*Corresponding author : Jonghoon Park, Ph. D.

Exercise Nutrition and Biochemistry Laboratory, Department of Physical Education, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul 02841, Republic of Korea.

Tel: +82-2-3290-2315

E-mail: jonghoonp@korea.ac.kr

Analysis of energy intakes, physical activities and metabolic syndrome according to the income level in Korean elderly people: Korean National Health and Nutrition Examination Survey 2016–2018

Eun-Sook Sung[1] / Sijin Lee[2] / Youngjun Lee[1] / Seunghee Lee[1] / Jonghoon Park[1,2*]

1. Department of Physical Education, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul 02841, Republic of Korea
2. Department of Physical Education of education college, 145 Anam-ro, Seongbuk-gu, Seoul 02841, Republic of Korea

[Purpose] To determine the correlations of differences in the income level with the presence of metabolic syndrome (MetS), energy intake, and physical activity across Korean elderly populations.

[Methods] We obtained data from 2,139 elderly individuals (aged >65 years) based on the Korea National Health and Nutrition Examination Survey (KNHANES) (2016–2018). We analyzed the levels of physical activity (PA) and energy intake using the survey data. Moreover, we analyzed the differences in energy intake and PA levels according to the income level and MetS.

[Results] Compared with the non-MetS group, the MetS group displayed significantly higher levels of waist circumference (p=0.000), triglycerides (p=0.000), systolic blood pressure (p=0.000), diastolic blood pressure (p=0.016), and fasting blood glucose (p=0.000) for both high and low income levels. However, the level of high-density lipoprotein cholesterol was significantly lower in the MetS group than that in the non-MetS group (p=0.000). The level of smoking in non-MetS men was significantly higher than that in MetS men across all participants (p=0.047). Except carbohydrate intake, the total energy intake (p=0.022), fat intake (p=0.009), and protein intake (p=0.005) were significantly lower in the MetS group than those in the non-MetS group for high income levels. We obtained similar results for low income levels. The two-way analysis of variance (ANOVA) did not identify an interaction between the income level and the presence of MetS; however, the total energy, i.e., the level of total energy intake, was significantly lower in participants with low income levels than in those with high income levels. For high income levels, transport PA (p=0.002), vigorous recreational PA (p=0.001), moderate recreational PA (p=0.001), and total PA (p=0.000) were significantly lower in the MetS group than those in the non-MetS group. For low income levels, moderate occupational PA (p=0.012), transport PA (p=0.018), and total PA ((p=0.000) were significantly lower in the MetS group than those in the non-MetS group. The total PA, i.e., the level of energy consumption, was significantly lower in the elderly with low income levels than in those with high income levels.

[Conclusion] Regardless of the income level, the elderly with MetS exhibited low levels of energy intake and PA, compared with those without MetS. In addition, regardless of the presence of MetS, the elderly with low income levels exhibited lesser energy intake and PA. These findings implied the need for balanced nutrient intake and increased participation in PA as well as education and program development to prevent MetS in the elderly.

[Keywords] income level, energy intake, metabolic syndrome, physical activity, elderly

INTRODUCTION

South Korea has been identified as an aging society since 2000, where the population aged ≥65 years exceeds 7%[1]. According to Statistics Korea, the elderly population aged ≥65 years in the Korean society would occupy 20.3% of the total population by 2025[2]. This rapid progression of the aging phenomenon may induce economic and social issues[3]. The trend of a continuous increase in health care costs owing to metabolic syndrome (MetS), primarily caused by an imbalance in nutrient intake and the lack of physical activity (PA), is a major concern[3-7]. MetS occurs because of complex interactions among genetic factors, inappropriate dietary habits, and insufficient PA[8,9]. According to the 6th Korea National Health and Nutrition Examination Survey (KNHANES), an analysis of the general population in South Korea, 17.0% of the elderly population aged ≥65 years displayed an insufficient level of total calorie intake, whereas 31.4%, 81.3%, 60.5%, and 61.5% displayed less than the estimated average requirement (EAR) of protein intake, calcium intake, vitamin A intake, and vitamin C intake, respectively[10]. The levels of income and education were determined as the primary cause of such nutrient deficiency, with an imbalance in nutrient intake predominantly concentrated in the low socioeconomic status group[11]. A decline in the socioeconomic status, particularly with respect to the level of education, would increase irregular daily routines with a lack of balanced nutrient intake, thus upsurging the prevalence of chronic diseases[11].

The lack of PA has been identified as the fourth major risk factor of global mortality; nonetheless, a significant percentage of the total population did not perform adequate PA[7,12]. Increasingly, studies are investigating the correlation between the level of income and PA. Several studies have demonstrated a positive correlation between personal income and participation in PA[13-19]. Meltzer and Jena reported that the high income group displayed 26% higher energy consumption through PA with approximately 3% higher intensity, compared with the low income group[20]. Likewise, the level of income is supposedly the critical determinant of

PA[18,19]. By contrast, improved economy and increased income enhance the total PA, which is higher for individuals close to unemployment on the scale of income level[14,15,18]. Health equality has become one of the most significant political goals not only worldwide but also in South Korea[21]. Considering it to be a sensitive indicator of the fairness of public order, an additional increase in social injustice would sufficiently induce a deterioration in health-related inequality[22]. Thus, researchers should attempt to apply the health indicators of the KNHANES to determine the current status of health inequality caused by differences in income levels across the elderly populations in South Korea to minimize social loss; however, there are limited studies on the correlations of the income level with nutrient intake and the presence of MetS in the elderly. Thus, we aimed to determine the association between the differences in income levels and those in nutrient intake and MetS in the elderly by analyzing the data of the 7th KNHANES (2016–2018).

MATERIALS AND METHODS

Sample and design

This study used cross-sectional data from the KNHANES from 2016 to 2018, conducted by the Korea Centers for Disease Control and Prevention (KCDC). The data are updated every 3 years. Therefore, we used the most up-to-date available data. The details of the study design and data source profiles followed the methods described in the guidelines for the use of raw KNHANES data and in the final report on the sampling frame[23].

From 2016 to 2018, 24,269 individuals completed health interview surveys, nutrition surveys, and health examinations, conducted according to the tenets of the Declaration of Helsinki. This interview survey was approved by the Institutional Review Board of the KCDC (Reference number; 2018-01-03-P-A). Preceding the survey, all participants were informed about the purpose and procedures of the survey, and written informed consent was obtained from each volunteer prior to participation. Of these individuals, 19,313 people aged under 65 years were excluded; thus, 4,956 people aged over 65 years were retained. Subsequently, we excluded 2,497, 193, and 127 individuals with middle-class income, previously diagnosed or treated for cancer (gastric, colorectal, liver, cervical, breast, thyroid, lung, and other cancers), and with missing data, respectively (Figure 1). A total of 2,139 elderly people were eventually included in this study.

We used the age data extracted among the items of the questionnaire from the KNHANES raw data (2016–2018). The elderly people aged ≥65 years were divided into four groups according to their equivalised monthly household income, ranging from Group I with the highest income to Group IV with the lowest income. Following the exclusion of the middle groups II and III, we selected the groups I and IV to represent the high and low income levels. Moreover, the participants were divided according to the presence of MetS into two groups, namely the MetS group and non-
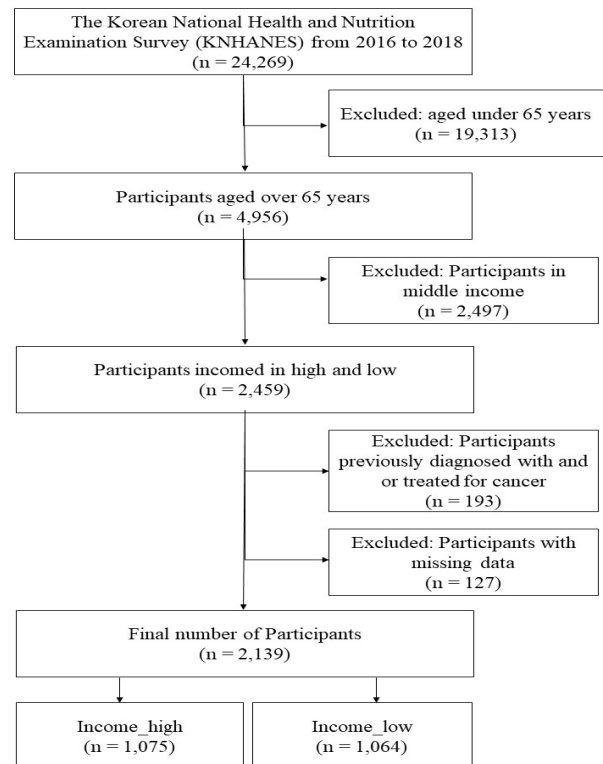

Figure 1. Flow diagram for the selection of the study participants.

MetS group. Table 1 summarizes the characteristics of all participants.

Metabolic syndrome

MetS diagnosis was based on the recently harmonized guidelines of the National Cholesterol Education Program-Adult Treatment Panel III[24], American Heart Association, and National Heart Lung and Blood Institute[25]. For the waist circumference, we followed the criteria suggested by the Korean Society for the Study of Obesity[26]. MetS was diagnosed if the participants met three or more of the following criteria[27]: waist circumference >90 cm (men) or >85 cm (women); systolic blood pressure >130 mmHg or diastolic blood pressure >85 mmHg; fasting triglyceride (TG) levels >150 mg/dL; fasting HDL-C levels <40 mg/dL (men) or <50 mg/dL (women); and fasting glucose (FG) levels >100 mg/dL

Physical activity

The Global Physical Activity Questionnaire (GPAQ) comprises 16 questions grouped to determine the PA undertaken in different behavioral domains as follows: work, transport, and recreational activities. It analyzes the following five domains of PA: vigorous-intensity work, moderate-intensity work, transport, vigorous-intensity recreation, and moderate-intensity recreation. The participants responded freely to the five domains without any additional option regarding the number of times they performed PA per week and the minutes per day. We used the World

Table 1. Descriptive characteristics of the participants.

	Total (n=893)			Male (n=220)			Female (n=673)		
	Non-MetS (n=626)	MetS (n=267)	*p*-Value	Non-MetS (n=145)	MetS (n=75)	*p*-Value	Non-MetS (n=481)	MetS (n=192)	*p*-Value
Age (years)	74.3 ± 0.2	74.7 ± 0.3	0.931	72.7 ± 0.4	72.9 ± 0.8	0.903	74.8 ± 0.2	75.4 ± 0.4	**0.039**
Height (cm)	154.2 ± 0.4	155.1 ± 0.6	0.348	165.2 ± 0.5	165.6 ± 0.7	0.997	150.8 ± 0.3	150.9 ± 0.5	0.507
Body weight (kg)	56.2 ± 0.4	62.9 ± 0.7	0.133	61.7 ± 0.9	70.1 ± 1.0	0.860	54.6 ± 0.4	60.1 ± 0.7	0.485
BMI (kg/m^2)	23.6 ± 0.1	26.1 ± 0.2	0.335	22.6 ± 0.2	25.5 ± 0.3	0.975	23.9 ± 0.2	26.4 ± 0.3	0.449
Alcohol	30.6±2.1	28.7±3.1	0.157	65.1±4.0	58.1±7.7	0.568	20.2±2.1	17.0±2.8	0.155
Smoking	8.7±1.2	12.1±2.7	0.099	32.7±3.5	29.7±7.5	**0.047**	1.4±057	5.1±1.6	0.021

Values are expressed as means standard errors; BMI, body mass index; Alcohol, Percentage of drinking at least once a month in the past year; Smoking, Percentage of smoking five packs (100 cigarettes) or more in their lifetime and currently smoke; and MetS, metabolic syndrome. * *p*<0.05, ** *p*<0.01, and *** *p*<0.001.

Health Organization GPAQ analysis guidelines to analyze the GPAQ data[28]. A person's caloric consumption was four times and eight times likely higher on being moderately and vigorously active, respectively, than that while sitting quietly. Therefore, while calculating the total energy expenditure of an individual using GPAQ data, four and eight metabolic equivalents (METs) were allocated to the time spent in moderate and vigorous activities, respectively, as follows:

- Vigorous intensity activity: occupational (MET) = 8.0 × vigorous intensity PA (day/week) × 1-day vigorous intensity PA (min/day)
- Moderate intensity activity: occupational (MET) = 4.0 × moderate intensity PA (day/week) × 1-day moderate intensity PA (min/day)
- Vigorous intensity activity: recreational (MET) = 8.0 × vigorous intensity PA (day/week) × 1-day vigorous intensity PA (min/day)
- Moderate intensity activity: recreational (MET) = 4.0 × moderate intensity PA (day/week) × 1-day moderate intensity PA (minutes/day)
- Transport (MET) = 4.0 × transport PA (day/week) × 1-day transport PA
- Total PA (MET) = vigorous intensity activity: occupational + moderate intensity activity: occupational + vigorous intensity activity: recreational + moderate intensity activity: recreational + transport.

PA levels were classified into four groups as follows: inactive (0–249 MET min/week), somewhat active (250–499 MET min/week), active (500–999 MET min/week), and very active (>1,000 MET min/week). These cut-off points were based on their equivalence to the following PA thresholds: 250 MET min/week represented an energy expenditure dose equivalent to half of the threshold; 500 MET min/week was equivalent to the minimal threshold; and 1,000 MET min/week was equivalent to twice the minimal threshold[29].

Energy intake

The nutrition outcomes were obtained by a 24-h recall method by interviewing the target households in person. Trained dietitians collected the nutrition survey data from the participants' homes 1 week following the health interview and health examination. Daily energy intake was calculated using the Korean Food and Nutrient Database of the Rural Development Authority. The following items were included in the analyses: total energy intake, carbohydrate intake, protein intake, and fat intake per day. The energy intake data was converted to kcal. Carbohydrates and proteins were calculated by converting them to 4 kcal per 1 gram, whereas fat was converted to 9 kcal per 1 gram.

Statistical analysis

The continuous variables are presented as mean and standard error. We verified the normality of the distribution of all outcome-variable data using the Kolmogorov–Smirnov test. The post-mortem independent t-test was performed to analyze the risk factors for MetS as well as PA levels and energy intakes between the non-MetS and MetS groups, and the sex characteristics of the dependent variable in each group. We performed the one-way analyses of variance (ANOVA) to analyze the differences in risk factors for MetS, PA levels, and energy intakes between participants with and without MetS, and between men and women. Upon obtaining a significant interaction effect by the two-way ANOVA, we performed a Bonferroni post-hoc test to separately compare the household-specificity of the dependent variables in each group (with and without MetS). Moreover, we determined the relationships between PA levels or energy intake and MetS using logistic regression analysis after controlling for the covariates. The logistic regression analysis findings are presented as odds ratios (ORs) and their associated 95% confidence intervals (CIs). Statistical analyses were performed using SPSS version 25.0 for Windows (IBM Corp., Armonk, NY, USA). The level of significance was set at 0.05.

RESULTS

Differences in metabolic syndrome components according to the income level

Table 2 summarizes the levels of MetS components based on the presence of MetS in elderly individuals with low and high income levels. For both low and high income levels, the waist circumference (W; $p=0.000$), TG ($p=0.000$), SBP ($p=0.000$), DBP ($p=0.016$), and FG ($p=0.000$) were significantly higher in the MetS group than those in the non-MetS group, whereas the HDL-C ($p=0.000$) was significantly lower in the MetS group than that in the non-MetS group. The income level and the presence of MetS displayed a significant interaction effect for FG ($p=0.029$), with a trend of high FG in the elderly with MetS and low income levels.

Differences in energy intake according to the income level and the presence of MetS

Table 3 summarizes the energy intake based on the presence of MetS in the elderly individuals with low and high income levels. The total energy intake ($p=0.000$), carbohydrate intake ($p=0.011$), fat intake ($p=0.009$), and protein intake ($p=0.000$) were significantly lower in the MetS group than those in the non-MetS group. Except carbohydrate intake, the total energy intake ($p=0.022$), fat intake ($p=0.009$), and protein intake ($p=0.005$) were significantly lower in the MetS group than those non-MetS group for high income levels. We obtained similar results for low income levels. The two-way ANOVA did not detect an interaction between the income level and the presence of MetS; however, the total energy, i.e., the level of total energy intake, was signifi-

Table 2. Differences in metabolic syndrome components according to the income level.

Factors	Group	Total	Income type		ANOVA			
			High	Low		*F*-value	*p*-value (η^2)	Power
Waist (cm)	Non-MetS (n=1602)	83.71±8.60	83.95±8.44	83.45±8.76	I	0.607	0.436(0.000)	0.122
	MetS (n=537)	90.05±8.62	90.14±8.75	89.97±8.52	M	217.936	**0.000(0.093)****	1.000
	p-value	**0.000****	**0.000****	**0.000****	I×M	0.151	0.698(0.000	0.067
TG (mg/dL)	Non-MetS (n=1602)	111.86±55.01	110.90±53.15	112.90±56.97	I	2.842	0.092(0.001)	0.392
	MetS (n=537)	191.68±89.73	186.75±95.93	195.78±83.47	M	589.527	**0.000(0.216)****	1.000
	p-value	**0.000****	**0.000****	**0.000****	I×M	1.158	0.282(0.001)	0.189
HDL-C (mg/dL)	Non-MetS (n=1602)	50.19±11.58	50.84±11.47	49.50±11.67	I	5.585	**0.018(0.003)***	0.656
	MetS (n=537)	41.16±8.59	41.84±9.05	40.59±8.15	M	269.993	**0.000(0.112)****	1.000
	p-value	**0.000****	**0.000****	**0.000****	I×M	0.007	0.934(0.000)	0.051
SBP (mmHg)	Non-MetS (n=1602)	125.58±16.71	125.84±17.20	125.30±16.18	I	0.052	0.819(0.000)	0.056
	MetS (n=537)	135.69±16.33	135.60±16.16	135.76±16.49	M	147.809	**0.000(0.065)****	1.000
	p-value	**0.000****	**0.000****	**0.000****	I×M	0.184	0.668(0.000)	0.071
DBP (mmHg)	Non-MetS (n=1602)	71.70±9.60	71.84±9.66	71.55±9.55	I	0.009	0.926(0.000)	0.051
	MetS (n=537)	73.76±10.40	73.56±10.12	73.94±1063	M	17.481	**0.000(0.008)****	0.987
	p-value	**0.016***	**0.016***	**0.001****	I×M	0.458	0.499(0.000)	0.104
FG (mg/dL)	Non-MetS (n=1602)	103.47±21.23	103.44±21.49	103.50±20.56	I	4.969	**0.026(0.002)***	0.606
	MetS (n=537)	125.56±36.07	122.46±31.87	128.14±39.09	M	287.326	**0.000(0.119)****	1.000
	p-value	**0.000****	**0.000****	**0.000****	I×M	4.763	**0.029(0.002)***	0.588

TG; triglyceride, HDL-C; high-density lipoprotein cholesterol, SBP; systolic blood pressure, DBP; diastolic blood pressure, and FG; fasting blood glucose. Values are expressed as means standard errors, Main effect = I (Income) and M (Metabolic syndrome), Interaction effect = I × M (Income × Metabolic syndrome), * $p<0.05$, ** $p<0.001$.

Table 3. Differences in energy intake according to the income level and the presence of MetS.

Factors	Group	Total	Income type		ANOVA			
			High	Low		F-value	p-value (η^2)	Power
Total Energy intake (kcal)	Non-MetS (n=1602)	1694.71±74086	1800.41±770.25	1578.48±689.19	I	35.414	**0.000(0.018)*****	1.000
	MetS (n=537)	1545.65±657.66	1668.58±660.57	1442.50±638.39	M	12.654	**0.000(0.007)*****	0.945
	p-value	**0.000****	**0.022***	**0.006****	I × M	0.003	0.956(0.000)	0.050
Carbohydrate intake (g)	Non-MetS (n=1602)	291.45±128.33	305.00±134.42	276.54±119.61	I	18.098	**0.000(0.009)*****	0.989
	MetS (n=537)	274.57±116.93	289.60±116.59	261.96±115.93	M	5.172	**0.023(0.003)***	0.623
	p-value	**0.011***	0.124	0.091	I × M	0.004	0.950(0.000)	0.050
Fat intake (g)	Non-MetS (n=1602)	27.69±22.27	31.95±22.63	22.99±20.89	I	62.822	**0.000(0.032)*****	1.000
	MetS (n=537)	23.52±17.69	28.10±18.10	19.68±16.42	M	10.669	**0.001(0.005)****	0.904
	p-value	**0.000****	**0.009****	**0.010****	I × M	0.059	0.807(0.000)	0.057
Protein intake (g)	Non-MetS (n=1602)	56.15±29.70	62.13±30.72	49.58±27.07	I	65.823	**0.000(0.033)*****	1.000
	MetS (n=537)	49.66±25.88	55.95±27.73	44.39±22.98	M	14.624	**0.000(0.008)*****	0.969
	p-value	**0.000****	**0.005****	**0.006****	I × M	0.112	0.738(0.000)	0.063

Values are expressed as means standard errors, Main effect = I (Income) and M (Metabolic syndrome), Interaction effect = I × M (Income × Metabolic syndrome), and *** p<0.05, ** p<0.01, and *** p<0.001.**

cantly lower in the elderly people with low income levels than in those with high income levels.

Differences in physical activity levels according to the income level and the presence of MetS

Table 4 summarizes the PA based on the presence of MetS in the elderly people with low and high income levels. Vigorous occupational PA (p=0.023), moderate occupational PA (p=0.003), transport PA (p=0.000), vigorous recreational PA (p=0.002), moderate recreational PA (p=0.000), and total PA (p=0.000) were significantly lower in the MetS group than those in the non-MetS group. For high income levels, transport PA (p=0.002), vigorous recreational PA (p=0.001), moderate recreational PA (p=0.001), total PA (p=0.000) were significantly lower in the MetS group than those in the non-MetS group. For low income levels, moderate occupational PA (p=0.012), transport PA (p=0.018), and total PA (p=0.000) were significantly lower in the MetS group than those in the non-MetS group. The two-way ANOVA did not identify an interaction between the income level and the presence of MetS; however, the total PA, i.e., the level of energy consumption, was significantly lower in the elderly people with low income levels than in those with high income levels.

DISCUSSION

We aimed to determine the presence of MetS and energy intake according to the income levels using the raw data of 2,139 elderly people aged ≥65 years from the 7th KN-HANES (2016–2018).

Upon analyzing the MetS components based on the presence of MetS, participants with MetS exhibited significantly higher W, TG, SBP, DBP, and FG than those without MetS, whereas the HDL-C level was significantly lower in those with MetS. Regarding the interaction effect between the income level and MetS, the presence of MetS exerted a significant effect on the FG and HDL-C levels. The income level is related to MetS incidence and the risk of cardiovascular diseases[30,31]. Notably, the income level exerted a greater impact on the FG and HDL-C levels across the five MetS components in this study.

Upon analyzing the energy intake based on the presence of MetS, participants with MetS exhibited significantly lower levels of the total energy intake, carbohydrate intake, fat intake, and protein intake than those without MetS. In addition, both low and high income levels displayed significantly lower levels of total energy intake, fat intake, and protein intake in those with MetS. The two-way ANOVA did not identify an interaction between the income level and the presence of MetS; nonetheless, the total energy, i.e., the level of total energy intake, was significantly lower for low

Table 4. Differences in physical activity levels according to the income level and the presence of MetS.

Factors	Group	Total	Income type		ANOVA			
			High	Low		F-value	p-value (η²)	Power
Occupational vigorous	Non-MetS (n=1602)	16.78±294.33	23.68±355.58	9.34±209.11	I	0.317	0.574(0.000)	0.087
	MetS (n=537)	0.00±0.00	0.00±0.00	0.00±0.00	M	1.678	0.195(0.001)	0.253
	p-value	**0.023***	0.055	0.445	I × M	0.317	0.574(0.000)	0.087
Occupational moderate	Non-MetS (n=1602)	54.64±498.89	37.81±381.92	72.79±599.69	I	0.785	0.376(0.000)	0.144
	MetS (n=537)	14.79±120.25	12.79±137.97	16.45±103.41	M	3.479	0.062(0.002)	0.462
	p-value	**0.003****	0.116	**0.012***	I × M	0.515	0.473(0.000)	0.111
Transport	Non-MetS (n=1602)	403.02±765.35	426.17±700.70	378.08±829.14	I	1.295	0.255(0.001)	0.206
	MetS (n=537)	285.94±538.24	304.13±478.16	270.79±583.96	M	10.270	**0.001(0.005)****	0.893
	p-value	**0.000*****	**0.002****	**0.018***	I × M	0.042	0.837(0.000)	0.055
Recreational vigorous	Non-MetS (n=1602)	33.91±315.88	60.46±423.44	5.29±112.31	I	4.269	**0.039(0.002)***	0.542
	MetS (n=537)	6.41±98.07	7.54±103.51	5.46±97.47	M	3.625	0.057(0.002)	0.477
	p-value	**0.002****	**0.001****	0.982	I × M	3.671	0.055(0.002)	0.482
Recreational moderate	Non-MetS (n=1602)	112.21±384.86	150.77±438.31	70.66±312.33	I	11.623	**0.001(0.005)****	0.926
	MetS (n=537)	54.97±250.74	77.21±270.71	36.45±231.66	M	9.239	**0.002(0.004)****	0.860
	p-value	**0.000*****	**0.001****	0.052	I × M	1.231	0.267(0.001)	0.199
Total physical activity	Non-MetS (n=1602)	620.57±1173.74	698.88±1180.30	536.18±1161.49	I	4.898	**0.027(0.002)***	0.600
	MetS (n=537)	362.10±633.29	401.67±600.31	329.15±658.70	M	22.503	**0.000(0.010)*****	0.997
	p-value	**0.000*****	**0.000*****	**0.000*****	I × M	0.720	0.396(0.000)	0.136

Values are expressed as means standard errors, Main effect = I (Income) and M (Metabolic syndrome), Interaction effect = I × M (Income × Metabolic syndrome), and * *p<0.05*, ** *p<0.01*, and *** *p<0.001*.

income levels than that for high income levels. The daily dietary energy and nutrient intakes decrease with age, and the level of the household income of the elderly people is a critical factor influencing the pattern of dietary intake[33-36]. Particularly, previous studies demonstrated a pattern of higher protein intake and more balanced nutrient intake in the elderly individuals of a household with high income levels. Likewise, the income level exerted a significant impact on the protein intake in this study; the elderly individuals with low income levels exhibited a lower level of protein intake than those with high income levels, consistent with previous studies. Moreover, low-income elderly populations with obesity aged ≥65 years displayed an imbalance in the nutrient intake with significant effects on obesity, MetS, and cardiovascular diseases[32].

Upon analyzing the PA based on the presence of MetS, participants with MetS exhibited significantly lower levels of vigorous occupational PA, moderate occupational PA, transport PA, vigorous recreational PA, moderate recreational PA, and total PA than those without MetS. In addition, upon analyzing the PA for the elderly individuals with high income levels, participants with MetS exhibited significantly lower levels of transport PA, vigorous recreational PA, moderate recreational PA, and total PA. By contrast, the elderly individuals with low income levels and MetS exhibited significantly lower levels of moderate occupational PA, transport PA, and total PA. The two-way ANOVA did not identify an interaction between the income level and the presence of MetS; however, the elderly people with low income levels displayed a significantly lower level of total PA, i.e., the

level of energy consumption. Low PA levels accounted for approximately 9% of the causes of early mortality worldwide[33], while low-income countries displayed a low PA levels[34]. The low PA levels of low-income countries were reportedly correlated with an increased prevalence of MetS[34]. Moreover, recreational PA performed by an elderly individual was influenced by thee monthly income; an increase in the average monthly income increased the recreational PA[35]. In another study, the elderly individuals with low income levels demonstrated relatively lesser recreational time with consequent marginal recreational PA, compared with those with high income levels. In addition, the income level was correlated with the level of education such that those with a higher level of education were more likely to perceive the benefits of regular PA, consistent our findings[36-38]. Thus, considering the perspective of policy-making, balanced nutrient intake and participation in recreational PA should be encouraged regardless of the income level in the elderly people, while improving their health through education and program development.

This study had several limitations. First, the cross-sectional design made it difficult to verify the causal relationships among the income, energy intake, and PA levels in the participants. Second, socioeconomic variables, such as the education level or socio-interrelationship, were inadequately corrected. Despite these limitations, our findings may increase the reliability of the results and could be generalized as a national trend based on the KNHANES data.

In conclusion, the elderly individuals with MetS exhibited low levels of energy intake and PA regardless of the income level, compared with those without MetS. In addition, those with low income levels exhibited lower levels of energy intake and PA regardless of the presence of MetS. These findings implied the need for balanced nutrient intake and increased participation in PA as well as education and program development to prevent MetS in the elderly people.

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