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The Relationship Between Lack of Sleep and Excessive Weight

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ABSTRACT

Sleep is necessary for the body to function properly, so the duration and quality of sleep are significant for human health. Several studies have found that sleep is vital in regulating physiological functions such as energy balance, appetite, and body weight. Several studies also show increased appetite due to decreased leptin levels and increased ghrelin levels due to lack of sleep. Poor sleep quality reduces activity and results in excess body weight. The aim of this research was to see the relationship between lack of sleep and the incidence of excess body weight at Junior High School of Bakti Mulya 400, South Jakarta, Indonesia. The method used in this research was a correlational descriptive method. The research was conducted on 72 students of Bakti Mulya 400 Middle School. Body height was measured using a microtome and body weight was measured using a weight scale. Body Mass Index is calculated using the formula according to WHO. Respondents were asked to fill out a questionnaire. Data entry and analysis continued using SPSS 23 program. Based on the results of research on 36 people with a Body Mass Index of 18.5-22.9, 12 people didn't get enough sleep, and 24 people got enough sleep. Meanwhile, of 36 people with a Body Mass Index > 23, there were 21 people didn't get enough sleep, and 15 got enough sleep. The conclusion from the research results is that sleep duration has a significant relationship with excess body weight, but sleep quality does not have a substantial relationship with excess body weight.

Keywords: Appetite, Excess body weight, Ghrelin, Lack of sleep, Leptin

INTRODUCTION

Sleep is one of the most important activities in human life. The duration and quality of sleep are significant for human health. Sleep is necessary for the body to function correctly because many systems in the body only work when humans sleep and there are also systems in the body that must be rested. Even though sleeping is a pleasant activity for most people, there are people who find it difficult to sleep at night. Even though I had intended to sleep, my eyes couldn't close, and I didn't feel sleepy. Apart from difficulty falling asleep, frequently waking up indicates poor sleep quality1. There are several theories that explain why lack of sleep can increase the likelihood of obesity. 1.) People who lack sleep will be too tired to do activities so the process of burning calories is reduced. 2.) People who don't sleep enough will eat more because they are awake later and thus have more time to eat. 3.) Lack of sleep can also be a lack of sleep to being overweight

Everyone's sleep needs are different, but on average, adults need around seven to eight hours per night, teenagers need about nine hours per night, and toddlers need about 16 hours per day. Two internal factors regulate sleep:

1. Internal Factors

a. Homeostasis

Homeostasis is the body's process of maintaining a stable state of blood pressure, body temperature, and acid-base balance.

The length of sleep each night is regulated by homeostatic control. Although the neurotransmitters involved in sleep homeostasis are not fully understood, evidence suggests that adenosine can induce sleep. As long as the body is awake, the amount of adenosine continues to increase and causes the need for sleep to continue until it is finally unbearable. Conversely, the amount of adenosine decreases during sleep, reducing the need for sleep. Lack of sleep causes the body to demand additional sleep to cover the deficiency by taking a nap or sleeping longer in the next sleep cycle. If not, the body must accept the consequences, namely negative changes in body performance, ability to think, and mood.

b. Circadian Rhythms

In humans, the biological clock is found in a collection of neurons in the brain's hypothalamus called the suprachiasmatic nucleus (SCN). Light and darkness regulate circadian rhythms and help the body determine when it is time to sleep and wake up.

The homeostasis system makes people increasingly sleepy as time goes by while awake, regardless of whether it is day or night. Meanwhile, circadian rhythms help people stay awake as long as there is light, encouraging people to sleep immediately after dark. Because of this interaction, it has been agreed that the best quality of sleep is when you sleep according to your circadian rhythm, go to bed, and wake up simultaneously every day, including holidays[16,17].

2. Sleep Cycle

Sleep consists of two phases: the REM (Rapid Eye Movement) phase and the NREM (Non Rapid Eye Movement) phase. The NREM phase is divided into stages: Stage One, Stage Two, Stage Three, and Stage Four, followed by the REM phase. The NREM and REM phases occur alternately around 4-6 cycles a night [1,19]

a. NREM Phase (Non Rapid Eye Movement)

A stable and slow heart rate, respiratory rate, and low blood pressure characterize NREM. NREM is the quiet stage of sleep.

1. Stadium One

At this stage, a person will experience shallow sleep and can be awakened easily by sounds or other disturbances. Brain wave frequency decreases from alpha waves (8 – 13 Hz) to theta waves (4 – 7 Hz). The eyes will move slowly, and muscle activity will slow down. A person enters the hypnagogic stage.

2. Stadium Two

It usually lasts 10 to 25 minutes. Heart rate slows, and body temperature decreases. At this stage, eye movement stops. Brain waves show the presence of sleep spindles and K-complex. Someone experiences sleep paralysis.

3. Stadium Three

This stage is more profound than the previous stage. At this stage, the individual has difficulty waking up, and if they wake up, the individual cannot immediately adjust and often feels confused for several minutes. Brain waves decrease to delta waves (0.5 – 4 Hz).

4. Stage Four

This stage is the deepest stage of sleep. Blood pressure and body temperature decrease, respiratory frequency is slower, and the body does not move. Delta waves become more pronounced.

Stages three and four are considered deep sleep and are the part of sleep needed to feel well-rested and energetic during the day. The NREM sleep phase usually lasts between 70 and 100 minutes, after which it will enter the REM phase. During the first hour of REM, the process is faster and becomes more intense and more prolonged when morning approaches or when one wakes up[1,19]

b. REM Phase (Rapid Eye Movement)

In normal sleep, the REM sleep period lasts 5-20 minutes, on average occurring every 90 minutes, with the first period occurring 80-100 minutes after a person falls asleep. During REM sleep, the eyes rush in various directions, even though the eyelids remain closed. Breathing also becomes more rapid,

irregular, and shallow. Heart rate and pulse increase. The brain wave frequency increases to very active beta waves (12 Hz), accompanied by active dreams and external muscle tone until temporary paralysis occurs [1,19].

If a person does not experience REM enough, the next day, he will tend to be hyperactive less able to control his emotions, and his appetite will increase. Meanwhile, if NREM is not enough, the physical condition becomes less agile [19]

Epidemiology of Overweight and Obesity

According to WHO, obesity is defined as an abnormal or excessive accumulation of fat likely to cause several health risks to individuals. Obesity is different from overweight, which refers more to being overweight [18].

According to the World Health Organization (WHO), there was an increase in the prevalence of obesity in children and adolescents by 2.5% from 1990 to 2010. Around 35 million of the 45 million children worldwide who are obese come from developing countries. In the last ten years, the prevalence or incidence of obesity throughout the world has shown a significant increase. Currently, 1.6 billion adults worldwide are overweight, and at least 400 million of them are obese.[4.22]

The prevalence of overweight and obesity, according to the 2013 Basic Health Research (Riskesdas) has increased compared to the 2010 Riskesdas. The current incidence of excess weight in adolescents is proven by the national prevalence based on Riskesdas data (2013). The prevalence of underweight adults is 8.7 percent, overweight 13.5 percent, and obesity 15.4 percent. Nationally, the problem of obesity in children aged 5-12 years is still high, namely 18.8 percent, consisting of obesity 10.8 percent and obesity 8.8 percent. The prevalence of obesity in adolescents aged 13-15 years in Indonesia is 10.8 percent, consisting of 8.3 percent obese and 2.5 percent very obese [7]

Fat and Energy Balance

The structure of the human body is composed of 60-65% water, 10-28% fat, 15-18% protein, 6% minerals, 1.5% carbohydrates, and a little vitamin. Fat, as the second largest body component after water, is divided into two parts:

1. Essential (structural) fat, namely fat, which is part of the structure of the brain, bone marrow, nervous tissue, and other organs.
2. Stored fat, which functions as a storage place for energy reserves. Stored fat (depot) is in the tissue cells under the skin, between and inside muscle cells, in the mammary glands, and in adipose tissue in the abdominal and chest cavities and around the organs located in both cavities.

The fat percentage range in average men is between 10-18% of body weight and in women 18-27%. The percentage of total fat energy reserves in men is 4.4%, and in women is 9% [5]

Fat tissue is the largest energy storage depot for mammals. Its main task is to store energy in triglycerides through the lipogenesis process, which occurs in response to excess energy, and mobilize energy through the lipolysis process to respond to energy deficiency. Under normal circumstances, these two processes are tightly regulated [2]

Leptin hormone

Leptin comes from Greek which means thin. This hormone was first identified in 1994. Leptin is a hormone produced by adipose tissue and is a member of the adipocytokines which play a role in adipose tissue hormone signaling. Leptin is regarded as a body weight regulatory hormone. lt binds to a specific receptor in the brain and functions as a lipostat. When the fat stores in the adipose tissue are adequate, leptin levels are high. This signals to restrict the feeding behaviour and limit fat deposition. Peptin stimulates lipolysis and inhibits lipogenesis. Any genetic defect in leptin or its receptor will lead to extreme overeating and massive obesity. Treatment of such obese individuals with leptin has been shown to reverse obesity[34]

Leptin has an important role in signaling that regulates energy homeostasis, reducing

appetite, adipose tissue mass and body weight. Leptin is secreted periodically and has diurnal variations, leptin concentrations are high in the evening and morning. Leptin expression increases after meals and the presence of insulin, glucocorticoids, endotoxins, and cytokines. Leptin expression decreases in hunger and the presence of testosterone, thyroid hormone and low temperature[8]. Studies in mice and rats have shown that the hypothalamus is central to the regulation of food intake and body weight. Through research it has also been shown that plasma leptin can penetrate the blood brain and cerebrospinal fluid barriers. After being released by fatty tissue into the blood vessels, leptin penetrates the blood brain barrier and binds to hypothalamic leptin receptors, providing information regarding the status of energy supplies in the body. This will result in a decrease in appetite and an increase in energy expenditure from available fat6In the long term, leptin can reduce appetite body weight, increase physical activity, and change endocrine function and metabolism. Leptin also plays a role in short-term food intake and body weight regulation. Leptin is produced by adipose tissue and in the stomach in small quantities. In the short term, leptin made from the stomach can control the food intake that can be received. The short-term role of leptin is demonstrated by peptides that induce gastric leptin release. Gastric leptin secretion is stimulated by insulin, a hormone that is released into the blood vessels immediately after eating [6]

Increasing the amount of leptin causes a decrease in appetite, and decreasing the amount can increase appetite. Apart from that, leptin also increases the rate of fat breakdown. If the amount of leptin increases, the metabolic rate will also increase. If the amount of leptin decreases, metabolism will slow down. The number of calories burned is regulated by thermogenesis, a process by which the body, especially muscles, produces heat. Based on research by Monash University in Australia, the hormone leptin can increase thermogenesis, thereby helping burn fat [9]

From several previous studies, it is known that lack of sleep affects the amount of leptin. During sleep, leptin increases, informing the brain that the body has plenty of energy and does not trigger feelings of hunger. When you don't get enough sleep, the amount of leptin will be minimal, making the brain think the body lacks energy. The brain will trigger feelings of hunger even though the body does not need food and will store the calories eaten as fat. The amount of leptin depends mainly on the duration of sleep. Several studies have found that sleeping less than six hours per night is associated with a decrease in the hormone leptin, reduced insulin sensitivity, and an increase in the hormone ghrelin[12,13,14]

The effect of sleep duration on the amount of leptin is through the mechanism of increasing sympathetic nerve activity. Leptin release is inhibited by sympathetic nerve activity. The sympathetic nerves work when the body is awake, so lack of sleep can cause a decrease in leptin release caused by increased sympathetic nerve activity.[15]

Ghrelin hormone

In contrast to leptin, ghrelin acts as an appetite stimulator. It is released most in the stomach, and when the amount increases, it will send hunger signals to the brain and provide information that now is the time to eat. After eating, the amount of ghrelin decreases within three hours. Age, gender, BMI, amount of insulin, leptin, and Growth Hormone (GH) influence the amount of ghrelin. Leptin can reduce the amount of ghrelin. Strenuous exercise increases the amount of GH, which can reduce hunger and food intake by reducing the amount of circulating ghrelin[11], divide the ghrelin pathway in increasing appetite into three. First, after being released by the stomach into the blood vessels, ghrelin will penetrate the blood-brain barrier and bind to its receptor in the hypothalamus. Second, ghrelin goes to the brain via the vagal nerve and nucleus tractus solitarius. Third, ghrelin is produced in the hypothalamus and directly affects various hypothalamic nuclei[6]

Cortisol hormone

Cortisol is a steroid hormone from the glucocorticoid group which is generally produced by the adrenal glands. This hormone is usually produced when you wake up in the morning, when exercising, and also during acute stress. Research also shows that the hormone cortisol increases in people who don't get enough sleep. Cortisol plays an important role in metabolism, it is involved in regulating protein and carbohydrate metabolism by promoting protein degradation and the conversion of amino acids into glucose. As a result, the blood glucose level rises[31]. Cortisol hormone increases glucose production by the liver through gluconeogenesis metabolism, but inhibits the performance of the insulin hormone, resulting in insulin resistance. When resistance occurs, insulin blocks the performance of leptin which sends satiety signals to the brain, as a result the brain does not respond so the body immediately stops eating and the body thinks it still needs energy. If this is the case, the person will continue to feel hungry and want to eat continuously [10.21].

Repeated elevation of cortisol can increase body weight. The first pathway is through visceral fat storage. Cortisol can move triglycerides from storage sites to visceral fat. Cortisol also helps the development of adipocyte cells into mature fat cells. At the cellular level, the enzyme 11-hydroxysteroid dehydrogenase converts cortisone to cortisol in adipose tissue. The more this enzyme is in visceral fat cells, cortisol production at the tissue level will increase. Apart from that, visceral fat cells have more cortisol receptors than subcutaneous fat[21]

Based on the background above, where many factors influence a person's lack of sleep, the research aims to see the relationship between lack of sleep and the incidence of being overweight.

MATERIALS & METHODS

Types of research

The method used in this research is a correlational descriptive method using a quantitative approach, namely describing the relationship between lack of sleep and excess body weight.

Population and Sample

The population in this study were all students at Junior high school Bakti Mulya 400, South Jakarta - Indonesia. The sample in the study was a part of the population. Researchers used a sampling technique using the simple random sampling method.

Determine the number of samples:

$$n = \frac{N}{1 + N(e)^2}$$

Information:

n = sample size

N = population size

e = percent allowance for inaccuracy due to sampling error

which can still be tolerated or desired = 10%.

With a population of 248 people, the required sample size was 72 divided into: 36 people with a normal BMI, namely 18.5 – 22.9 and 36 people with an excessive BMI, namely > 23.

Inclusion and Exclusion Criteria

1. Inclusion Criteria

a. The student at Junior high school of Bakti Mulya 400, South Jakarta - Indonesia

b. Have a Body Mass Index (BMI) > 18.5

2. Exclusion Criteria

a. Smoke

b. Currently taking drugs

c. Having underweight or a Body Mass Index (BMI) < 18.5

Variable Identification

This research discusses two variables, namely the independent variable and the dependent variable. The independent variable is a variable that influences or is the cause of the dependent variable. Meanwhile, the dependent variable is a variable that is controlled or is a result of the existence of the independent variable. In this study, the independent variables are (X1) sleep duration, (X2) sleep quality, and (X3) eating

habits, and the dependent variable (Y) is body weight.

Ways of working

Researchers tested the validity and reliability of the questionnaire using 30 samples. Then, the researcher made a research permission letter through the dean to be submitted to SMP Bakti Mulya 400. After the school was approved, the researcher measured the respondents' height and weight and asked them to fill out a valid and reliable questionnaire. The points asked in the questionnaire are sleeping hours, sleep quality, eating habits, and other activities. Next, data entry and analysis continued using the SPSS 23 program.

RESULT AND DISCUSSION

The research results that describe the relationship between sleep duration and body weight can be seen through the results of data processing using SPSS 23 as in Table 1

Table 1 Chi-Square Analysis of Sleep Duration - Excess Body Weight

Sleep Duration	Weight				X^2	P
	Normal		Excessive			
	N	%	N	%		
≥ 8 hours	24	58,33	15	33,33	4,531	0,03*
< 8 hours	12	41,67	21	66,67		
Total	36	100	36	100		

Note: X^2 = Chi Square; P = *p-Value*; *Meaningful/significant

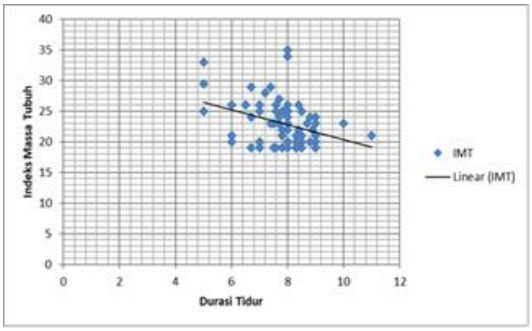
Table 1 shows sleep duration with the incidence of excess body weight. The Chi-Square test analysis shows a significant relationship between sleep duration and the incidence of excess body weight, which can be seen from $X^2 = 4.531$ with p-value = 0.03 because the p-value is smaller than the significance level of 0.05.

If sleep duration is divided into two categories, namely less than eight hours and more than eight hours, it is known that of the 36 children with excess body weight, 66.67% slept less than eight hours every day, and 33.33% slept more. equals eight hours every day.

Pearson Product-Moment Correlation (r) analysis explains the strength and direction of the relationship (correlation) between two variables. The correlation number ranges from -1 to +1. A correlation number of more than 0 indicates a positive association; that is, if variable X increases, then variable Y also increases. A correlation figure of less than 0 shows a negative association; if variable X increases, then variable Y decreases. The closer the correlation number is to 1, the stronger the correlation. The r correlation number ranges from 0.1-0.3, indicating a weak correlation, 0.3-0.5 showing a moderate correlation, and 0.5-1.0, indicating a strong correlation. The correlation number r can be calculated using the formula:

$$r = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

From calculating r based on the formula above, where x is sleep duration, and y is BMI, we get r of -0.351. From these results, sleep duration and BMI have a moderate correlation and a negative association. This can be seen in the following curve:



Picture 1. Pearson Product-Moment Correlation (r) analysis

The curve is said to be linear because all pairs of points (xi, yi) appear clustered around a straight line. This indicates a relationship between variable x (sleep duration) and y (BMI). A downward curve indicates a negative association; namely, if sleep duration increases, then BMI will decrease, and if sleep duration decreases, then BMI will increase.

People who sleep less often are less likely to experience enough REM sleep, so the next day they will show a tendency to be hyperactive, less able to control their emotions, and have an increased appetite.

Table 2. Chi-Square Analysis of Sleep Quality - Excess Weight

Sleep Quality	Weight				X^2	P
	Normal		Excessive			
	N	%	N	%		
Good	32	88,89	33	91,67	0,158	0,69*
Bad	4	11,11	3	8,33		
Total	36	100	36	100		

Note: X^2 = Chi Square; P = *p-Value*; *Meaningful/significant

***No significant relationship**

Table 2 shows sleep quality with the incidence of excess body weight. The results of the analysis using the Chi-Square test show that there is no significant relationship between sleep quality and the incidence of excess body weight, which can be seen from X^2 = 0.158 with p-value = 0.69 because the p-value is greater than the significance level of 0.05

Table 3. Chi-Square Analysis of Eating Habits - Excess Weight

Eating Habit	Weight				X^2	P
	Normal		Excessive			
	N	%	N	%		
Good	22	61,11	26	72,22	1,000	0,317*
Bad	14	38,89	10	27,78		
Total	36	100	36	100		

Note: X^2 = Chi Square; P = *p-Value*; *Meaningful/significant

***No significant relationship**

Table 3 shows eating habits with the incidence of being overweight. The results of analysis using the Chi-Square test show that there is no significant relationship between eating habits and the incidence of excess body weight, which can be seen from X^2 = 1.000 with p-value = 0.317 because the p-value is greater than the significance level of 0.05. This shows that, based on this research, eating habits do not affect body weight. The research found that out of 72 children, 39 (54.16%) felt hungry when staying up late. This can occur due to an increase in the hormone ghrelin and a decrease in the hormone leptin, so the brain will send hunger signals. It was also found that 29 out of 72 children (40.27%) felt tired the next day after staying up late. This causes children's activity to decrease so that fat burning is reduced, resulting in excess body weight.

The research results also showed that 41 out of 72 children (56.94%) consumed glucose while staying up late. When glucose enters the body, the pancreas will secrete insulin. This insulin can block the action of the hormone leptin. If this continues to happen, it can result in excess weight. Apart from that, of the 72 children, 31 children (43%) did not regularly exercise at least three times per week. As explained in Chapter II, not exercising regularly can cause the body to become resistant to leptin so the body cannot respond to commands or signals from this hormone.

CONCLUSION

Based on the research results obtained, the following conclusions can be drawn:

1. There is a significant relationship between the length of sleep (sleep quantity) and the incidence of excess body weight.
2. Respondents tend to consume foods containing glucose when staying up late.
3. Respondents who don't get enough sleep will feel more tired so their activity will decrease.
4. There is no significant relationship between sleep quality and eating habits and the incidence of excess weight.

Declaration by Authors

Ethical Approval: Approved

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