ORIGINAL ARTICLE

Sitting Time and Screen Time are not associated with Body Weight and Body Mass Index Changes during Covid-19 Pandemic

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ABSTRACT

Introduction: COVID-19 pandemic has made significant changes in life. Sedentary lifestyle, increased usage of gadget, and increased sitting duration could lead to body weight and nutritional status changes. This study aimed to analyze the differences of sitting and screen time with weight changes and body mass index (BMI). **Methods:**: Online cross-sectional survey performed among 401 individuals older than 18 years in Surabaya. Self-administered questionnaire included questions related to sedentary activities, namely sitting and using gadget duration in a day. Self-reported weight and height before and during pandemic were used to calculate BMI before and during COVID-19 pandemic. Data analysis used the Chi-square test. **Results:** Study found that 47.9% of respondents did not experience significant changes in their body weight before and during COVID-19 pandemic. People who experienced no change in their body weight spent less than 6 hours sitting (50.8%) and people who experienced weight loss spent more than six hours using their gadgets (59.3%). It also found that 44.6% of respondents had normal nutritional status where 45.3% used gadgets with a duration of more than 6 hours and 45.8% used the time to sit for less than 6 hours. Body weight changes and BMI changes are not significantly different compared to sitting time (p-value=0.692) and screen time (p-value=0.099) during COVID-19 pandemic. **Conclusion:** There are no association between screen time and sitting time to body weight and BMI during pandemic COVID-19

Keywords: Body mass index, Body weight changes, COVID-19 pandemic, Screen time, Sitting time

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) pandemic is an ongoing global problem with more than 1.8 million deaths worldwide in 2020 (Dong, 2020). The number of deaths due to COVID-19 has reached more than 33,673 worldwide (1). COVID-19 was first discovered in Indonesia in early March 2020 where the number of patients has reached more than 1,500 (2). There are regions that have the most patients in Indonesia—one of them is Surabaya, East Java. As of August 6th, 2021, there were 1,2% additional cases in Surabaya, resulting the cumulative COVID-19 57.235 cases (2).

The lifestyle of people began to shift along the increase of confirmed COVID-19 cases in Surabaya. Worksites, universities, and schools have again started to lock down and implement work and study activities at home. Lockdown will not eradicate viral infection in patients but can reduce the rate of virus spread. A study conducted in Wuhan, China, showed that lockdown had positive impact on the spread of COVID-19 which doubling time increases from 2 days to 4 days, even longer after additional testing and diagnostic methods (3).

With the self-isolation and lockdown notice, life habits will change which may result in an unpredictable behavior changes, such as people have to stay at home longer than usual and are only allowed to go out to do urgent things such as buying food or health reasons. Nonetheless, all work and learning processes are carried out online at home using gadgets and tools at home.

This lifestyle change may enhance sedentarism namely increased of screen and sitting time duration, decrease outdoor time, and physical activity (4).

Screen time refers to duration of time spent in front of screen of an electronic device, namely laptop, computers, smartphones, tablets, electronic games, television (TV), and other visual devices for many purposes, namely for working, learning process, inter-personal communications, and other organizational activities or entertainment purposes (5–9). Many studies have shown results that lockdown periods can affect human health and wellbeing by increasing a sedentary lifestyle which has a negative effect on life quality (3,4,10). Physical inactivity is associated with higher risk of weight gain leading to overweight and obesity, cardiovascular and metabolic disease (11–13). Overweight and obesity appear to be the leading cause of non-communicable diseases, including cardiovascular and metabolic diseases, gallbladder disease, musculoskeletal disorders, such as osteoarthritis (14).

To our knowledge, data analyzing the associations between screen time and sitting time and body weight and body mass index changes during COVID-19 pandemic in Indonesia are scarce. Therefore, present study aimed to analyze the association between sitting and screen time with body weight and BMI changes during COVID-19 pandemic.

MATERIALS AND METHODS

Study Design

A cross-sectional online study was carried out from May to June, 2020 among individuals aged more than 18 years old domiciled in Surabaya, Indonesia. The calculated sample size was minimum 234 participants based on the population size of the study including 20% of estimated dropout level. This study relied upon a structured validated questionnaire made by researcher using 20 participants other than the subjects used in this study. The validation test of the questionnaire was carried out with 3 experts, based on content validity index for each question resulted a high validity with a Fleiss' Kappa result of more than 0.81. Online survey consisted of a web link to internet-based questionnaire on Google Forms in Bahasa Indonesia. Participants were Indonesia citizen who experienced activity changes from outdoor activity to school or work from home due to COVID-19 pandemic social restriction policy. Recruited subjects were randomly sampling and able to meet the inclusion criteria which included both male and female aged 18 to 45 years old, willing to participate, completed the anonymous questionnaire, while those who were diagnosed by doctors with any clinical conditions who required medical and dietary therapy namely diabetes, hepatitis, and chronic kidney disease were excluded. The questionnaire was distributed to the participants in accordance with the inclusion criteria set by researchers using a range of methods: invitation via e-mails, via social networking sites in example Facebook, Instagram, also WhatsApp message. In addition, we asked participants to share study link for a wider reach of people who received the invitation to the study, thus increased the study participants.

The online survey included an introduction elaborating background and purpose of study, procedure, time needed to complete questionnaire, as well as voluntary participation. Informed consent was written in simple and understandable terms on the first page of the questionnaire and need to be signed by participants. Ethical approval was obtained from Health Research Ethics Committee, Faculty of Nursing, Universitas Airlangga, Indonesia (2115-KEPK).

Self-Reported Anthropometric Measurements

Participants self-reported their weight and height (last known and last measured before and during the pandemic). Before pandemic data refer to the 3 months (from December 2019-February 2020) prior to the first case of COVID-19 identified in Indonesia which is in 2nd March 2020. Meanwhile during pandemic refer to the 3 months after the first case of COVID-19 identified in Indonesia (March 2020-May 2020). Their body mass index (BMI) was calculated using equation body mass (kg)/height (m2) and classified according to Asia-Pacific BMI classification. We categorized into four groups based on Asia population standards: underweight (BMI <18.5 kg/m^2), normal (18.5 kg/m2 ≤ BMI ≤ 22.9 kg/m^2), overweight (23 kg/m^2 ≤ BMI ≤ 24.9 kg/m^2), and obesity (BMI 25.0 ≥ kg/m^2). Changes in body weight were asked for the time period of 3 months before COVID-19 pandemic and 3 months during COVID-19 pandemic. Weight loss reported if there are losing of ≥ 1 kg per month and weight gain reported if there are gaining of ≥ 1 kg per month.

Self-Administered Online Questionnaire

The self-administered online questionnaire consisted of questions on socio-demographic characteristics including age, educational level (middle school, high school, diploma level, university level graduate), place of residence (owned house, boarding house, family's house), employment status during pandemic (university student, civil servant, private employees, entrepreneurship, freelancer, unemployed), salary and allowances per month, and sedentary lifestyle, namely screen and sitting time durations (less or more than six hours per day). The participants were asked to assess their time spent on a particular activity, especially activities carried out in front of the gadget screen. Participants were categorized into low screen and sitting time (<6 hours per day) and high screen and sitting time (>6 hours per day). Even though the questionnaire is distributed online, participants get assistance and monitor from researchers through Whatsapp communication (via chat or voice call) for those who are met difficulties in completing the questionnaire appropriately also in final checking of questionnaire completion so as to minimize

bias of missing value in data processing.

Statistical Analysis

Data analysis was performed with IBM SPSS Statistics. The result is statistically significant when p-value <0.05. Descriptive statistics method were used to analyze the demographic data of the subjects, height, weight, and BMI of subject, total screen and sitting time. Moreover, inferential statistics were applied by using the Chi-square test in order to find out the association between sitting and screen time duration with body weight and BMI changes before and during COVID-19 pandemic.

RESULT

A total of 401 subjects, 84 (20.9%) males and 317 (79.1%) females, completely filled the questionnaire. The age range of the participants was 18 to 43 years old. The mean age of the participants was 21.87±2.6 years old. The mean height of the participants was 159±7.2 cm, mean weight before the pandemic was 56.86±12.85 kg. Before pandemic, the mean BMI of the participants was 22.4±4.3 kg/m^2 and during pandemic, the mean was 22.7±4.7 kg/m^2.

Table I. Respondents characteristics

Variables	n (mean ± SD)
Age (years old)	21.87 ± 2.6
Height (cm)	159.05 ± 7.15
Weight (kg)	56.86 ± 12.85
Body weight changes during pandemic	
Loss (kg)	3.43 ± 2.94
Gain (kg)	3.18 ± 2.08
Body Mass Index	
Before pandemic (kg/m^2)	22.4 ± 4.3
During pandemic (kg/m^2)	22.7 ± 4.7

Based on categorization of the educational level, the majority of participants experienced weight loss and weight gain were high school graduates (68.5% and 47.1%). There was no association between educational level and body weight changes. Changes in body weight loss, stable, and gain were all experienced by participants who live at their parents' house (72.2%, 68.2%, and 71.0%, respectively) and were university students (70.4%, 50.0%, and 58.7% respectively). No association were found between place of residence (p-value=0.703), employment status during pandemic (p-value=0.624), and changes in body weight.

Weight gain during COVID-19 pandemic was found in 38.7%, while a loss in weight was found in 13.5% of participants. Almost half (47.9%) of the participants did not experience any change in their body weight and 38.7% experienced weight gain during the pandemic. Before pandemic, the nutritional status of participants who experienced weight loss, weight gain, and no change in their body weight tend to be normal (50.0%, 53.1%, and 41.3% respectively). However, during pandemic, the nutritional status of participants who experienced weight loss were underweight (42.6%) and those who experienced weight gain were categorized as obesity (45.2%).

Participants who experienced changes in their body weight, both weight loss (55.6%) and weight gain (51.6%), spent more than six hours sitting. However, participants with stable body weight spent less than six hours sitting (53.1%). Participants who experienced no changes (52.6%) and those who experienced changes (loss 59.3%; gain 51%) in their body weight spent more than six hours for their screen time during the pandemic. There were no association between sitting (p-value=0.455) and screen time (p-value=0.573) duration and changes in body weight.

Table II. Differences between variables with body weight changes

Variables	Total 100% (n=401)	Changes in Body Weight			p-Value
		Loss 13.5% n = 54	Stable 47.9% n = 92	Gain 38.7% n = 155	
Educational level					
Middle school graduate	4 (0.0%)	0 (0.0%)	1 (0.5%)	3 (1.9%)	0.162
High school graduate	191 (47.6%)	37 (68.5%)	82 (42.7%)	73 (47.1%)	
Diploma graduate	38 (9.5%)	1 (1.9%)	20 (10.4%)	17 (11.0%)	
University graduate	167 (41.6%)	16 (29.6%)	89 (46.4%)	62 (40.0%)	
Place of residence					
Owned house	25 (6.2%)	5 (9.3%)	11 (5.7%)	9 (5.8%)	0.703
Family's house	280 (69.8%)	39 (72.2%)	131 (68.2%)	110 (71.0%)	
Boarding house	75 (18.7%)	8 (14.8%)	40 (20.8%)	27 (17.4%)	
Friend's house	21 (5.2%)	2 (3.7%)	10 (5.2%)	9 (5.8%)	
Employment status during pandemic					
University student	225 (56.1%)	38 (70.4%)	96 (50.0%)	91 (58.7%)	0.624
Civil servant	5 (1.2%)	0 (0.0%)	5 (2.6%)	0 (0.0%)	
Private employees	82 (20.4%)	9 (16.7%)	46 (24.0%)	27 (17.4%)	
Entrepreneurship	12 (3.0%)	1 (1.9%)	7 (3.6%)	4 (2.6%)	
Freelancer	41 (10.2%)	4 (7.4%)	18 (9.4%)	19 (12.3%)	
Unemployed	25 (6.2%)	2 (3.7%)	13 (6.8%)	10 (6.5%)	
Others	11 (2.7%)	0 (0.0%)	7 (3.6%)	4 (2.6%)	

CONTINUE

Table II. Differences between variables with body weight changes (cont.)

Variables	Total 100% (n=401)	Changes in Body Weight			p-Value
		Loss 13.5% n = 54	Stable 47.9% n = 92	Gain 38.7% n = 155	
BMI Category before pandemic					
Underweight	63 (15.8%)	13 (24.1%)	39 (20.3%)	12 (7.7%)	0.000
Normal	193 (48.3%)	27 (50.0%)	102 (53.1%)	64 (41.3%)	
Overweight	60 (15.0%)	7 (13.0%)	23 (12.0%)	30 (19.4%)	
Obesity	84 (21.0%)	7 (13.0%)	28 (14.6%)	49 (31.6%)	
BMI Category during pandemic					
Underweight	69 (17.2%)	23 (42.6%)	39 (20.3%)	7 (4.5%)	0.000
Normal	179 (44.6%)	21 (38.9%)	102 (53.1%)	56 (36.1%)	
Overweight	50 (12.5%)	5 (9.3%)	23 (12.0%)	22 (14.2%)	
Obesity	103 (25.7%)	5 (9.3%)	28 (14.6%)	70 (45.2%)	
Sitting Time Duration					
Less than 6 hours	201 (50.1%)	24 (44.4%)	102 (53.1%)	75 (48.4%)	0.455
More than 6 hours	200 (49.9%)	30 (55.6%)	90 (46.9%)	80 (51.6%)	
Screen Time Duration					
Less than 6 hours	189 (47.1%)	22 (40.7%)	91 (47.4%)	76 (49.0%)	0.573
More than 6 hours	212 (52.9%)	32 (59.3%)	101 (52.6%)	79 (51.0%)	

Before the pandemic, 16% of the participants who were underweight experienced changes in their BMI during pandemic. Almost half (7.8%) of them experienced a change in BMI to normal with 20.3% experiencing a decrease and 18.8% experiencing weight gain. Out of 48.1% of participants who had normal nutritional status before the pandemic, 5.7% of them became overweight and 1% became obese with 33.2% experienced weight gain, whereas 5.2% became underweight with 14% experienced weight loss. Fifteen percent of the participants who were overweight before the pandemic became obese (31.7%) and experienced normal nutritional status (5%) during the pandemic with 11.7% experienced weight loss and half of them experienced weight gain. Most of the people (97.6%) who were obese before the pandemic stayed obese during the pandemic.

Participants who both spent less (43.9%) and more than six hours (45.3%) for their screen time had normal BMI, followed by those who were obese (28%; 23.6%). Thus,

Table III. Differences of BMI category before pandemic with BMI during pandemic and weight changes

Variables	BMI Category before the Pandemic			
	Underweight 16% n = 64	Normal 48.1% n = 193	Overweight 15% n = 60	Obesity 20.9% n = 84
BMI during the Pandemic				
Underweight	59 (92.2%)	10 (5.2%)	0 (0.0%)	0 (0.0%)
Normal	5 (7.8%)	170 (88.1%)	3 (5.0%)	1 (1.2%)
Overweight	0 (0.0%)	11 (5.7%)	38 (63.3%)	1 (1.2%)
Obesity	0 (0.0%)	2 (1.0%)	19 (31.7%)	82 (97.6%)
Weight changes				
Loss	13 (20.3%)	27 (14.0%)	7 (11.7%)	7 (8.3%)
Gain	12 (18.8%)	64 (33.2%)	30 (50.0%)	49 (58.3%)
Stable	39 (60.9%)	102 (52.8%)	23 (38.3%)	28 (33.3%)

there were not association found between screen time duration and BMI of subjects. The same trend implied with the sitting time category where participants who both spent less (45.8%) and more than six hours (43.5%) sitting time had normal BMI, followed by those who were obese (25.9%; 25.5%). There were not association found between sitting time duration and BMI of subjects.

Table IV. Differences between screen time and sitting time with body mass index during pandemic

Body Mass Index	Screen Time				p-value
	Less than six hours		More than six hours		
	n	%	n	%	
Underweight	27	14.3	42	19.8	0.099
Normal	83	43.9	96	45.3	
Overweight	26	13.8	24	11.3	
Obesity	53	28.0	50	23.6	
Body Mass Index	**Sitting Time**				**p-value**
	Less than six hours		More than six hours		
	n	%	n	%	
Underweight	33	16.4	36	18.0	0.692
Normal	92	45.8	87	43.5	
Overweight	24	11.9	26	13.0	
Obesity	52	25.9	51	25.5	

DISCUSSION

Our study revealed that during study period of COVID-19 pandemic in Indonesia, men subjects increased body weight by 4.08 kg, whereas women increased by 2.89 kg on average. The main finding of this study was that the two main variables, screen time and sitting time and BMI

of participants were not associated. This results were in contrast with several studies which concluded that there was an association between sitting time and BMI, as well as screen time duration and BMI. The differences in the results obtained might be due to several reasons which influence the data collection phase, the methodology of anthropometric measurements in determining nutritional status, and the differences of indicator in obesity. First, the approach in this study which the data were collected during the pandemic was different from any other studies. There were two studies which used computer-assisted telephone interviewing (CATI) in which all questions were read over the telephone by interviewer and answers from participants were directly documented in electronic system (15). However, the current study used self-administered online questionnaires. Compared with CATI, online surveys are considered more cost-effective and more convenient. The data results also tend to be of better quality, such as reducing social desirability bias in responses (16).

One of the weaknesses of self-administered online surveys is that the research team cannot always monitor the engagement of participants in filling out the surveys, so the participants may not complete them. It was said that the level of non-response was higher in the self-administered survey compared to filling out a survey accompanied by an interviewer. This is because of the presence of interviewer and their ability to motivate the participants to engage in the surveys. In addition, a more interactive situation between interviewers and participants can create a more interesting atmosphere than when participants have to fill out the survey themselves (16).

In addition, the process of anthropometric measurement for BMI measure plays important role in affecting results. A self-reported height and weight measurements can be affected by the response and some recall bias. It is very common to find underestimation of BMI because weight commonly underestimated, in other hand height often overestimated (17–23). Several studies have also found great discrepancy in self-reported and measured height and weight in certain population groups, such as overweight or obese individuals and healthy persons (20,21,24–27).

Furthermore, a study conducted by Suliga (2018) showed a long sitting time had association with abdominal obesity, one of the indicators of metabolic syndrome (28). In papers by several authors, it has been confirmed that sitting time was also has association with a greater risk of abdominal obesity in women (29) and was positively correlated with waist circumference in men (30,31). The method of measuring changes in nutritional status, especially for obesity, can also use waist circumference to determine abdominal obesity. The method in measuring nutritional status which the previous researchers chose to use was different from the current study. The nutritional status measurement method used is body height and body weight measurements which were calculated and categorized into BMI categories. There were two which used waist circumference as the indicator of obesity, specifically abdominal obesity (30,31).

Sitting time had significant differences between waist circumference in men subjects and BMI in men and women (30). Study conducted by Barlow also explained that sitting for long time is associated with high amount of adiposity (31). Apart from being a marker of abdominal obesity, waist circumference is also an indicator of on increased the risk of metabolic syndrome (MetS), which indicated the accumulation of some risk factors, in example abdominal obesity, abnormal glycemia, dyslipidemia, and hypertension (30,32,33). Waist circumference, as well as, waist-to-hip ratio are also useful for assessing the visceral fat accumulation which can detect if subjects are at risk in primary health care setting (34–36). In addition, research conducted by Borel used several anthropometric measurements to determine the best marker of obesity-related to cardio-metabolic diseases from BMI, neck circumferences, and waist to hip ratio (34). Each measurement is useful in specific conditions or populations. In an Healthy Twin study in Korea, measurements using waist circumference, waist-to-hip ratio, and BMI were more predictive to predict metabolic risks if compared to direct body fat measurements, and waist circumference and waist-to-hip ratio also showed an association with metabolic risk factors and general adiposity (37,38).

Among the various measurements and assessments of obesity, BMI is being the first developed by World Health Organization and most widely used (37,39). Because of its convenience, inexpensiveness, and non-invasive BMI measurement, BMI is often used in measuring nutritional status because its measurement is on height and weight assessed by proper equipment (CDC). However, there are also limitations in BMI measurements, such as it only measures excess weight rather than excess fat and it does not reflect fat distribution (40).

Nevertheless, there were also a few studies which supported the result of this study. The study done by Kalirathinam (2019) concluded that screen time was not associated significantly with BMI among university students (41). There was also a study conducted by Laurson (2014) that showed there was not an association between screen time and BMI. Changes in BMI are multifactorial (42). There are possible factors which might influence the changes, such as dietary intake, physical activity, lack of food care, increased appetite, and genetic factors (41,43). Therefore, with the results obtained in this study, we can conclude that sitting time and screen time were not the factor which contributes to weight changes and BMI changes.

We believe this study has several strengths and limitations, because this study is a cross sectional study so that this study cannot identify the causal relationship between screen time, sitting time with body weight changes and BMI changes. Second, because the questionnaire used is based on self-reporting data, there is a possibility of bias from participants in filling out. Last, we did not explore the duration of screen time and sitting time for what activities and what types of devices were used. This study also includes a large population which increase the study validity and reliability. For further study, we suggest to use longitudinal method that can follow up more comprehensive factors (in example dietary habit, food choices, or physical fitness) and changes related to body weight during pandemic for certain times.

CONCLUSION

During pandemic COVID-19 in Indonesia, men subjects increased higher body weight changes than woman on average. Two main variables, screen time and sitting time and BMI of participants were not associated with BMI of the subjects.

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REFERENCES

1. Organization WH. Coronavirus disease (COVID-19) situation dashboard. 2020.
2. Indonesia KKR. Info Infeksi Emerging Kementerian Kesehatan RI [Internet]. Kementerian Kesehatan Republik Indonesia. 2021. Available from: https://covid19.kemkes.go.id/
3. Lau H, Khosrawipour V, Kocbach P, Mikolajczyk A, Schubert J, Bania J, et al. The positive impact of lockdown in Wuhan on containing the COVID-19 outbreak in China. J Travel Med. 2021;27(3):1–7.
4. Balanz6–Martнnez V, Atienza–Carbonell B, Kapczinski F, De Boni RB. Lifestyle behaviours during the COVID-19 – time to connect. Acta Psychiatr Scand. 2020;141(5):399–400.
5. AACAP. Media Habits During COVID-19: Children & Teens on Screens in Quarantine. 2020;
6. Kir6ly O, Potenza MN, Stein DJ, King DL, Hodgins DC, Saunders JB, et al. Preventing problematic internet use during the COVID-19 pandemic: Consensus guidance. Compr Psychiatry. 2020;100:1–4.
7. UNICEF. Rethinking screen-time in the time of COVID-19 | UNICEF Office of Global Insight & Policy. Available from: https://www.unicef.org/globalinsight/stories/rethinking-screen-time-time-covid-19
8. Ting DSW, Carin L, Dzau V, Wong TY. Digital technology and COVID-19. Nat Med. 2020;26(4):458–61.
9. Robbins T, Hudson S, Ray P, Sankar S, Patel K, Randeva H, et al. COVID-19: A new digital dawn? Digit Heal. 2020;6:1–3.
10. Pecanha T, Goessler KF, Roschel H, Gualano B. Social isolation during the COVID-19 pandemic can increase physical inactivity and the global burden of cardiovascular disease. Am J Physiol - Hear Circ Physiol. 2020;318(6):H1441–6.
11. Lippi G, Henry BM, Sanchis-Gomar F. Physical inactivity and cardiovascular disease at the time of coronavirus disease 2019 (COVID-19). Eur J Prev Cardiol. 2020;27(9):906–8.
12. Sanyaolu A, Okorie C, Marinkovic A, Patidar R, Younis K, Desai P, et al. Comorbidity and its Impact on Patients with COVID-19. SN Compr Clin Med. 2020;2(8):1069–76.
13. Osborne B, Brandon AE, Smith GC, Turner N. Impact of lifestyle and clinical interventions on mitochondrial function in obesity and type 2 diabetes. Mitochondria in Obesity and Type 2 Diabetes: Comprehensive Review on Mitochondrial Functioning and Involvement in Metabolic Diseases. Elsevier Inc.; 2019. 367–397 p.
14. Ghee LK. A review of adult obesity research in Malaysia. Med J Malaysia. 2016;71(June):1–19.
15. S6nchez E, Lecube A, Bellido D, Monereo S, Malagyn MM, Tinahones FJ. Leading factors for weight gain during covid-19 lockdown in a Spanish population: A cross-sectional study. Nutrients. 2021;13(3):1–12.
16. Christensen L, Christensen L. Transport Survey Methods : Best Practice for Decision Making The Role of Web Interviews as Part of a National Travel Survey The Role of Web Interviews as Part of a National Travel Survey. 2016.
17. Gorber SC, Tremblay M, Moher D, Gorber B. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: A systematic review. Obes Rev. 2007;8(4):307–26.
18. Engstrom JL, Paterson SA, Doherty A, Trabulsi M, Speer KL. Accuracy of self-reported height and weight in women: An integrative review of the literature. J Midwifery Women's Heal. 2003;48(5):338–45.
19. Himes JH, Hannan P, Wall M, Neumark-Sztainer D. Factors associated with errors in self-reports of stature, weight, and body mass index in Minnesota adolescents. Ann Epidemiol. 2005;15(4):272–8.
20. Wang Z, Patterson CM, Hills AP. A comparison of self-reported and measured height, weight and BMI in Australian adolescents. Aust N Z J Public Health. 2002;26(5):473–8.
21. Elgar FJ, Stewart JM. Validity of self-report screening for overweight and obesity: Evidence from the Canadian community health survey. Can J Public

Heal. 2008;99(5):423–7.
22. Brener ND, McManus T, Galuska DA, Lowry R, Wechsler H. Reliability and validity of self-reported height and weight among high school students. J Adolesc Heal. 2003;32(4):281–7.
23. Bowring AL, Peeters A, Freak-Poli R, Lim MSC, Gouillou M, Hellard M. Measuring the accuracy of self-reported height and weight in a community-based sample of young people. BMC Med Res Methodol. 2012;12.
24. Roberts RJ. Can self-reported data accurately describe the prevalence of overweight? Public Health. 1995;109(4):275–84.
25. Spencer EA, Appleby PN, Davey GK, Key TJ. Validity of self-reported height and weight in 4808 EPIC–Oxford participants. Public Health Nutr. 2002;5(4):561–5.
26. Nyholm M, Gullberg B, Merlo J, Lundqvist-Persson C, Restam L, Lindblad U. The validity of obesity based on self-reported weight and height: Implications for population studies. Obesity. 2007;15(1):197.
27. Sherry B, Jefferds ME, Grummer-Strawn LM. Accuracy of adolescent self-report of height and weight in assessing overweight status: A literature review. Arch Pediatr Adolesc Med. 2007;161(12):1154–61.
28. Suliga E, Cieśla E, Rębak D, Kozieł D, Głuszek S. Relationship between sitting time, physical activity, and metabolic syndrome among adults depending on body mass index (BMI). Med Sci Monit. 2018;24:7633–45.
29. Gardiner PA, Healy GN, Eakin EG, Clark BK, Dunstan DW, Shaw JE, et al. Associations between television viewing time and overall sitting time with the metabolic syndrome in older men and women: The Australian diabetes obesity and lifestyle study. J Am Geriatr Soc. 2011;59(5):788–96.
30. Sohn M, Cho KH, Han K Do, Choi M, Kim YH. Sitting Time and Obesity or Abdominal Obesity in Older South Koreans: Korean National Health and Nutrition Examination Survey 2013. Behav Med. 2017;43(4):251–8.
31. Barlow CE, Shuval K, Balasubramanian BA, Kendzor DE, Radford NB, DeFina LF, et al. Association Between Sitting Time and Cardiometabolic Risk Factors After Adjustment for Cardiorespiratory Fitness, Cooper Center Longitudinal Study, 2010-2013. Prev Chronic Dis Public Heal Res Pract Policy. 2016;13(E181).
32. Kuller LH, Kinzel LS, Pettee KK, Kriska AM, Simkin-Silverman LR, Conroy MB, et al. Lifestyle intervention and coronary heart disease risk factor changes over 18 months in postmenopausal women: The women on the move through activity and nutrition (WOMAN study) clinical trial. J Women's Heal. 2006;15(8):962–74.
33. Joo S, Lee S, Choi HA, Kim J, Kim E, Kimm K, et al. Habitual snoring is associated with elevated hemoglobin A1c levels in non-obese middle-aged adults. J Sleep Res. 2006;15(4):437–44.
34. Borel AL, Coumes S, Reche F, Ruckly S, Pйpin JL, Tamisier R, et al. Waist, neck circumferences, waist-to-hip ratio: Which is the best cardiometabolic risk marker in women with severe obesity? The SOON cohort. PLoS One. 2018;13(11):1–15.
35. Desprйs JP. Is visceral obesity the cause of the metabolic syndrome? Ann Med. 2006;38(1):52–63.
36. Despres JP. Excess visceral adipose tissue/ectopic fat: The missing link in the obesity paradox? J Am Coll Cardiol. 2011;57(19):1887–9.
37. Park JH, Joh HK, Lee GS, Je SJ, Cho SH, Kim SJ, et al. Association between sedentary time and cardiovascular risk factors in Korean adults. Korean J Fam Med. 2018;39(1):29–36.
38. Booth FW, Laye MJ, Lees SJ, Rector RS, Thyfault JP. Reduced physical activity and risk of chronic disease: the biology behind the consequences. Eur J Appl Physiol. 2008;102(4):381–90.
39. Gennuso K, Gangnon R, Matthews C, Thraen-Borowski K, Colbert L. Sedentary behavior, physical activity, and markers of health in older adults. Med Sci Sport Exerc. 2013;45:1493–500.
40. Network SBR. Letter to the editor: Standardized use of the terms "sedentary" and "sedentary behaviours." Appl Physiol Nutr Metab. 2012;37(3):540–2.
41. Kalirathinam D, Hui TX, Jacob S, Sadagobane SK, Chellappan ME. Association between screen time and body mass index among university students. Sci Med (Porto Alegre). 2019;29(3):e33149.
42. Laurson KR, Lee JA, Gentile DA, Walsh DA, Eisenmann JC. Concurrent Associations between Physical Activity, Screen Time, and Sleep Duration with Childhood Obesity. ISRN Obes. 2014;2014:1–6.
43. Sherwood NE, Jeffery RW, French SA, Hannan PJ, Murray DM. Predictors of weight gain in the Pound of Prevention study. Int J Obes. 2000;24(4):395–403.