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Association between Metabolic Syndrome and Alcohol Consumption: A Cross-sectional Study

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Abstract:

Objective: To determine the association between metabolic syndrome and alcohol consumption, including drinking patterns and risk of harm.

Materials and Methods: A cross-sectional study was conducted on 400 participants recruited from the Outpatient Unit of the Family Medicine Department, Faculty of Medicine, Chiang Mai University. Physical examination and blood tests were carried out to evaluate the presence of metabolic syndrome. The drinking patterns were stratified into four levels, which were abstinence, occasional drinking, light–moderate drinking, and heavy drinking (>40 gm/day). The Alcohol Use Disorders Identification Test was used to evaluate the risk of harm from alcohol consumption.

Results: The percentage of current drinkers was 27.3%, and most of them were men (87.2%). Waist circumference, triglyceride levels, and diastolic blood pressure were significantly higher among those with a heavy drinking habit and harmful alcohol use/dependence. High density lipoprotein cholesterol (HDL-C) showed different results. A J-shaped association was found between HDL-C and drinking pattern, but an inverse relationship was indicated with the risk of harm. Metabolic syndrome was found to be significantly associated with heavy drinking (OR=4.4, 95% Confidence Interval (CI) 1.2–15.6, p-value 0.021) and the harmful use/dependent categories (OR=5.0, 95% CI 1.1–23.1, p-value 0.039).

Conclusion: The results suggest that alcohol drinking tends to be associated with an increased risk of metabolic syndrome. This condition should be screened regularly especially in those with heavy drinking or at-risk drinking habits.

Keywords: alcohol, AUDIT, metabolic syndrome, non-communicable disease, risk of harm

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Introduction

Excessive alcohol intake is known to cause extensive health problems. According to the World Health Organization (WHO) report, about 40.0% of the world's population drinks alcohol excessively. Globally, the harmful use of alcohol has been proven to cause approximately 3.3 million deaths every year (or 5.9% of all deaths worldwide), and 5.1% of the global burden of diseases is attributable to alcohol consumption.[1] Included in this, is metabolic syndrome, which is a major risk factor for non-communicable diseases (NCDs) such as hypertension (HTN), diabetes mellitus (DM), and cardiovascular diseases (CVD), which are major problems throughout the world.[2]

Studies regarding the association of alcohol consumption with cardiovascular risk have found that light-to-moderate alcohol consumption is significantly associated with a lower incidence of cardiovascular and all-cause mortality. J-shaped pooled curves were observed in a study's overall analysis.[3] However, several other studies have reported controversial results as regards the benefits and adverse effects of drinking alcohol.[4,5]

As for Thailand, alcohol use is a major public health problem in all age groups[6], especially in the Northern Region where, currently, the number of alcohol drinkers, including those as young as 15 years of age, is the highest in the country.[7,8] Screening for alcohol problems on a primary level by using the Alcohol Use Disorders Identification Test (AUDIT)[9] is recommended by the WHO to assess the problems caused by drinking and identify the at-risk groups in order to provide proper treatment. The knowledge regarding the relationship of alcohol intake with occurrence of metabolic syndrome will help in the early prediction and planning of care for the prevention of NCDs. The current evidence of the relationship between the risk of harm and metabolic syndrome is scarce. Most studies conducted on alcohol consumption patterns have yielded controversial results.[10] Therefore, the researchers were interested in studying both the quantity and the level of risk assessment by AUDIT to be utilized in the evaluation of alcohol use disorder and metabolic syndrome.

Material and Methods

A cross-sectional study was performed. The participants, who were above 18 years of age, had come to the hospital either for consultation regarding general diseases or an annual physical examination, both with and without comorbidities, and they were recruited for the study between December 2016 and January 2017 from the outpatient care setting of the Family Medicine Department, Faculty of Medicine, Chiang Mai University. The sample size was calculated based on a previous research study by Tresserra-Rimbau et al.[11] using the formula of two independent proportions (two-tailed test); the number of samples in each group was 82. A research study by Lerssrimongkol[12] at the outpatient clinic of the Family Medicine Department of the same hospital showed the prevalence of metabolic syndrome among healthy Thai adults to be 24.6%, so the sample size required at least 333 cases. The researcher recruited a total of 400 participants. All individuals enrolled in the study signed a written informed consent before undergoing the interview, physical examination, and blood sample collection, and answering the questionnaires. All procedures were approved by the Research Ethics Committee of the Faculty of Medicine, Chiang Mai University, Thailand (No. 392/2559).

The data were collected from completed clinical records, and the assessments of alcohol-related problems were carried out by trained personnel. The data were divided into four parts. The first part consisted of personal data like age, sex, occupation, education, income, history of

smoking, and amount of smoking (pack-year). The second part comprised physical examination findings such as weight (kilogram; kg) and height (centimeter; cm) using a digital meter to measure and calculate the body mass index (BMI) automatically, waist circumference (WC) measured at the navel (National Institutes of Health Multi-ethnic Study of Atherosclerosis or NIH MESA protocol)[13] using a waist tape measure, and blood pressure (BP) measured by trained staff in the sitting position after the patient had sat for at least 5 min. The third part consisted of the blood test, which comprised fasting blood glucose (FBS), high density lipoprotein cholesterol (HDL-C), total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), and triglycerides (TG) within the last 3 months to investigate for the presence of metabolic syndrome diagnostic criteria according to the American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement (AHA/NHLBI) and the International Diabetic Federation (IDF).[14,15] The fourth part, the questionnaire, consisted of questions enquiring about drinking patterns[16] stratified into four levels, which were abstinence (non-drinkers), occasional drinking (irregular drinkers), light-to-moderate drinking (regular drinkers who drink 10–40 gram (g)/day), and heavy drinking (regular drinkers who drink >40 g/day). The AUDIT was used as a tool in this study to assess the risk of harm from alcohol consumption, which was divided into four levels: non-drinkers, low risk (score 1-7), hazardous risk (score 8-15), and harmful use/dependence (score >16).[17] The questionnaires regarding the assessment of dietary intake and physical activity were adapted from those utilized/proposed by the National Statistical Office.[18,19] (Supplementary Table 1)

All analyses were performed using STATA SE 12.1 for Windows. The descriptive data are displayed in terms of percentages. The examination of the association between alcohol consumption and metabolic syndrome indicators utilized the t-, chi-square, and ANOVA tests. Multivariate logistic regression analysis models were used to calculate the odds ratios (ORs) and the 95% confidence intervals (CIs) for each drinking category adjusted for age, sex, smoking, and BMI. P-values<0.05 were considered statistically significant. Missing values were excluded from the analysis.

Results

Of the four hundred subjects, those with metabolic syndrome comprised 55.5% (222 subjects), and the data were compared between patients with and those without metabolic syndrome, as shown in Table 1. Patients with metabolic syndrome were primarily female (59.5%), with a higher average of BMI than those without metabolic syndrome (p-value<0.001). The other variables were not statistically significant.

Table 2 shows that the overall alcohol consumption rate was 27.3% (109 of 400 subjects), with the majority being occasional and low-risk drinkers. Younger age, male sex, and smoking were associated with increased amounts of drinking and more dangerous levels of risk of harm.

The comparison between the amount of alcohol intake and AUDIT risk level with the various factors of metabolic syndrome found the same trend in association as that between drinking patterns and AUDIT risk trends. Some metabolic syndrome indicators—waist circumference, diastolic blood pressure (dBP), and TG—were found to be associated with a greater quantity of alcohol consumption and greater risk of harm due to it (p-value 0.007, <0.001, and <0.001, respectively). However, the FBS association with alcohol consumption was the highest with heavy drinking and the lowest with mild-to-moderate drinking (p-value 0.004), but it did not associate with risk level (p-value 0.606). A J-shaped association was found between HDL-C and drinking pattern; HDL-C, however,

was found to have an inverse relationship with the risk of harm (Figure 1). The systolic BP, TC, and LDL-C were not found to be associated with either the quantity or the level of risk. Metabolic syndrome, according to the diagnostic criteria from the AHA/NHLBI and IDF, was not found to be statistically associated with drinking, with either drinking pattern or risk level.

Table 1 Demographic data of study population

Variable	Total (n=400)	No metabolic syndrome (N=178)	Metabolic syndrome (N=222)	p-value
Age (years), mean±S.D.	61.8±10.1	61.1±10.6	62.4±9.7	0.207
Female sex, n (%)	218 (54.5)	87 (48.8)	131 (59.5)	0.043
BMI (kg/m^2), mean±S.D.	25.7±4.1	24.2±3.7	26.8±4.0	<0.001
Underlying diseases				
No underlying disease	28 (7.0)	24 (13.5)	4 (1.8)	<0.001
Diabetes mellitus	89 (22.2)	14 (7.9)	75 (33.8)	<0.001
Hypertension	265 (66.2)	97 (54.5)	168 (75.7)	<0.001
Dyslipidemia	225 (56.2)	69 (38.8)	156 (70.3)	<0.001
Other	72 (18.0)	37 (20.8)	35 (15.8)	0.194
Living in an urban area, n (%)	182 (45.5)	87 (48.88)	95 (42.8)	0.225
Smoking, n (%)	79 (19.7)	39 (22.4)	39 (17.5)	0.221
Pack-year among smokers, mean±S.D.	12.1±10.8	13.4±11.8	10.9±9.7	0.302
Higher education, n (%)	143 (35.7)	62 (34.8)	81 (36.5)	0.731
Drinkers, n (%)	109 (27.2)	50 (28.1)	59 (26.6)	0.735
Standard drink (drink/day) among drinkers, mean±S.D.	4.3±3.2	4.34±2.8	4.3±3.4	0.926
Income, n (%)				0.562
<10,000 baht/month	162 (40.5)	76 (42.7)	86 (37.7)	
10,000–30,000 baht/month	160 (40.0)	66 (37.1)	94 (42.3)	
>30,000 baht/month	78 (19.5)	36 (20.2)	42 (18.9)	
Dietary intake				
Cooking oil frequently, n (%)	95 (23.7)	44 (24.7)	51 (23.0)	0.683
Protein and protein products, >4 day/wk, n (%)	237 (59.2)	109 (61.2)	128 (57.6)	0.469
High fat food, >4 day/wk, n (%)	42 (10.5)	22 (12.4)	20 (9.0)	0.277
Snacks, >4 day/wk, n (%)	11 (2.7)	4 (2.2)	7 (3.1)	0.582
Fast food, >4 day/wk, n (%)	2 (0.5)	0 (0.0)	2 (0.9)	0.204
Fruits and vegetables, >4 day/wk, n (%)	348 (87.0)	158 (88.7)	190 (85.6)	0.348
Sweets, >4 day/wk, n (%)	164 (41.0)	72 (40.4)	92 (41.4)	0.841
Physical activity				
No exercise, n (%)	197 (49.2)	85 (47.7)	112 (50.4)	0.592
Housework, n (%)				0.685
≤2 times/wk	96 (24.0)	44 (24.7)	52 (23.4)	
3–4 times/wk	37 (9.2)	14 (7.9)	23 (10.3)	
Nearly everyday – everyday	267 (66.7)	120 (67.4)	147 (66.2)	
Sedentary lifestyle (hr/day), mean±S.D.	6.8±2.2	6.7±2.2	6.9±2.3	0.200

S.D.=standard deviation, BMI=body mass index, wk=week, hr=hour, kg/m^2=kilogram/square meters

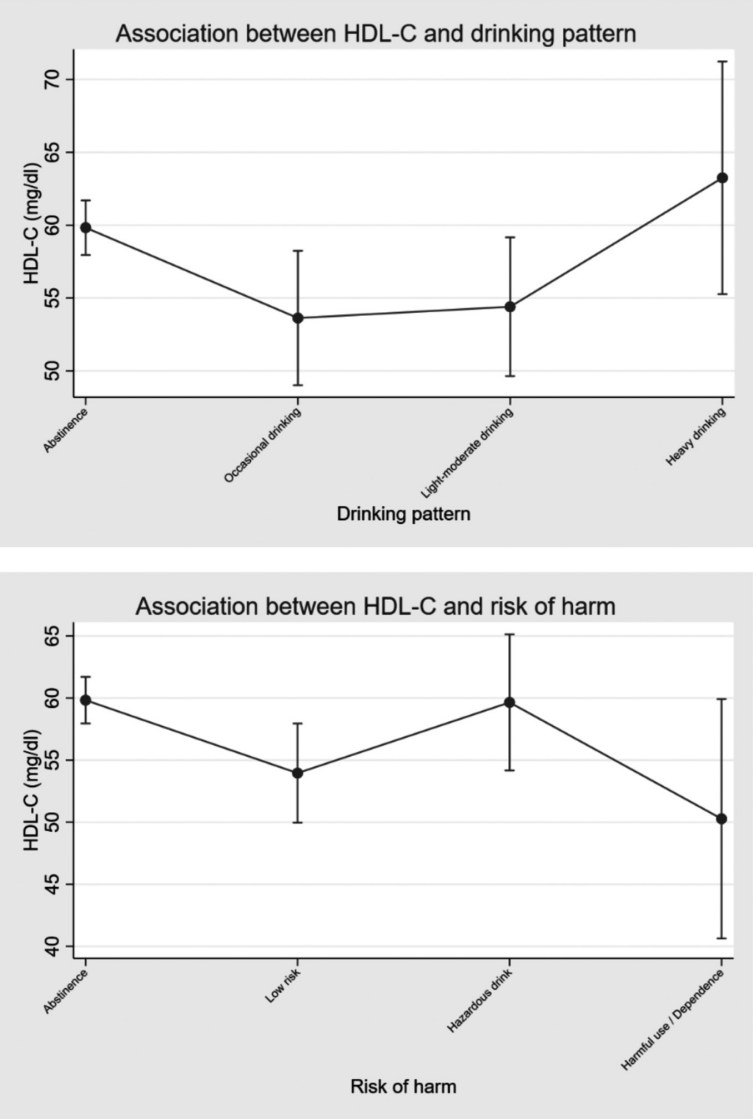
Table 2 Association between alcohol consumption (volume and risk of harm) and individual metabolic syndrome components

Variable (n=400)	Abstinence (n=291)	Amount (volume) of alcohol intake				Risk of harm			
		Occasional drinking (n=48)	Light–moderate drinking (n=45)	Heavy drinking (n=16)	p-value	Low risk (n=64)	Hazardous drink (n=34)	Harmful use/dependence (n=11)	p-value
Age (years), mean±S.D.	63.7±9.87	58.1±7.3	58.1±9.2	49.8±11.1	<0.001	58.4±7.6	55.7±10.8	52.0±10.0	<0.001
Men, n (%)	87 (29.9)	35 (72.9)	44 (97.8)	16 (100.0)	<0.001	50 (78.1)	34 (100)	11 (100)	<0.001
BMI (kg/m^2), mean±S.D.	25.5±4.4	26.4 ±3.4	25.9±3.2	25.3±3.1	0.585	26.2±3.2	25.7±3.5	26.2±3.2	0.693
Smoking, n (%)	36 (12.3)	10 (22.8)	21 (46.7)	12 (75.0)	<0.001	16 (25.0)	19 (58.8)	8 (72.73)	<0.001
WC (cm), mean±S.D.	84.0±9.9	87.9±9.2	87.5±8.56	88.2±7.8	0.007	87.7±8.4	87.2±9.4	90.4±8.3	<0.001
sBP (mmHg), mean±S.D.	135.2±14.5	134.6±12.7	132.7±12.0	138.2±11.9	0.525	132.4±12.8	137.1±10.7	137.1±12.9	0.336
dBP (mmHg), mean±S.D.	77.5±10.1	81.6±8.3	82.4±8.7	84.8±9.0	<0.001	81.5±8.2	82.6±7.9	87.1±11.6	<0.001
FBS (mg/dl), mean±S.D.	106.7±26.1	107.4±23.9	103.5±14.9	130.2±45.3	0.004	107.4±21.2	110.1±33.8	116.4±30.4	0.606
Triglycerides (mg/dl), mean±S.D.	130.8±60.8	151.9±82.6	160.9±88.1	279.9±337.4	<0.001	160.2±94.1	149.8±64.5	332.9±396.9	<0.001
Total cholesterol (mg/dl), mean±S.D.	180.4±42.1	172.5±40.1	180.4±39.2	180.2±54.8	0.687	174.1±35.3	181.7±53.3	178.1±40.4	0.729
HDL-C (mg/dl), mean±S.D.	59.8±16.1	53.6±14.8	54.4±12.4	63.2±28.6	0.015	53.9±14.4	59.6±20.5	50.3±15.9	0.020
LDL-C (mg/dl), mean±S.D.	116.1±33.7	114.2±40.2	117.9±30.7	98.3±45.1	0.233	112.3±34.9	119.6±44.4	101.1±27.4	0.396
Metabolic syndrome, n (%)	163 (56.0)	26 (54.2)	23 (51.1)	10 (62.5)	0.865	37 (57.8)	14 (41.2)	8 (72.7)	0.229

BMI=body mass index, WC=waist circumference, sBP=systolic blood pressure, dBP=diastolic blood pressure, FBS=fasting blood sugar, HDL-C=high-density lipid cholesterol, LDL-C=low-density lipid cholesterol, S.D.=standard deviation

Abstinence=no drinking, occasional drinking=irregular drinking, light–moderate drinking=regular drinking of 10–40 g/day, and heavy drinking=regular drinking of >40 g/day. Low risk (AUDIT score 1–7), hazardous drinking (AUDIT score 8–15), and harmful use/dependence (AUDIT score >16).

kg/m^2=kilogram/square meters, cm=centimeter, mmHg=millimeter of mercury, mg/dl=milligram/deciliter



HDL-C=high density lipoprotein cholesterol, mg/dl=milligram/deciliter

Figure 1 Association between high density lipoprotein cholesterol and alcohol drinking

The results of the multivariate analysis using a logistic regression model and adjusted odds ratios for age, sex, smoking, and BMI are shown in Table 3. The ratios comparing non-drinkers with metabolic syndrome were significantly increased in the heavy drinker (OR=4.4, 95% confidence interval (CI) 1.2–15.6, p-value 0.021) and harmful use/dependent categories (OR=5.0, 95% CI 1.1–23.1, p-value 0.039).

Table 3 Association between metabolic syndrome and alcohol consumption analyzed via logistic regression analysis

Alcohol consumption	Adjusted odds ratio*	95% CI	p-value
Amount of alcohol intake			
Non-drinker	1.0		
Occasional drinker	1.2	0.6–2.6	0.555
Light–moderate drinker	1.5	0.7–3.2	0.342
Heavy drinker	4.4	1.2–15.6	0.021
AUDIT risk score			
Abstinence	1.0		
Low risk	1.5	0.8–2.9	0.220
Hazardous drinking	1.0	0.4–2.6	0.925
Harmful use/dependence	5.0	1.1–23.1	0.039

CI=confidence interval
*adjusted for age, sex, smoking, and BMI

Discussion

This study found the prevalence of current drinking behavior of 27.3% to be primarily about occasional and low-risk drinking. Based on the assessment of both the quantity of alcohol and the level of risk from alcohol drinking, their association with metabolic indicators was in the same direction; an exception was HDL-C, which had a J-shaped association with the amount of alcohol intake but an inverse association with risk level. The prevalence of metabolic syndrome was increased among heavy and harmful use/dependent drinkers.

The current alcohol drinking ratio found by this study was 27.3%, which is higher than that of the total world population (22.6%).[1] However, this is slightly lower than that of the Thai population. A situational report of alcohol consumption in 2017[19] found that 28.4% of the country's population are drinkers. The drinkers tended to be male and young; as a matter of fact, drinking in greater quantities was found to be associated with younger ages[17], a finding that is similar to the findings of various studies conducted in several countries.[20–23]

The association between alcohol consumption and the components of metabolic syndrome was found to have both negative and positive effects. The negative impacts on health included an increase in the risk for having high blood sugar and TG levels as well as a larger WC due to belly fat. This is consistent with the findings of previous studies, which have reported that heavy drinking is associated with an increased risk of diabetes, dyslipidemia, and metabolic syndrome among liquor consumers.[24] This can be explained by the fact that alcohol can increase blood sugar levels and calory intake. Caton et al. reported the effect of high-dose alcohol (4 units) on stimulating appetite and increasing food intake, thus alcohol may contribute to a positive energy balance via its additive effects to the total energy intake.[25] The excess energy in the body is transformed into TG, resulting in higher levels of serum TG.[26] The accumulation of excessive fat increases waist circumference and body weight.[27] Nevertheless, some studies have reported that the moderate consumption of alcohol accounts for an energy balance equation minimizing weight gain due to heat generation from thermogenesis[28]; however, this was not observed in this study.

Moreover, alcohol consumption is associated with an elevated BP.[29] In this study, an association with only dBP level was found, and it was higher. This is rather surprising as, in general, alcohol can cause high BP as regards both sBP and dBP. This could be explained by several mechanisms such as enhanced sympathetic activity, stimulation of the renin–angio-tensin–aldosterone system, increased cortisol levels, increased vascular reactivity, oxidative injury, and the inhibition of nitric oxide production without time dependency.[30,31] However, a previous study found that alcohol consumption increases both sBP and dBP, but only dBP values increase

enough to be clinically significant.[32] This may also be explained by the fact that heavy drinkers tend to carry an increased risk of high dBP, and they are mostly male, with sedentary lifestyles, who also engage in heavy smoking.[33,34]

In addition, the authors found that alcohol could have a positive effect on health by elevating serum HDL-C levels via raising the transport rates of the major HDL apolipoproteins apoA-I and -II.[35,36] However, it is not recommended to use alcohol as a means to increase the level of HDL-C.[37] Long-term drinking has been found to be associated with lower HDL-C concentrations.[38] This would explain why HDL-C was inversely related to the risk of harm compared to its relationship with the amount of alcohol intake. Most questions in AUDIT pertain to the time spent consuming alcohol, the estimated duration of this risk behavior, and self-perception as regards one's drinking habit. Drinkers who reported to have high risk of harm could be associated with a longer duration of exposure to alcohol, which may result in liver injury and interference with cholesterol synthesis.[39]

Apart from HDL-C, there were other metabolic syndrome biomarkers that were associated with the level of risk in the same manner as the amount of consumption. The reason for this might be that people who drink large quantities of alcohol are often assessed as having a higher risk of harm. The AUDIT questionnaire consists of questions enquiring about the amount of alcohol, and if the answer is "high amounts," then the risk will be considered as "increased." In addition, those who drink large amounts of alcohol are more likely to have health problems or social consequences, which may influence their perception of incurring a higher level of harm.[37]

The strength of the present study is the utilization of risk assessment obtained via the AUDIT questionnaire to study its association with metabolic syndrome, which, to the authors' knowledge, has not yet been studied in Thailand. However, the study has some limitations. Firstly, most participants suffered from chronic diseases, which may not be a fair representation of the characteristics of the general population. Secondly, as mentioned in the discussion section, using the AUDIT risk assessment to compare to the quantity of alcohol consumption might confound the interpretation of the data as one question in AUDIT aims to assess the amount of drink. Accordingly, the results could be similar. Future studies need to consider using other risk assessment questionnaires, the results for which may be different. Lastly, as the measurement of WC used in this study is different from the more commonly used method recommended by WHO, this could have possibly led to an underestimation of the prevalence of metabolic syndrome. However, even when using these two different measures, similar patterns of association between cardiometabolic risks and WC have been reported.[40]

Conclusion

Alcohol drinking tends to be associated with an increased risk of metabolic syndrome, especially when heavy drinking (in excess of 40 g/day) is involved and among patients who check positive for harmful use or alcohol dependency in level of risk. Offering advice to help patients restrict their drinking habits can be beneficial in the attempt to reduce the incidence of metabolic syndrome. At the same time, people who drink alcohol, especially heavy drinkers and those who are at high risk of harm, should be assessed for metabolic problems in order to prevent further complications due to this condition.

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Conflict of interest

None to declare

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Supplementary Table 1 Example of the questionnaire for assessing dietary intake and physical activity adapted from the National Statistical Office

Diet

Which cooking method do you usually use? (choose only one)

- ☐ (1) boiling
- ☐ (2) stewing
- ☐ (3) stir-frying
- ☐ (4) frying
- ☐ (5) half-cooking
- ☐ (6) toasting/grilling
- ☐ (7) baking
- ☐ (8) other_____

During the past month, how many days per week did you eat …	Never	1–2 days/week	3–4 days/week	5–6 days/week	Everyday
1. Meat or processed meat					
2. High-fat food					
3. Snacks					
4. Junk food					
5. Fruit and vegetable					
6. Sweet drinks/energy drinks					

Physical activity

On average, how many days per week do you …	Frequency (days/week)
A. Have vigorous activity/exercise? (at least 20 minutes continuously)	
B. Have moderate activity/exercise (at least 20 minutes continuously)	
C. Have light activity (at least 20 minutes continuously)	
D. Walk non-stop for at least 10 minutes	
How often do you do housework or gardening?	☐ Never/rarely ☐ ≤2 times/week ☐ 3–4 times/week ☐ Nearly everyday/everyday
How many hours per day do you …	Duration (hours/day)
A. Sleep during daytime	
B. Watch television or use the computer	
C. Sit (in all situations)	