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Research Article

Comparison of clinical characteristics and dietary intakes according to phenotypes of type 2 diabetes mellitus in South Korea: a cross-sectional study

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Objectives: Clinical nutrition treatment is the central part of diabetes management, such as prevention, treatment, and self-management of diabetes, and personalized clinical nutrition treatment, which enables improvement in patients with type 2 diabetes mellitus (T2DM). Our study aimed to contribute to the improvement of appropriate nutrition management in personalized treatment for obese and non-obese diabetes patients.

Methods: T2DM patients were recruited as participants, and 36 final participants were assigned to the lean diabetes mellitus group (LDM; body mass index [BMI] < 25 kg/m^2) and the obese diabetes mellitus group (ODM; BMI ≥ 25 kg/m^2). We assessed the dietary intakes, body composition, dietary habits, the Korean version of obesity-related quality of life, and biochemical indices.

Results: According to the phenotype's comparison, the ODM group had a high prevalence of T2DM complications and hypertension, had a dietary habit of less than 10 minutes of mealtime duration and preferred fast food intake, and had a low obesity-related quality of life. However, the LDM group had a high choice of Korean dishes at the time of eating out and a high intake of vitamin C, and iodine because of the intake of vegetables and seaweeds.

Conclusion: We observed differences in diet, nutrient intake, and clinical characteristics according to the phenotype of T2DM patients. In particular, obese diabetes patients have an increased risk of cardiovascular diseases, bad dietary habits, and low obesity-related quality of life. Therefore, personalized nutrition treatment is needed in consideration of the risk of cardiovascular disease and dietary habits for patients in the ODM group, as well as determining the energy requirements of Korean patients with T2DM.

Keywords: diabetes mellitus, type 2; obesity; feeding behavior; cardiovascular disease

INTRODUCTION

Rapid socioeconomic development and changes in lifestyle have led to stress, an increased intake of energy-dense foods, irregular dietary habits, and a lack of physical activities, thereby causing an increase in metabolic diseases. Among them, obesity and type 2 diabetes mellitus (T2DM) are recognized as major public health problems worldwide. The global obesity prevalence rate nearly tripled between 1975 and 2016, and the global diabetes prevalence population reported in the 10th edition of the International Diabetes Federation in 2021 is expected to increase to 537 million adults (20–79 years old) and 642 million by 2040.

In the case of Korea, the prevalence of diabetes among adults aged 30 or older was reported to be 16.3% as of 2021, and the prevalence of obesity was also reported to be 37.1% as of 2021, continuously increasing for 10 years [1, 2]. Moreover, about 54.4% of patients with T2DM as of 2019–2020 were found to be accompanied by obesity, showing the severity of both diabetes and obesity [1].

T2DM can manifest various phenotypes through interactions with different environmental and genetic factors. Recent studies have focused on the severity of diabetes and its phenotype rather than the recent etiology and genetic factors [3]. T2DM phenotype can be divided according to the body mass index (BMI). In Korea, the incidence of non-obese diabetes is relatively higher than in Western countries. However, in recent years, the number of obese diabetic patients has increased. This trend is commonly observed in Asia, including Korea, and is related to a greater risk of T2DM in the Asian population than in the Caucasian population, despite lower BMI [4-7]. The studies have shown that the accompanying overweight and obesity in Asians with diabetes can increase the risk of health problems such as microvascular and cardiovascular complications. The risk of complications such as diabetic retinopathy, end-stage renal disease, and cardiovascular disease (CVD) is higher in overweight and obese individuals with diabetes compared to those with normal weight [5, 8-10]. Therefore, for the rapidly increasing number of non-obese and obese diabetic patients to learn self-management lifestyle of clinical nutrition therapy and control their diabetes, differences in diets and other factors must be understood first.

The purpose of this study was to evaluate differences in and relationships of clinical characteristics, dietary habits, obesity-related quality of life, nutrient intake, and biochemical indicators in obese and non-obese T2DM patients. This study aimed to suggest appropriate nutrition management strategies in personalized treatment of obese and non-obese diabetes patients and thereby, contribute to improved health of these patients.

METHODS

Ethics statement

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and obtained clearance from the Institutional Review Boards of Changwon Fatima Hospital (approval No. 17-04). All participants provided informed consent.

1. Study design

This study was a cross-sectional study and compared two groups based on their diabetes phenotypes. It was described in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement, available at https://www.strobe-statement.org/.

2. Setting and participants

T2DM patients between the age of 19 and 60 years were recruited in this study. Participants were visited to Changwon Fatima Hospital (Changwon, Korea) for diabetes management from April 2017 to July 2018. Recruitment was carried out through publicity at the endocrine center within the hospital. The number of participants was determined using on an effect size of 0.9, a significance level of 0.05, and a power of 0.9. A total of 36 participants who understood the contents and purpose of the study and voluntarily wished to participate were enrolled. T2DM was diagnosed as glycated hemoglobin level ≥ 6.5% or fasting blood glucose level ≥ 126 mg/dL. The participants were assigned to lean diabetes mellitus group (LDM; BMI < 25 kg/m^2, n = 18) and obese diabetes mellitus group (ODM; BMI ≥ 25 kg/m^2, n = 18). Given that Asians have a higher risk of CVD than Caucasians, obesity has been defined differently in Asia com-

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pared to other regions. Specifically, the World Health Organization (WHO) Asia-Pacific Guidelines recommend a low BMI cutoff point of 25 kg/m^2 for obesity [11]. Thus, lower BMI cutoff points have been used in studies conducted in Asia, including Korea [12]. Patients with thyroid, cerebrovascular, gallbladder, or gastrointestinal diseases, gout, depression, and mental conditions, such as porphyria, alcohol addiction, schizophrenia, and drug addiction, were excluded from the study. Additionally, those who were under prescription of weight control drugs, who were pregnant or lactating, and who participated in commercial diabetes programs within 30 days from the start date of this study were excluded.

3. General characteristics, health-related lifestyle, and medical history

The general characteristics, health-related lifestyle, and intake of medication of all participants were analyzed through questionnaires and medical interviews. The general characteristics of age, marital status (married/not married), occupation (office worker, production worker, service, business, housewife, etc.) were assessed. The health-related lifestyle was categorized as follows: smoking status (never-smoked, ex-smoker, current smoker), alcohol consumption (yes, no), physical activity (yes, no), intake of dietary supplements. Data on diabetic complications (hypertension, hyperlipidemia, etc.) were collected and multiple responses were used.

4. Anthropometric and body composition measurements

The participants were asked to undress any accessories and shoes and stand in an upright position with comfortable clothes to conduct anthropometric and body composition measurements using bioimpedance analysis program (InBody 720; InBody Co., Ltd.). BMI was calculated by dividing the body weight (kg) by the square of height (m). According to the WHO Asia Pacific and the Korean Society for the Study of Obesity (KSSO), obesity was defined as BMI of > 25 kg/m^2. Skeletal muscle mass (SMM), body fat mass (BFM), percent of body fat mass (PBF), intracellular water, extracellular water, and total body water were measured and used in this study. As suggested by the KSSO, waist circumference ≥ 90 cm and ≥ 85 cm were considered as abdominal obesity for male and female, respectively. While standing comfortably in a vertical position with arms stretched, waist circumference was measured between the lowest lower rib and iliac crest, and hip circumference was measured at the widest part of the pelvis. Systolic blood pressure and diastolic blood pressure were measured using a standard electric pressure gauge (FT 500; Jawon Medical) in a relaxed state. All measurements were made by a single trained researcher.

5. Nutrition intake assessment

To investigate the daily intake of nutrients, such as energy, carbohydrate, protein, and fat, 24-hour recall method was used. Prior to assessment, a trained clinical nutritionist educated the study participants on the recording method and explained accurate observational measurements and food material recordings to the study participants. After assessment, the exact amount of food intake was investigated through one-on-one inter-views with the participants for the names of food consumed in a total of 3 days, including 2 days on weekdays and 1 day on weekends. The collected data was analyzed using the Computer Aided Nutritional Analysis Program 5.0 (CAN-Pro 5.0; The Korean Nutrition Society) to calculate average daily intake of nutrients. Nutrient intake was compared to the standards for each sex and age group as suggested in the 2020 Dietary Reference Intakes for Koreans (KDRIs) by the Ministry of Health and Welfare and Korean Nutrition Society. Nutrient intake was then converted into percentage to calculate KDRIs % [13].

6. Dietary habit evaluation

The dietary habits of the participants were investigated using a questionnaire that consisted of a total of 13 items on the number of meals per day, eating breakfast, regularity of mealtime, mealtime duration, frequency of snack, and frequency of eating out. A questionnaire developed for adults in Korea [14] was modified and used for this study.

7. Food intake frequency evaluation

A draft version of food intake frequency questionnaire was prepared based on the food intake frequency of the National Health and Nutrition Examination Survey. The questionnaire was then revised according to the purpose of this study [15]. The items of food intake frequency questionnaire were subdivided into 62 categories, including carbohydrates (7 types), legumes and potatoes (5 types), meat and seafoods (14 types), vegetables and seaweeds (13 types), fruits (11 types), dairy products (3 types), beverages (6 types), and instant foods (3 types). For each food item, the amount of intake per serving was presented. The frequency of intake was divided into "rarely," "6–11 times a year," "once a month," "2–3 times/month," "once a week," "2–3 times/week," "4–6 times/week," "once a day," "twice a day," and "three times a day." In this study, frequency of food intake was converted into servings/per day. The frequency of nutrient intake was analyzed using CAN-Pro version 5.0 for experts to calculate nutrient intake.

8. Evaluation of obesity-related quality of life

Much research mainly evaluated health-related quality of life using Europe version quality of life (EuroQol) questionnaire. EuroQol comprises of two parts, the health states descriptive system and visual analogue scale. The Korean version of those tools has been modified culturally and translated [16]. The Korean version quality of life (KOQOL) was established to evaluate obesity related quality of life after sufficient testing for reliability and validity. The Korean version of obesity-related quality of Life, developed by Park *et al.* [17], was used. The reliability analysis results of KOQOL showed that Cronbach's alpha coefficient was 0.838. The questionnaire consisted of a total of six sub-domains and 15 items with four items on psychosocial health, three items on physical health, three items on task, two items on daily living, two sex-related items, and one food-related item. Each item was scored on a 4-point Likert scale (one point: "not at all," two points: "sometimes," three points: "often," and four points: "always"). A higher score indicated a lower quality of life.

9. Biochemical examination

On the second visit, approximately 10 mL of blood was collected from the brachial vein after 12 hours of fasting. Blood was centrifuged at 3,000 rpm for 15 minutes to separate the serum, which was then used to test various biochemical parameters. Fasting glucose, triglycerides, total cholesterol, high-density lipoprotein-cholesterol, low-density lipoprotein-cholesterol, aspartate aminotransferase, and alanine aminotransferase levels were measured using an enzymatic quantification kit (AM201, AM157S, AM202, A203ST, AM103-K, AM102, Asan set Assay kit; Asan Pharmaceutical Co.) [18]. Atherogenic index was calculated using total cholesterol and HDL-C according to Lauer *et al.*'s formula [19]. Serum insulin concentration was measured using a commercial kit (80-INSHU-E01.1, Insulin EIA; ALPCO Co.), and homeostasis model assessment of insulin resistance (HOMA-IR), which is an indicator of insulin resistance was assessed using a formula suggested by Bradford [20].

10. Statistical analysis

The study results were analyzed using the Statistical Package for Social Science Statistics (SPSS version 26; IBM Corp.). Data are presented using mean ± standard deviation, and the chi-square test was conducted to compare the characteristics and dietary habits of the participants. When the expected counts were less than 5, analysis was performed using Fisher's exact test. The Mann-Whitney *U*-test conducted to compare differences in anthropometric measurement and body composition, nutrition intake, food intake frequency, and biochemical parameters between the two groups. The obesity-related quality of life variables was tested for Normality Test using Shapiro-Wilk analysis and independent t-tests were performed. A *P*-value of < 0.05 was considered statistically significant.

RESULTS

1. General characteristics of the participants

The general characteristics of the participants are shown in Table 1. The participants were divided into two groups according to BMI. A total of 18 participants were included in each of the ODM and LDM groups. There was no significant difference between the two groups in general characteristics, but the prevalence of diabetic complications was significantly higher in the ODM group. The prevalence of hypertension was significantly higher in the ODM group ($P = 0.011$), and the prevalence of dyslipidemia also tended to be high.

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Table 1. General characteristics of the participants

Variable	ODM (n = 18)	LDM (n = 18)	Total (n = 36)	*P*-value
Sex				0.157
Male	14 (77.8)	10 (55.6)	24 (66.7)	
Female	4 (22.2)	8 (44.4)	12 (33.3)	
Age (year)	41.9 ± 10.2	47.7 ± 10.1	44.8 ± 10.4	0.097
Marital status				0.423
Married	13 (72.2)	15 (83.3)	28 (77.8)	
Not married	5 (27.8)	3 (16.7)	8 (22.2)	
Occupation				0.292[1)]
Office worker	7 (38.9)	5 (27.8)	12 (33.3)	
Production worker	3 (16.7)	4 (22.2)	7 (19.4)	
Service	0 (0.0)	4 (22.2)	4 (11.1)	
Business	2 (11.1)	1 (5.6)	3 (8.3)	
Housewife	2 (11.1)	4 (22.2)	6 (16.7)	
Etc.	4 (22.2)	0 (0.0)	4 (11.1)	
Smoking status				0.169
Never-smoked	7 (38.9)	11 (61.1)	18 (50.0)	
Ex-smoker	5 (27.8)	1 (5.6)	6 (16.7)	
Current smoker	6 (33.3)	6 (33.3)	12 (33.3)	
Alcohol consumption				0.317
Yes	7 (38.9)	10 (55.6)	17 (47.2)	
No	11 (61.1)	8 (44.4)	19 (52.8)	
Physical activity				0.083
Yes	9 (50.0)	14 (77.8)	23 (63.9)	
No	9 (50.0)	4 (22.2)	13 (36.1)	
Intake of dietary supplement	9 (42.8)	12 (57.1)	21 (58.3)	0.407
Intake of medication	16 (88.9)	13 (72.2)	29 (80.6)	0.206
Comorbidities				
Complication of diabetes mellitus	13 (72.2)	7 (38.9)	20 (55.6)	0.044
Hypertension	9 (50.0)	2 (11.1)	11 (30.6)	0.011
Hyperlipidemia	16 (88.9)	11 (61.1)	27 (75.0)	0.054

n (%) or Mean ± SD.
The data were obtained from a chi-square test.
ODM, obese diabetes mellitus group; LDM, lean diabetes mellitus group.
1)The data were obtained from a Fisher's exact test.

2. Anthropometric measurements and body composition

Anthropometric measurements and body composition per group are shown in Table 2, for male, the weight of the ODM group was 89.1 kg and that of the LDM group was 66.3 kg, showing that the weight of the ODM group was higher ($P = 0.001$). Accordingly, the BMI of male in the ODM group was 29.8 kg/m^2, and that of the LDM group was 23.0 kg/m^2, which was higher in the ODM group ($P < 0.001$). SMM, BFM, PBF, protein, and mineral were significantly higher in the ODM group than in the LDM group in male, but only BFM and PBF were statistically significantly higher in the ODM group in female ($P < 0.050$).

3. Percentage of nutrition intake of Recommended Nutrient Intake (RNI)

Table 3 shows the percentage of nutrition intake compared to the Korean Dietary Reference Intakes per group. There were significant differences in the intake of vitamin C and iodine between the ODM and LDM groups ($P < 0.05$). Energy intake of each group was lower compared to that of Estimated Energy Requirements

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Table 2. Anthropometric measurements and body composition of the participants

Variable	Male		*P*-value	Female		*P*-value
	ODM (n = 14)	LDM (n = 10)		ODM (n = 4)	LDM (n = 8)	
Weight (kg)	89.1 ± 17.6	66.3 ± 7.9	0.001	70.0 ± 8.4	55.4 ± 7.3	0.016
Height (cm)	172.6 ± 6.5	169.6 ± 5.3	0.212	159.0 ± 4.4	160.0 ± 4.8	0.808
BMI (kg/m^2)	29.8 ± 5.2	23.0 ± 2.1	< 0.001	27.7 ± 3.4	21.6 ± 2.2	0.004
AC (cm)	35.7 ± 5.5	29.9 ± 1.9	< 0.001	32.3 ± 2.9	27.7 ± 2.4	0.008
Waist (cm)	98.1 ± 11.4	83.1 ± 5.7	< 0.001	90.2 ± 5.9	75.8 ± 11.8	0.028
Hip (cm)	103.8 ± 9.9	92.9 ± 5.1	0.001	97.4 ± 6.3	86.1 ± 7.5	0.028
WHR	0.94 ± 0.0	0.89 ± 0.0	0.011	0.93 ± 0.0	0.88 ± 0.1	0.368
SBP (mmHg)	130.4 ± 12.7	124.0 ± 15.4	0.212	129.5 ± 7.2	117.7 ± 12.4	0.109
DBP (mmHg)	80.5 ± 7.3	76.8 ± 14.7	0.213	77.5 ± 8.4	68.5 ± 8.5	0.129
SMM (kg)	33.5 ± 4	29.5 ± 3.6	0.022	24.1 ± 1.9	21.1 ± 3.0	0.154
BFM (kg)	29.2 ± 13.3	13.9 ± 2.6	< 0.001	25.8 ± 5.5	16.1 ± 3.1	0.004
PBF (%)	31.7 ± 7.5	20.9 ± 2.4	< 0.001	36.6 ± 3.6	28.9 ± 3.2	0.004
ECW/TBW	0.382 ± 0.008	0.378 ± 0.008	0.212	0.386 ± 0.004	0.389 ± 0.005	0.283

Mean ± SD.
Differences among groups were assessed by Mann-Whitney *U*-test.
ODM, obese diabetes mellitus group; LDM, lean diabetes mellitus group; BMI, body mass index; AC, arm circumference; WHR, waist-hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; SMM, skeletal muscle mass; BFM, body fat mass; PBF, percent of body fat mass; ECW, extracellular water; TBW, total body water.

(EER). The rate of carbohydrate intake was 181.3% and 185.3% in the ODM and LDM groups, respectively, which were higher than the RNI. The rate of protein intake was 120.7% in the ODM and 107.7% in the LDM, both groups intake more carbohydrate and proteins than RNI. There was no significant difference in the percentage of macronutrient intake between the two groups.

4. Dietary habits

The dietary habits of the participants are shown in Table 4. For the number of meals per day, most of the participants had three meals per day (47.2%, n = 17), followed by those who had two meals per day (33.3%, n = 12), and irregular number of meals (19.4%, n = 7). Approximately 44.4% of the total participants answered that they always had breakfast. Comparing the eating habits of the two groups, significant differences were found in mealtimes duration and types of eating out.

The LDM group showed a difference from the ODM group in that the mealtime was '20 minutes' the most (83.3%) (P = 0.006). These findings indicate that obese diabetic patients had a shorter mealtime duration than the lean diabetic patients. And 55.6% of the participants mainly consumed "Korean dishes" for eating out. In the LDM group, 77.8% of the participants mainly consumed "Korean dishes," which was higher than that in the ODM group. In the ODM group, 27.8% of the participants mainly consumed "fast food," which was significantly higher than in the LDM group (0.0%).

5. Food intake frequency

The frequency of food intake is shown in Table 5. Food was divided into 11 groups, and one serving per day was treated as one for average intake. The intake of rice cakes and chicken was higher in the ODM group than in the LDM group (P = 0.050). The intake of pork, fruits such as tangerines, grapes, strawberries, oranges and yogurt were higher in the LDM group (P < 0.050). In both the groups, the intake frequency of mixed grains was more than once a day, suggesting a tendency to choose food with high levels of dietary fiber among carbohydrate foods. For meats and eggs intake frequency, the intake frequency of eggs as protein source was the highest at 0.4 and 0.5 in the ODM and LDM groups, respectively. And it was confirmed that fruit intake was low in both the groups. For milk and dairy products, the intake frequency of milk was 0.2 in the ODM group and 0.3 in LDM group, which was less than once a day.

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Table 3. Percentage of nutrition intake of Korean RNI of the participants

Variable	ODM (n = 18)	LDM (n = 18)	*P*-value
Energy[1)]	75.5 ± 24.0	76.1 ± 14.4	0.673
Carbohydrate	181.3± 60.6	185.3 ± 59.1	0.791
Protein	120.7± 45.2	107.7 ± 26.5	0.389
Fiber	69.7± 29.8	79.2 ± 41.2	0.963
Vitamin A	90.3 ± 47.1	115.9 ± 61.7	0.355
Vitamin D	9.3 ± 8.2	9.2 ± 7.9	0.308
Vitamin E	29.3 ± 12.3	23.2 ± 15.4	0.118
Vitamin K	46.8 ± 108.9	40.0 ± 45.2	0.293
Vitamin C	73.5 ± 48.6	123.9 ± 80.3	0.030
Vitamin B_1	151.2 ± 61.5	149.5 ± 45.9	0.839
Vitamin B_2	84.2 ± 30.9	90.8 ± 27.9	0.584
Niacin	99.2 ± 42.7	90.7 ± 28.3	0.226
Vitamin B_6	28.9 ± 18.4	20.9 ± 13.1	0.815
Folate	21.2 ± 10.4	20.5 ± 10.9	0.650
Vitamin B_{12}	155.7 ± 234.4	34.5 ± 31.4	0.022
Pantothenic acid	16.1 ± 18.6	14.2 ± 9.0	0.501
Biotin	4.3 ± 6.2	8.2 ± 10.9	0.279
Calcium	49.3 ± 21.9	62.2 ± 28.3	0.214
Phosphorus	144.5 ± 47.1	144.9 ± 45.7	0.938
Sodium	201.5 ± 84.7	200.8 ± 71.2	0.815
Chloride	3.0 ± 5.6	3.5 ± 4.6	0.406
Potassium	68.2 ± 21.5	76.4 ± 24.9	0.308
Magnesium	28.7 ± 12.5	29.6 ± 14.7	0.481
Iron	162.8 ± 72.7	158.9 ± 65.3	0.988
Zinc	62.6 ± 23.0	75.4 ± 28.1	0.339
Copper	82.2 ± 44.2	84.6 ± 45.4	0.815
Fluoride	0.5 ± 0.6	0.6 ± 0.6	0.815
Manganese	41.7 ± 17.6	48.8 ± 25.8	0.743
Iodine	31.4 ± 22.9	123.5 ± 172.3	0.038
Selenium	96.3 ± 39.1	83.2 ± 33.5	0.288
Cholesterol	64.4 ± 37.3	61.8 ± 40.1	0.841

Mean ± SD.
Differences among groups were assessed by Mann-Whitney *U*-test.
ODM, obese diabetes mellitus group; LDM, lean diabetes mellitus group.
[1)]Ratio of estimated energy requirements.

6. Korean version of obesity-related quality of life

Obesity-related quality of life of the participants is shown in Table 6. The total score was 28.2 in the ODM group, which was significantly higher than in the LDM group (23.7), suggesting that the quality of life was lower in the ODM group (*P* = 0.043). Analysis of the sub-domains showed that there were statistically significant differences in work-related health (*P* = 0.014) and diet

Table 4. Dietary habits of the participants

Variable	ODM (n = 18)	LDM (n = 18)	Total (n = 36)	*P*-value
No. of meals per day				0.102
3 times	7 (38.9)	10 (55.6)	17 (47.2)	
2 times	7 (38.9)	5 (27.8)	12 (33.3)	
Irregular	4 (22.2)	3 (16.7)	7 (19.4)	
Eating breakfast				0.539
Always	7 (38.9)	9 (50.0)	16 (44.4)	
Sometimes	5 (27.8)	5 (27.8)	10 (27.8)	
None	6 (33.3)	4 (22.2)	10 (27.8)	
Regularity of meal time				0.811
Regular	7 (38.9)	6 (33.3)	13 (36.1)	
Sometimes irregular	9 (50.0)	9 (50.0)	18 (50.0)	
Irregular	2 (11.1)	3 (16.7)	5 (13.9)	
Mealtime duration (min)				0.006
≤ 10	9 (50.0)	2 (11.1)	11 (30.6)	
10–20	6 (33.3)	15 (83.3)	21 (58.3)	
20–30	3 (16.7)	1 (5.6)	4 (11.1)	
> 30	0 (0.0)	0 (0.0)	0 (0.0)	
Meal size				0.509
Until full	1 (5.6)	3 (16.7)	4 (11.1)	
Irregular	16 (88.9)	13 (72.2)	29 (80.6)	
Small	1 (5.6)	2 (11.1)	3 (8.3)	
Diversity of food intake				0.241
Eat anything	9 (50.0)	8 (44.4)	17 (47.2)	
Sometimes	9 (50.0)	7 (38.9)	16 (44.4)	
Always	0 (0.0)	3 (16.7)	3 (8.3)	
Appetite				0.793
Always	8 (44.4)	9 (50.0)	17 (47.2)	
Sometimes	10 (55.6)	9 (50.0)	19 (52.8)	
No appetite	0 (0.0)	0 (0.0)	0 (0.0)	
Frequency of overeating				0.234
0–1/week	3 (16.7)	8 (44.4)	11 (30.6)	
2–3/week	14 (77.8)	10 (55.6)	24 (66.7)	
≥ 4/week	1 (5.6)	0 (0.0)	1 (2.8)	
Frequency of snack				0.956
0–1/week	4 (22.2)	6 (33.3)	10 (27.8)	
2–3/week	8 (44.4)	7 (38.9)	15 (41.7)	
≥ 4/week	6 (33.3)	5 (27.8)	11 (30.6)	
Frequency of eating out				0.496
0–1/week	4 (22.2)	8 (44.4)	12 (33.3)	
2–3/week	9 (50.0)	8 (44.4)	17 (47.2)	
≥ 4/week	5 (27.8)	2 (11.1)	7 (19.4)	

(Continued to the next page)

Table 4. Continued

Variable	ODM (n = 18)	LDM (n = 18)	Total (n = 36)	*P*-value
Eating out type				0.355
Korean dishes	6 (33.3)	14 (77.8)	20 (55.6)	
Western food	3 (16.7)	2 (11.1)	5 (13.9)	
Chinese dishes	2 (11.1)	2 (11.1)	4 (11.1)	
Japanese dishes	2 (11.1)	0 (0.0)	2 (5.6)	
Fast food	5 (27.8)	0 (0.0)	5 (13.9)	
Frequency of night eating				0.503
0–1/week	12 (66.7)	8 (44.4)	20 (55.6)	
2–3/week	6 (33.3)	8 (44.4)	14 (38.9)	
≥ 4/week	0 (0.0)	2 (11.1)	2 (5.6)	

n (%).
Differences among groups were assessed by Fisher's exact test.
ODM, obese diabetes mellitus group; LDM, lean diabetes mellitus group.

distress ($P = 0.007$) domains between the two groups.

7. Biochemical parameters

The biochemical parameters of the participants are shown in Table 7. There were no significant differences in biochemical parameters between the two groups.

DISCUSSION

The purpose of this study was to evaluate differences in clinical characteristics, dietary habits, obesity-related quality of life, nutrient intake levels, and biochemical parameters in obese and non-obese diabetic patients. The results of this study showed differences in dietary habits according to the phenotype of patients with type 2 diabetes and showed nutrition intake problems.

This study showed the relationship between obesity and CVD prevalence in patients with type 2 diabetes. Einarson *et al.* [8] reported that the prevalence of CVDs, such as dyslipidemia and hypertension, which are predictive factors for CVDs, increases when BMI increases among patients with T2DM. Similarly, in this study, the ODM group showed a significantly higher CVD comorbidity than the LDM group with Hypertension 50%. The waist circumference was found to be a value corresponding to abdominal obesity in both male and female in ODM for male and female when the KSSO's abdominal obesity standards were applied. It has been

Table 5. Daily food intake frequency of the participants

Variable	ODM (n = 18)	LDM (n = 18)	*P*-value
Carbohydrates			
Rice	1.9 ± 1.0	1.7 ± 0.9	0.118
Mixed grain	1.3 ± 1.2	1.1 ± 0.8	0.323
Ramen	0.2 ± 0.3	0.2 ± 0.3	0.372
Noodles	0.2 ± 0.2	0.1 ± 0.2	0.501
Bread	0.3 ± 0.5	0.2 ± 0.3	0.584
Rice cake	0.1 ± 0.1	0.0 ± 0.1	0.050
Confectionary	0.3 ± 0.5	0.2 ± 0.3	0.252
Legumes			
Bean curd	0.5 ± 0.4	0.6 ± 0.6	0.563
Legumes	0.6 ± 0.7	0.7 ± 0.7	0.913
Soybean milk	0.1 ± 0.2	0.1 ± 0.3	0.521
Potatoes			
Potato	0.2 ± 0.3	0.3 ± 0.5	0.883
Sweet potato	0.1 ± 0.1	0.1 ± 0.2	0.086
Meat and eggs			
Beef	0.2 ± 0.3	0.3 ± 0.3	0.226
Chicken	0.2 ± 0.2	0.1 ± 0.1	0.004
Pork	0.2 ± 0.3	0.3 ± 0.3	0.029
Ham	0.1 ± 0.1	0.1 ± 0.2	0.055
Eggs	0.4 ± 0.3	0.5 ± 0.3	0.226
Seafoods			
Mackerel	0.1 ± 0.1	0.1 ± 0.1	0.696
Tuna	0.1 ± 0.1	0.1 ± 0.1	0.265
Croaker	0.0 ± 0.0	0.0 ± 0.0	0.245
Pollack	0.0 ± 0.0	0.0 ± 0.0	0.521
Anchovy	0.2 ± 0.3	0.3 ± 0.7	0.839
Fish ball	0.1 ± 0.2	0.2 ± 0.3	0.521
Squid	0.0 ± 0.0	0.0 ± 0.1	0.864
Shellfish	0.1 ± 0.1	0.1 ± 0.2	0.443
Salted seafood	0.1 ± 0.2	0.0 ± 0.0	0.696
Vegetables			
Chinese cabbage	1.4 ± 1.0	1.3 ± 1.0	0.606
Radish	0.9 ± 0.9	0.5 ± 0.6	0.443
Radish leaves	0.2 ± 0.3	0.2 ± 0.3	0.406
Bean sprouts	0.4 ± 0.5	0.2 ± 0.1	0.606
Spinach	0.2 ± 0.3	0.3 ± 0.7	0.424
Cucumber	0.5 ± 0.5	0.4 ± 0.7	0.521
Red pepper	0.3 ± 0.3	0.2 ± 0.2	0.660
Pumpkin	0.3 ± 0.5	0.2 ± 0.3	0.481
Cabbage	0.2 ± 0.3	0.3 ± 0.7	0.719
Tomato	0.4 ± 0.6	0.6 ± 0.9	0.584
Mushrooms	0.3 ± 0.5	0.3 ± 0.4	0.372
Seaweeds			
Sea mustard	0.1 ± 0.1	0.2 ± 0.2	0.372
Laver	0.5 ± 0.7	0.3 ± 0.4	0.628

(Continued to the next page)

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Table 5. Continued

Variable	ODM (n = 18)	LDM (n = 18)	*P*-value
Fruits			
Tangerine	0.0 ± 0.1	0.1 ± 0.1	0.014
Persimmon	0.0 ± 0.0	0.0 ± 0.1	0.215
Pear	0.0 ± 0.1	0.0 ± 0.0	0.226
Watermelon	0.1 ± 0.2	0.1 ± 0.2	0.074
Oriental melon	0.1 ± 0.2	0.0 ± 0.0	0.181
Strawberry	0.0 ± 0.0	0.0 ± 0.0	< 0.001
Grape	0.0 ± 0.0	0.0 ± 0.1	0.042
Peach	0.0 ± 0.0	0.1 ± 0.2	0.152
Apple	0.2 ± 0.5	0.2 ± 0.4	0.462
Banana	0.1 ± 0.1	0.1 ± 0.2	0.203
Orange	0.0 ± 0.0	0.2 ± 0.7	0.019
Milk and dairy products			
Milk	0.2 ± 0.3	0.3 ± 0.5	0.171
Yogurt	0.1 ± 0.1	0.1 ± 0.3	0.037
Ice cream	0.1 ± 0.2	0.0 ± 0.1	0.406
Beverages			
Soft drink	0.1 ± 0.2	0.0 ± 0.1	0.521
Coffee	1.3 ± 1.1	1.6 ± 1.0	0.134
Tea	0.2 ± 0.5	0.2 ± 0.3	0.339
Beer	0.1 ± 0.1	0.2 ± 0.5	0.888
Soju	0.1 ± 0.1	0.2 ± 0.5	0.584
Rice wine	0.0 ± 0.0	0.0 ± 0.1	0.203
Instant foods			
Hamburger	0.0 ± 0.0	0.0 ± 0.1	0.946
Pizza	0.0 ± 0.0	0.0 ± 0.0	0.694
Fried foods	0.1 ± 0.2	0.0 ± 0.0	0.126

Mean ± SD.
Differences among groups were assessed by Mann-Whitney *U*-test.
ODM, obese diabetes mellitus group; LDM, lean diabetes mellitus group.

Table 6. Obesity-related quality of life of the participants

Variable	ODM (n = 18)	LDM (n = 18)	*P*-value
Psychosocial health	6.4 ± 2.3	5.4 ± 2.2	0.189
Physical health	6.5 ± 1.7	5.9 ± 1.7	0.298
Work-related health	6.7 ± 2.5	4.8 ± 1.9	0.014
Lifestyle	3.6 ± 1.5	2.9 ± 0.8	0.098
Sexual activity	3.1 ± 1.2	3.5 ± 1.7	0.429
Diet distress	1.9 ± 1.0	1.2 ± 0.4	0.007
Total KOQOL score	28.2 ± 7.1	23.7 ± 5.6	0.043

Mean ± SD.
Differences among groups were assessed by t-test.
ODM, obese diabetes mellitus group; LDM, lean diabetes mellitus group.

Table 7. Biochemical parameters of the participants

Variable	ODM (n = 18)	LDM (n = 18)	*P*-value
Glucose (mg/dL)	128.4 ± 33.1	125.4 ± 29.8	0.913
Insulin (μIU/mL)	6.0 ± 2.1	8.4 ± 5.5	0.339
HOMA-IR	1.9 ± 0.8	2.6 ± 1.7	0.424
TC (mg/dL)	170.7 ± 41.2	183.9 ± 27.7	0.111
HDL-C (mg/dL)	30.5 ± 10.4	34.6 ± 9.6	0.181
LDL-C (mg/dL)	54.6 ± 15.7	58.1 ± 10.0	0.214
TG (mg/dL)	178.8 ± 65.7	146.1 ± 136.6	0.043
Atherogenic index	5.0 ± 1.5	4.7 ± 1.7	0.719
AST (IU/L)	14.8 ± 5.8	12.6 ± 8.1	0.134
ALT (IU/L)	29.6 ± 15.4	25.3 ± 16.3	0.214

Mean ± SD.
Differences among groups were assessed were assessed by Mann-Whitney *U*-test.
ODM, obese diabetes mellitus group; LDM, lean diabetes mellitus group; HOMA-IR, homeostatic model assessment of insulin resistance; TC, total cholesterol; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; TG, triglyceride; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

reported that the prevalence of atherosclerosis, high blood pressure, and CVD is high in patients with T2DM accompanied by abdominal obesity [21, 22].

Nagao *et al.*'s study [23] showed the prevalence of CVD in non-obese patients with abdominal obesity (BMI < 25 kg/m^2) was similar in obese patients (BMI ≥ 25 kg/m^2) and was higher than in non-obese patients without abdominal obesity (BMI < 25 kg/m^2). In this study, the prevalence of waist circumference and hypertension in the ODM group was high, showing results consistent with this. Therefore, it is important for T2DM patients to prevent CVD when accompanied by obesity or abdominal obesity, and for this, it is believed that intervention in reducing visceral fat accumulation through weight loss is necessary.

The percentage of nutrient intake was analyzed per group. Energy intake was 75.5% in the ODM group and 76.1% in the LDM group, which suggested diabetic patients' intake lower calories compared to EER. The results were consistent; the energy intake of diabetic patients in Korea was 93.9% of the EER, whereas the energy intake of diabetic patients in this study was lower [24]. In Korean obese adults without diabetes, energy intake was 2,627.9 kcal [25], and in normal-weight adults, it was 2,261.0 kcal (middle-aged men) [26], which was higher than the energy intake of the participants of this study regardless of obesity. Analysis of nutrient intake showed that the intake of vitamin C and iodine was high in the LDM group, and the intake of vitamin B_{12} was high in the ODM group. However, the intake rates of most nutrients for vitamins and minerals were lower than the KDRIs. Both groups showed low intake rates of calories, vitamin D, vitamin E, calcium, potassium, magnesium, and zinc, which are likely to be deficient in diabetic patients [27-29]. Therefore, it is thought that patients with T2DM, with or without obesity, should need the importance of obtaining daily vitamin and mineral requirements through a balanced diet while consuming total energy appropriate for each individual's energy requirements.

Dietary habits are integrated into an individual's daily life over a long period of time, and are closely related to age, cultural, social, economic, and psychological factors. According to the Korea National Health and Nutrition Examination Survey, the proportion of unhealthy and irregular dietary habits, such as skipping breakfast and eating out, among Koreans is increasing every year [2]. It has been revealed through many articles that eating speed among dietary habits contributes to metabolic states such as obesity as well as the development of insulin resistance through its effect on body weight [30, 31]. In this study, 50% of the participants answered 'less than 10 minutes' in ODM. This is consistent with a study in which T2DM patients reported that those who reported their eating speed had a higher BMI [32, 33], and that chewing food slowly and thoroughly can contribute to weight loss and maintenance [34, 35].

The consumption of fast food in the eating out type is on the rise worldwide, and the consumption of such fast food has a great adverse effect on the quality of the diet because it is high in energy density and lacks in nutrients [36]. In this study, 77.8% of the respondents in the LDM group consumed 'Korean dishes' and did not consume fast food, but in the ODM group, 27% chose fast food, resulting in a high intake of convenience food. Jung and Chae's study [37] found that traditional Korean food, which contain high levels of whole grains and vegetables and low amounts of red meat increased the intake of antioxidant nutrients, vitamin A, C, E and β-carotene, thereby reducing serum gamma glutamyl-transerase, a risk factor for CVD. It has also been reported to reduce blood sugar and improve weight, BFM.

T2DM participants in this study had excessively restricted intake of fruits and dairy products regardless of obesity, which was consistent with a study of dietary intake in Korean diabetic patients [24].

In the case of obesity or overweight, the quality of life deteriorates due to a combination of factors such as the occurrence of physical function limitations or accompanying complications. However, relatively few studies have been conducted on obesity in patients with T2DM. In this study, the ODM group showed a higher score than the LDM group of 23.7 with a total score of 28.2, consistent with a study that found that obesity-related quality of life was further impaired as BMI increased [38]. Among the six areas, it was found that they had more difficulties in the areas of work-related health and diet distress. Lee *et al.*'s study [39] reported that obesity-related quality of life was improved through weight loss after obesity treatment. Therefore, it is thought that if a lifestyle intervention program is carried out for type 2 diabetes patients, obesity-related quality of life, including social health and daily life, can be improved.

In summary, our study indicated that both the LDM and ODM groups had unbalanced nutrient intakes in the differences in dietary intake according to obesity in T2DM patients. In addition, unhealthy eating behaviors such as fast eating speed and increased fast food intake were higher in obese diabetic patients. Therefore, patients with T2DM should consume a balanced diet of various food groups such as fruits and dairy products to prevent complications and chronic diseases [35]. In addition, when diabetic patients with obesity choose a type of eating out, it is thought that nutrition education is necessary to encourage them to consider Korean food consisting of whole grains and vegetables, as well as to have a habit of chewing their meals slowly. We suggest that a comprehensive lifestyle modification, including individualized nutrition treatment, is necessary in consideration of the risk of the disease and dietary habits that are characteristic when divided into phenotypes.

Limitations

This study had some limitations. Data were self-re-

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ported based on 24-hour recall for nutrition intake assessment. The amount of food intake recorded by the participants may be less than the actual intake. As a small cross-sectional study, it is difficult to generalize the results due to the small number of participants, which complicates the establishment of a clear causal relationship.

Previous studies have showed that classifying obese patients according to the location or amount of adipose tissue may be appropriate. However, BMI is correlated with body fat percentage, so it may be suitable for this study [40]. Despite these limitations, this study demonstrated an association between the prevalence of CVD, bad dietary habits, and obesity when T2DM patients were classified according to phenotype. In addition, it is meaningful in that it compared dietary habits, nutrient intake, and obesity-related quality of life in Korean diabetic patients. The results of this study will help to implement more effective medical nutrition treatment reflecting dietary habits to prevent CVD in T2DM patients with obesity.

Conclusion

In conclusion, obese diabetes patients had an increased risk of CVDs, bad dietary habits, and low obesity-related quality of life. Therefore, based on these findings, personalized nutrition treatment considering the risk and differences in dietary habits according to the phenotype of diabetes would be necessary for treatment of diabetic patients. Personalized nutrition treatment, including strategies for selection of food and nutrient balance and dietary education, would be helpful for effective treatment of diabetes. Future studies on the effects of personalized treatment in patients according to the obesity status in T2DM patients and related mechanisms would be necessary.

CONFLICT OF INTEREST

There are no financial or other issues that might lead to conflict of interest.

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DATA AVAILABILITY

Research data is available after a reasonable request to the corresponding author.

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