

## Eating behavior affects cardio-metabolic risk in high school teenagers in a developing country

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### ABSTRACT

**BACKGROUND** Modernization negatively changes lifestyle, characterized by excessive eating and reduced energy consumption, and concurrently increases the cardio-metabolic risk. This study was aimed to evaluate the association between eating behavior and cardio-metabolic risk factors including body mass index (BMI) in percentile, blood pressure (BP) in percentile, waist circumference, and heart rate in total subjects and gender sub-groups.

**METHODS** This analytical cross-sectional study was done from July to November 2018. High schools in four provinces of Indonesia and students were selected using purposive sampling. Subjects' profiles were collected from interview and cardio-metabolic parameters were measured at the study sites. Data were analyzed with chi-square and independent t-test.

**RESULTS** Subjects who were overweight/obese and had high BP accounted for 27.1% and 9.3–12.0% of the total subjects ( $n = 768$ ), respectively. Subjects who having breakfast tended to have lower BMI ( $p = 0.006$ ), and the lower consumption of western meals had lower heart rate ( $p = 0.02$ ). Male subjects had more meal frequency and had less quantity of snacks than female subjects ( $p < 0.001$ ). Male subjects with routine intake of vegetables had low heart rate ( $p = 0.03$ ). Female subjects with routine breakfast had better BMI ( $p < 0.001$ ), and lower diastolic BP ( $p = 0.004$ ) and waist circumference ( $p = 0.02$ ), whereas those who consumed Western meals had higher heart rate ( $p = 0.046$ ) and waist circumference ( $p = 0.001$ ).

**CONCLUSIONS** Eating behaviors are likely to affect cardio-metabolic risk factors, and the effects vary within gender groups.

**KEYWORDS** blood pressure, body mass index, cardiovascular, eating behavior, risk, teenagers

Cardiovascular disease (CVD) due to atherosclerosis has the highest mortality rate worldwide. The mortality rate of CVD accounts for 37% of the total rate in Indonesia.<sup>1</sup> A previous study on subjects with low socioeconomic status in Yogyakarta showed medium CVD risk, which was likely to increase metabolic disorders.<sup>2</sup> The atherosclerotic process initiates since childhood and manifests as CVD in adults.<sup>3</sup>

At the early stage of atherosclerosis, obesity increases the arterial stiffness due to endothelial

dysfunction and insulin sensitivity, which intensifies with sodium retention and sympathetic effects and increases the cardiac output and blood pressure (BP). In a population study, the overweight and obese children aged between 9–11 years had higher heart rate and systolic blood pressure (SBP) compared with their normal-weight peers.<sup>4</sup> Furthermore, the obesity significantly increase the risk of events primary hypertension in children.<sup>5</sup> BP in children (<19 years) is generally classified based on BP in

percentile.<sup>6</sup> Meanwhile, in the 2017 American College of Cardiology/American Heart Association (ACC/AHA) hypertension guideline, children aged 14 years or above can be categorized normal if the BP is <120/80 mmHg.<sup>7</sup> Research shows that sex contributes to cardio-metabolic risks and affects the epidemiological profile of such risks.<sup>7</sup> Male and female subjects have different thresholds of waist circumference,<sup>8</sup> obesity profiles,<sup>9</sup> and calculators for body mass index (BMI) percentile<sup>10</sup> and BP percentile.<sup>11,12</sup>

Eating behavior and lifestyle are two significant factors in childhood obesity.<sup>13</sup> Children worldwide generally consume excess nutrients including high calories, carbohydrates, saturated fat, and sodium, and their eating behavior resembles that of the Western society.<sup>14</sup> Modernization also brings development in transportation, which causes less physical activity and a significant decline in energy consumption.<sup>15</sup> Many studies of eating behavior and cardio-metabolic risk factors have been found in adult subjects, but fewer studies have been conducted in teenagers subjects. Moreover, no research has investigated the relationship of eating behavior covering snack consumption to cardio-metabolic risk factors. In developing countries, including Indonesia, economic growth, environmental changes, and social media have significant influence, that is, they negatively affect lifestyle, including eating behavior and physical activity, and potentially raise obesity and CVD risks.<sup>9</sup> This study explored whether economic growth, particularly variables of energy consumption, affect some cardio-metabolic parameters. The study was conducted among Indonesian teenagers considering that atherosclerosis commences at the early decades of human life. This study was aimed to evaluate the effect of eating behavior on cardio-metabolic risk factors including BMI, BP, heart rate, and waist circumference among high school students aged between 14–18 years from four cities of Indonesia and to compare the variables within gender groups.

## METHODS

### Type and design of the study

This observational study with a cross-sectional design was done from July to November 2018. Subjects were senior high school students in four provinces of Indonesia, i.e., South Sumatera (Palembang), Bali (Denpasar and Sukowati), West Borneo (Pontianak),

and D.I. Yogyakarta (Yogyakarta and Bantul). The high schools were selected through purposive sampling methods. Subjects' profiles were collected from a face-to-face written interview, and cardio-metabolic parameters were measured at the study sites. The four provinces represent the most populated islands of Indonesia, except for Sulawesi. According to the Basic National Health Survey (2013),<sup>16</sup> Bali ranked 1<sup>st</sup> (lowest), West Borneo ranked 2<sup>nd</sup>, D.I. Yogyakarta ranked 6<sup>th</sup>, and South Sumatera ranked 30<sup>th</sup> (almost highest) in terms of the number of underweight teenagers aged 14–18 years.

### Subject selection

Subjects were selected among students of grades 10 or 11 through cluster random sampling. All students in the cluster provided by the schools were included as subjects. Students who do not sign informed consent will be excluded. Minimum subjects in a group were calculated with PS program<sup>®17</sup> for independent t-test analysis for two main variables (BMI percentile and BP percentile). The study set the following criteria for sample size of  $\alpha$  (type I error of 0.05), power (0.80), mean BMI, and BP difference between male and female subjects ( $\delta = 5\%$ ), standard deviation between groups ( $\sigma = 15\%$ ), and ratio between groups ( $m = 1$ ). The minimum subjects based on the calculation in each group were 142, BMI and BP percentile had four groups, and the minimum total subjects became 568.

### Variables

The independent variable included was eating behavior, and the additional variables were living with parents, cigarette consumption, and exercise. The dependent variables were BMI percentile and BP percentile, and the additional variables were waist circumference, heart rate, absolute BP, and BMI.

### Procedures

All instruments had passed the validity and reliability tests. Omron<sup>®</sup> sphygmomanometer, weight scale, and stature ruler were calibrated by the Metrology Institution to ensure validity. Reliability test was previously conducted by testing the instruments in three subjects with three replicates. Precision was estimated as coefficient of variation (CV), which was obtained from standard deviation divided with mean value; most instruments with <5 replicates were valid for imprecision levels at <5–10% CV.<sup>18</sup> All the instruments

used in this study met the reliability requirement, except for heart rate that exceeded the standard of CV at 10.5%.

The questionnaires for subjects' interviews were tested among 20 volunteers for their understanding of the content. The questionnaire consisted of personal information, i.e., age, gender, living with parents/not, eating behavior, cigarette consumption, and exercise. Personal, eating, and lifestyle behavior were collected from a face-to-face written interview, and the cardio-metabolic risk factors were measured at the study sites. BMI percentile was obtained from the online Center for Disease Center calculator<sup>10</sup> and SBP/DBP percentile was calculated using BP calculator.<sup>11,12</sup> The data in percentile were calculated based on the profiles of age, gender, and height. Waist circumference was generally measured in percentile, but the threshold for categorization was not available; therefore, this study used the absolute waist parameter.

#### Data analysis

The eating behaviors encompassed seven categorical parameters, e.g.: frequency of meals ( $\leq 3$  or  $> 3$  times per day), daily breakfast (always/frequent and rare/never), vegetable intake daily (always/frequent and rare/never), fruit intake daily (always/frequent and rare/never), Western/high-calorie meal (yes and no), frequency of snacks ( $\leq 3$  and  $> 3$  times per day), and snack quantity. These categories in each variable were a favorable aspect of cardio-metabolic risk. Snacks were defined as the amount of food/beverage eaten between meals. Snack quantity obtained from a Likert scale questionnaire which was categorized as moderate/little if the quantity ranged from zero to less than the meal quantity; otherwise, it was categorized as large/massive snack quantity. All data obtained were analyzed even though there was some missing data because it was not filled in by respondents completely.

The BMI percentile was stratified into underweight ( $< 5$ th percentile), normal weight (5– $< 85$ th percentile), overweight (85– $< 95$ th percentile), and obesity ( $\geq 95$ th percentile).<sup>19</sup> The SBP/DBP in percentile was stratified into normal BP ( $< 90$ th percentile), prehypertension (90– $< 95$ th percentile), stage I hypertension (95th percentile– $< \text{stage II threshold}$ ), and stage II hypertension (99th percentile plus 5 mmHg).<sup>11,12</sup> Meanwhile, the SBP/DBP was also classified by normal absolute BP  $< 120 / < 80$  mmHg according to the 2017 ACC/AHA hypertension guideline,<sup>7</sup> and the heart rate threshold was  $< 100$  times per min.<sup>20</sup> The cut-off of

waist circumference for male and female were  $< 90$  cm and  $< 80$  cm, respectively.<sup>8</sup> Cigarette consumption was defined as active smoking. Physically active was the condition of having  $\geq 120$  min exercise weekly and calculated based on at least 4 times weekly, with each activity lasting for  $\geq 30$  min. The ratio data of cardio-metabolic risk factors between the groups were analyzed with independent t-test, whereas categorical cardio-metabolic risk profiles between groups were analyzed with gamma test. Association of eating behaviors and cardio-metabolic risk profiles were analyzed with adjusted  $p$  linear regression.

#### Ethical issue

This descriptive, non-invasive study had complied with the ethical issue guidelines. The study protocol was approved by the Ethics Committee of Universitas Kristen Duta Wacana Yogyakarta (No: 679/C.16/FK/2018). The study was conducted at schools supervised by school teachers. The subjects were described in the study procedure and requested to sign informed consents prior to their participation. All subjects, treated as anonymous, were allowed to leave the study in case of inconvenience.

## RESULTS

There were 768 subjects, which consisted of male ( $n = 382$ ) and female ( $n = 386$ ) senior high school teenagers. The waist circumferences of 96 subjects were missing due to technical problems during measurement; nevertheless, the subjects still conformed to the minimum sample size. Teenagers had more favorable lifestyle and eating behavior, namely, low cigarette consumption (5.7%), routine breakfast (55.0%), vegetable intake daily (57.3%), Western/high-calorie meal (22.7%), snack frequency  $\leq 3$  times (86.4%), and moderate/little snack quantity (74.6%). Few subjects had  $\geq 120$  min weekly exercise, particularly in the female group. Moreover, the fruit intake was low and particularly lower in the male group (Table 1).

Subject profile comprising seven eating behavior variables and three other variables (Table 1). All the variables were compared between the gender groups. The numbers of male teenagers who were smokers ( $p < 0.001$ ), performed exercise  $\geq 120$  min in a week ( $p < 0.001$ ), had  $> 3$  times meal ( $p = 0.002$ ), and consumed snacks in moderate quantity ( $p = 0.001$ ) were higher than female teenagers. The high consumption of

cigarette and high frequency of meal were variables to elevate cardio-metabolic risk, whereas exercise and moderate quantity of snack were considered as variables to lower cardio-metabolic risk. The remaining

eating behavior namely living with parents, have a breakfast, vegetable and fruit intake, Western/high-calorie meal, and snack frequency were not different between the gender groups (Table 1).

**Table 1.** Characteristic profiles among all subjects and gender sub-groups

Profiles	n (%)	Gender		<i>p</i> *
		Male, n (%) (N = 382)	Female, n (%) (N = 386)	
<b>Live with parents</b>				
Yes	634 (82.5)	308 (80.6)	326 (84.4)	0.13
No	129 (16.8)	72 (18.9)	57 (14.8)	
Missing data <sup>†</sup>	5 (0.6)	2 (0.5)	3 (0.8)	
Cigarette consumption	44 (5.7)	44 (11.5)	0 (0.0)	<b>&lt;0.001</b>
<b>Exercise ≥120 min/week</b>				
Yes	242 (31.5)	173 (45.2)	69 (17.9)	<b>&lt;0.001</b>
No	525 (68.4)	208 (54.5)	317 (82.1)	
Missing data <sup>†</sup>	1 (0.1)	1 (0.3)	0	
<b>Meal frequency</b>				
≤3 times	721 (93.9)	349 (91.4)	372 (96.4)	<b>0.002</b>
>3 times	44 (5.7)	32 (8.3)	12 (3.1)	
Missing data <sup>†</sup>	3 (0.4)	1 (0.3)	2 (0.5)	
<b>Breakfast</b>				
Always/frequent	421 (54.8)	218 (57.1)	203 (52.6)	0.21
Seldom/never	345 (44.9)	163 (42.6)	182 (47.2)	
Missing data <sup>†</sup>	2 (0.3)	1 (0.3)	1 (0.2)	
<b>Vegetable intake</b>				
Always/frequent	438 (57.0)	231 (60.5)	207 (53.6)	0.07
Seldom/never	326 (42.4)	150 (39.2)	176 (45.6)	
Missing data <sup>†</sup>	4 (0.6)	1 (0.3)	3 (0.8)	
<b>Fruit intake</b>				
Always/frequent	314 (40.9)	147 (38.5)	167 (43.3)	0.16
Seldom/never	448 (58.3)	233 (61.0)	215 (55.7)	
Missing data <sup>†</sup>	6 (0.8)	2 (0.5)	4 (1.0)	
<b>Western/high-calorie meal</b>				
Yes	174 (22.7)	96 (25.1)	78 (20.2)	0.10
No	593 (77.3)	285 (74.6)	308 (79.8)	
Missing data <sup>†</sup>	1 (0.1)	1 (0.3)	0	
<b>Snack frequency</b>				
≤3 times	658 (85.7)	330 (86.4)	328 (85.0)	0.57
>3 times	104 (13.5)	49 (12.8)	55 (14.2)	
Missing data <sup>†</sup>	6 (0.8)	3 (0.8)	3 (0.8)	
<b>Snack quantity</b>				
Moderate/little	560 (72.9)	300 (80.6)	260 (67.4)	<b>&lt;0.001</b>
Massive	191 (24.9)	72 (19.4)	119 (30.8)	
Missing data <sup>†</sup>	17 (2.2)	10 (2.6)	7 (1.8)	

\*Chi-square test

<sup>†</sup>Missing data because of unanswered questions

**Table 2.** Cardio-metabolic risk profiles in total subjects and gender sub-groups

Profile	Total subjects, mean (SD)	Gender subgroup, mean (SD)		p*
		Male	Female	
Age (years)	16.0 (0.7)	16.2 (0.7)	15.8 (0.6)	<b>&lt;0.001</b>
BMI (kg/m <sup>2</sup> )	22.2 (4.7)	22.4 (5.1)	21.9 (4.2)	0.12
BMI in percentile	55.1 (32.5)	54.4 (35.0)	55.8 (29.8)	0.56
SBP (mmHg)	114.2 (13.1)	119.3 (12.2)	109.2 (12.0)	<b>&lt;0.001</b>
DBP (mmHg)	72.7 (8.9)	73.5 (9.3)	71.9 (8.5)	<b>0.02</b>
Heart rate (x/min)	86.8 (14.1)	83.9 (14.3)	89.7 (13.3)	<b>&lt;0.001</b>
Waist circumference (cm)	80.8 (25.6)	83.7 (35.2)	77.9 (8.1)	<b>0.003</b>
Meals/day	2.6 (0.7)	2.8 (0.90)	2.5 (0.6)	<b>&lt;0.001</b>
Snacks/day	2.0 (1.5)	1.9 (1.5)	2.1 (1.5)	0.15

SD=standard deviation; BMI=body mass index; SBP=systolic blood pressure; DBP=diastolic blood pressure

\*Independent t-test

**Table 3.** Categorical cardio-metabolic risk profiles in total subjects and sub-groups

Categories	Total, n (%)	Sub-group, n (%)		p*
		Male	Female	
BMI percentile				0.27
Underweight (<5th percentile)	72 (9.4)	49 (12.9)	23 (6.0)	
Normal weight (5th–<85th percentile)	487 (63.5)	213 (55.9)	274 (71.0)	
Overweight (85th–<95th percentile)	121 (15.8)	58 (15.2)	63 (16.3)	
Obese (≥95th percentile)	87 (11.3)	61 (16.0)	26 (6.7)	
SBP percentile				<b>0.005</b>
Normal SBP (<90th percentile)	643 (84.7)	304 (80.9)	339 (88.5)	
Prehypertension (90th–<95th percentile)	45 (5.9)	34 (9.0)	11 (2.9)	
Stage I (95th–< stage II threshold)	60 (7.9)	29 (7.7)	31 (8.1)	
Stage II hypertension	11 (1.4)	9 (2.4)	2 (0.5)	
DBP percentile				0.69
Normal DBP (<90th percentile)	604 (79.6)	298 (79.3)	306 (79.9)	
Prehypertension (90th–<95th percentile)	64 (8.4)	28 (7.4)	36 (9.4)	
Stage I (95th–< stage II threshold)	84 (11.1)	45 (12.0)	39 (10.2)	
Stage II hypertension	7 (0.9)	5 (1.3)	2 (0.5)	
SBP with absolute cut-off				<b>&lt;0.001</b>
Normal SBP (<120 mmHg)	490 (64.4)	195 (51.7)	295 (76.8)	
Elevated SBP (120–<130 mmHg)	167 (21.9)	114 (30.2)	53 (13.8)	
Stage I hypertension (130–<140 mmHg)	84 (11.0)	50 (13.3)	34 (8.9)	
Stage II hypertension (≥140 mmHg)	20 (2.6)	18 (4.8)	2 (0.5)	
DBP with absolute cut-off				0.20
Normal DBP (<80 mmHg)	599 (78.7)	290 (76.9)	309 (80.5)	
Stage I hypertension (80–<90 mmHg)	133 (17.5)	69 (18.3)	64 (16.7)	
Stage II hypertension (≥90 mmHg)	29 (3.8)	18 (4.8)	11 (2.9)	

BMI=body mass index; SBP=systolic blood pressure; DBP=diastolic blood pressure

\*Gamma-test

The participants had normal mean cardio-metabolic risk of BMI, BP, heart rate, and waist circumference between gender. Male teenagers had older age, higher SBP, higher DBP, slower heart rate, and higher meal frequency than female teenagers. BMI percentile was not different between male and female (Table 2).

Table 3 showed the parameter of cardio-metabolic risk profiles in total subject and sub-groups gender. The cardio-metabolic risk profiles namely BMI and blood pressure were the same between gender except SBP (Table 3). Fruit intake and snack frequency were not affected the cardio-metabolic risk. Corresponding to gender difference in the four variables of eating behavior, age, and exercise duration, the *p*-value in the eating behavior was analyzed with adjusted *p* linear regression with gender, duration of exercise, and age factors. After the adjustment, breakfast and vegetable intake affects BMI, whereas Western meal and snack quantity affects heart rate. Although the lower meal frequency had a higher BMI, the analysis can be biased due to imbalanced sample size in each subgroup, with only 5.8% of subjects having meals >3 times daily.

In the gender subgroup analysis (Figure 1), male teenagers with routine vegetable intake had low heart rate ( $p = 0.03$ ). Female teenagers with moderate quantity of snacks had wider waist circumference ( $p = 0.03$ ), those who had Western meals had worse heart rate ( $p = 0.046$ ) and waist circumference ( $p = 0.001$ ), and those with routine breakfast had better BMI ( $p < 0.001$ ), waist circumference ( $p = 0.02$ ), and DBP ( $p = 0.004$ ). In the overall and subgroup subject analyses, fruit intake and snack frequency did not affect the cardio-metabolic risk parameters ( $p > 0.05$ ) (Figure 1).

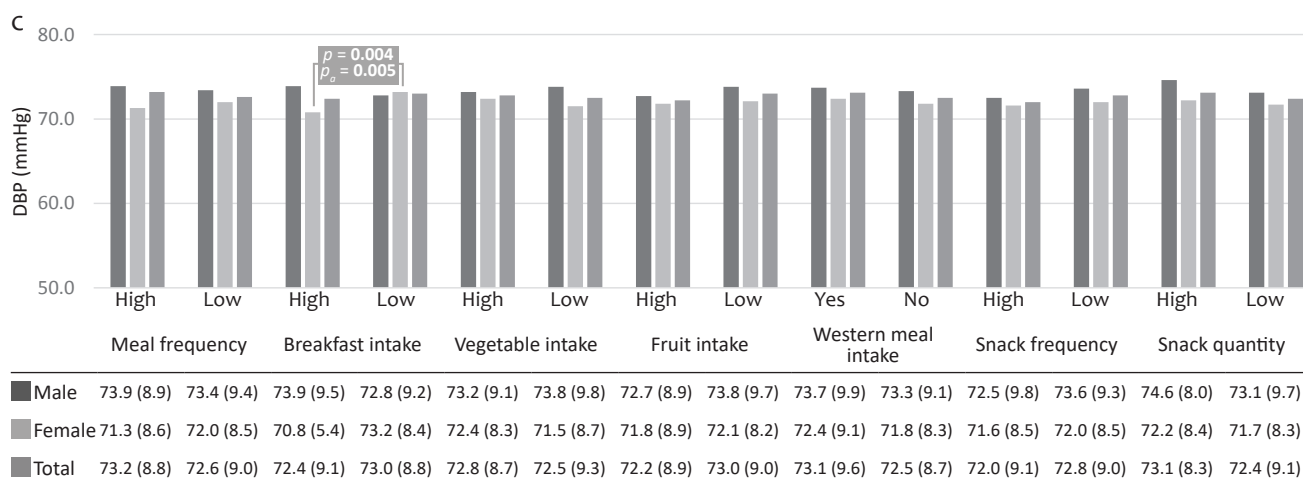
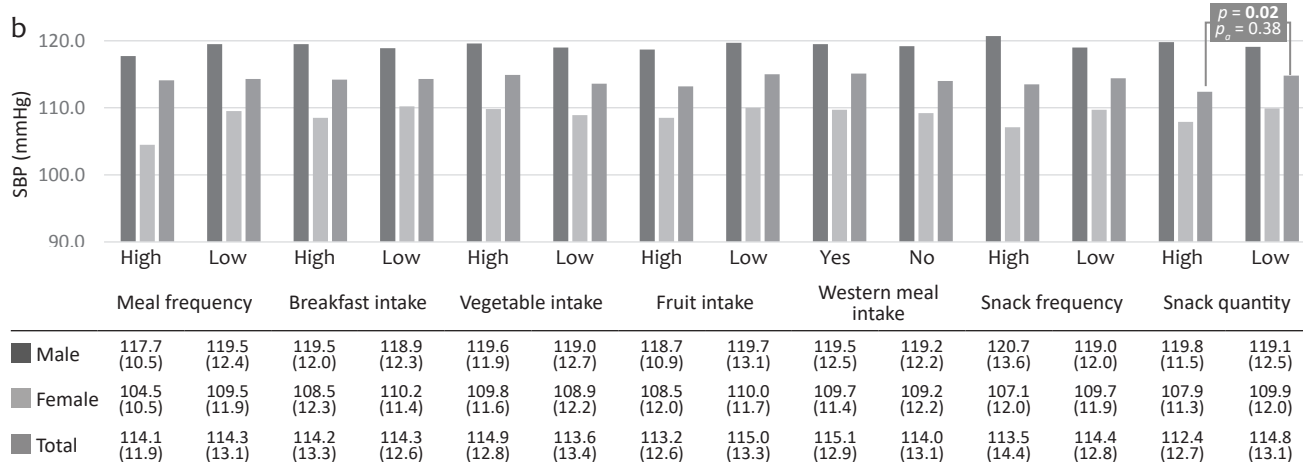
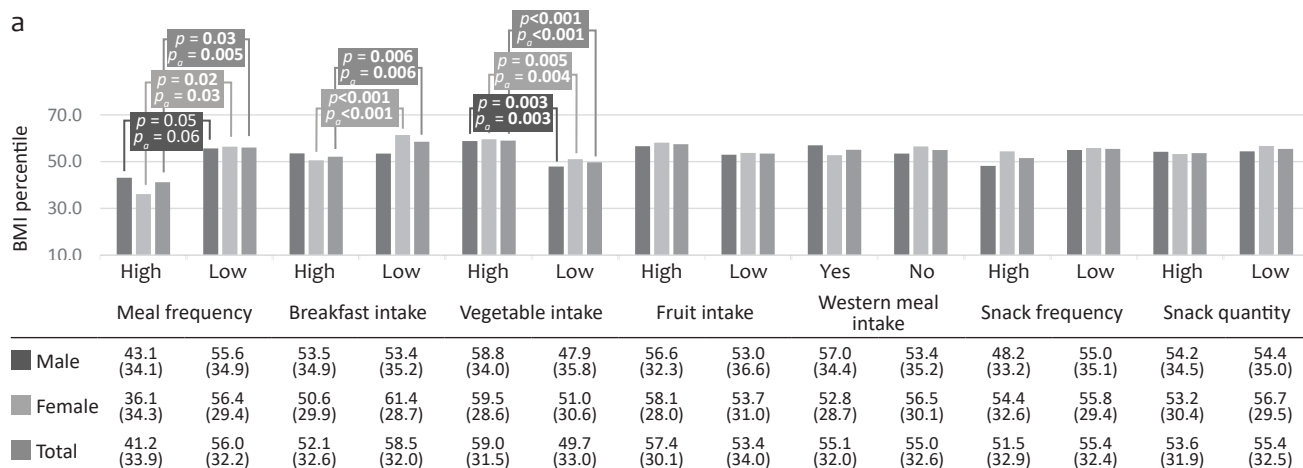
## DISCUSSION

This study was aimed to evaluate the association of eating behavior on cardio-metabolic risk factors in high school teenagers. The evaluation was conducted in 768 total subjects. The further evaluation was done in gender groups to considering that gender affects CVD.<sup>7</sup> In this study, the percentage of male and female subjects that living with parents almost the same. Living with parents may influence the eating behavior of teenagers. A study in China, mothers with elementary or below education level were 49% (odds ratio and [95% confidence interval] = 1.49 [1.10–2.03]) more likely to serve Western meal to their children

than those with college or above education level.<sup>21</sup> In another study, feeding intervention of parents with their young children improved the dietary quality.<sup>22</sup> Therefore, in this study, living with parents had similar contribution on both gender group. The subjects had relatively good eating behavior and cardio-metabolic profiles. Regarding the findings that parents positively influenced children's diet so it could be concluded that living with parents was likely to contribute to eating behavior and cardio-metabolic parameters.

In this study, teen subjects had averages of 2.6 times of meals and 2.0 times of snacks. This finding is similar to common daily meal frequency of adult in USA that is, three meals and some snacks between meals.<sup>23</sup> Eating food, both meals and snacks, supplies nutrients required for daily living. In contrast, another finding showed that the subjects did not consume excessive nutrition, as shown in the following lines of evidence: higher proportion of subjects with moderate quantity of meals and snack, routine vegetable intake, and avoidance of Western/high-calorie meals.<sup>15</sup> In this study, vegetable and fruit daily intake represented a meal with high contents of fiber and nutrients, which are favorable for cardiovascular health; meanwhile, Western/high-calorie meals are detrimental for cardiovascular health.<sup>24,25</sup> The overall subjects had lived with good eating behavior with more proportion of teenagers with healthy eating behavior. A low proportion of teenagers had Western meals. This finding contradicts that in reference, which showed the high prevalence of fast food consumption in major cities in China among children.<sup>21</sup> In the present study, the frequencies of eating breakfast, vegetables, fruits, and Western meals were not different between the gender groups. The consumption of vegetables and moderate snack was higher in the male group than in the female group. Our finding showed different result from previous study which conducted a survey among 12–18 year old Australian teenagers, where male teenagers consumed more high-calorie fat and sugar.<sup>26</sup> Most subjects lived with their parents, and their meals prepared at home were likely to cause no disparity in most eating behavior between the gender groups.

Subjects with exercise activity  $\geq 120$  min weekly with a lower proportion was female teenagers (17.9%). However, a reduction in exercise activity is associated with the decline in energy expenditure. The increase in obesity epidemic is occurring against the background of continuous decline in the energy expenditure.<sup>15</sup>



**Figure 1.** Association of eating behaviors and cardio-metabolic risk profiles. BMI=body mass index; SBP=systolic blood pressure; DBP=diastolic blood pressure;  $p_a$ =adjusted  $p$ -value to gender, exercise, and age. All data were describe as mean (SD). Other variables that were not mentioned above had  $p>0.05$   $p$ -value analyzed with independent t-test

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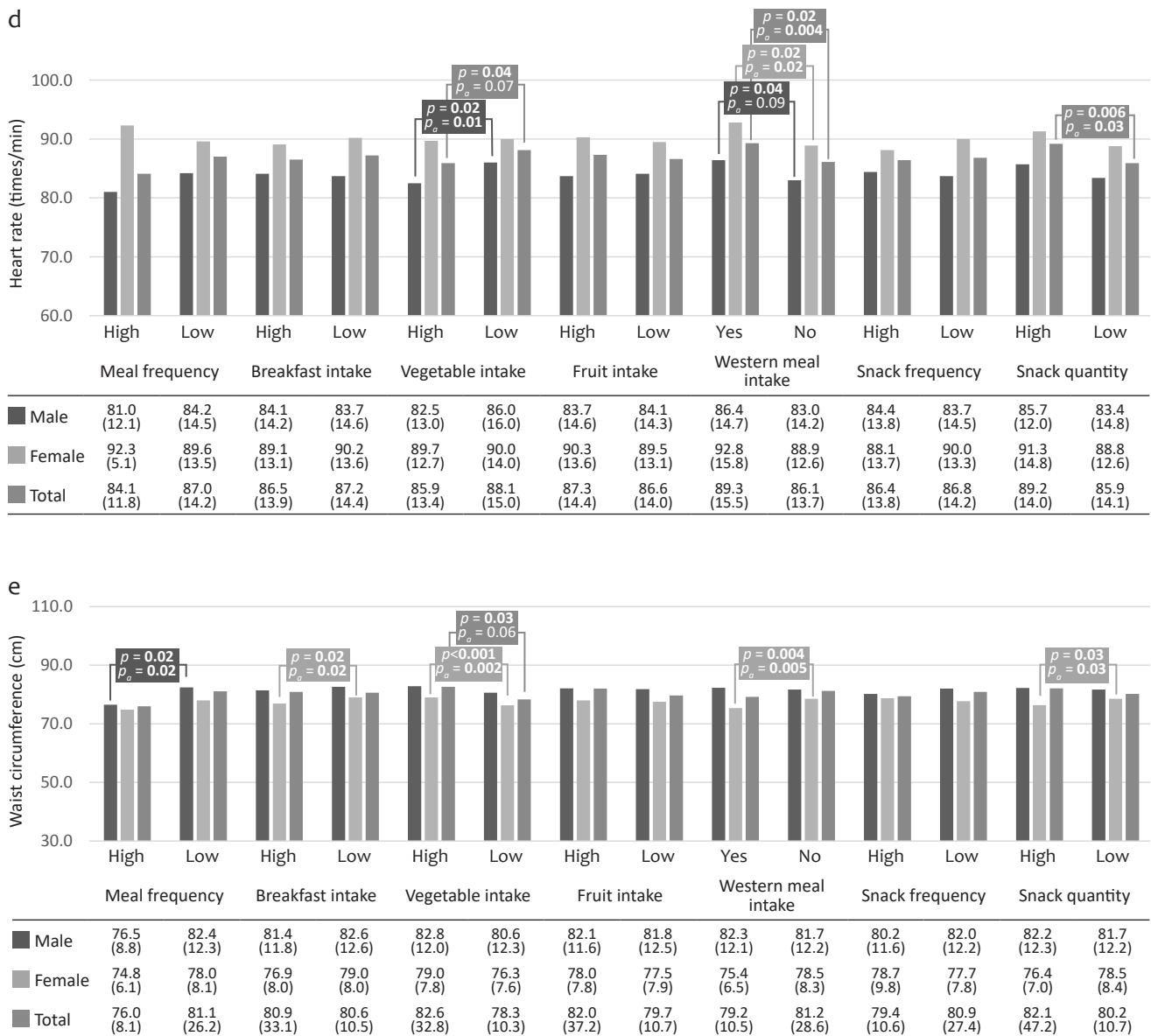


Figure 1. (continued)

Therefore, exercise is the most urgent required factor for CVD prevention. The low exercise rate among subjects will cause a definite CVD problem in their future life.<sup>27</sup>

The prevalence of high BP among teenagers 15–17 years old was 13.6% for SBP in percentile and 21.3% for DBP in percentile; these values exceed that (5.3%) obtained in National Basic Health Survey in 2013.<sup>16</sup> Moreover, the exact hypertension rates in the community were generally higher than the reported prevalence because the disease progresses without symptoms and is often under-recognized.<sup>6</sup> This finding can be considered as early signal of hypertension and should be anticipated for prevention of CVD in their future life. Healthy lifestyle, including healthy eating

habits, and maintenance of cardio-metabolic risk are an important solution. The prevalence of hypertension was higher in male teenagers than female at 18.1% versus 9.4% for SBP ( $p < 0.001$ ) and 23.1% versus 18.7% ( $p = 0.20$ ) for DBP. This finding conforms to the global data that male subjects have higher prevalence of hypertension than female subjects before the menopausal period.<sup>7</sup>

BMI in percentile for male teenagers were similar with female ( $p = 0.56$ ), while the waist circumference of male wider than female ( $p = 0.003$ ). However, the difference between female and male teen around 6 cm. According to the standard, the difference of waist circumference should be at 10 cm.<sup>8</sup> Measuring obesity using BMI is practical, fast, easy, and inexpensive,



but the method cannot distinguish body mass with and without fat;<sup>19</sup> meanwhile, waist circumference can represent the subject's central obesity and fat mass. The overall subjects had normal BMI and waist circumference. Another finding showed that gender disparity in obesity was not persistent. Evidence from a national survey revealed that more female subjects had central obesity<sup>28</sup> and similar prevalence in worldwide, particularly in lower middle income countries, showed that more obesity in female subjects.<sup>9</sup> The intraabdominal fat was lower in girls, as reported by a population-based study on 12–18 year old teenagers.<sup>29</sup> Female teenagers had more overweight/obese subjects with wider waist circumference but less overweight/obese subjects with BMI (Table 2).<sup>19</sup>

The male subjects had worse SBP but not DBP than female subjects; similar results were found in SBP/DBP in percentile and absolute measurement. This finding conforms to the 2017 ACC/AHA hypertension guideline that BP in children can be measured in percentile; for teenagers aged  $\geq 14$  years, BP is classified based on the JNC7 threshold for adults (Table 2 and 3).<sup>7</sup>

In overall subjects, teenagers with more frequent breakfast daily had low BMI (adjusted  $p = 0.007$ ). Routine breakfast would avoid skipping meal, which induced snack consumption.<sup>30</sup> Snack consumption from dessert or sweets were likely related to high-calorie intake and BMI increase.<sup>31</sup> In this study, low intake of vegetable but not fruit was associated with BMI, waist circumference, SBP, and DBP. Other study conducted in teenagers aged  $\geq 16$  years showed that fruit, salad, cereals, and fish intake had lower DBP ( $p = 0.0025$ ) after adjustment for age, gender, and physical activity.<sup>26</sup>

This study described that eating behavior, meal frequency, breakfast, vegetable intake, fruit intake, western/high-calorie meal, snack frequency, and snack quantity, did not affect BP and waist circumference in overall subjects but affected waist circumference in the female group. The physiological systems in teenagers are likely to compensate for the effect, since no unfavorable clinical effect due to unhealthy lifestyle had emerged yet. Age  $>40$  year old had an impact in the development and incidence of CVDs.<sup>32,33</sup> However, eating behavior as one of factors may contribute partially to cardio-metabolic risk. Other factors, such as interests and activities, family history of CVD, and socioeconomic background, also contributed to CVD risk.<sup>2</sup> As family history of CVD is a cardiovascular risk

factor,<sup>3</sup> in this study most subjects could not provide those information.

Similar to the finding in the overall subjects, eating behavior were not associated with the subject's SBP/DBP in both gender groups, except for routine breakfast in female teenagers that had positive significant effect on DBP. Skipping breakfast would increase CVD risk and it was higher in female participants.<sup>34</sup> Adjusted  $p$  results from the association of eating behavior and cardio-metabolic risk which adjusted duration of exercise and age factors after being classified by gender. A study conducted in Tokyo showed that DBP is a more important BP component for prediction of developing hypertension than SBP in  $<50$ -year-old subjects. Reducing DBP can prevent hypertension. The study recommended initiating early therapeutic lifestyle changes among younger subject aged  $<50$  years when slight increase in DBP occurs.<sup>35</sup> Routine breakfast could likely decrease hunger and snack craving throughout the day and maintain bodyweight accordingly. The observation from this study supported the effect of routine breakfast on better cardio-metabolic outcomes, including better BMI in percentile in the overall subjects. The positive effect of breakfast was more intense in female teenagers, as evident by better BMI in percentile, DBP, and waist circumference.

The mean values of cardio-metabolic risk parameters in the overall subjects were normal (Table 2); nevertheless, some subjects had a risk of potential CVD (Table 3). This finding should be the reason for concern by parents, teachers, clinicians, and health educators/authorities. Implementation of healthy lifestyle as early as possible will be beneficial to control CVD morbidity and mortality rate in future life.<sup>36</sup> In a prospective follow-up study in hypertensive subjects, the intervention was beneficial regardless of the change in body weight, resulting in achieving lower BP and low-density lipoprotein level.<sup>37</sup> Similarly, one study conducted in a community in 2018 confirmed that health education by pharmacists increased the proportion of non-smoking subjects and reduced the CVD risk.<sup>38</sup>

We found some abnormality results in this study, for example, teenagers with routine vegetable intake had higher BMI, and female teenagers with routine vegetable intake had wider waist circumference than their peers ( $p < 0.001$  versus  $0.10$ , respectively). The unusual results occurred due to the limitation of the study. The study was conducted with a cross-sectional design and could not reveal the subject's baseline

condition. The number of subjects varied in each school and/or province and in each subgroup. Moreover, cardio-metabolic risk parameters were accumulated by multiple factors. Our study observed eating behavior on seven variables/factors. We declared that one single factor of eating behavior was insufficiency to show good relationship with cardiometabolic factors. Further studies with randomized control method or good design cohort should be conducted to evaluate correlation among variables (Figure 1).

The other cardio-metabolic risk factors, such as levels of cholesterol, triglyceride, and blood glucose, were not measured due to the limitations of the study method. We recommend that further studies should be conducted with cohort design to confirm the present results and determine all other causes of cardio-metabolic risk among teenagers. In conclusion, eating behaviors, including routine breakfast, low quantity of snack intake, and avoiding Western/high-calorie meals were likely to have positive effect on cardio-metabolic risk factors. Further studies are suggested to generalize the results to other populations.

#### Conflict of Interest

The authors affirm no conflict of interest in this study.

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