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Original Article

Associations Between Health Literacy and Dietary Intake: A Cross-sectional Study of Adults With Metabolic Syndrome in Thailand

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Abstract

Background: Health literacy (HL) is an indicator of health outcomes, but its role in dietary intake has received little attention. Excessive dietary intake increases the risk of metabolic syndrome (MetS). Therefore, this study aimed to investigate the HL score, dietary intake, and nutrient intake of participants and the relationship between HL score and dietary intake among adults with MetS in Thailand.

Methods: In this cross-sectional study, 2527 adults aged 18–59 years in primary care services, Phetchaburi, Thailand were included in the study using a multistage sampling technique. We determined HL scores using the Health Literacy Questionnaire (HLQ) and dietary intake using a semi-quantitative Food Frequency Questionnaire. We used multiple linear regression analysis to investigate the associations between HL score and dietary intake.

Results: HL scores were significantly lower in patients with MetS compared with participants without it ($P<0.05$). Participants with MetS had significantly higher calorie and fat intake than participants without it ($P<0.05$), and participants with MetS had higher fat and lower carbohydrate intake. The results of multiple linear regression showed a significant negative association between HL score and dietary intake, after controlling for potential confounding variables ($\beta=-0.053$, $P<0.05$).

Conclusion: Our findings suggest that low HL score is associated with high dietary intake. Therefore, improving HL might play an important role in reducing dietary intake to decrease the risk of MetS.

Keywords: Health literacy, Dietary intake, Metabolic syndrome

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Introduction

Based on the global data, 20%–25% of adults suffer from metabolic syndrome (MetS), which is a cluster of common abnormalities, including hypertension, elevated fasting plasma glucose (FPG), high blood cholesterol or triglycerides, and abdominal obesity (1). Adults with MetS are twice as likely to have type 2 diabetes mellitus (T2DM) and five times more likely to have cardiovascular disease (CVD) than people without MetS (2). The major causes of MetS are abdominal obesity and the resulting insulin resistance, most probably due to overeating and a sedentary lifestyle, which can cause an imbalance between dietary intake (DI) and calorie use (3). Healthy nutrition and physical activity are protective factors against MetS (1). Previous studies revealed that DI is associated with MetS (4-6). Approximately 80% of Thai people have levels of DI that exceed the recommended intake, which increases the risk of MetS (7). One study reported that Korean women with high carbohydrate intake had an increased risk of MetS (8). By contrast, another study reported that those with MetS had higher fat intake than those without it among older adults in the Balearic Islands (9). Therefore, additional research is needed to fully understand the role of dietary and nutrient intake in the development of MetS.

Health literacy (HL) is a relatively new concept in health promotion. A low HL score is a risk factor that is potentially modifiable and is associated with behaviors that increase the risk of MetS (1), such as poor diet (3), inadequate physical activity (10), and unhealthy lifestyle (11). HL is related to the individual's ability to access and understand health information on making decisions about health promotion and disease prevention (12). Individuals with high levels of HL are much more capable of understanding available nutritional information and making healthier choices. In Thailand, there are studies demonstrating limited HL among many adults. Several studies have shown that HL was significantly associated with MetS. Tajdar et al (1) reported that low HL was associated with a high incidence of MetS among older people in Germany, and Cheng et al reported that, among patients aged 23–88 years receiving health check-ups in Taipei, low HL was associated with MetS in women but not in men (13). A study conducted in Iran found that HL was lower in people who consumed junk food than in those who did not consume fast food, suggesting that HL is associated with fast-food intake (14). In addition, a study of school-age children in Iran found that a high HL was linked with a healthy dietary pattern, suggesting that HL may play an important role in shaping DI (3). However, no similar study has been conducted on adults, and there is no evidence available on the potential relationship between HL and diet in Thailand (15,16). Therefore, we investigated differences in HL score and DI between participants with and without MetS and tested for an association between HL score and DI. We hypothesized that higher HL would be correlated with reduced DI, contributing to a decreased risk of MetS.

Materials and Methods

Participants

This cross-sectional study was conducted from May 2022 to May 2023 in Phetchaburi province, central Thailand. The target population of our study was adults aged 18–59 years, who lived in the Phetchaburi province and received services from 119 primary care units, including two urban health centers, one large-scale health-promoting hospital, and 116 health-promoting hospitals. The population included 248 767 people.

Data Collection and Sampling

The target sample size was computed using G*Power version 3.1.9.7. Considering an effect size (large) of 0.35, a power of 0.80, 12 independent variables, and a significance level of 0.05, the minimum sample size was calculated to be 2106. However, after considering a drop-out rate of 20%, it was estimated to be 2527 (17). A total of 2527 people who agreed to participate in this study formed the study group. Inclusion criteria were providing informed consent, being 18–59 years old, being able to read, write, and speak Thai, and having no disabilities. By contrast, a lack of interest in participating, insufficient time, and incomplete survey submissions were among the exclusion criteria. A total of 2527 people who met the inclusion criteria were selected using a multistage sampling technique. In the first stage, Phetchaburi province in Thailand was selected using purposive sampling method. In the second stage, two sub-districts were selected using lottery method from a list of sub-districts. In the third stage, the participants were selected by systematic random sampling from each primary care service. We determined the sampling interval, which was number four, and selected number two as the random start. Then, we added the sampling interval periodically to select additional samples by selecting every fourth participant from the list and excluding if they were not present or refused to participate in the study.

Questionnaires

A self-reported questionnaire was developed based on a literature review that consisted of three parts as follows:

General Demographic Characteristics Questionnaire

General demographic characteristics included gender, age, marital status, education level, socioeconomic status, and health-related behaviors, such as smoking, alcohol consumption, exercise, duration of sleep, and history of chronic disease. The socioeconomic status of the participants was classified into lower (contractors or general employees), middle (entrepreneurs, independent tradesmen, business owners, and farmers), or upper classes (professionals with specific skills, managers, and administrators).

Our questionnaire asked about the intensity of exercise, which was classified as low (less than 150 min/wk of moderate activity or 75 min/wk of strenuous exercise), moderate (150-300 min/wk of moderate activity or 75 min/wk of vigorous exercise), and high (more than 300 min/wk of exercise) (18). The question about the duration of sleep was closed-ended: "In the last week, on average, how many hours of sleep did you get per day (including daytime naps)?". The responses were <8 hours or ≥ 8 hours (19).

Health Literacy Questionnaire-18

The Health Literacy Questionnaire-18 (HLQ-18), a self-made scale modelled after the HLQ™ was used in the study (20). This summated rating scale consists of 18 items measuring 6 dimensions including access, cognition, communication, self-management, media, and decision-making (Cronbach's $\alpha = 0.93$). A participant's total score was the sum of the scores for all items (range 0–90).

Dietary and Nutrient Intake

In this study, DI refers to the amount of food, including specific types of food and calories consumed daily by an individual. Nutrient intake refers to the amount of macronutrients, such as carbohydrates, proteins, and fats consumed daily by an individual (21). The Semi-quantitative Food Frequency Questionnaire (Semi-FFQ) was developed and validated based on a cross-sectional study conducted by Overvad (22). The Semi-FFQ consisted of 54 food items, including their sources and portion sizes, from the Thai Dietary Reference Intake (Thai DRIs) database (23). Food records were collected on three days, which included two working days (Monday and Friday) and one rest day (Saturday or Sunday), with one week between them. Our questionnaire is considered adequate based on the evaluated standards of Thai DRIs. Participants completed the questionnaires under the supervision of the researchers. Participants were given approximately 30 minutes to complete the forms.

Anthropometric and Biochemical Markers

Anthropometric measurements were performed to assess nutritional status, including weight (measured using a digital scale) and height (measured using a Detecto scale). Body mass index (BMI) was calculated as weight (kg)/(height (m)^2, using self-reported values. We used the Asian BMI classification system determined by the World Health Organization (WHO) (8), which includes underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23–24.9 kg/m^2), obese class 1 (25–29.9 kg/m^2), and obese class 2 (>30 kg/m^2). We diagnosed MetS according to the new International Diabetes Federation (IDF) criteria for South Asians, which were based on Chinese, Malay, and Asian Indian populations. These guidelines specify that individuals diagnosed with MetS must have a waist circumference (WC) cut-off point of ≥ 90 cm for men and ≥ 80 cm for women, in addition to two of the following four factors: systolic blood pressure (BP) of ≥ 130 mm Hg and/or diastolic BP of ≥ 85 mmHg, FPG of ≥ 100 mg/dL, triglyceride (TG) level of ≥ 150 mg/dL, and high-density lipoprotein cholesterol (HDL-C) cut-off point of < 40 mg/dL for men and < 50 mg/dL for women (24). WC was measured in the horizontal plane at the mid-point between the iliac crest and the lowest rib. Doctors measured BP with a sphygmomanometer while the patients were seated. Blood samples were collected in the morning after at least 8 hours of overnight fasting. The blood volume collected was approximately 15–20 mL for the analysis of serum biochemistry, lipid profile (including HDL-C and TG), and FPG. Laboratory analysis of fasting serum lipids and FPG was performed by the medical laboratory technologist in each hospital.

Statistical Analysis

Data were analyzed using a Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as mean and standard deviation (SDs) for continuous variables and frequencies and percentages for categorical variables. We tested whether continuous variables were normally distributed using the Kolmogorov-Smirnov test. Independent *t* tests were used to test for differences in means between the groups with MetS and without MetS. The univariate linear regression analysis was performed to study the association between HL score and DI. The univariate linear regression analysis was applied for each of the independent variables with a *P* value of less than 0.25 which should be included in the first multiple linear regression controlled for the effect of other covariates. Associations between DI and various factors were presented as mean differences with 95% confidence intervals (CIs). The level of statistical significance was set at *P* value < 0.05 (two-tailed).

Results

Study Populations

This cross-sectional study included 1195 adults with MetS and 1332 (52.7%) adults without MetS. Overall, the prevalence of MetS was 47.28%, according to IDF criteria. The mean age of the participants with MetS was higher than the mean age of those without it (51.0 years vs 47.6 years; $P < 0.05$). MetS was observed in 36.2% and 63.8% of men and women, respectively ($P < 0.05$). The majority of participants with MetS were married (79.3%), had an education level of primary school or lower (53.2%), were in the middle socioeconomic class (56.4%), and had a history of chronic disease (74.3%). Participants with MetS had a higher BMI than those without it (28.02 ± 4.89 km/m^2 vs. 22.64 ± 3.64 km/m^2) and reported almost no exercise. The comparison of characteristics of participants in the two groups is shown in Table 1.

Description of HL Score by Participant Characteristics

The HLQ-18 consisted of 18 questions. The mean HL score was 48.71 ± 14.46. The mean HL scores of participants with MetS were 43.71 ± 13.19 and 47.26 ± 14.19 for men and women, respectively. The mean HL scores of participants without MetS were 52.80 ± 14.54 and 48.87 ± 14.06 for men and women, respectively (data not shown). HL scores were significantly lower in participants with MetS than in those without it (45.98 ± 13.94 vs. 51.18 ± 14.47; $P < 0.05$). Among participants with MetS, the HL score of women was higher than that of men (47.26 ± 14.19 vs. 43.71 ± 13.19; $P < 0.05$) (Table 2).

Description of Dietary and Nutrient Intake by Participant Characteristics

There were significant differences in DI, as measured by 54 items in the Semi-FFQ, between participants with and without MetS (Table 3). Mean DI of participants with MetS was 2259.10 ± 465.03 kcal/d, with a fat intake of 36.5%, carbohydrate intake of 47.2%, and protein intake of 14.8%. Interestingly, both calorie and fat intake were higher than the recommended limits of the Thai DRIs and WHO. DI of participants with MetS was significantly higher than that of those without it (2259.10 ± 465.03 /kcal/d vs. 1805.23 ± 333.19 /kcal/d; $P < 0.05$). Participants with MetS had higher fat intake, lower carbohydrate intake, and lower protein intake than participants without MetS ($P < 0.05$). Men with MetS had higher DI than women with MetS (2567.83 ± 415.11 /kcal/d vs. 2084.30 ± 395.92 /kcal/d; $P < 0.05$).

Association Between HL and DI

Tables 4 and 5 show the results of univariate linear regression and multiple linear regression analyses, indicating an association between HL score and other independent variables related to DI. Based on the results of the univariate linear regression analysis, the HL score was significantly associated with DI ($\beta = -0.132$, $P < 0.05$; Table 4). Based on the results of the multiple linear regression, this association remained significant after adjustment for potential confounding variables, including gender, education level, smoking habits, alcohol use, exercise, and BMI. HL score was significantly negatively associated with DI ($\beta = -0.053$, $P < 0.05$; Table 5).

Discussion

This study investigated HL score, DI, and nutrient intake

Table 1. Characteristics of Participants with MetS (n = 1195) and Participants without MetS (n = 1332)

Characteristics	Total (N = 2527)	Without MetS (n = 1332)	With MetS (n = 1195)	*P* Value
Age (y)	49.25 ± 12.47	47.60 ± 13.34	51.08 ± 11.14	< 0.001
Gender				
Men	983 (38.9)	551 (41.4)	432 (36.2)	0.007
Women	1544 (61.1)	781 (58.6)	763 (63.8)	0.007
Marital status				
Single	583 (23.1)	327 (56.1)	256 (20.7)	< 0.001
Married	1944 (76.9)	964 (43.9)	980 (79.3)	< 0.001
Education level				
Primary school or lower	1281 (50.7)	624 (48.3)	657 (53.2)	0.001
Secondary school or above	1246 (49.3)	667 (51.7)	579 (46.8)	0.001
Socioeconomic status				
Lower	865 (34.2)	494 (37.1)	371 (31.0)	< 0.001
Middle	1226 (48.5)	552 (41.4)	674 (56.4)	< 0.001
Upper	436 (17.3)	286 (21.5)	150 (12.6)	< 0.001
History of health-related behaviors				
Smoking				
No	2068 (81.8)	1090 (84.4)	978 (79.1)	< 0.001
Yes/used	459 (18.2)	201 (15.6)	258 (20.9)	< 0.001
Alcohol consumption				
No	1972 (78.0)	1061 (82.2)	911 (73.7)	< 0.001
Yes/used	555 (22.0)	230 (17.8)	325 (26.3)	< 0.001
Exercise				
No	1737 (68.7)	813 (61.0)	924 (77.3)	< 0.001
Yes				
Low class	307 (38.8)	61 (4.6)	246 (20.6)	< 0.001
Moderate class	375 (47.5)	350 (26.3)	25 (2.1)	0.006
High class	108 (13.7)	108 (8.1)	0 (0.00)	< 0.001
BMI (k/m^2)	25.19 ± 5.05	22.64 ± 3.64	28.02 ± 4.89	< 0.001
Sleep time (h)				
< 8	1,581 (62.5)	791 (59.4)	790 (66.1)	0.146
≥ 8	946 (37.5)	541 (40.6)	405 (33.9)	< 0.001
History of chronic disease				
No	1126 (44.6)	819 (61.5)	307 (25.7)	< 0.001
Yes	1401 (55.4)	513 (38.5)	888 (74.3)	< 0.001

of participants with and without MetS and the association between HL score and DI among adults with MetS in Thailand.

In the first part of our study, we found that HL score was lower in participants with MetS than in those without it. Another study conducted in Germany reported similar results. In participants aged 18–60 years old, the risk of MetS increased as the HL score decreased. Therefore, adults with lower HL were more likely to have MetS than those with higher HL (1). Individuals with lower HL have more difficulty understanding the written and oral instructions given by health care professionals, resulting in poor self-care decisions and more health problems (25). Contrarily, high levels of HL are associated with the ability to understand available nutrition information and make healthier choices (26). Indeed, a study of working adults in Thailand found that protective factors against MetS in women were nutrition literacy and behavior (27). Most studies suggest that poor HL is a risk factor for developing MetS (1). However, two studies conducted in Japan and Taipei reported contradictory results concerning the association between HL and the prevalence of MetS. Yokokawa et al (28) studied the association between HL and the prevalence of MetS among Japanese people and concluded that the proportions of participants with MetS, defined as a WC of ≥ 90 cm and FPG of ≥ 110 mg/dL, did not differ significantly between higher and lower HL groups. They also found a negative association between HL and MetS among men; however, they found no significant relationship among women. On the other

Table 2. HL Scores of Participants with MetS (n=1195) and Participants without MetS (n=1332)

Categorical Variable	Without MetS HLQ-18 Scores	With MetS HLQ-18 Scores	*P* Value
Gender			
Men	52.80±14.54	43.71±13.19	<0.001*
Women	48.87±14.06	47.26±14.19	<0.001*
Age group			
<50	55.29±13.59	48.28±14.00	<0.001*
≥50	46.30±13.96	44.13±13.61	<0.001*
Marital status			
Single	53.78±13.42	45.02±13.94	<0.001*
Married	50.05±14.58	45.30±13.98	<0.001*
Education level			
Primary school or lower	47.49±13.79	45.40±13.30	<0.001*
Secondary school or above	53.34±13.41	48.20±13.37	<0.001*
Socioeconomic status			
Lower	46.81±14.05	47.65±12.90	<0.001*
Middle	54.22±13.42	44.26±14.10	<0.001*
Upper	57.58±14.46	49.54±14.59	<0.001*
History of health-related behaviors Smoking			
No	51.00±14.53	46.48±13.84	<0.001*
Yes/used	52.42±14.00	43.85±14.17	<0.001*
Alcohol consumption			
No	50.42±14.28	46.75±13.79	<0.001*
Yes/used	55.54±14.83	43.74±14.14	<0.001*
Exercise			
No	49.97±13.73	44.07±13.50	<0.001*
Yes			
Low class	58.89±13.3	52.95±12.89	<0.001*
Moderate class	53.07±15.38	47.96±17.69	<0.001*
High class	49.17±16.63	0±0.00	-
BMI			
Normal	51.14±14.49	45.77±12.61	<0.001*
Overweight	51.14±13.67	46.47±14.86	<0.001*
Obese class I	51.19±14.62	45.07±13.96	<0.001*
Obese class II	52.68±14.84	47.20±13.82	<0.001*
Sleep time (hours)			
<8	48.30±13.81	45.20±13.46	<0.001*
≥8	51.21±9.60	51.28±9.64	0.491
History of chronic disease			
No	53.09±14.18	44.99±15.09	<0.001*
Yes	46.73±16.06	47.30±13.54	0.021*
HL overall	51.18±14.47	45.98±13.94	<0.001*

MetS: metabolic syndrome.
Values are expressed as means±SD. Significant at *$P<0.05$ using independent *t* test.

hand, Cheng et al (13) reported that, among participants aged 23–88 years receiving health check-ups in Taipei, the proportion of people with MetS was higher in the lower HL score group. The *P* for trend between MetS and HL was marginally significant. In female participants, lower HL was significantly related to a higher prevalence of MetS; the trend between HL and MetS was not significant in men. This might be due to the fact that HL is a key factor in adopting preventive lifestyle behaviors among adults with MetS. Women are more likely to have healthier lifestyles than men, particularly in terms of smoking and alcohol consumption (28). A study of 1817 Japanese individuals in the city of Fukushima found that HL was associated with access to health information and health behaviors. They explained that a high HL may be associated with the characteristics of a healthier lifestyle, which can contribute to a lower prevalence of MetS among men (29). This may be because people with higher levels of HL are more likely to adopt appropriate behaviors and be able to perceive and act on health-related information (30). In the present study, we found that adults with MetS had low HL scores. Therefore, the high HL score may play a role in promoting self-care behaviors and skills and adopting and maintaining DI patterns among adults with MetS.

Our second aim was to investigate dietary and nutrient intake in participants with and without MetS. We found that participants with MetS had a diet with higher fat intake (36.5%), but lower carbohydrate intake (47.2%) and protein intake (14.8%) than those without MetS. The WHO recommends that fat intake should not exceed 30% of total caloric intake (31). Our results showed that the fat intake of participants with MetS was above the recommended limit (20%–35% of total caloric intake), but the carbohydrate and protein intake of the same participants was within the recommended range (45%–65% and 10%–15% of total caloric intake, respectively). Two studies conducted in the Balearic Islands and Japan have found results similar to ours. Julibert et al (9) compared older adults with MetS and those without MetS in terms of fat intake and reported that the participants with MetS had higher fat intake than those without it. Freire et al (32) found that after adjusting for confounding variables, MetS was positively associated with fat intake among Japanese Brazilians. Considering specific food groups, only fried food intake was shown to be associated with an increased risk of MetS. This result is in agreement with another study that examined the role of specific dietary fats, which emphasized dietary guidelines and also showed a significant relationship between fatty acid consumption and the risk of MetS (33). This might be because an energy-dense high-saturated fat diet promotes MetS, insulin resistance, and obesity (33). On the contrary, some studies have found that linoleic acid consumption was inversely related to MetS, which corroborates the benefits of reducing the risk of diseases involving insulin resistance (32). Linoleic acid reduced the incidence of CVD and T2DM, possibly by decreasing risk factors for those diseases, for instance, by reducing blood cholesterol levels and the resulting impact on insulin and glucose metabolisms (34). Unlike the PREDIMED study, they did not find a significant association between DI and MetS. The PREDIMED randomized trial determined the long-

Table 3. DI and Nutrient Intake of Participants with MetS (n = 1195) and Participants without MetS (n = 1332)

Categorical Variable	Without MetS	With MetS	*P* Value
	DI (/kcal/d)	DI (/kcal/d)	
Gender			
Men	1960.73 ± 313.82	2567.83 ± 415.11	< 0.001*
Women	1706.13 ± 306.43	2084.30 ± 395.92	< 0.001*
Age group			
< 50	1802.57 ± 346.50	2363.87 ± 492.59	< 0.001*
≥ 50	1809.29 ± 312.15	2175.32 ± 423.86	< 0.001*
Marital status			
Single	1783.95 ± 356.72	2326.13 ± 505.24	< 0.001*
Other	1825.43 ± 326.88	2260.35 ± 457.78	< 0.001*
Education level			
Primary school or lower	1810.61 ± 312.70	2160.81 ± 442.80	< 0.001*
Secondary school or above	1874.23 ± 379.69	2287.18 ± 456.13	< 0.001*
Socioeconomic status			
Lower	1834.56 ± 350.74	2195.18 ± 461.33	< 0.001*
Middle	1864.47 ± 322.38	2273.37 ± 463.72	< 0.001*
Upper	1774.86 ± 325.91	2360.53 ± 459.05	< 0.001*
History of health-related behaviors			
Smoking			
No	1777.93 ± 327.01	2214.48 ± 452.96	< 0.001*
Yes/used	1972.35 ± 322.73	2447.34 ± 469.11	< 0.001*
Alcohol consumption			
No	1768.34 ± 321.65	2200.40 ± 457.08	< 0.001*
Yes/used	1970.10 ± 334.76	2428.17 ± 446.62	< 0.001*
Exercise			
No	1789.83 ± 323.01	2269.91 ± 469.54	< 0.001*
Yes			
Low class	1802.6 ± 420.5	2173.15 ± 419.16	< 0.001*
Moderate class	1811.6 ± 468.4	2705.30 ± 445.48	< 0.001*
High class	1869.0 ± 327.3	-	-
BMI			
Underweight	1388.13 ± 136.85	-	-
Normal	1650.18 ± 198.01	1,688.37 ± 211.64	0.591
Overweight	1908.15 ± 191.51	1949.18 ± 252.88	0.720
Obese class I	2105.97 ± 216.60	2240.45 ± 313.08	< 0.001*
Obese class II	2615.38 ± 344.59	2705.69 ± 414.21	0.177
History of chronic disease			
No	1808.85 ± 329.30	2313.12 ± 451.65	< 0.001*
Yes	1841.30 ± 357.45	2216.52 ± 474.39	< 0.001*
DI (/kcal/d)	1805.23 ± 333.19	2259.10 ± 465.03	< 0.001*
Carbohydrate intake (% total calorie)	50.85 ± 58.57	47.21 ± 62.60	< 0.001*
Protein intake (% total calorie)	16.41 ± 18.77	14.88 ± 17.91	< 0.001*
Fat intake (% total calorie)	34.36 ± 30.58	36.53 ± 22.80	< 0.001*

MetS: metabolic syndrome.
Values are expressed as means ± SD. Significant at *$P < 0.05$ using independent *t* test.

term effects of the Mediterranean diet on the prevalence of MetS in older adults. The participants were randomly assigned to 1 of the 3 dietary interventions: a Mediterranean diet supplemented with nuts, a Mediterranean diet supplemented with extra virgin olive oil, and a low-fat diet. The risk of progressing MetS did not differ between those on the Mediterranean diet and the control group. In addition, a diet supplemented with nuts or olive oil

Table 4. The Results of Univariate Linear Regression Investigating the Association between HL Score and other Independent Variables related to DI in Adults (n=2527)

Independent Variable	β	95% CI		*P* Value
Gender	-0.374	-384.964	-316.961	<0.001*
Age	-0.017	-2.073	.792	0.381
Marital status	-0.005	-37.126	28.068	0.785
Education level	0.049	2.845	25.230	0.014*
Occupation	0.040	0.991	52.216	0.042*
Smoking	0.201	208.009	305.751	<0.001*
Alcohol consumption	0.247	246.073	335.163	<0.001*
Exercise	-0.124	-83.335	-43.710	<0.001*
BMI	0.846	74.809	78.581	<0.001*
Sleep time	-0.051	-68.284	-9.428	0.010*
History of chronic disease	-0.024	-1.042	.295	0.273
HL	-0.132	-5.403	-2.953	<0.001*

Table 5. The Results of Multiple Linear Regression Analysis Investigating the Association Between HL and DI in Adults (n=2527)

Independent Variable	β	95% CI		*P* Value
Gender	-0.355	-348.093	-317.921	<0.001*
Education level	0.071	15.432	25.620	<0.001*
Smoking	-0.026	-57.597	-8.155	0.009*
Alcohol consumption	0.028	10.393	55.872	0.004*
Exercise	0.003	-6.203	9.742	0.010
BMI	0.838	74.556	77.329	<0.001*
HL	-0.053	-2.170	-1.198	<0.001*

This association remained significant after adjustment for potential confounding variables, including gender, education level, smoking habits, alcohol use, exercise, and BMI

was not associated with a decreased prevalence of MetS compared to a low-fat diet (35). Olive oil supplementation is consistent with the efficacy of dietary monounsaturated fatty acids for reduction of risk factors associated with MetS and CVD (36). On the contrary, a study of older adults in the Balearic Islands found that participants with MetS had higher total fat intake than those without MetS (9). The high caloric density of high-fat diets plays an important role in weight gain (37). Therefore, high dietary fat intake causes excessive caloric intake and increases the risk of MetS. Our study showed that fat intake in participants with MetS exceeded the recommended intake. Therefore, providing knowledge of adequate fat intake, with the goal of reducing fat and caloric intake, is a key strategy for the prevention of MetS.

In addition, we evaluated the association between the HL score and DI among adults with MetS in Thailand. Our results revealed a significant negative association between the HL score and DI, indicating that high HL scores result in reduced, and therefore better, DI. These findings correspond with those of Buja et al (15), who conducted a systematic literature review on the relationship between HL and DL. They reported that three studies revealed an association between high HL and a low sugar intake, indicating that healthier dietary practices are associated with a greater perception of food labels and suggesting that HL might play a role in improving adult's diets. Interestingly, a study conducted in Iran, which revealed the association between HL and junk food intake in adults, found that HL was lower in those who consumed junk food than in those who did not consume junk food, indicating that those with lower HL levels were more likely to consume junk food. The findings suggest that HL is associated with the level of fast-food intake (14). Surprisingly, some studies revealed that DI was not significantly associated with HL. A study performed in Switzerland found no significant association between HL and salt intake, but the awareness variable "salt content impacts food/menu choice" was associated with salt intake (38).

One of the strengths of this study was the large sample size and precise effect estimates adjusted for potential confounders. Additionally, our research has investigated and analyzed several important variables related to DI in adults with MetS. Besides, estimates of DI were derived from multiple days (2-3 days/week), which are considered more representative of usual intake. Our study has weaknesses due to the large sample size taking a long time to obtain data collection and analysis. Moreover, there are some limitations to this study. The main limitation of our study is its cross-sectional design; therefore, causality cannot be inferred. Another limitation is that food records collected have recall bias that can occur whenever an attempt is made to collect data retrospectively. Further longitudinal research is required to demonstrate the causal association between HL and DL.

Conclusion

The findings of this study showed differences between HL score and DI in participants with MetS and those without MetS, indicating lower HL scores and higher calorie and fat intake in patients with MetS compared with those without Mets. In addition, this study revealed a negative association between HL score and DI (energy) in adults with MetS and identified HL score as a protective factor for MetS. Therefore, future research should be done to develop intervention programs related to HL effectiveness in improving DI appropriately and adequately to decrease the risk of MetS.

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Authors' Contribution

Conceptualization: Aravan Mungvongsa.
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Competing Interests

The authors have no conflict of interests associated with the material presented in this paper.

Ethical Approval

The study was approved by the Ethics Committee of Mahasarakham University (Date and Number: 28032022/ECMSU109398). The Ethics Committee of the Phetchaburi Provincial Public Health Office granted the approval to conduct research in primary healthcare facilities. All participants took part in the study voluntarily and gave informed consent, as required by our ethics committee.

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References

1. Tajdar D, Schäfer I, Lühmann D, Fertmann R, Steinberg T, van den Bussche H, et al. The link between health literacy and three conditions of metabolic syndrome: obesity, diabetes and hypertension. Diabetes Metab Syndr Obes. 2022;15:1639-50. doi: 10.2147/dmso.s363823.
2. Cornier MA, Dabelea D, Hernandez TL, Lindstrom RC, Steig AJ, Stob NR, et al. The metabolic syndrome. Endocr Rev. 2008;29(7):777-822. doi: 10.1210/er.2008-0024.
3. Doustmohammadian A, Omidvar N, Keshavarz-Mohammadi N, Eini-Zinab H, Amini M, Abdollahi M, et al. Low food and nutrition literacy (FNLIT): a barrier to dietary diversity and nutrient adequacy in school age children. BMC Res Notes. 2020;13(1):286. doi: 10.1186/s13104-020-05123-0.
4. Ahn Y, Park SJ, Kwack HK, Kim MK, Ko KP, Kim SS. Rice-eating pattern and the risk of metabolic syndrome especially waist circumference in Korean Genome and Epidemiology Study (KoGES). BMC Public Health. 2013;13:61. doi: 10.1186/1471-2458-13-61.
5. Song SJ, Lee JE, Paik HY, Park MS, Song YJ. Dietary patterns based on carbohydrate nutrition are associated with the risk for diabetes and dyslipidemia. Nutr Res Pract. 2012;6(4):349-56. doi: 10.4162/nrp.2012.6.4.349.
6. Aekplakorn W, Satheannoppakao W, Putwatana P, Taneepanichskul S, Kessomboon P, Chongsuvivatwong V, et al. Dietary pattern and metabolic syndrome in Thai adults. J Nutr Metab. 2015;2015:468759. doi: 10.1155/2015/468759.
7. Thai Dietetic Association 2018. The Emergency Medicine Society of Thailand is Under a Project to Prevent and Promote Thai People from Getting Sick in an Emergency. Available from: https://www.hfocus.org/content/2017/08/14349. Accessed June 22, 2023.
8. Cho YA, Choi JH. Association between carbohydrate intake and the prevalence of metabolic syndrome in Korean women. Nutrients. 2021;13(9):3098. doi: 10.3390/nu13093098.
9. Julibert A, Del Mar Bibiloni M, Mateos D, Angullo E, Tur JA. Dietary fat intake and metabolic syndrome in older adults. Nutrients. 2019;11(8):1901. doi: 10.3390/nu11081901.
10. Peiris C, Harding K, Porter J, Shields N, Gilfillan C, Taylor N. Understanding the hidden epidemic of metabolic syndrome in people accessing community rehabilitation: a cross-sectional study of physical activity, dietary intake, and health literacy. Disabil Rehabil. 2023;45(9):1471-9. doi: 10.1080/09638288.2022.2065540.
11. Shibuya A, Inoue R, Ohkubo T, Takeda Y, Teshima T, Imai Y, et al. The relation between health literacy, hypertension knowledge, and blood pressure among middle-aged Japanese adults. Blood Press Monit. 2011;16(5):224-30. doi: 10.1097/MBP.0b013e32834af7ba.
12. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: a systematic review and integration of definitions and models. BMC Public Health. 2012;12:80. doi: 10.1186/1471-2458-12-80.
13. Cheng YL, Shu JH, Hsu HC, Liang Y, Chou RH, Hsu PF, et al. High health literacy is associated with less obesity and lower Framingham risk score: sub-study of the VGH-HEALTHCARE trial. PLoS One. 2018;13(3):e0194813. doi: 10.1371/journal.pone.0194813.
14. Namdar A, Naghizadeh MM, Zamani M, Montazeri A. Exploring the relationship between health literacy and fast food consumption: a population-based study from southern Iran. BMC Public Health. 2021;21(1):757. doi: 10.1186/s12889-021-10763-3.
15. Buja A, Grotto G, Montecchio L, De Battisti E, Sperotto M, Bertoncello C, et al. Association between health literacy and dietary intake of sugar, fat and salt: a systematic review. Public Health Nutr. 2021;24(8):2085-97. doi: 10.1017/s1368980020002311.
16. Shahavandi M, Ghorbaninejad P, Mohammadpour S, Djafari F, Shahinfar H, Sheikhhossein F, et al. Higher health literacy score is associated with better healthy eating index in Iranian adults. Nutrition. 2021;90:111262. doi: 10.1016/j.nut.2021.111262.
17. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175-91. doi: 10.3758/bf03193146.
18. United States Department of Health and Human Services. Physical Activity Guidelines for Americans. 2nd ed. 2018. Available from: https://health.gov/sites/default/files/2019-09/Physical_Activity_Guidelines_2nd_edition.pdf. Accessed June 15, 2023.
19. Kim CE, Shin S, Lee HW, Lim J, Lee JK, Shin A, et al. Association between sleep duration and metabolic syndrome: a cross-sectional study. BMC Public Health. 2018;18(1):720. doi: 10.1186/s12889-018-5557-8.
20. Simpson RM, Knowles E, O'Cathain A. Health literacy levels of British adults: a cross-sectional survey using two domains of the Health Literacy Questionnaire (HLQ). BMC Public Health. 2020;20(1):1819. doi: 10.1186/s12889-020-09727-w.
21. Ahn J, Abnet CC, Cross AJ, Sinha R. Unit 3 Assessing Exposure to the Environment. Dietary intake and nutritional status. 2016. p. 189-198.
22. Overvad K, Tjønneland A, Haraldsdóttir J, Ewertz M, Jensen OM. Development of a semiquantitative food frequency questionnaire to assess food, energy and nutrient intake in Denmark. Int J Epidemiol. 1991;20(4):900-5. doi: 10.1093/ije/20.4.900.
23. Bureau of Nutrition. Dietary reference intake for Thais 2020. 1st ed. Bangkok: Department of Health, Ministry of Public Health (printed at A.V. Progressive Partnership); 2020. p. 39-54.
24. Kassi E, Pervanidou P, Kaltsas G, Chrousos G. Metabolic syndrome: definitions and controversies. BMC Med. 2011;9:48. doi: 10.1186/1741-7015-9-48.
25. Maleki Chollou K, Gaffari-Fam S, Babazadeh T, Daemi A, Bahadori A, Heidari S. The association of health literacy level with self-care behaviors and glycemic control in a low education population with type 2 diabetes mellitus: a cross-sectional study in Iran. Diabetes Metab Syndr Obes. 2020;13:1685-93. doi: 10.2147/dmso.s253607.
26. Jiang F, Liu Y, Hu J, Chen X. Understanding health empowerment from the perspective of information processing: questionnaire study. J Med Internet Res. 2022;24(1):e27178. doi: 10.2196/27178.
27. Mungvongsa A, Mahaweerawat C, Yangyuen S, Jareanpon C, Somdee T. Gender differences relevant to metabolic syndrome in a working population in Phetchaburi province, Thailand. J Med Assoc Thai. 2023;106(4):444-50. doi: 10.35755/jmedassocthai.2023.04.13840.
28. Yokokawa H, Fukuda H, Yuasa M, Sanada H, Hisaoka T, Naito

T. Association between health literacy and metabolic syndrome or healthy lifestyle characteristics among community-dwelling Japanese people. Diabetol Metab Syndr. 2016;8:30. doi: 10.1186/s13098-016-0142-8.
29. Suka M, Odajima T, Okamoto M, Sumitani M, Igarashi A, Ishikawa H, et al. Relationship between health literacy, health information access, health behavior, and health status in Japanese people. Patient Educ Couns. 2015;98(5):660-8. doi: 10.1016/j.pec.2015.02.013.
30. World Health Organization. Health Promotion. Available from: https://www.who.int/teams/health-promotion/enhanced-wellbeing/ninth-global-conference/health-literacy. Accessed May 19, 2023.
31. World Health Organization. Healthy Diet. 2018. Available from: https://www.who.int/publications/m/item/healthy-diet-factsheet394. Accessed May 19, 2023.
32. Freire RD, Cardoso MA, Gimeno SG, Ferreira SR. Dietary fat is associated with metabolic syndrome in Japanese Brazilians. Diabetes Care. 2005;28(7):1779-85. doi: 10.2337/diacare.28.7.1779.
33. Julibert A, Bibiloni MDM, Tur JA. Dietary fat intake and metabolic syndrome in adults: a systematic review. Nutr Metab Cardiovasc Dis. 2019;29(9):887-905. doi: 10.1016/j.numecd.2019.05.055.
34. Wen Y, Shang Y, Wang Q. Exploration of the mechanism of linoleic acid metabolism dysregulation in metabolic syndrome. Genet Res (Camb). 2022;2022:6793346. doi: 10.1155/2022/6793346.
35. Babio N, Toledo E, Estruch R, Ros E, Martínez-González MA, Castañer O, et al. Mediterranean diets and metabolic syndrome status in the PREDIMED randomized trial. CMAJ. 2014;186(17):E649-57. doi: 10.1503/cmaj.140764.
36. Gillingham LG, Harris-Janz S, Jones PJ. Dietary monounsaturated fatty acids are protective against metabolic syndrome and cardiovascular disease risk factors. Lipids. 2011;46(3):209-28. doi: 10.1007/s11745-010-3524-y.
37. Warwick ZS, Schiffman SS. Role of dietary fat in calorie intake and weight gain. Neurosci Biobehav Rev. 1992;16(4):585-96. doi: 10.1016/s0149-7634(05)80198-8.
38. Luta X, Hayoz S, Gréa Krause C, Sommerhalder K, Roos E, Strazzullo P, et al. The relationship of health/food literacy and salt awareness to daily sodium and potassium intake among a workplace population in Switzerland. Nutr Metab Cardiovasc Dis. 2018;28(3):270-7. doi: 10.1016/j.numecd.2017.10.028.