inactive physical activity, and the largest percentage is found in school children with obese nutritional status (case group), about 78.9% compared to school children with non-obese nutritional status (group control) equal to 36.8%. This result is not much different from Mekonnen, et al. (2018) found that a lack of physical activity in a moderate category is associated with overweight and obesity among school-aged children [8].

#### **4.3. Sleep Duration**

The sleep duration of school children was assessed from the interviews using the PSQI questionnaire. The results showed that the average sleep duration of school children with obese nutritional status or group of cases was shorter, about 8.79 hours per day, compared with school children with non-obese nutritional status or the control group, about 9.50 hours per day. The average sleep duration of obese school children, when compared with the number of sleep needs of children aged 6 - 12 years, is 10 hours a day, and then the child's sleep time is classified as less [13]. Furthermore, after being grouped into categories of lack of sleep duration and enough information is obtained that most of the sample group cases of obese children have a duration of sleep less than 10 hours per day, which is equal to 76.3% compared to the control group or non-obese children that are 42.1%. This study's results align with Marfuah (2013) research in Yogyakarta, which states that children with less sleep duration are found in obese children [1].

#### **4.4. Physical Activity and Incidence of Obesity Risk**

Based on the results of bivariate analysis, there was an association between physical activity and the risk of obesity in school children at 30 elementary schools and Kartika I-10 Padang (p-value <0.05) with a magnitude of risk (OR) of about 6.43. It means that school children with inactive physical activity had a risk of 6.43 times being obese than those with active physical activity. This finding is supported by the research of Syam (2021), which also found a significant relationship between physical activity and the incidence of obesity in elementary school students Makasar [14]. The same result is known through Mekonnen's study, which found that increased odds of obesity are performed in low physical activity than in moderate activity (OR=2.87, 95% CI: 1.21-6.82) [8]. Yuli (2014) in Setyowati (2014) obtained different results who found no significant relationship between physical activity and the nutritional status of obesity in children [15]. The difference in the results obtained can be seen from the sample distribution based on physical activity.

The results show that physically active children or being involved in active physical activity can regulate food intake and energy balance due to increased appetite sensitivity. However, insulin sensitivity is a precise mechanism between physical activity that can encourage appetite regulation. Active activity can reduce the occurrence of accumulation of fat in the body associated with an increase in insulin

sensitivity and the emergence of a feeling of fullness. Excessive food intake, when accompanied by active physical activity, can reduce the risk of obesity, especially in school children. A further mechanism where physical activity can affect appetite is to change the action of intestinal peptides. The hormone involved in the short-term regulation of appetite is the cholecystokinin hormone (CCK), and CCK levels have been shown to increase after physical activity [16].

#### **4.5. Sleep Duration and Incidence of Obesity Risk**

The results showed a statistically significant relationship between the duration of sleep with the risk of obesity in elementary school children (p-value <0.05) with a magnitude of risk (OR) of 4.43. The result means school children with less sleep duration are 4.43 times greater risk to be obese than those with sufficient sleep duration. This finding is supported by the study of Chen, et al (2022), who also found an association between sleep duration and significantly increased the incidence of obesity in children with an OR value of 1.32, 95% CI: 1.06-1.64 [17]. The study is also the same with Hao Wang, et al (2018) who found an association between sleep duration with the risk of obesity [18]. Specifically, these studies identified that a child who sleeps 8 hours a day has the lowest risk for obesity.

Based on theory, it can be explained that several hormones mediate interactions between short sleep time and metabolism and high body mass index (BMI). The hormone that plays a role in regulating appetite is leptin and ghrelin. Children who have less sleep (2-4 hours a day) can lose leptin hormone by 18% and an increase of 28% in ghrelin, which impacts increasing children's appetite by 23-24% [3]. Both hormones are closely related to one's hunger and satiety process. We know that ghrelin works by activating NPY-producing neurons in the hypothalamus and stimulating appetite. In contrast, the leptin hormone works by inhibiting NPY (appetite stimulant) and stimulating the release of melanocortin (appetite suppressant) [19].

#### **4.6. Physical Activity and Sleep Duration with Incidence of Obesity Risk After Controlling for Child Food Intake**

Further analysis by multiple logistic regression tests were used to determine confounding variables (energy intake, protein intake, carbohydrate intake, and fat intake) that affected the association between physical activity, and sleep duration with the risk of obesity in school-aged children. The analysis results show that energy, protein, and fat intake confounded physical activity with the risk of obesity. In contrast, the variable energy intake and fat intake confounded the sleep duration and the risk of obesity. Besides determining the confounding variable, an interaction test is also carried out to determine the interaction between variables. The results of the analysis revealed that no variables interacted with physical activity and sleep duration with the risk of obesity.

A person's weight reflects the long-term balance between energy intake and energy output. According to Almatier, excessive energy from food intake of energy sources will be

stored as fat in the body [20]. If this condition occurs continuously, it can cause an accumulation of fat in the body and trigger obesity. This is supported by the research of Yamin *et al.* (2013), which states that excessive energy intake has a risk of 4,058 times greater for obesity (OR = 4,058; 95% CI: 1,320 - 2,417) [21].

Protein can be relied upon as a source of energy, but not in a sudden (acute) state. The body needs protein, but consuming too much protein will also cause problems. An excessive protein intake will cause deaminase, leading to excess protein in the body being stored in fat, which will cause obesity. This is in line with the study of Ji-Soo (2022) which proved that the protein ratio were significantly higher in the obese and severely obese groups than in the overweight group [22]. Institute of Medicine shows that consuming excess fat is more in the group of obese children [23]. WHO recommends consuming 20-30% of total energy needs. Every one gram of fat gives nine calories. Enough fat is needed in the body [24]. However, too much fat reserve (more than 20% of normal body weight) will cause obesity leading to more severe health problems [20].

## 5. Conclusion

The study results show that almost all school children with obese nutritional status have inactive physical activity and less sleep duration than those with non-obese nutritional status. Physical activity and child sleep duration are proven to be associated with the risk of obesity in this research. School children with less active physical activity are 22.96 times obese compared to children with active physical activity after controlling energy, protein, and fat intake. Furthermore, school children with a sleep duration are less than 2.26 times at risk of obesity than those with sufficient sleep duration after controlled energy intake and fat intake. For this reason, it is recommended that the school institution and parents motivate school children to be more active in physical activities and get adequate sleep every day so that the risk of obesity can be prevented.

## Conflicts of Interest

All the authors do not have any possible conflicts of interest.

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