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# SLEEP DURATION, ANTHROPOMETRIC MEASUREMENTS AND METABOLIC SYNDROME IN OVERWEIGHT/OBESE ADOLESCENTS

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***ABSTRACT***

**Introduction:** *Adolescents have sleep problems, as their sleep duration does not meet the recommended sleep duration of 8-10 hours, leading to various sleep-related problems. Sleep duration is suspected to have detrimental effects on health, such as non-communicable diseases including obesity, cardiovascular disease (CVD), and type 2 diabetes mellitus (T2DM). However, the correlation between sleep duration and the prevalence of obesity and metabolic syndrome (MetS) is still conflicting, especially in the adolescent population. This study aimed to examine and analyze the effect of sleep duration on anthropometric measurements and MetS in overweight/obese adolescents.* **Methods:** *A cross-sectional study involving healthy overweight/obese adolescents was conducted from September to October 2019 to evaluate the effect of sleep duration on anthropometric measurements, lipid profiles, fasting blood glucose levels, and blood pressure in overweight/obese adolescents.* **Results and discussion:** *A total of 197 subjects showed no significant differences in body height, BMI, waist circumference, blood pressure, and lipid profile based on sleep duration categories. Subjects with short sleepers were older than those with sufficient sleep ($p<0.05$). However, long sleepers were heavier, had larger BMI-for-age z-scores, and larger waist circumferences than sufficient and short sleepers ($p<0.05$). However, the differences between the short, sufficient, and long sleepers were U-shaped. Sleep duration was not correlated with MetS or MetS components (abdominal obesity, hyperglycemia, hypertriglyceridemia, hypertension, and low HDL-c).* **Conclusion:** *Long sleepers (>11 h/night) were heavier, had greater BMI-for-age z-scores, and larger waist circumference than (<sufficient sleeper (6-10 h/night), or short sleepers 6 h/night).*

***Keywords***: *Adolescents, Metabolic syndrome, Overweight, Sleep duration*

## INTRODUCTION

The recommended sleep duration for adolescents is 8–10 hours (Paruthi et al., 2016). However, owing to many factors, adolescents have a higher risk of sleep problems (Illingworth, 2020), which affects their sleep quality (Jakobsson et al., 2019). In Turkey, 50.37% of adolescents who slept less than 8–10 hours per night experienced sleep problems due to alcohol/cigarette use, Internet usage, watching TV, eating before going to bed (Tetik and Kar Şen, 2021), caffeine intake, noise, traffic, and pollution. This leads to insufficient sleep, reduced sleep quality, and irregular sleep patterns, which in turn contribute to various health consequences (Vandendriessche et al., 2022).

The relationship between sleep duration and overweight/obesity is well documented. Some studies suggest that short sleep duration contributes to obesity, whereas others indicate that long sleep duration may have a protective effect (Deng et al., 2021; Mitchell et al., 2013; Sunwoo et al., 2020). However, another study found that the prevalence of short sleep duration was related to females, with the risk of being overweight/obese by 1.95-times for a sleep duration of 7 h/day. However, the risk of obesity-related sleep duration is a U-shaped association (Wang et al., 2018). This study aimed to determine the effect of sleep duration on anthropometric measurements and metabolic syndrome in overweight/obese adolescents.

## METHODS

A cross-sectional study involving healthy overweight/obese adolescents was conducted from

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September to October 2019 to evaluate the effect of sleep duration on anthropometric measurements, lipid profiles, fasting blood glucose levels, and blood pressure in overweight/obese adolescents.

This study recruited healthy overweight/obese adolescents aged 13–18 years from schools in Surabaya and Sidoarjo, Japan. The subjects were required to have no history of drug or alcohol use. No infectious, chronic, or congenital diseases. The exclusion criteria were taking dyslipidemia medication or hormonal therapy for 6 months before the study, taking antibiotics or steroids, or medication that influenced body weight.

Two researchers conducted anthropometric measurements by asking the subjects to wear minimum clothes, without accessories or a tail (for females), hats, watches, shoes or shocks, belts, etc. Body weight was measured using a digital scale (Seca Robusta 813) by asking the subjects to step on the scale after “on mode” was activated for 30 seconds, and then the body weight displayed on the screen was recorded. For body height measurements, the subjects were asked to step on a stadiometer floor plate (Seca 213 portable stadiometer) in a straight position, and then the head positioner was pulled down until it touched the head. Height was recorded according to the scale position. To measure waist circumference, the researchers wrapped the measuring tape (Seca 201) around the subject’s stomach in the standing position, above the hip bones, and in line with the belly button. Make sure the tape measure is not coiled, neither too tight nor too loose. Stick the end of meter 0 in the navel, while the rest goes around the stomach, ensuring that the tape is not twisted. Waist circumference was measured at the end of the exhalation period. Hip circumference was measured by wrapping the measuring tape around the largest part of the hip in the standing position to ensure that the tape was not twisted. The hip measurement was located at the end of the tape, where it met zero on the measuring tape wrapped around the body.

Blood pressure was measured by placing the cuff on the right arm and then tightening it according to the arm’s size. Subsequently, the power button was pressed and the microprocessor was allowed to drive air pressure into the cuff. Blood pressure appears in the manometer tube column. During the measurements, the participants were in a sitting position after 10 min of rest. Measurements were performed using an Omron Automatic Blood Pressure Monitor HEM-8712 (Omron Health Care Co., Ltd, Japan).

Blood analysis was performed via vena cubitus by a laboratory employee at a volume of 5 ml and then placed in a non-EDTA tube. Name, sex, birth date, and school identity were recorded using labelled paper and wrapped around a tube for identification. After that, the tube was placed in an ice box containing an ice block and then transported to the laboratory for further analysis, including fasting blood glucose, fasting insulin, and lipid profile. Before the blood was collected, the subjects were asked to fast for 12 h or stop consuming food after dinner.

The ethical clearance study was reviewed ethically and declared appropriate by the Health Research Ethical Committee, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia, number 141/EC/KEPK/FKUA/2020.

The statistical analysis conducted in this study included tests of normality, Levene’s test of homogeneity, one-way ANOVA (or Kruskal Wallis) with further analysis (post hoc) LSD, or Mann Whitney and Fischer’s exact test, with a significance value of $<0.05$.

## RESULTS AND DISCUSSIONS

A total of 197 subjects were recruited, consisting of 98 males (49.75%) and 99 females (50.25%). No significant differences were observed in body height, BMI, HAZ, hip circumference, screen time, fasting blood glucose (FBG), total cholesterol, HDL-c, LDL-c, triglycerides, and blood pressure among short sleepers (<6 h/day), sufficient sleepers (6–10 h/day), and long sleepers (>10 h/day) ($p > 0.05$).

There was at least one pair of groups with a significant difference in the age distribution (p=0.009). Subjects with short sleepers were older than those with sufficient sleep (p=0.006). Even though there was no significant difference, long sleeper adolescents were older than those in the other groups. Body weight variables showed that at least one pair of groups had a significant difference (p=0.001); subjects with long sleepers

**Table 1.** Subject's characteristics

| Variables | All subjects | Short (n=28) + SD | Sufficient (n=133) x + SD | Long (n=3) x + SD | p value |
|---|---|---|---|---|---|
| Age, months old | 187.58 ± 18.10 | 195.93 ± 16.37 | 185.92 ±18.03 | 202.00 ±13.08 | 0.009[1] |
| Body weight, kg | 90.03 ± 15.29 | 93.99 ± 13.63 | 88.85 ±15.09 | 117.90 ±10.61 | 0.001[1] |
| Body height, cm | 147.22 ± 24.13 | 145.62 ±27.14 | 147.53 ±23.62 | 145.00 ±31.75 | 0.934[2] |
| BMI, kg/m2 | 34.39 ± 5.07 | 34.97 ±4.83 | 34.19 ±5.07 | 40.07 ±5.78 | 0.111[1] |
| BMI-for-age z-score | 2.95 ± 0.63 | 2.99± 0.64 | 2.93 ±0.61 | 4.13 ±0.82 | 0.004[1] |
| HAZ | -0.51 ± 1.08 | -0.68 ±0.84 | -0.49 ±1.12 | -0.83 ±0.38 | 0.597[1] |
| Waist circumference, cm | 98.90 ± 11.47 | 101.51 ±11.80 | 98.12 ±11.17 | 117.67 ±7.57 | 0.005[1] |
| Hip circumference, cm | 111.48 ± 10.08 | 111.66 ± 10.97 | 111.21 ± 9.80 | 124.67 ± 12.06 | 0.071[1] |
| Screen time, hour/day | 3.15 ± 1.42 | 3.46 ± 1.50 | 3.07 ± 1.39 | 4.67 ± 1.53 | 0.102[2] |
| FBG, mg/dl | 87.13 ± 6.77 | 87.29 ± 7.54 | 87.04 ± 6.67 | 91.00 ± 5.20 | 0.220[2] |
| Total cholesterol, mg/dl | 174.04 ± 34.13 | 172.86±26.22 | 174.18 ± 35.53 | 178.00 ±26.51 | 0.963[1] |
| HDL-c, mg/dl | 43.40 ± 7.72 | 42.43 ± 6.69 | 43.64 ±7.81 | 39.00 ±12.49 | 0.455[1] |
| LDL-c, mg/dl | 115.45 ± 29.08 | 115.86±19.84 | 115.19 ±30.56 | 126.00 ±18.25 | 0.815[1] |
| Triglyceride, mg/dl | 116.12 ± 62.50 | 109.10±56.58 | 116.80 ± 63.69 | 144.00 ±55.67 | 0.468[2] |
| Systolic-BP, mmHg | 127.15 ± 12.80 | 125.82 ± 12.31 | 127.27 ±12.97 | 132.67 ± 9.29 | 0.626[2] |
| Diastolic-BP, mmHg | 82.64 ± 9.29 | 82.32 ± 8.43 | 82.64 ±9.47 | 85.33 ± 9.23 | 0.895[2] |

[1]Oneway anova; [2]Kruskal Wallis
Abbreviations: BMI, body mass index; HAZ, height-for-age z-score; FBG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; LDL-c, low-density lipoprotein cholesterol; BP, blood pressure

**Table 2.** The distribution and prevalent of MetS and MetS components between sleep duration groups

| Variables | Short(n=28) | Sufficient (n=133) | Long (n=3) | p value |
|---|---|---|---|---|
| **Sex, n(%)** | | | | 0.166[1] |
| Male | 18 | 78 | 2 | |
| Female | 10 | 88 | 1 | |
| **BMI-for-age z-score categories, n (%)** | | | | 0.139[1] |
| Overweight | 15 | 94 | 0 | |
| Obesity | 13 | 72 | 3 | |
| **MetS, n(%)** | 13 | 73 | 2 | 0.704[1] |
| **Abdominal obesity, n(%)** | 25 | 155 | 3 | 0.545[1] |
| **Hypertension, n(%)** | 16 | 106 | 2 | 0.791[1] |
| **Hypertriglyceridemia, n(%)** | 7 | 61 | 1 | 0.472[1] |
| **Hyperglycemia, n(%)** | 0 | 3 | 0 | 1.000[1] |
| **Low HDL-c, n(%)** | 13 | 66 | 2 | 0.522[1] |

[1]Fischer exact
Abbreviations: BMI, body mass index; MetS, metabolic syndrome; HDL-C, high-density lipoprotein cholesterol

were heavier than those with short sleepers (p=0.009) and sufficient sleepers (p=0.001). There was at least a pair of groups showing significant differences in BMI-for-age z-score (p=0.004), and long sleepers had bigger BMI-for-age z-scores than short sleepers (p=0.003).

years and sufficient sleepers (p=0.001). Waist circumference showed significant differences across sleep duration groups (p=0.005). Long sleepers had a significantly larger waist circumference than short sleepers (p=0.019) and sufficient sleepers (p=0.003).

Table 2 summarizes the prevalence of MetS and MetS components among the groups. Sex, BMI-for-age z-score categories, MetS, and MetS components showed no significant differences between short, sufficient, and long sleepers in overweight/obese adolescents.

Discussion Sleep is important for human beings, as it promotes growth, learning and cognitive development, and immunity, so poor sleep quality may lead to the development of non-communicable diseases. Adolescence is a period of development and maturation characterized by various changes, including alterations in sleep patterns. Older adolescents tend to have longer sleep onset times. This change is due to the intrinsic circadian timing system and homeostatic sleep-wake system (Bruce et al., 2017).

A study conducted in adolescents noted that a decline in sleep duration was associated with older age, with the prevalence of short sleep being 17.9%. The possibility of adolescents with short sleep durations being overweight was 10% (Corrêa et al., 2021). A study conducted in children aged 5-9 showed that sleep duration was reduced with an increase in age, and the older the children, the more late they went to bed (Kawada et al., 2008). Therefore, older adolescents have a higher prevalence of sleep deprivation (Kansagra, 2020). The incidence of sleep deprivation in adolescents increased with educational stage (Wang et al., 2022). Exogenous and endogenous factors may affecting the sleep duration, such as lifestyle, socioeconomic status, and environment (Illingworth, 2020), which also stated by other, socioeconomic factors, such as unemployed parents and living in big city also inflicting the incidence of sleep deprivation (Lundqvist, 2014). Other study also noted that rural adolescents were more prevalent of having sleep deprivation than urban adolescents due to watching television, academic performance, and academic stress (Li et al., 2023). A study in adolescents also found that short sleepers (<6 h/night) had a higher risk for having depressive symptoms (Zhou et al., 2022).

A study conducted in adolescents 14-19 years old, the short sleep duration group had heavy weight than sufficient sleep duration, and it affecting the BMI (Yılmaz et al., 2022), while a study in adult also found the similar result, with the weight gain of 0.97 ± 1.4 kg, being male gained more wight than female. This weight gained due to subjects with short sleep consumed more calories (130.0 ± 43.0% of daily caloric requirement) from meals and additional calories (Spaeth et al., 2013). Another study reported that sleep deprivation affects hormonal homeostasis, such as reducing leptin levels but increasing ghrelin levels, which further leads to hunger cues (Arjadi et al., 2023). In a simple manner, sleep reduction also causes physical activity reduction, which leads to excess body weight (Cooper et al., 2018; Djojosaputro and Rahmawati, 2023). An in vitro study noted that this body weight gain is due to an increase in ghrelin (Arjadi et al., 2023).

Another study also noted that obese adolescents slept less than normal adolescents (Olds et al., 2010), and short sleep duration (<10 h/day) was also associated with an increase in BMI z-score in children, but the association was sex-dependent, in which girls did not show a correlation (Pattinson et al., 2018), which is also supported by other studies. Male adolescents with short sleep had a higher risk of being obese by 1.8-times than female (Suglia et al., 2014), a longitudinal analysis and meta-analysis study showed that this effect was for both males and female (1.2 to 1.3-times) (Miller et al., 2018; Suglia et al., 2014). A study conducted in adults showed an a-U shape effect of sleep duration on BMI, in which both short (less than 6 h/day) and long (more than 9 h/day) sleep durations were correlated with the prevalence of obesity; short sleep duration increases the risk by 2.51-times and long sleep duration increases the risk by3.97-times (Henriques et al., 2018). It has also been reported that an additional hour of sleep lowers the risk of obesity by 10% (Chehal et al., 2022). A study also highlighted that the increment of sleep duration by 1-hour h reduce a 0.56 kg/m2 of BMI by 4.2 %, which has a protective effect against obesity by 4.2% (Do, 2019). However, the relationship between sleep duration and BMI is still under debate, as others found a relationship, while others did not find any relationship in the preadolescent population (Sung et al., 2011).

Sleep duration is also correlated with waist circumference in adults and is related to leptin reduction, but does not affect appetite (Muhammad et al., 2020). Similar results also highlighted the role of short sleep duration in the prevalence of abdominal obesity, which increased the risk of abdominal obesity by 2.38 to 2.64, in all age categories and sex. A similar result also noted that adults with sleep durations of more than 9 h/night had a negative effect on waist circumferences, but the correlation was only seen in women (Najafian et al., 2010). A meta-analysis also found that sleep duration was negatively correlated with waist circumference, which means that the shorter the sleep duration, the larger the waist circumference (Sperry et al., 2015). Similar results were also recorded in female university students, who concluded that short (<2 h/night) and long (>8 h/night) hours were correlated with abdominal obesity, thus increasing the risk of MetS (Borowska et al., 2022).

However, this study did not prove the correlation between sleep duration and sex, the prevalence of MetS, or even MetS components, including abdominal obesity, as shown in a meta-analysis study, which noted that men with short sleep may have MetS by 1.12-times, and the risk of having abdominal obesity by 1.09-times in women. However, long sleepers (>10 h/night) had a higher risk of MetS (1.28 to 1.4) and hypertriglyceridemia (1.33 to 1.41). Long-sleeper women had a higher risk of having low levels of HDL-c, hyperglycemia, and abdominal obesity by 1.24, 1.39, and 1.14, respectively, which means that long-sleepers had a greater risk of MetS than men (Kim et al., 2018). An adult study also found that short sleepers (<6 h/night) tended to have abdominal obesity (Ford et al., 2014). However, these studies were performed in adults, with different references for MetS determination. Another study also noted that women with long sleepers (>9h/night) tend to have greater percent body fat than men (Suliga et al., 2017), while another study also noted that short sleepers had 3.4 + 1 cm more girth than long sleepers for both men and women (Ford et al., 2014). Studies in children had similar results as our study, and found that sleep duration did not have a strong association with MetS (OR=1.1), and did not affect BMI (β= −0.03, −0.01) or other outcomes (Sung et al., 2011).

## CONCLUSION

Long sleepers (>11 h/night) were heavier, had greater BMI-for-age z-scores, and larger waist circumference than (<sufficient sleeper (6-10 h/night), or short sleepers 6 h/night).

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