

Virtual learning due to COVID-19 pandemic and body weight changes in children aged 6-12 years

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Abstract

Background The COVID-19 pandemic has led to school closures and virtual learning implementation. The situation has affected children's lifestyles and created an obesogenic environment.

Objective To evaluate the impact of virtual learning during the pandemic on body weight changes in children.

Methods This cross-sectional study was conducted on 6-12 years age children who experienced virtual school learning in Jakarta, Indonesia. Parents or guardians were asked to complete an online questionnaire about lifestyle changes and children's anthropometric data both before and during the virtual learning period. Changes in the weight-for-age Z-score (WAZ) and BMI Z-score (BMIZ) were analyzed using the Wilcoxon signed-rank test.

Results A total of 206 children were assessed. There was a significant relation between virtual learning due to the COVID-19 pandemic and WAZ and BMIZ changes among children aged 6-12 years. Approximately 64% of the children experienced WAZ decrement ($P=0.000$), and 77.1% experienced BMIZ decrement ($P=0.000$).

Conclusion This study do not align with existing studies' indicating that the pandemic lead to weight gain in children. Instead, the results shows that virtual learning period causes both WAZ and BMIZ to decrease. [Paediatr Indones. 2024;64:509-16; DOI: <https://doi.org/10.14238/pi64.6.2024.509-16>].

Keywords: body weight; children; COVID-19; virtual learning

Since March 2020, the COVID-19 pandemic has had a significant impact on various aspects of life, including school closures and the transition to virtual learning due to lockdown restrictions.¹ This situation has particularly affected children, as a vulnerable population, influencing their health and well-being.² Several studies have reported negative changes during the pandemic, including an increase in high-calorie foods intake, greater screen time, reduced physical activity, and sleep disturbances.³⁻⁶

The pandemic has led to heightened rates of unemployment and income reduction, leading to elevated levels of financial instability and material uncertainty, known as income precarity. In such cases, families might have lacked access to essential resources required to sustain healthy behaviors. During the pandemic, food insecurity, commonly linked with lacking resources and diminished dietary

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standards, has surged. This situation worsened due to heightened stress and mental health issues experienced by both children and parents. Factors associated with food insecurity, such as challenges in obtaining essential food supplies and disruptions in household food access, were strongly linked to increased likelihoods of both weight loss and weight gain among children and parents.⁷

A systematic review study demonstrated that lockdown resulted in a significant increase of body weight and body mass index (BMI). This phenomenon appeared to be more prevalent among younger children with preexisting overweight/obesity.⁸ In support of this finding, a previous study speculated that BMI Z-score (BMIZ) and childhood obesity prevalence would rise proportionally to the length and severity of the pandemic.⁹ Another study observed that weight fluctuations were common during the pandemic, with a predominant trend towards weight gain. According to parental recall, 5.5% of children experienced more weight loss than anticipated, while 20.2% exhibited greater weight gain than expected in the initial year of the pandemic.⁷ It is crucial to identify these changes early, as the accumulation of weight over time and the development of overweight or obesity pose an increased risk of future health conditions.³ To the best of our knowledge, the number of studies that provide the weight body changes of children in Indonesia was still limited.

In this study, we aim to evaluate how body weight in school-aged children changed due to the COVID-19 pandemic by comparing their weight before and during the implementation of virtual learning. We also investigated lifestyle factors that may have directly or indirectly affected the weight changes.

Methods

This was a cross-sectional study of children attending school in Jakarta, Indonesia who experienced virtual learning during the pandemic. The enforcement date for virtual learning due to COVID-19 pandemic was set as March 31, 2020, when the Jakarta government implemented school closures. The 'before virtual learning' refers to the period prior to this date, while 'during virtual learning' encompasses the time from this date until the questionnaire was completed.

School-aged children in Jakarta, 6-12 years, who had no underlying medical conditions affecting their height and weight and had been regularly attending school before the pandemic were included. We recruited the subjects by distributing an online questionnaire via WhatsApp groups and collaborating with several schools in Jakarta to ask the parents or guardians to participate in this study. An informed consent page was included in the online questionnaire to provide information about the study and to ensure the subjects agreed to take part. Children whose parents did not complete the questionnaire were excluded from the study.

The data for this study were collected from October 2021 to January 2022. Parents or guardians were instructed to complete the online questionnaire independently without any external interference. The questionnaire consists of 4 sections: demographics of the parents, demographics of the children, dietary habits, physical activity and sleep patterns. Parents' educational levels were categorized as low or high. 'Low educational level' refers to those whose highest completed education was senior high school or lower, and 'high educational level' refers to those whose highest completed education was bachelor's degree or higher. The term 'school days during virtual learning' indicates the number of days per week that children participated in school activities online. Meanwhile, the 'duration of virtual learning activities' defines as the number of hours per day that children used electronic devices for schoolwork (excluding leisure use). Eating frequency was recorded as times per day for most meals, except for fast food intake, which was measured in times per week. The height and weight were recorded to the nearest 0.1 cm and 0.1 kg based on the self-reports. For each child, Z-scores for height, weight, and BMI before and during virtual learning were calculated. The CDC online calculator by *Medscape* was used for height-for-age Z-score (HAZ) and weight-for-age Z-score (WAZ), the BMI Z-score (BMIZ) was calculated using the CDC online calculator from the *Children's Hospital of Philadelphia*®. We also used the 2000 CDC Growth Charts to plot anthropometric measurements.

The characteristics of the subjects and parents were summarized in table format. The Kolmogorov-Smirnov test was used assess data normality, with a P value greater than 0.05 indicating a normal

distribution. If the data were normally distributed, a paired sample t-test was conducted to compare differences in HAZ, WAZ, and BMIZ before and during the virtual learning period. If the data were not normally distributed, the Wilcoxon signed-rank test was applied. A P value less than 0.05 within 95% confidence interval (CI) was considered statistically significant for both tests. The statistical analysis was performed using IBM SPSS version 25. The study received approval from The Ethics Committee of the Faculty of Medicine, University of Indonesia/Dr. Cipto Mangunkusumo Hospital.

Results

A total of 254 individuals initially responded to the online questionnaire. However, 48 respondents were excluded from the study (3 answered that they were unwilling to participate in the study, 9 filled out the data incorrectly, and 36 did not complete the questionnaire). This left 206 subjects included in the final analysis. Approximately 76.7% of the respondents had a low educational level, and 58.3% reported a monthly income of less than 4,000,000 IDR. Additionally, 61.7% of the respondents indicated that their income had decreased compared to before the pandemic (Table 1).

Table 2 shows the characteristics of the children, with gender proportions evenly divided. Most of the children (63.5%) were in 4th to 6th grades of elementary school, with the median duration of virtual learning activities was 4 hours. During the virtual learning period, there was a slight increase in the prevalence of children classified as overweight and obese, with increases of 0.5% and 2.5%, respectively.

Table 3 illustrates the changes in HAZ, WAZ, and BMIZ before and during the virtual learning period. A significant number of children experienced a decrease in WAZ (64.0%) and BMIZ (77.1%). To analyze these changes, Wilcoxon signed-rank test was performed, as the data did not follow a normal distribution. The changes in both WAZ and BMIZ were found to be statistically significant (P value <0.05).

Table 4 shows the changes in children's dietary habits. The majority of children reported that their frequency of consuming snacks, fast foods, fried

foods, soda, and sugar-sweetened beverages remained unchanged, with percentages of 55.8%, 78.1%, 75.2%, 90.3%, and 77.2%, respectively. Meanwhile, Table 5 highlights sleep patterns and physical activities during virtual learning, indicating that these aspects did not change significantly compared to before virtual learning. Regarding gadget usage, excluding time spent on virtual learning activities, there median duration decreased from 3 hours per day to 2 hours per day.

Discussion

Based on the data we collected, since the implementation of virtual learning due to the COVID-19 pandemic, 64% of children experienced a decrease in their Weight for age Z-scores (WAZ). Additionally, the BMI Z-scores (BMIZ) showed similar results, with 77.1% of children reporting a decline after virtual learning began. These findings contrast with a meta-analysis which evaluated the effects of virtual learning on children's nutritional status across 14 articles. Among those, 5 out of 8 studies assessing BMIZ reported an increase, while the remainder showed stable distributions.⁸ A cohort retrospective

Table 1. Baseline respondents' characteristics

Variables	(N=206)
Relationship with subject, n(%)	
Mother	30 (14.5)
Father	171 (83)
Custodians	5 (2.5)
Median age (range), months	37.8 (28.0-49.0)
Median number of children (range)	2 (0-7)
Educational level, n(%)	
Low	158 (76.7)
High	48 (23.3)
Occupation, n(%)	
Having any	70 (34)
No occupation	136 (66)
Monthly income, n(%)	
<4,000,000 IDR	120 (58.3)
≥4,000,000 IDR	86 (41.7)
Total income during pandemic, n(%)	
Same as before pandemic	67 (32.5)
Higher than before pandemic	12 (5.8)
Lower than before pandemic	127 (61.7)
Family type	
Single parent family	18 (8.7)
Nuclear family	188 (91.3)

Table 2. Baseline children’s characteristics

Variables	(N=206)
Median age (range), months	10 (6.5-13.6)
Gender, n(%)	
Boys	103 (50.0)
Girls	103 (50.0)
Educational level, n(%)	
Kindergarten	3 (1.5)
1 st -3 rd grades of elementary school	72 (35.0)
4 th -6 th grades of elementary school	131 (63.5)
School days during virtual learning	
1-2 days per week	20 (9.7)
3-4 days per week	19 (9.2)
5 days per week	167 (81.1)
Median duration of virtual learning activities in a day (range). hours	4 (1-6)
Nutritional status*, n(%)	
Before virtual learning	
Severe underweight	5 (2.4)
Underweight	26 (12.6)
Normal	85 (41.4)
Overweight	31 (15.0)
Obesity	59 (28.6)
During virtual learning	
Severe underweight	6 (2.9)
Underweight	23 (11.2)
Normal	81 (39.3)
Overweight	32 (15.5)
Obesity	64 (31.1)
History of being infected with COVID-19	
Yes	12 (5.8)
No	194 (94.2)
Median weight for age Z-score (range)	
Before virtual learning	0.58 (-6.94-3.61)
During virtual learning	0.19 (-7.39-2.72)
Median height for age Z-score (range)	
Before virtual learning	0.14 (1.72)
During virtual learning	0.46 (1.45)

*Nutritional status was calculated based on the measurement of weight/height from the 2000 CDC Growth Chart

Table 3. Changes in HAZ, WAZ, and BMIZ

Variables	(N=206)	P value
HAZ changes, n(%)		0.000
Increased	56 (27.2)	
Decreased	150 (72.8)	
WAZ changes, n(%)		0.000
Increased	73 (35.4)	
Decreased	132 (64.0)	
Not changed	1 (0.6)	
BMIZ changes, n(%)		0.000
Increased	46 (22.3)	
Decreased	159 (77.1)	
Not changed	1 (0.6)	

study in US¹⁰ involved 191,846 subjects and a study in China¹¹ with 207,536 subjects found that children aged 6-17 years, particularly those aged 8-12 years and 6-11 years respectively, experienced the most significant weight gain. Meanwhile, another study conducted in Rome¹² which involved 176 subjects aged 8-18 years showed a slight decrease in mean BMI (from 27.7 [SD 4.8] to 27.6 [SD 4.0]) after the pandemic. It is estimated that differences in the number and age range of subjects contributed to the varied results.

When comparing Z-score analysis with nutritional status interpretation, it was found that

Table 4. Dietary habits changes

Variables	(N=206)		
Frequency of eating	Increased	Not changed	Decreased
Meal	43 (20.9)	144 (69.9)	19 (9.2)
Snacks	61 (29.6)	115 (55.8)	30 (14.6)
Fast foods	30 (14.6)	161 (78.1)	15 (7.3)
Fried foods	31 (15.0)	155 (75.2)	20 (9.8)
Fruits	36 (17.5)	155 (75.2)	15 (7.3)
Vegetables	21 (10.2)	173 (84.0)	12 (5.8)
Dairy products	25 (12.1)	168 (81.6)	13 (6.3)
Salty foods	5 (2.4)	189 (91.8)	12 (5.8)
Soda	5 (2.4)	186 (90.3)	15 (7.3)
Sugar-sweetened drinks	9 (4.4)	159 (77.2)	38 (18.4)
Watching television or playing games while eating, n(%)			
Yes		140 (68.0)	
No		66 (32.0)	
Sources of food during pandemic, n(%)			
Always cooks their own		101 (49.0)	
Often cooks their own		82 (39.8)	
Often buys food		19 (9.2)	
Always buys food		4 (2.0)	

Table 5. Sleep pattern and physical activities changes

Variables	(N=206)	
Sleep pattern	Before virtual learning	During virtual learning
Median bedtime (range), pm	09.00 (7-14)	09.00 (6.3-14)
Median wake up time (range), am	05.30 (4-10)	06.00 (4-13)
Median sleep duration (range), hours	8.5 (4-12)	9.0 (6-14)
Exercise frequency, n(%)		
Increased		29 (14.1)
Decreased		29 (14.1)
Not changed		148 (71.8)
Exercise duration during virtual learning, n(%)		
<1 hour		146 (70.9)
1-2 hours		54 (26.2)
> 2 hours		6 (2.9)

the prevalence of obesity among children increased by 2.5% (from 28.6% to 31.1%), and the prevalence of overweight children rose by 0.5% (15.0% to 15.5%) during virtual learning. This suggests that a significant decrease in WAZ and BMIZ does not necessarily indicate a significant change in overall nutritional status. A study conducted in New York, US¹³ showed an association between nutritional status and increased BMI, revealing that children who were initially obese experienced the highest increases in BMI. It is also important to note that prior to the onset of virtual learning due to the pandemic, the prevalence of overweight children aged 6-12 years in Indonesia had already increased.¹⁴

Several factors may contribute to the notable decrease in children's WAZ and BMIZ during virtual learning. The first factor involves changes in children's dietary habits. Many studies found an increase in WAZ after the COVID-19 pandemic.¹⁵ A study in Gyeonggi-do Province, South Korea,¹⁶ showed that greater consumption of fast food had a statistically significant effect on the increase in WAZ. Additionally, an online survey conducted in US,¹⁷ indicated that various food types saw an uptick during the pandemic, specifically high-calorie foods (33.2%) and processed foods (46.6%). Our study found that the frequency of fast-food consumption remained stable during the pandemic at 78.1%, with only a small

portion of subjects (14.6%) reporting an increase. This consistent frequency of fast-food consumption is believed to account for the slight decrease in WAZ, given that the type of food contributing to weight gain (high-calorie foods) remained relatively unchanged.

The second factor influencing the results is the economic status of the. In our study, 61.6% of parents experienced a decline in income after the pandemic, with 56.1% earning less than 4,000,000 IDR. This finding aligns with 2 previous studies conducted in Indonesia which indicated that higher income and better economic status are associated with a higher prevalence of overweight or obesity in children.^{14,18} We suspect that the decrease in parental income after the pandemic has affected the quality and type of food, although the frequency of consumption remained constant.

Another important factor is the level of physical activity during virtual learning. Regarding gadget usage, apart from activities related to virtual learning, the median duration of used decreased from 3 hours per day to 2 hours per day. This result is consistent with the study by *European Childhood Obesity Project*,¹⁹ which reported that prolonged gadget usage correlates with a higher BMIZ ($P < 0.01$). In contrast, another study found that children who experienced a decreased BMIZ showed a longer duration of gadget usage (P value < 0.05).²⁰ We believe there may be a high possibility of respondent bias, as participants were not monitored while answering the questions. According to the recommendations for physical activity for children and adolescents in the Asia Pacific region, screen time should be limited to no more than 2 hours per day, as it is classified as a sedentary activity.²¹

After the pandemic, the frequency of exercise among children has remained unchanged, with most exercising for less than an hour. This contrasts with the findings of a prospective study using online parent-reported survey in US,²² which suggest that children tend to be more physically inactive, and their parents are also less active, leading to a significant increase in sedentary behavior. It is important to note that this study focused solely on the frequency of exercise and did not assess the overall physical activity levels of children throughout the day. Consequently, the relationship between exercise frequency and change in children's WAZ and BMIZ remains inconclusive.

Additionally, the majority of children did not meet the recommended exercise guideline of at least 60 minutes per day.²¹

Furthermore, the study revealed that there were no significant changes in children's sleep duration, except for an increase of about 30 minutes before virtual learning period. This finding is consistent with the COV-EAT study in Greece,²³ which found that children's sleep duration before and after the pandemic did not change significantly. The mechanism underlying the relationship between sleep duration and increased body mass index in children are not yet fully understood. However, studies suggest that lack of sleep may contribute to weight gain by stimulating appetite due to higher levels of ghrelin and lower levels of leptin, resulting in increased calorie intake.²⁴ In addition, reduced sleep duration can also affect food choices, leading to a decrease intake in vegetable consumption and an increase in fast food intake.²⁴ The recommended sleep duration for children aged 6-12 years is around 9-12 hours per day.²⁵

In this study, we acknowledge a limitation regarding the diversity of our subjects, as most of them belong to the same grade level. Additionally, respondents also completed the questionnaire without supervision from the researchers, which may led to misinterpretations of the questions or errors in the answer format. Anthropometric measurements in this study used a self-report method and were not standardized. Our study also did not assess whether the pandemic weight gain exceeded the typical pre-pandemic weight changes. However, this research represents the first study in Indonesia to investigate the relationship between virtual learning activities and changes in body weight among school-age children. In addition to examining anthropometric aspects, we also analyze socioeconomic factors that are believed to play a significant role.

In conclusion, this study shows that virtual learning causes a decrease in the WAZ and BMIZ. Several factors found to be influencing are increased fast-food consumption, lower income after the pandemic, and decreased physical activity due to virtual learning. Information from this study can be used to increase awareness of the public and the policy makers that COVID-19 pandemic decreased children's nutritional status and can be controlled by

improving the factors that are found to be influencing. We suggest that future study utilize larger sample sizes and objective measurement techniques to enhance the statistical and clinical significance of the research findings.

Conflict of interest

None declared.

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References

1. United Nations International Children's Emergency Fund. Covid-19 and School Closure [updated 2021 march; cited 2022 Sept 24]. Available from: <https://data.unicef.org/resources/one-year-of-covid-19-and-school-closures/>
2. Singh S, Roy D, Sinha K, Parveen S, Sharma G, Joshi G. Impact of COVID-19 and lockdown on mental health of children and adolescents: a narrative review with recommendations. *Psychiatry Res.* 2020;293:113429. DOI: <https://doi.org/10.1016/j.psychres.2020.113429>
3. Pujia R, Ferro Y, Maurotti S, Khoory J, Gazzaruso C, Pujia A, et al. The effects of COVID-19 on the eating habits of children and adolescents in Italy: a pilot survey study. *Nutrients.* 2021;13:2641. DOI: <https://doi.org/10.3390/nu13082641>
4. Rossi L, Behme N, Breuer C. Physical activity of children and adolescents during the COVID-19 pandemic-a scoping review. *Int J Environ Res Public Health.* 2021;18:11440. DOI: <https://doi.org/10.3390/ijerph182111440>
5. Trott M, Driscoll R, Irlado E, Pardhan S. Changes and correlates of screen time in adults and children during the COVID-19 pandemic: a systematic review and meta-analysis. *EClinicalMedicine.* 2022;48:101452. DOI: <https://doi.org/10.1016/j.eclinm.2022.101452>
6. Sharma M, Aggarwal S, Madaan P, Saini L, Bhutani M. Impact of COVID-19 pandemic on sleep in children and adolescents: a systematic review and meta-analysis. *Sleep Med.* 2021;84:259-67. DOI: <https://doi.org/10.1016/j.sleep.2021.06.002>
7. Tester JM, Rosas LG, Leung CW. Food insecurity and pediatric obesity: a double whammy in the era of COVID-19. *Curr Obes Rep.* 2020;9:442-50. DOI: <https://doi.org/10.1007/s13679-020-00413-x>
8. La Fauci G, Montalti M, Di Valerio Z, Gori D, Salomoni MG, Salussolia A, et al. Obesity and COVID-19 in children and adolescents: reciprocal detrimental influence-systematic literature review and meta-analysis. *Int J Environ Res Public Health.* 2022;19:7603. DOI: <https://doi.org/10.3390/ijerph19137603>
9. An R. Projecting the impact of the coronavirus disease-2019 pandemic on childhood obesity in the United States: A microsimulation model. *J Sport Health Sci.* 2020;9:302-12. DOI: <https://doi.org/10.1016/j.jshs.2020.05.006>
10. Brooks CG, Spencer JR, Sprafka JM, Roehl KA, Ma J, Londhe AA, et al. Pediatric BMI changes during COVID-19 pandemic: an electronic health record-based retrospective cohort study. *EClinicalMedicine.* 2021;38:101026. DOI: <https://doi.org/10.1016/j.eclinm.2021.101026>
11. Hu J, Liu J, Wang J, Shen M, Ge W, Shen H, et al. Unfavorable progression of obesity in children and adolescents due to COVID-19 pandemic: a school-based survey in China. *Obesity.* 2021;29:1907-15. DOI: <https://doi.org/10.1002/oby.23276>
12. Cipolla C, Curatola A, Ferretti S, Giugno G, Condemi C, Delogu AB, et al. Eating habits and lifestyle in children with obesity during the COVID19 lockdown: a survey in an Italian center. *Acta Biomed.* 2021;92:e2021196. DOI: <https://doi.org/10.23750/abm.v92i2.10912>
13. Miller A, Bochner R, Sohler N, Calixte R, Chan C, Umpaichitra V, et al. Modified body mass index z-scores in children in New York City during the COVID-19 pandemic. *Pediatr Obes.* 2022;17:e12958. DOI: <https://doi.org/10.1111/ijpo.12958>
14. Oddo VM, Maehara M, Rah JH. Overweight in Indonesia: an observational study of trends and risk factors among adults and children. *BMJ Open.* 2019;9:e031198. DOI: <https://doi.org/10.1136/bmjopen-2019-031198>
15. Weaver RG, Hunt ET, Armstrong B, Beets MW, Brazendale K, Turner-McGrievy G, et al. COVID-19 leads to accelerated increases in children's BMI Z-Score gain: an interrupted time-series study. *Am J Prev Med.* 2021;61:161-9. DOI: <https://doi.org/10.1016/j.amepre.2021.04.007>
16. Woo S, Yang H, Kim Y, Lim H, Song HJ, Park KH. Sedentary time and fast-food consumption associated with weight gain during COVID-19 lockdown in children and adolescents with overweight or obesity. *J Korean Med Sci.* 2022;37:e103. DOI: <https://doi.org/10.3346/jkms.2022.37.e103>
17. Adams EL, Caccavale LJ, Smith D, Bean MK. Food insecurity,

- the home food environment, and parent feeding practices in the era of COVID-19. *Obesity*. 2020;28:2056-63. DOI: <https://doi.org/10.1002/oby.22996>
18. Rachmi CN, Li M, Alison Baur L. Overweight and obesity in Indonesia: prevalence and risk factors-a literature review. *Public Health*. 2017;147:20-9. DOI: <https://doi.org/10.1016/j.puhe.2017.02.002>
 19. Schwarzfischer P, Gruszfeld D, Socha P, Luque V, Closa-Monasterolo R, Rousseaux D, et al. Effects of screen time and playing outside on anthropometric measures in preschool aged children. *PLoS One*. 2020;15:e0229708. DOI: <https://doi.org/10.1371/journal.pone.0229708>
 20. Bordon S, Srebernick SM, Bernardi JLD, Leandro-Merhi VA. Screen time, body mass index and neck circumference: is there an association with social class in children?. *Rev Bras Cineantropom Desempenho Hum*. 2019;21:e58235. DOI: <https://doi.org/10.1590/1980-0037.2019v21e58235>
 21. Loo BKG, Okely AD, Pulungan A, Jalaludin MY. Asia-Pacific consensus statement on integrated 24-hour activity guidelines for children and adolescents. *Br J Sports Med*. 2022;56:539-45. DOI: <https://doi.org/10.1136/bjsports-2021-104527>
 22. Dunton GF, Do B, Wang SD. Early effects of the COVID-19 pandemic on physical activity and sedentary behavior in children living in the U.S. *BMC Public Health*. 2020;20:1351. DOI: <https://doi.org/10.1186/s12889-020-09429-3>
 23. Androutsos O, Perperidi M, Georgiou C, Chouliaras G. Lifestyle changes and determinants of children's and adolescents' body weight increase during the first COVID-19 lockdown in Greece: the COV-EAT study. *Nutrients*. 2021;13:930. DOI: <https://doi.org/10.3390/nu13030930>
 24. Cooper CB, Neufeld EV, Dolezal BA, Martin JL. Sleep deprivation and obesity in adults: a brief narrative review. *BMJ Open Sport Exerc Med*. 2018;4:e000392. DOI: <https://doi.org/10.1136/bmjsem-2018-000392>
 25. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, et al. Recommended amount of sleep for pediatric populations: a consensus statement of the American Academy of Sleep Medicine. *J Clin Sleep Med*. 2016;12:785-6. DOI: <https://doi.org/10.5664/jcsm.5866>