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Original Article

The Gangwon Obesity and Metabolic Syndrome Study: Methods and Initial Baseline Data

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Background: The prevalence of obesity has been continuously increasing, especially in rural areas of South Korea. Therefore, it is important to examine various genetic, behavioral, and environmental factors associated with obesity in these rural areas. The Korean Society for the Study of Obesity commenced a community-based prospective cohort study of the Gangwon area called the Gangwon Obesity and Metabolic Syndrome (GOMS) study to investigate longitudinal changes in the status of obesity and its related factors.

Methods: A total of 317 adults 40–69 years of age were recruited from Hongcheon and Inje districts, Gangwon province, as part of the first wave of this cohort study. Information on participants' demographic, behavioral, psychological, dietary, and environmental factors and past medical histories were collected by self-administered questionnaires and interviewer-administered questionnaires. Anthropometric measurements, blood tests, and a hand grip strength test were performed, and skin keratin and stool samples were collected. Among the 317 enrolled subjects, two participants who did not have anthropometric data were excluded from the data analyses, resulting in an inclusion of a total of 315 participants.

Results: The mean age of the 315 participants in the GOMS initial baseline survey was 58.5 years old, 87 of them were men, and the mean body mass index was 24.7±3.7 kg/m^2. Among all participants, 48.9% had hypertension, 21.4% had diabetes mellitus (DM), 55.6% had dyslipidemia, and 46.0% had metabolic syndrome (MS). Both the prevalence rates of DM and MS were significantly higher in men.

Conclusion: The first baseline survey of the GOMS study was initiated, and a more detailed analysis of respondents' data is expected to be continued. Further follow-up and additional recruitment will allow the investigation of risk factors and the etiology of obesity and its comorbidities in rural areas of Gangwon province.

Key words: Obesity, Metabolic syndrome, Cohort

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INTRODUCTION

Cases of obesity have been increasing worldwide, having nearly tripled since 1975.[1] In South Korea, the prevalence of obesity has also steadily increased over a recent 11-year period from 29.7% in 2009 to 36.3% in 2019.[2] Prevention and management of obesity are important because obesity places a big burden on public health due to its comorbidities, which include hypertension, type 2 diabetes mellitus (DM), cardiovascular diseases, osteoarthritis, obstructive sleep apnea, reproductive pathologies, and some cancers. In individuals with obesity, the relative risks of type 2 DM and myocardial infarction were 2.6 and 1.2 times higher, respectively, than in those without obesity.[2]

The prevalence of obesity is different from region to region even within the same country.[3] This trend is becoming more salient worldwide. From 1985 to 2017, the increases in mean body mass index (BMI) were 2.09 kg/m^2 (95% credible interval, 1.73–2.44) and 2.10 kg/m^2 (1.79–2.41) among rural women and men, respectively, compared to 1.35 kg/m^2 (1.05–1.65) and 1.59 kg/m^2 (1.33–1.84) in urban women and men globally.[3] This increase in obesity in rural areas is also notable in the United States. The prevalence of obesity in rural America is higher than that in urban America.[4] A lack of physical activity and low income were suggested as predisposing factors for the increased risk of obesity among rural Americans.[4] The prevalence of obesity in rural areas was also higher than that in urban areas in South Korea (27.5% and 23.4%), respectively, in 2013.[5] Gangwon province ranked first with an obesity prevalence of 39.6% in 2017 among metropolitan cities and provinces in South Korea.[5] The obesity prevalence rates of men and women in Gangwon province in 2017 were 47.3% and 28.6%, ranking second for men and first for women.[5] According to the Korean Statistical Information Service, Inje, Hwacheon, and Yanggu districts have the highest obesity prevalence rates (44.9%, 41.0%, and 40.6%, respectively), and Hongcheon district also has a high obesity prevalence (40.1%).[6] Gangwon province is South Korea's representative rural area, being surrounded by high mountains and deep valleys formed by the Taebaek mountains running north to south on the peninsula, so about 82% of the province is composed of mountainous areas. Characteristics of the mountainous regions of Gangwon province may include a lack of medical resources and the health service system.

Some new possible factors for the progression of obesity in rural areas could be suggested, in addition to previously suggested factors such as differences in demographic factors, physical activity level, and dietary patterns. First, several issues of neighborhood environments are known to be related to obesity. High walkability has been shown to be linked with substantially lower prevalence rates of obesity in several studies.[7] Social networks, social norms, and residential segregation are also associated with obesity.[8] Second, there are remarkable seasonal variations in physical activities and energy requirements between the farming season and off-season among farmers in rural areas in South Korea, and the differences vary further according to the type of farming.[9,10] Third, the endogenous circadian clock has been known to regulate energy homeostasis,[11] and there may be differences in the circadian rhythm between farmers and non-farmers living in the same rural area.

The Korean Society for the Study of Obesity decided to commence a community-based prospective cohort study of middle-aged and elderly adults living in rural areas in Gangwon province to determine their status of body weight and composition and investigate the longitudinal changes in obesity-related factors and obesity, which was named the Gangwon Obesity and Metabolic Syndrome (GOMS) study. The specific aims of the GOMS study were (1) to identify environmental, genetic, and behavioral factors involved in the progression of body fat accumulation and the development of obesity co-morbidities and (2) to provide evidence for policy development and practice to prevent and control obesity in rural areas in Korea.

METHODS

Enrollment of the study population

The first baseline cohort survey of the GOMS study was designed to recruit 300 Korean adults aged 40–69 years living in the western inland region of Gangwon province (Yeongseo). This region is marked by high mountains and plateaus with deep valleys, and the obesity prevalence of the region is higher than that in other regions. The rationales for the inclusion criteria of age were as follows: (1) the incidences of chronic diseases increase significantly after the age of 40 years and (2) there are different characteristics of obesity in people aged ≥ 70 years compared to obesity in the general population. The first survey was conducted in the period of June 18 to

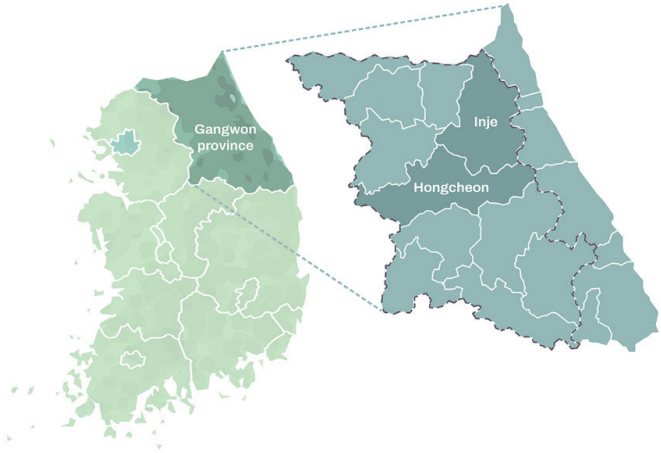

Figure 1. The survey area of the Gangwon Obesity and Metabolic Syndrome study.

July 3, 2022, in Hongcheon district and between July 9 to 24, 2022, in Inje district of Gangwon province (Fig. 1). We excluded (1) subjects who were Korean-illiterate and (2) subjects with moderate or severe cognitive dysfunction.

The recruitment was publicized through diverse tools. The recruitment notice was published both online and offline. It contained study information with inclusion criteria, contact phone numbers, and a QR code by which residents of that area could show their interest in participation. It was issued in local life information magazines and at community facilities, local hospitals, and local public health agencies. Onsite registration was also available. Finally, 153 participants from Hongcheon and 164 participants from Inje district (totaling 317 residents) participated in the cohort baseline survey.

Sample size calculations

We obtained a statistical power of 88% for detecting differences between the two study groups (36% of participants had BMI ≥ 23 kg/m^2 vs. 64% of participants had BMI < 23 kg/m^2) in the two-sample t-test using the sample size of 300, assuming that the mean triglyceride levels were 127 mg/dL and 176 mg/dL, respectively, with a 130 mg/dL standard deviation.[12] For logistic regression, if the probabilities of elevated triglyceride levels were 15% for participants with mean BMI values and 28% for those with mean plus standard deviation BMI values, the inclusion of 119 participants would result in a statistical power of > 85%. Therefore, a sample size of 300 would be expected to have a statistical power of > 85%.

Table 1. Composition of the survey questionnaire

Category	Item
Demographic data	Marital status
	Education level
	Household types
	Household income per month
	Occupation
Lifestyle information	Smoking (including electronic cigarette)
	Alcohol drinking
	Exercise
	Physical activity and its seasonal variation
	Recent change of body weight
	Maximum and minimum of body weight
	Body image
	Sleep
	Horne and Östberg morningness-eveningness questionnaire: a reduced scale[13-16]
	The modified Yale Food Addiction Scale 2.0[17,18]
	Food security[19]
	Community food environment[20,21]
	Community walking environment[22]
	Social network type[23]
	Farming activities
	Meal frequency
Medical history	Women's health issues (menstrual history, reproductive history, breastfeeding, hormone therapy)
	Family history
	Past medical history with current medications, including supplements
	Past surgical history, including bariatric surgery
Psychological status	Depression (K-DEP)[24,25]
	Anxiety (K-ANX)[26,27]
	Quality of life (WHOQOL-BREF)[28-30]
Dietary data	Food frequency questionnaire[31]

K-DEP, Korean Screening Tool for Depression Disorders; K-ANX, Korean Screening Tool for Anxiety Disorders; WHOQOL-BREF, World Health Organization Quality of Life Brief Version.

Assessment of lifestyle factors, socioeconomic status, and comorbidities

Demographic data, lifestyle information, body weight changes, medical history, psychological status, and dietary data were assessed using a self-administered questionnaire (Table 1).[13-31] The survey questionnaires were delivered to the participants in advance or given onsite, who filled them out by themselves. Considering the filled-in questionnaire, trained researchers interviewed participants to complete missing questions or rectify the wrong answers. Each participant's interview took about 0.5–1 hour.

The questionnaire included sociodemographic variables related to obesity (marital status, education level, house income, occupation, etc.) and behavioral factors (smoking, alcohol drinking, physical activity, etc.). Types of marital status included single, married, separated, widowed, divorced, and other. Education was divided into the following seven levels: no education, elementary, middle school, high school, college, university, and graduate school. Monthly household income was divided into the following five levels: < 2.0, 2.0–4.0, 4.0–6.0, 6.0–8.0, and ≥ 8.0 million Korean won. Occupation types included manager, professional, office worker, service worker, sales worker, agricultural/forestry/fishery worker, simple labor, military, housewife, unemployed, and other.

Regarding behavioral factors, smoking, the usage of electronic cigarettes, alcohol drinking, exercise, physical activity, sleep pattern, and chronotype[14-16] were investigated. A questionnaire for smoking investigated the usage of general cigarettes, "heat-not-burn" cigarettes, and electronic cigarettes. For alcohol drinking, the type of alcohol, the frequency of drinking, the typical amount of alcohol consumed, and the maximum amount of alcohol consumed in a day were explored. Types, frequency, intensity, and duration of exercise and physical activity were evaluated. In order to assess detailed lifestyle and social environment factors in the rural community, we assessed the seasonal variation of physical activities, food addiction,[17,18] the status of food security,[19] the community environment of food and walking,[20-22] the social network,[23] and farming activities.

Dietary data were obtained by a validated food frequency questionnaire that has been previously used in the Korea National Health and Nutrition Examination Survey.[31] Past medical history records were assessed for hypertension, dyslipidemia, ischemic heart disease, stroke, diabetes, thyroid disease, and cancer. For women, menstrual and reproductive history, breastfeeding, and usage of artificial estrogen hormone were assessed based on the self-reported answer to the relevant question. The survey questionnaire also covered depression,[24,25] anxiety,[26,27] and quality of life[28-30] to determine their psychological status.

The selection of questionnaires was performed by experts of relevant fields, who referred to previous surveys such as the Korea National Health and Nutrition Examination Survey and the Korean Genome and Epidemiology Study (KoGES). The Korean versions of questionnaires on depression,[24,25] anxiety,[26,27] morningness–eveningness,[13-16] food addiction,[17] quality of life,[28-30] and the food frequency questionnaire[31] adopted in this study have been validated in previous studies. The composition of the whole survey questionnaire, specific questionnaires used in the survey, and their validity studies in the Korean language are shown in Table 1.

Anthropometric measurements

Height, weight, waist circumference (WC), and hip circumference were measured by well-trained investigators. Height was measured in the erect position with a tape measure to the nearest 0.1 cm. Body weight was measured while wearing light clothes with bare feet using a bioelectrical impedance analysis device (ACCUNIQ BC720; SELVAS Healthcare, Daejeon, Korea) to the nearest 0.1 kg, and waist and hip circumferences were measured with a tape measure to the nearest 0.1 cm. WC was measured at the midpoint between the lower margin of the rib cage and the upper margin of the iliac creast, and hip circumference was measured with the most protruding part of the hip horizontally. Body composition, including body fat mass (kg), lean body mass (kg), and body fat percentage (%), was assessed by bioelectrical impedance analysis (ACCUNIQ BC720; SELVAS Healthcare). After taking enough rest, the blood pressure (BP) and pulse rate were measured twice in a sitting position using an automatic sphygmomanometer (BP500; SELVAS Healthcare), and the average value was used.

Hand grip strength test

Hand grip strength was evaluated using a digital hand dynamometer (TKK-5401; TAKEI, Tokyo, Japan) in both hands in a standing position with neutral positioning of the wrist and forearm and an extended elbow.

Blood tests

Blood collection was performed under fasting and smoking cessation for ≥ 2 hours and abstinence from alcohol for ≥ 2 days by trained health professional personnel. The complete blood cell count and serum levels of glucose, insulin, glycosylated hemoglobin (HbA1c), total cholesterol, triglycerides, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, aspartate aminotransferase, alanine transaminase, high-sensitivity C-reactive protein, thyroid-stimulating hormone, gamma-glutamyl

transferase, albumin, total protein, creatinine, carotenoids (carotene, cryptoxanthin, lutein, zeaxanthin, and lycopene), retinoids, and tocopherol were assessed. Participants' extra blood samples were stored at −75°C in deep freezers of the Korean Society for the Study of Obesity and the Korean Institute of Nutrition at Hallym University for future research. The storage process was carried out according to the general introduction of storage presented by the International Society for Biological and Environmental Repositories.

Skin keratin examination

Adhesive tape (D-squame tape; CuDerm Corp., Dallas, TX, USA) was placed on the upper anterior forearms, subjected to a constant pressure, and peeled off twice on the same spot. This method was used to collect lipids and probiotics in the keratin of the skin. This is a non-invasive inspection method that is performed by attaching the tape and then peeling it off immediately. Through this, skin lipid metabolites and skin lactic acid probiotics bacteria can be analyzed.

Stool test and gut microbiome analysis

Participants were provided a fecal kit in advance to collect feces on the morning of the survey date or the previous day. Participants were instructed to collect a sample at least the size of their thumbnail. Comprehensive analysis of gut microbiota was planned to be conducted with the collected fecal samples.

Definitions

For this study, a current smoker referred to someone who has smoked > 5 packs (100 cigarettes) in their lifetime and has smoked in the last month, and a current drinker was defined as someone who drank alcohol more than once a month.

BMI was classified into six categories, as follows: < 18.5 (underweight), 18.5–22.9 (normal), 23.0–24.9 (pre-obesity), 25.0–29.9 (class I obesity), 30.0–34.9 (class II obesity), and ≥ 35.0 kg/m^2 (class III obesity). Additionally, central obesity was defined as WC ≥ 90 cm for men and ≥ 85 cm for women according to the Korean Society for the Study of Obesity.[32]

Metabolic syndrome (MS) was defined according to a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; the National Heart, Lung, and Blood Institute; the American Heart Association; the World Heart Federation; the International Atherosclerosis Society; and the International Association for the Study of Obesity,[33] with Korean-specific cutoff values of WC set according to the Korean Society for the Study of Obesity.[32] Broadly, an individual should have ≥ 3 of the following criteria to be diagnosed with MS: (1) WC ≥ 90 cm for men or ≥ 85 cm for women; (2) triglycerides ≥ 150 mg/dL or taking dyslipidemia drugs; (3) HDL cholesterol < 40 mg/dL for men or < 50 mg/dL for women; (4) systolic BP ≥ 130 mmHg, diastolic BP ≥ 85 mmHg, or treatment of previously diagnosed hypertension; and (5) fasting plasma glucose ≥ 100 mg/dL or treatment of previously diagnosed type 2 DM.

Hypertension was defined by systolic BP ≥ 140 mmHg, diastolic BP ≥ 90 mmHg, or taking hypertension drugs.[34] DM was defined by fasting glucose ≥ 126 mg/dL, HbA1c ≥ 6.5%, or taking diabetes drugs.[35] Dyslipidemia was defined by a serum level of (1) total cholesterol ≥ 240 mg/dL, (2) triglycerides ≥ 200 mg/dL, (3) serum HDL cholesterol < 40 mg/dL in men or < 50 mg/dL in women, (4) serum LDL cholesterol ≥ 160 mg/dL, or (5) taking dyslipidemia drugs.[36]

Statistical analyses

Data are presented as mean ± standard deviation values or as a number (percentage), unless indicated otherwise. To compare the baseline characteristics between men and women, the chi-squared test and independent-samples t-test were used. All statistical analyses were performed using Stata 17.0 (StataCorp., College Station, TX, USA). A two-tailed *P*-value of < 0.05 was considered statistically significant.

Ethics statement

The protocol for this study was reviewed and approved by the Institutional Review Board of Hallym University (No. HIRB-2021-077-2-RR). The study objectives were explained to the participants and written informed consent was obtained.

RESULTS

The general characteristics of participants in the first baseline survey of the GOMS cohort study 2022 are presented in Table 2. In this first baseline survey, a total of 317 individuals in the Hong-

Table 2. General characteristics of participants in the first baseline survey of the GOMS cohort study, 2022

Variable	Total (n=315)	Men (n=87)	Women (n=228)	*P**
Age (yr)	58.5±7.0	60.3±6.9	57.8±7.0	0.005
40–49	43 (13.7)	9 (10.3)	34 (14.9)	
50–59	123 (39.1)	23 (26.4)	100 (43.9)	
60–69	149 (47.3)	55 (63.2)	94 (41.2)	
Education attainment				0.044
Less than high school graduation	118 (37.6)	28 (32.2)	90 (39.7)	
High school graduation	131 (41.7)	33 (37.9)	98 (43.2)	
More than college entrance	65 (20.7)	26 (29.9)	39 (17.2)	
Monthly household income (KRW)				0.161
<2 million	92 (29.2)	19 (22.4)	73 (32.7)	
2–4 million	122 (39.6)	35 (41.2)	87 (39.0)	
>4 million	94 (30.5)	31 (36.5)	63 (28.3)	
Current smoker†	45 (14.5)	29 (33.3)	16 (7.1)	<0.001
Current drinker‡	181 (58.0)	66 (75.9)	115 (51.1)	<0.001
Body mass index (kg/m^2)	24.7±3.7	25.4±3.6	24.5±3.8	0.068
Obesity status (kg/m^2)§				0.047
Underweight (<18.5)	7 (2.2)	0	7 (3.1)	
Normal (18.5 to <23)	108 (34.3)	23 (26.4)	85 (37.3)	
Pre-obesity (23 to <25)	71 (22.5)	21 (24.1)	50 (21.9)	
Class I obesity (25 to <30)	101 (32.1)	36 (41.4)	65 (28.5)	
Class II obesity (30 to <35)	25 (7.9)	5 (5.8)	20 (8.8)	
Class III obesity (≥35)	3 (1.0)	2 (2.3)	1 (0.4)	
Central obesity‖	141 (44.8)	42 (48.3)	99 (43.4)	0.438
Hypertension¶	154 (48.9)	49 (56.3)	105 (46.1)	0.103
Diabetes mellitus**	67 (21.4)	25 (29.1)	42 (18.5)	0.042
Dyslipidemia††	174 (55.6)	45 (52.3)	129 (56.8)	0.474
Metabolic syndrome‡‡	144 (46.0)	49 (57.0)	95 (41.9)	0.017

Values are presented as mean±standard deviation or number (%). For the analysis based on blood samples, participants who did not complete ≥8 hours of fasting before blood drawing were excluded (n=2, 1 man and 1 woman); there are missing values in education attainment (n=1), household income (n=7), smoking status (n=4), and drinking status (n=3).

*An independent-samples t-test was used for continuous variables and the chi-square test was used for categorical variables; †Defined as someone who has smoked >5 packs (100 cigarettes) in their lifetime and has smoked in the last month; ‡Defined as someone who drank alcohol more than once a month; §Categorized based on the body mass index; ‖Defined by WC ≥90 cm for men or WC ≥85 cm for women; ¶Defined by systolic BP ≥140 mmHg, diastolic BP ≥90 mmHg, or taking hypertension drugs; **Defined by fasting glucose ≥126 mg/dL, HbA1c ≥6.5%, or taking diabetes drugs; ††Defined as a serum level of (1) total cholesterol ≥240 mg/dL, (2) triglycerides ≥200 mg/dL, (3) serum HDL cholesterol <40 mg/dL in men or <50 mg/dL in women, (4) serum LDL cholesterol ≥160 mg/dL, or (5) taking dyslipidemia drugs; ‡‡Defined as having ≥3 of the 5 following criteria: (1) WC ≥90 cm for men or ≥85 cm for women; (2) triglycerides ≥150 mg/dL or taking dyslipidemia drugs; (3) HDL cholesterol <40 mg/dL for men or <50 mg/dL for women; (4) systolic BP ≥130 mmHg, diastolic BP ≥85 mmHg, or treatment of previously diagnosed hypertension; and (5) fasting plasma glucose ≥100 mg/dL or treatment of previously diagnosed type 2 diabetes mellitus.

GOMS, Gangwon Obesity and Metabolic Syndrome; KRW, Korean won; WC, waist circumference; BP, blood pressure; HbA1c, glycosylated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

Table 3. Key results from blood samples in the first baseline survey of the GOMS cohort study, 2022

Variable	Total (n=313)	Men (n=86)	Women (n=227)	*P**
Total protein (g/dL)	7.1±0.4	7.1±0.4	7.1±0.4	0.950
Albumin (g/dL)	4.4±0.2	4.4±0.2	4.4±0.2	0.605
Creatinine (mg/dL)	0.8±0.4	0.9±0.2	0.7±0.4	<0.001
FBG (mg/dL)	105.2±24.7	109.2±20.4	103.7±26.0	0.082
AST (U/L)	26.7±9.2	29.1±12.8	25.8±7.2	0.004
ALT (U/L)	23.8±12.9	27.8±17.4	22.3±10.4	0.001
γ-GTP (U/L)	35.2±43.3	54.7±71.4	27.8±21.8	<0.001
Total cholesterol (mg/dL)	188.4±41.1	176.5±36.8	192.9±41.8	0.002
Triglyceride (mg/dL)	116.5±74.0	127.8±74.6	112.2±73.6	0.098
HDL cholesterol (mg/dL)	55.7±13.8	50.5±12.3	57.7±13.8	<0.001
LDL cholesterol (mg/dL)	107.1±35.9	100.3±32.9	109.7±36.7	<0.039
HbA1c (%)	6.0±0.9	6.1±0.9	6.0±0.9	0.241
WBC (10^3/μL)	6.0±1.6	6.4±1.5	5.8±1.6	0.002
RBC (10^6/μL)	4.6±0.5	5.0±0.4	4.5±0.4	<0.001
Hemoglobin (g/dL)	14.2±1.3	15.4±1.0	13.7±1.0	<0.001
Hematocrit (%)	43.9±3.7	46.6±3.2	41.9±3.1	<0.001
Platelet (10^3/μL)	250.8±60.7	230.9±53.6	258.4±61.6	<0.001
TSH (μIU/mL)	1.9±1.2	1.6±0.8	2.0±1.3	0.010
Insulin (μIU/mL)	8.8±7.8	9.0±10.3	8.8±6.7	0.789
Hs-CRP (mg/L)	1.0±1.8	0.9±1.0	1.1±2.1	0.413

Values are presented as mean±standard deviation.

*An independent-samples t-test was used.

GOMS, Gangwon Obesity and Metabolic Syndrome; FBG, fasting blood glucose; AST, aspartate aminotransferase; ALT, alanine aminotransferase; γ-GTP, gamma-glutamyl transferase; HDL, high-density lipoprotein; LDL, low-density lipoprotein; HbA1c, glycosylated hemoglobin; WBC, white blood cell; RBC, red blood cell; TSH, thyroid-stimulating hormone; Hs-CRP, high-sensitivity C-reactive protein.

cheon and Inje districts participated. Because of missing data on anthropometric measures for two participants, the descriptive statistics were analyzed using data from 315 participants, including 87 men and 228 women. Overall, the mean age was 58.5 years old, and the enrolled men were slightly older than the enrolled women. Approximately half of participants were in their 60s (47.3%), while a relatively small proportion of participants were in their 40s (13.7%). While there were participants who graduated college or more, most participants had graduated high school or less. About 33% of men were current smokers, while 7% of women were smokers. For alcohol drinking, 58.0% of the total population were current drinkers.

Regarding the status of obesity and related comorbidities, although the mean BMI and the prevalence rates of pre-obesity and class I obesity were greater in men, the proportion of class II obesity was higher in women. There was no significant difference in the

prevalence of central obesity between men and women. Among all participants, 48.9% had hypertension, 21.4% had DM, 55.6% had dyslipidemia, and 46.0% had MS. Both the prevalence rates of DM and MS were significantly higher in men.

Table 3 shows the results from the initial blood tests of 313 participants who fasted for ≥ 8 hours. The serum level of creatinine, aspartate aminotransferase, alanine aminotransferase, gamma-glutamyl transferase, white blood cells, red blood cells, hemoglobin, and hematocrit were higher among men than women. In contrast, women had higher values of total cholesterol, HDL cholesterol, LDL cholesterol, platelets, and thyroid-stimulating hormone.

DISCUSSION

This cohort study was designed to understand the high prevalence of obesity in Gangwon province and to explore the etiology of obesity and its comorbidities. More participants will be recruited, and participants will be followed up with throughout the coming years. This is the first cohort study of body weight and composition changes executed in a mountainous rural area in South Korea. This cohort study can serve as an invaluable asset in examining the geographical disparities in the obesity epidemic in South Korea. Our cohort research team consisted of experts in various fields, including endocrinology, family medicine, psychiatry, food and nutrition, and epidemiology, who have experience in obesity and cohort studies. Team members of this cohort study designed the study protocol to investigate the etiology of obesity in a particular area, focusing on a variety of aspects, including demographic factors, personal activity level, dietary patterns, neighborhood environments, seasonal variation in activities, types of farming, food addictions, and sleep habits. Collected fasting blood and fecal samples have been stored for future studies. Therefore, the investigated items in this project are abundant and diverse. Especially for obesity, it will be possible to identify related factors for the marked rural areas, and, furthermore, regional comparisons with urban areas can be performed. The GOMS study will improve our understanding of causes of marked increases in obesity incidence in rural areas and help to establish more effective health policies on obesity in such regions.

There are several domestic and international cohort studies that have included participants from local communities. The KoGES conducted by the National Institute of Health in Korea was a large-scale cohort study that provided information on various factors influencing the health and lifestyle status of its participants and the incidence of chronic diseases in both urban and rural areas.[37] Korean Frailty and Aging Cohort Study (KFACS) sought to recruit older adults aged 70–85 years at baseline and to assess their frailty status and transitions of frailty states in both urban and rural areas.[38,39] Compared to previous cohort studies conducted on a nationwide scale, including KoGES and KFACS, GOMS was prepared instead to focus on the specific health problems of "obesity" and "metabolic syndrome" in specific areas of the rural area in Gangwon province and is expected to provide additional health-related information of middle-aged adults in geographically specific areas of Korea.

This cohort is community-friendly. At the stage of recruitment and interview, the team worked with community facilities, local hospitals, and local public health agencies. Participants were allowed to discuss their health issues with team physicians even after the survey. However, considering that our study sites were relatively small rural areas where word-of-mouth is crucial in recruiting and maintaining participants for follow-ups, it will be important to build a stronger network that involves community and government entities and to provide benefits to community health and wellbeing.

There is a limitation of generalizability in this first survey. Our study population showed discrepancies in proportions of the sexes and in age distribution of the community residents. According to the Korean Statistical Information Service and Community Health Survey, the proportion of men living in the Hongcheon and Inje districts is slightly higher than that of women, and the population 60–69 years of age accounts for about 24% and 20% of residents, respectively.[6,40] No stratification at recruitment except district of residence resulted in more women and a high proportion of people in their 60s among the survey participants. Because recruitment was on a first-come, first-served basis and depended largely on word of mouth, the recruited cohort might be from a better neighborhood environment with a better social network. Discrepancies in obesity-related factors can be present between the participants of this study and the real inhabitants in the area. However, a cohort study, by its nature, is less prone to selection bias from recruitment or recall bias and allows investigators to explore a temporal relationship between exposures and outcomes. Stratified recruitment

is recommended to build a cohort that represents the general population in study regions. For future recruitment, the research team should implement some strategies to attract more men and younger participants, such as collaborating with some local companies and factories where men and younger residents can be reached out to more easily.

The results of the initial baseline laboratory tests were individually conveyed to the participants, and the subjects were free to ask for health counseling from the physicians on the research team. New participants will be recruited every 2 years in both districts. Follow-up interviews, anthropometric measurements, and laboratory tests will be conducted every 4 years.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

Study concept and design: KKK, JEL, and CBL; acquisition of data: all authors; analysis and interpretation of data: KKK, SP, JEL, and YJC; drafting of the manuscript: KKK, SP, JEL, and YJC; critical revision of the manuscript: KKK, SP, JEL, and YJC; statistical analysis: SP; obtained funding: BSK, KP, SP, and CBL; administrative, technical, or material support: KKK, SMK, WJK, SP, and JEL; and study supervision: KKK, JEL, and CBL.

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