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Hidden Risk in Normal BMI: Body Composition and Dietary Patterns of Middle-Aged and Older Japanese Women with Normal Weight Obesity

Yoshiko Hattori[1,3*], Akari Kato[1], Noriyo Sakaguchi[1], Chiaki Izumi[2], Akira Oshima[1], Kazuhisa Sugiyama[1], Masashi Hattori[2], Eiko Tachibana[3], Takayoshi Tsukahara[3]

[1]Health Checkup Center, Yamashita Hospital Medical Corporation, Aichi, Japan
Gastroenterology, Yamashita Hospital Medical Corporation, Aichi, Japan
[3]Graduate School of Nutritional Sciences, Nagoya University of Arts and Sciences, Aichi, Japan

**Corresponding author: yoshikoi@mvb.biglobe.ne.jp*

ABSTRACT *Background and Purpose.* The "Specific Health Checkup" program, launched in Japan in 2008, aims to prevent cardiovascular disease by targeting visceral fat accumulation. However, normal weight obesity (NWO), a condition marked by a normal body mass index (BMI) but excess body fat, often fails to be detected by existing screening criteria, even though it affects approximately 50% of women at risk for future cardiovascular events. To develop more effective prevention strategies, a deeper understanding of the physical and dietary characteristics of women with NWO is needed. *Methods.* This cross-sectional study analyzed 202 women (age range, 40–74 years) who underwent a Specific Health Checkup in 2023. Participants with a BMI of 18.5–24.9 kg/m^2 were assessed for body fat using bioelectrical impedance analysis and categorized as either standard (<30% body fat) or NWO (≥30%). Anthropometric, metabolic, and dietary differences were then compared between groups. *Results.* A total of 114 participants (56.4%) were classified as having NWO. The NWO group exhibited significantly higher body fat percentage and waist circumference, and significantly lower skeletal muscle mass, particularly in the lower limbs. Compared with the standard group, the NWO group had significantly higher levels of triglycerides and low-density lipoprotein cholesterol and significantly lower levels of high-density lipoprotein cholesterol. Dietary analysis revealed significantly higher intakes of bread, noodles, pickled vegetables, dairy products, and sugar-sweetened beverages, and a significantly lower intake of rice. *Conclusions.* In the present study, women with NWO demonstrated a distinct fat accumulation, muscle loss, and dietary pattern profile associated with increased metabolic risk. Therefore, screening and interventions should move beyond BMI to include body composition and dietary quality, with a focus on lower-limb muscle preservation and balanced nutrition.
Keywords: Normal weight obesity, Middle-aged and older women, Body fat percentage, Dietary habits

INTRODUCTION

In recent years in Japan, the number of obese individuals has been increasing as a result of changes in the social environment surrounding dietary habits, such as the Westernization of the diet and lack of exercise[1)]. According to the Ministry of Health, Labour and Welfare and the Japan Society for the Study of Obesity, obesity is defined as a body mass index (BMI) of 25 kg/m^2 or higher. However, an accurate diagnosis of obesity requires the precise assessment of fat accumulation in adipose tissue. When obesity is accompanied by obesity-related health disorders, it is referred to as obesity disease[2)].

BMI is a convenient index calculated from height and weight, and an increase in BMI is strongly correlated with diseases associated with obesity, such as coronary artery disease and cerebrovascular disorders. Therefore, BMI is used as a diagnostic tool for obesity. However, the measurement of body fat percentage is not obligatory, and BMI alone is insufficient for assessing the detailed composition of body weight[3)]. That is, even if a person falls within the standard weight range, muscle mass tends to decrease and body fat percentage tends to increase with age. Therefore, individuals may have a normal BMI but a higher proportion of fat than muscle, a condition known as normal weight obesity (NWO). Particularly, the proportion of individuals with NWO is higher among middle-aged and older women than among men across all age groups[4)].

Approximately 20% of deaths in Japan are due to cardiovascular diseases such as cerebrovascular disease and myocardial infarction[1]. Since 2008, with the aim of facilitating early intervention for individuals with risk factors such as hyperglycemia, lipid metabolism disorders, and hypertension—which are indicators of metabolic syndrome (MetS)—Japan has mandated "Specific Health Checkups" for public health insurance enrollees aged 40–74 years. These health checkups include screening of individuals with a BMI ≥25 kg/m^2 in addition to waist circumference (WC), a traditional MetS diagnostic criterion. The checkups include a questionnaire on medical history, a physical examination, height, weight, systolic blood pressure (SBP), diastolic blood pressure (DBP), liver function tests (aspartate aminotransferase [AST], alanine aminotransferase [ALT], gamma-glutamyltranspeptidase [γ-GTP]), blood lipid levels (triglycerides [TG], high-density lipoprotein cholesterol [HDL-C], low-density lipoprotein cholesterol [LDL-C]), fasting blood glucose (FBG), and urinalysis (sugar, protein).

According to the 2022 National Health and Nutrition Survey[5], the proportion of women who met the criteria for MetS or were considered at risk was 5.8%, which was significantly lower than that for men (22.0%). This is likely due to the fact that the average WC (about 80 cm) and BMI (about 22 kg/m^2) of middle-aged Japanese women do not meet the current MetS criteria[1].

However, women aged 40–64 years with even one risk factor have an increased risk of cardiovascular disease[6]. Therefore, the current WC criteria may miss up to 50% of women at risk of cardiovascular disease[7]. It has also been reported that even nonobese individuals can have substantial visceral fat accumulation[8]. Moreover, individuals with NWO are at higher risk of having multiple MetS components[7] and may miss receiving proper guidance, increasing their health risks.

Research on NWO has mainly focused on young women[9,10] and working men[3,11], with fewer reports on middle-aged and older women. Previous studies have found that, among working men, fast eating and high protein/carbohydrate intake[11] were characteristics of NWO, while among female college students, deficiencies in vitamin K, dietary fiber, and beans[10] were observed.

NWO has been associated with an 8.2-fold higher risk of developing MetS[12], as well as an increased risk of sarcopenic obesity in older age[13,14].

However, the current Japanese Specific Health Checkup screening criteria (WC and BMI) are not sufficient to identify many middle-aged women with NWO. Given this background, the present study aimed to clarify the physical condition, body composition, and dietary intake of middle-aged women with NWO to provide foundational data for more appropriate health guidance.

MATERIALS AND METHODS

A cross-sectional study was conducted on women who received a Specific Health Checkup.

Participants

From March 2023 to March 2024, of the 670 women who received a Specific Health Checkup at the Yamashita Hospital Health Checkup Center, 202 women who were aged 40–65 years, had a BMI of 18.5 to <25 kg/m^2, and for whom complete data on body composition, blood biochemistry, and responses to a Food Frequency Questionnaire based on food groups (FFQg) were available, were included in the analysis. Individuals taking medication for hypertension, dyslipidemia, or diabetes were excluded.

Body Composition Measurements

Height (cm) and weight (kg) were measured to calculate BMI (kg/m^2), and WC (cm) was measured. Body composition was assessed using the bioelectrical impedance method (InBody470; InBody Japan, Tokyo, Japan), which measures muscle mass (kg), skeletal muscle mass (kg), fat-free mass (kg), trunk muscle mass (kg), limb skeletal muscle mass (kg), body fat mass (kg), body fat percentage (%), trunk and limb fat mass (kg), and the waist–hip ratio.

Blood Pressure and Blood Biochemistry

After 10 minutes of rest, SBP and DBP (mmHg) were measured using a pulse wave monitor (Heart Station S MPV-5500; Nihon Kohden, Tokyo, Japan). Blood samples were collected in a fasting state to measure FBG (mg/dL), HbA1c (%), HDL-C (mg/dL), LDL-C (mg/dL), TG (mg/dL), AST (IU/L), ALT (IU/L), γ-GTP (IU/L), and the LDL/HDL ratio.

Food Frequency Questionnaire

Dietary intake was assessed using the FFQg (Ver. 6). Participants who consented to participate in the study were asked to complete the questionnaire after the health checkup. The responses were collected and checked by a registered dietitian.

Statistical Analysis

Based on prior studies[5)], the participants were classified into two groups: a standard group (BMI: 18.5 to <25 kg/m^2 and body fat percentage <30%) and an NWO group (BMI: 18.5 to <25 kg/m^2 and body fat percentage ≥30%). Statistical analysis was performed using EZR ver.1.65. Normality of data was checked. Student's *t*-test (for normal data) and the Mann–Whitney *U* test (for non-normal data) were used, with adjustments for age. FFQg data were converted per 1,000 kcal and analyzed using the Mann–Whitney *U* test. All tests were two-sided, with the level of significance set at p<0.05.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki, with full consideration for the rights and welfare of the participants. Informed consent was obtained in writing after explaining the study purpose, methods, and ethical considerations. This study was approved by the Ethics Committee of Yamashita Hospital (approval No. 2023-01).

RESULTS

Of the 202 women with a BMI between 18.5 and 25 kg/m^2, 88 were classified into the standard group and 114 (56.4%) into the NWO group based on body fat percentage.

Body Composition (Table 1)

Table1. Body Composition Results of the Participants(n=202)

	Standard group n＝88	NOW n＝114	p-Value
Age (years)	49.8 (±6.0)	52.9 (±6.3)	0.001
Height (cm)	159.1 (±5.2)	158.1 (±5.3)	0.658
Weight (kg)	52.2 (±4.9)	55.1 (±5.6)	<0.001
Waist circumference (cm)	73.4 (±4.1)	79.2 (±4.4)	<0.001
BMI (kg/m²)	20.4 (19.5 - 21.5)	22.3 (21.1 - 23.4)	<0.001
Body fat mass (kg)	13.5 (±2.2)	18.7 (±2.8)	<0.001
Muscle mass (kg)	36.5 (±3.4)	34.2 (±3.4)	<0.001
Fat-free mass (kg)	38.7 (±3.7)	36.4 (±3.6)	<0.001
Skeletal muscle mass (kg)	20.9 (±2.2)	19.4 (±2.2)	<0.001
Body fat percentage (%)	26.3 (24.4 - 27.9)	33.7 (32.3 - 35.9)	<0.001
Right upper limb muscle mass (kg)	1.8 (±0.3)	1.7 (±0.2)	0.089
Left upper limb muscle mass (kg)	1.8 (±0.3)	1.7 (±0.2)	0.167
Trunk muscle mass (kg)	16.8 (±1.6)	16.4 (±1.6)	0.392
Right lower limb muscle mass (kg)	6.0 (±0.7)	5.7 (±0.8)	0.048
Left lower limb muscle mass (kg)	6.0 (±0.7)	5.7 (±0.8)	0.053
Right upper limb fat mass (kg)	0.9 (0.7 - 1.0)	1.3 (1.1 - 1.4)	<0.001
Left upper limb fat mass (kg)	0.9 (0.8 -1.0)	1.3 (1.2 - 1.5)	<0.001
Trunk fat mass (kg)	6.3 (±1.3)	9.2 (±1.5)	<0.001
Right lower limb fat mass (kg)	2.2 (±0.3)	3.0 (±0.4)	<0.001
Left lower limb fat mass (kg)	2.2 (±0.3)	3.0 (±0.4)	<0.001
Waist-to-hip ratio	0.8 (±0.03)	0.9 (±0.03)	<0.001
SMI (kg/(m)²)	6.1 (±0.5)	5.9 (±0.5)	<0.05
ASM (kg)	15.60 (±1.8)	14.73 (±1.9)	0.054
ASM ratio (kg/body weight kg)	0.30 (0.29 - 0.31)	0.27 (0.26 - 0.28)	<0.001
ASM/BMI	0.76 (±0.08)	0.67 (±0.07)	<0.001

Normal data were analyzed with a Student's t-test (mean ± SD), and non-normal data with the Mann-Whitney U test (median, IQR). For comparisons other than age, ANCOVA was used for normally distributed data, and multiple regression analysis for non-normally distributed data, with age-adjusted p-values presented.

After adjusting for age, the NWO group had significantly higher values for body weight, WC, BMI, fat mass, body fat percentage, limb fat mass, and waist–hip ratio compared with the standard group. By contrast, the NWO group had significantly lower muscle mass, skeletal muscle mass, fat-free mass, and lower-limb muscle mass. No significant differences were observed in height, upper limb muscle mass, or trunk muscle mass.

Blood Biochemistry (Table 2)

Compared with the standard group, the NWO group had significantly higher TG, LDL-C, and LDL/HDL ratio values, and significantly lower HDL-C values. No significant differences in SBP,DBP, FBG, HbA1c, AST, ALT, or γ-GTP were observed.

Table2 blood pressure and blood biochemistry tests

	Standard group n＝88	NOW n＝114	p-Value
Systolic blood pressure (mmHg)	112.5 (103.8 - 124.0)	116.0 (112.0 - 141.0)	0.201
Diastolic blood pressure (mmHg)	70.8 (±10.5)	73.6 (±12.0)	0.191
Fasting Blood glucose (mg/dL)	93.0 (89.0 - 98.3)	96.0 (91.0 - 100.0)	0.767
HbA1c (%)	5.8 (5.0 - 6.9)	5.7 (5.2 - 7.4)	0.855
AST (IU/L)	19.5 (16.0 - 22.0)	19.0 (16.0 - 21.0)	0.126
ALT (IU/L)	15.0 (12.0 - 18.0)	15.0 (12.0 - 18.0)	0.701
γ-GTP (IU/L)	16.0 (13.0 - 23.0)	16.0 (13.0 - 24.0)	0.659
Triglycerides (mg/dL)	65.0 (51.0 - 84.0)	79.0 (61.0 - 112.0)	0.006
HDL cholesterol (mg/dL)	78.6 (±16.1)	73.7 (±18.1)	0.023
LDL cholesterol (mg/dL)	113.0 (97.8 - 129.3)	132.0 (112.0 -148.0)	0.002
LDL/HDL ratio	1.4 (1.2 - 1.8)	1.9 (1.5 - 2.4)	<0.001
Age at menopause (years)	49.7 (±3.5)	49.8 (±4.8)	0.617

Normal data were analyzed with a Student's t-test (mean ± SD), and non-normal data with the Mann-Whitney U test (median, IQR). For comparisons other than age, ANCOVA was used for normally distributed data, and multiple regression analysis for non-normally distributed data, with age-adjusted p-values presented.

FFQg Results (Tables 3 and 4)

No significant difference in total daily energy intake was seen between groups. However, when adjusted per 1,000 kcal, the NWO group had significantly higher bread/noodle, pickle, dairy product, and sweetened beverage (including fruit juice) intake, and significantly lower rice intake.

Nutritionally, the NWO group had significantly higher sodium, salt equivalent, and calcium intake, and significantly lower vitamin B_{12} intake per 1,000 kcal. No other significant differences were found.

Table3 Comparison of Food Intake Frequency Using the Density Method

	Standard group n=88	NOW n=114	p-Value
Grains (g/1000 kcal)	275.6 (207.9 - 354.2)	276.1 (206.3 - 328.8)	0.739
Rice (g/1000 kcal)	195.1 (138.6 - 273.1)	171.8 (110.7 - 230.3)	0.048
Bread and noodles (g/1000 kcal)	55.8 (33.1 - 87.3)	72.3 (49.1- 111.7)	0.009
Beans (g/1000 kcal)	40.0 (16.9 - 82.0)	40.4 (19.4 - 80.9)	0.869
Vegetables (g/1000 kcal)	71.4 (42.4 - 99.12)	73.7 (46.8 - 116.8)	0.354
Dark green and yellow vegetables (g/1000 kcal)	38.0 (20.4 - 57.4)	34.9 (20.6 - 57.1)	0.917
Light-colored vegetables (g/1000 kcal)	31.6 (16.4 - 44.01)	34.0 (19.0 - 54.4)	0.090
Pickled vegetables (g/1000 kcal)	1.0 (0.0 - 3.3)	2.4 (0.0 - 7.2)	0.013
Fruits (g/1000 kcal)	20.7 (8.1 - 52.7)	28.1 (7.8 - 60.4)	0.421
Mushrooms (g/1000 kcal)	2.3 (1.1 - 5.1)	2.5 (0.7 - 5.9)	0.594
Seaweed (g/1000 kcal)	4.2 (1.9 - 7.2)	3.6 (1.8 - 7.2)	0.496
Fish and shellfish (g/1000 kcal)	20.7 (13.6 - 35.8)	19.2 (7.5 - 32.9)	0.209
Meat (g/1000 kcal)	42.4 (27.1 - 61.4)	44.5 (27.9 - 68.1)	0.677
Eggs (g/1000 kcal)	28.6 (15.8 - 42.8)	27.3 (13.7 - 43.5)	0.634
Milk (g/1000 kcal)	25.8 (0.0 - 136.9)	87.5 (3.7 - 182.8)	0.042
Fats and oils (g/1000 kcal)	5.3 (4.0 - 6.9)	5.6 (4.1 - 7.0)	0.515
Sweets (g/1000 kcal)	3.8 (0.0 - 5.7)	3.4 (0.0 - 6.9)	0.590
alcohol (g/1000 kcal)	9.1 (0.0 - 123.0)	0.0 (0.0 - 50.6)	0.150
Sugar-sweetened beverages and fruit juice (g/1000 kcal)	288.7 (134.2 - 440.1)	318.7 (157.8 - 497.6)	0.054

All values were rounded to the second decimal place and expressed as median (interquartile range)

P-values were obtained using the Mann-Whitney U test and expressed to three decimal places.

Table4 Comparison of Energy Intake and Nutrient Intake (Comparison Using the Density Method)

	Standard group n=88	NOW n=114	p-Value
Energy (kcal/day)	1143.1 (951.9 - 1444.9)	1132.1 (903.1 - 1439.4)	0.900
Protein (g/1000 kcal)	40.2 (34.8 - 44.9)	40.4 (36.7 - 45.4)	0.653
Fat (g/1000 kcal)	33.1 (27.2 - 41.3)	35.3 (27.4 - 42.9)	0.550
Carbohydrates (g/1000 kcal)	128.5 (109.5 - 145.3)	128.3 (113.5 - 151.0)	0.678
Saturated fatty acids (g/1000 kcal)	10.2 (7.9 - 12.9)	10.8 (8.6 - 13.78)	0.177
Monounsaturated fatty acids (g/1000 kcal)	12.8 (10.6 - 15.3)	13.2 (9.9 - 16.5)	0.595
Polyunsaturated fatty acids (g/1000 kcal)	6.6 (5.4 - 8.0)	6.3 (5.2 - 8.1)	0.432
n-3 Polyunsaturated fatty acids (g/1000 kcal)	1.1 (0.8 - 1.5)	1.0 (0.7 - 1.4)	0.212
n-6 Polyunsaturated fatty acids (g/1000 kcal)	5.4 (4.7 - 6.5)	5.3 (4.4 - 6.7)	0.732
Cholesterol (mg/1000 kcal)	164.1 (133.0 - 226.6)	178.8 (117.2 - 228.2)	0.894
Sodium equivalent (g/1000 kcal)	3.8 (3.1 - 4.8)	4.2 (3.5 - 5.2)	0.029
Total dietary fiber (g/1000 kcal)	6.0 (4.2 - 7.2)	5.9 (4.8 - 7.5)	0.167
Soluble dietary fiber (g/1000 kcal)	1.1 (0.7 - 1.8)	1.2 (0.9 - 1.8)	0.229
Insoluble dietary fiber (g/1000 kcal)	4.2 (3.3 - 5.2)	4.4 (3.6 - 5.7)	0.126
Vitamin A (μg RAE/1000 kcal)	353.0 (254.1 - 533.4)	319.0 (224.2 - 434.4)	0.156
Vitamin D (μg/1000 kcal)	4.5 (3.1 - 6.3)	4.4 (2.6 - 6.5)	0.255
α-Tocopherol (mg/1000 kcal)	3.3 (2.7 - 4.5)	3.2 (2.5 - 4.2)	0.226
Vitamin K (μg/1000 kcal)	117.9 (63.3 - 217.4)	110.7 (64.7 - 179.7)	0.536
Vitamin B_1 (mg/1000 kcal)	0.7 (0.6 - 1.0)	0.8 (0.6 - 1.1)	0.130
Vitamin B_2 (mg/1000 kcal)	0.6 (0.5 - 0.7)	0.6 (0.5 - 0.7)	0.345
Niacin (mg NE/1000 kcal)	11.2 (9.0 - 14.4)	11.0 (8.8 - 13.5)	0.522
Vitamin B_6 (mg/1000 kcal)	0.8 (0.7 - 0.9)	0.8 (0.7 - 0.9)	0.780
Vitamin B_{12} (μg/1000 kcal)	3.7 (2.4 - 5.0)	3.0 (1.9 - 4.3)	0.034
Folate (μg/1000 kcal)	177.6 (131.7 - 226.6)	174.3 (139.0 - 228.2)	0.950
Vitamin C (mg/1000 kcal)	33.1 (20.7 - 56.4)	36.6 (25.1 - 56.5)	0.224
Phosphorus (mg/1000 kcal)	566.4 (469.0 - 645.2)	593.2 (515.6 - 691.2)	0.179
Potassium (mg/1000 kcal)	1411.0 (1088.3 - 1682.8)	1440.8 (1177.6 - 1766.5)	0.486
Calcium (mg/1000 kcal)	212.3 (140.4 - 294.0)	267.0 (162.6 - 368.4)	0.030
Sodium (mg/1000 kcal)	1484.5 (1220.9 - 1899.1)	1658.0 (1380.3 - 2040.1)	0.029
Iron (mg/1000 kcal)	4.7 (3.9 - 6.1)	4.7 (3.9 - 5.7)	0.531
Zinc (mg/1000 kcal)	4.7 (4.1 - 5.2)	4.6 (4.1 - 5.1)	0.660
Copper (mg/1000 kcal)	0.6 (0.5 - 0.7)	0.6 (0.5 - 0.7)	0.523
Iodine (mg/1000 kcal)	112.4 (35.1 - 167.4)	134.8 (42.1 - 209.9)	0.302
Magnesium (mg/1000 kcal)	164.3 (137.4 - 192.7)	165.6 (143.6 - 193.6)	0.655
Chromium (mg/1000 kcal)	3.2 (2.4 - 3.9)	3.5 (2.5 - 4.6)	0.079
Manganese (mg/1000 kcal)	1.8 (1.4 - 2.2)	2.0 (1.4 - 2.5)	0.153
Molybdenum (mg/1000 kcal)	134.8 (91.5 - 175.8)	124.4 (97.8 - 154.3)	0.456

All values were rounded to the second decimal place and expressed as median (interquartile range)

P-values were obtained using the Mann-Whitney U test and expressed to three decimal places.

DISCUSSION

This study focused on individuals with a high body fat percentage despite having a BMI and WC within standard ranges—so-called NWO. We aimed to investigate their physical characteristics, clinical indicators, and dietary habits as a basis for future guidance. Although the NWO group had significantly higher body fat percentage and lower lower-limb muscle mass compared with the standard group, they were not identified as candidates for lifestyle intervention under the current MetS screening criteria.

To our knowledge, there have been only a few reports on middle-aged Japanese women with NWO. Naito et al.[6)] reported NOW prevalence rates of 12.7% in the 40s, 21.3% in the 50s, and 29.0% in the 60s, totaling 63% for those aged 40–60 years. In the present study, the prevalence was 54.1%, likely because we excluded individuals with a BMI <18.5 kg/m^2 and those over 65 years of age.

The NWO group exhibited significantly higher body weight, BMI, and WC compared with the standard group. Additionally, they had significantly lower skeletal muscle mass, fat-free mass, and lower-limb muscle mass, as well as a lower skeletal muscle index, appendicular skeletal muscle mass (ASM), ASM/BW, and ASM/BMI, and a higher waist-to-hip ratio (WHR). The age-related decrease in hormone levels in women increases visceral fat and bone loss and the risk of cardiovascular events. In women, muscle mass is stable until about age 50 years, after which it decreases, particularly in the lower limbs[16)]. This was confirmed by adjusting for age. As a result of the age adjustment, a significant decrease in lower-limb muscle mass, as well as fat accumulation in the upper limbs, abdomen, and lower limbs, was observed; however, no changes were noted in trunk or upper limb muscle mass.

Decreased lower-limb muscle mass is increasingly recognized as a feature of NWO, especially in relation to metabolic disorders[17)]. Recent studies have emphasized maintaining leg muscle mass to reduce the risk of developing MetS and insulin resistance[18)]. Skeletal muscle mass plays a central role in basal metabolism, particularly large muscle groups in the legs (quadriceps femoris, hamstrings), which are critical for daily activities and energy expenditure[19)]. A decline in this area reduces energy use and is considered to explain, at least in part, the mechanism by which body fat percentage increases even when body weight is within the normal range. Such a decline is caused by not only aging, but also a lack of exercise and protein intake, highlighting the importance of muscle maintenance in preventing NWO[20)].

The mean WHR of the NWO group was 0.87, which meets the MetS threshold for women (0.85; WHO[21)]). A higher WHR indicates upper body/abdominal fat accumulation and a greater risk of complications and death[22)]. The WHR is associated with mortality more consistently than BMI and should be considered alongside fat distribution[22)].

Bin et al.[23)] studied oxidative stress, adipocytokines, and inflammation markers in middle-aged women, and reported that lower body fat mass was correlated with these factors more than BMI, WC, or trunk fat. In women, regional fat distribution beyond abdominal fat deserves attention. These findings suggest that NWO is associated with an increased visceral fat area, decreased lower-limb muscle mass, increased lower-limb fat accumulation, and related metabolic abnormalities, highlighting the need for accurate diagnosis from the perspective of sarcopenia prevention.

In blood biochemical tests, the NWO group had significantly higher levels of TG, LDL-C, and the LDL/HDL ratio compared with the standard group, whereas HDL-C levels were significantly lower. However, the median values of the blood biochemical test items were all below the threshold for health guidance interventions, suggesting that the group as a whole was not immediately subject to medical guidance. Nevertheless, In the NWO group, the 75th percentile value of SBP was 141 mmHg, which falls into the high blood pressure category. LDL-C levels of 148.0 mg/dL were observed, and 25% of the group fell within the diagnostic criteria for hyper-LDL cholesterolemia established by the Japan Atherosclerosis Society. These results support previous findings that individuals with a high body fat percentage, despite having a BMI <25 kg/m^2, exhibit elevated blood pressure and serum lipid levels, indicating a higher risk for lifestyle-related diseases[24,25)].

To assess the dietary characteristics of the NWO group, we evaluated their diets using the FFQg. Although the FFQg has been used in many studies and its validity has been confirmed[26)], recent developments in dietary survey methods, such as smartphone applications, have noted underreporting associated with the FFQg[27)]. Therefore, instead of aiming for an exact measurement of intake, we used intake per 1,000 kcal to capture dietary characteristics. As a result, the NWO group had significantly higher intakes of bread and noodles, pickled vegetables, dairy products, and sugar-sweetened beverages such as fruit juices compared with the standard group, whereas their intake of rice was significantly lower. The

Framingham Heart Study[28] reported a direct correlation between the increased intake of high-calorie beverages and visceral fat accumulation. Sun et al.[29] reported that excessive sucrose intake disrupts the circadian rhythm of lipid metabolism in the small intestine and liver, promoting fatty liver and leading to TG accumulation, thereby contributing to the development of lean MetS.

Furthermore, the NWO group showed a tendency toward lower rice intake and higher consumption of bread and noodles, suggesting a dietary pattern characterized by the excessive intake of refined carbohydrates. This also raises concerns about the overconsumption of ultra-processed foods, which has been increasing in recent years[30]. In particular, it has been reported that individuals who frequently consume commercially available breads and sweet breads often eat them with dairy products and tend to have fewer main and side dishes[31]. On the other hand, rice eaters have a greater intake of main and side dishes, showing a better nutritional balance. The study also indicated that bread-based meals often emphasize convenience, leading to the lower intake of animal-based foods. Vitamin B_{12} is mainly found in animal-based foods such as meat, seafood, and eggs; thus, a diet centered on bread may likely result in insufficient intake. Especially at breakfast, carbohydrate-dominant foods such as breads and sweet breads are often selected, limiting opportunities to consume vitamin B_{12}-rich foods and contributing to its deficiency.

In terms of nutrients, the intake of sodium and salt equivalents was significantly higher in the NWO than in the standard group. Validity studies comparing estimated intakes from the FFQg and weighed dietary records suggest that sodium and potassium intake can be screened with comparable accuracy, indicating the potential utility of the FFQg for screening purposes[32]. Therefore, it is possible that sodium content from processed carbohydrates such as bread and noodles, rather than traditional Japanese seasonings like miso and soy sauce, significantly contributed to the increased salt intake. The higher dairy product intake in the NWO group supports previous findings[31]. While dairy products, which are rich in calcium and protein, can contribute to bone and muscle health when consumed appropriately[33], their high energy density means that excessive consumption could promote fat accumulation. Therefore, promoting appropriate choices, such as switching to low-fat dairy products or soy dairy products and encouraging moderate intake, is important. Furthermore, depending on the type of daily products consumed—such as sweetened yogurts and flavored dairy beverages—excessive intake could promote fat accumulation and induce lipid metabolism abnormalities[34]. Particularly among health-conscious individuals, the possibility that excessive intake in an attempt to prevent osteoporosis could lead to unintended adverse effects cannot be denied.

This study has several limitations. First, as a cross-sectional study conducted in a single facility, the findings cannot be generalized. The dietary survey assessed the participants' intake over a specific period, and seasonal variations were not reflected; underreporting and overreporting are also possible. Furthermore, because participation was voluntary, it is possible that the participants had higher health consciousness than the general population. Nevertheless, the findings of this study provide valuable evidence that can be utilized in future nutritional and exercise guidance for individuals with NWO. The findings suggest that the dietary habits of NWO individuals could have cumulative adverse effects on body composition, such as increased body fat and decreased muscle mass. Future dietary guidance should emphasize the impact of staple food selection on body composition and nutritional status, advocating for maintaining rice-centered dietary habits and appropriately incorporating animal-based foods. This study highlighted the importance of promoting balanced eating habits and expanding nutritional literacy.

CONCLUSION

Women with NWO face an elevated risk of cardiometabolic disorders because of high body fat, reduced skeletal muscle mass, and inappropriate dietary patterns. However, the existing screening criteria, which are based solely on BMI and WC, may miss this at-risk group. Therefore, preventive strategies should include comprehensive body composition analysis and targeted lifestyle guidance to emphasize lower-limb muscle preservation and a return to balanced, minimally processed, rice-centered dietary patterns.

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