creative commons
C O M M O N S D E E D

저작자표시-비영리-변경금지 2.0 대한민국

이용자는 아래의 조건을 따르는 경우에 한하여 자유롭게

- 이 저작물을 복제, 배포, 전송, 전시, 공연 및 방송할 수 있습니다.

다음과 같은 조건을 따라야 합니다:

저작자표시. 귀하는 원저작자를 표시하여야 합니다.

비영리. 귀하는 이 저작물을 영리 목적으로 이용할 수 없습니다.

변경금지. 귀하는 이 저작물을 개작, 변형 또는 가공할 수 없습니다.

- 귀하는, 이 저작물의 재이용이나 배포의 경우, 이 저작물에 적용된 이용허락조건을 명확하게 나타내어야 합니다.
- 저작권자로부터 별도의 허가를 받으면 이러한 조건들은 적용되지 않습니다.

저작권법에 따른 이용자의 권리는 위의 내용에 의하여 영향을 받지 않습니다.

이것은 이용허락규약(Legal Code)을 이해하기 쉽게 요약한 것입니다.

Disclaimer

dCollection

A THESIS FOR THE DEGREE OF
MASTER OF SCIENCE IN FOOD AND NUTRITION

Association between diet quality and prevalence of obesity, dyslipidemia, and insulin resistance: The Filipino Women's Diet and Health Study (FiLWHEL)

필리핀 이주여성의 식사의 질과 비만,
이상지질혈증 및 인슐린 저항성과의 연관성 연구:
필리핀 여성건강연구(**FiLWHEL)**

February, 2021

Department of Food and Nutrition
Graduate School
Seoul National University
Hee Sun Kim

Association between diet quality and prevalence of obesity, dyslipidemia, and insulin resistance: The Filipino Women's Diet and Health Study (FiLWHEL)

필리핀 이주여성의 식사의 질과 비만,
이상지질혈증 및 인슐린 저항성과의 연관성 연구:
필리핀 여성건강연구(FiLWHEL)

지도교수 이 정 은

이 논문을 식품영양학석사 학위논문으로 제출함

2020 년 11 월

서울대학교 대학원
식품영양학과
김 희 선

김희선의 석사 학위논문을 인준함

2021 년 1 월

위 원 장 윤 지 현 (인)
부 위 원 장 강 민 지 (인)
위 원 이 정 은 (인)

Abstract

Association between diet quality and prevalence of obesity, dyslipidemia, and insulin resistance: The Filipino Women's Diet and Health Study (FiLWHEL)

Hee Sun Kim
Department of Food and Nutrition
The Graduate School
Seoul National University

With the rise of non-communicable disease world-wide, diet quality may be a key modifiable factor for the prevention of non-communicable disease. We aimed to investigate the association between diet quality and prevalence of obesity, dyslipidemia, and insulin resistance among Filipino immigrant women in Korea. A total of 413 participants of 2014-2016 baseline population from the Filipino Women's Diet and Health Study (FiLWHEL) were examined. Individual dietary intakes were evaluated through 24-hour recalls, then converted to two dietary quality scores; Minimum Dietary Diversity for Women (MDD-W) developed by Food and Agriculture Organization (FAO), and Data Derived Inflammation Index (DDII) originally developed by the nutritional epidemiology laboratory of Seoul National

University. Blood triglycerides, high-density lipoprotein cholesterols, glucose, and insulin levels were examined from the fasting blood samples. Logistic regression models was used to calculate odds ratios (ORs) with 95% confidence intervals (CIs). A statistically significant association was observed between MDD-W scores and decreased prevalence of abdominal obesity; OR (95%CIs) of the top vs the bottom category was 0.58 (0.36-0.94; *p* for trend=0.03). Increased inflammatory index was associated with elevated prevalence of dyslipidemia and insulin resistance; ORs (95%CIs) of the highest vs the lowest categories were 3.48 (1.85-6.54) for total cholesterols, 4.28 (2.05-8.93) for low density lipoprotein cholesterols, 7.30 (2.76-19.36) for triglycerides, 7.24 (2.79-18.76) for high triglycerides to high density lipoprotein cholesterols ratio, 3.71 (2.01-6.84) for glycated hemoglobin, 2.63 (1.09-6.33) for blood glucose, 10.71 (4.50-25.48) for insulin, and 10.31 (4.64-22.93) for Homeostasis Model Assessment of Insulin Resistance (*p* for trend <0.01 for all). Greater dietary diversity was inversely associated with prevalence of abdominal obesity in Filipino immigrant women. Pro-inflammatory scores based on diet and lifestyle factors were associated with increased prevalence of dyslipidemia and insulin resistance. Concerning the growing proportion of multicultural family unit, the immigrants may have a significant implication for well-being of the future generation. The results from the study suggests a need for population-specific public health intervention strategies including dietary guidelines for non-communicable disease prevention, concerning the metabolic differences of the target population. Further epidemiological studies on dietary quality index in relation to the chronic

disease are warranted.

Keywords: Dietary diversity, Obesity, Dyslipidemia, Insulin resistance, Inflammation, Cross-sectional studies

Student Number: 2019-23341

Contents

List of Tables

List of Figures

List of Abbreviations

ADA	American Diabetes Association
BMI	Body Mass Index
CIs	Confidence Intervals
DDII	Data Derived Inflammatory Index
FAO	Food and Agriculture Organization
FBG	Fasting Blood Glucose
FiLWHEL	Filipino Women's Health and Diet study
HbA1c	Glycated Hemoglobin
HDL-C	High Density Lipoprotein Cholesterols
HOMA-IR	Homeostasis Model Assessment of Insulin Resistance
LDL-C	Low Density Lipoprotein Cholesterols
MDD-W	Minimum Dietary Diversity for Women
ORs	Odds Ratios
SD	Standard Deviation
T2DM	Type 2 Diabetes Mellitus
TC	Total Cholesterols
TG	Triglycerides
WHO	World Health Organization

I. Introduction

With the rise of non-communicable disease in both developed and developing countries, significant changes in the public health priorities have been implemented for non-communicable disease prevention – mainly obesity, type 2 diabetes mellitus, and cardiovascular disease (Mozaffarian, 2016; Popkin et al., 2020). Of note, the modern dietary guidelines not only aim to prevent nutrient deficiencies, but also chronic disease. Recently, 'food-based' guidelines have been accentuated regarding the chronic disease prevention. (Hruby et al., 2016; Mozaffarian & Ludwig, 2010; Smitasiri & Uauy, 2007). The growing burden of non-communicable disease provoked the demand for a holistic approach of food consumption that can supervise the double burden of malnutrition, under- and over-nutrition. 'Food-based' guidelines attempt to reflect the synergistic contributions of dietary patterns including food composition, preparation methods, and underlying social interactions. To ensure the compliance and effectiveness of the established guidelines, quantitative measurements as diet quality scores have been developed using both empirical and a priori methods, such as Mediterranean diet score, Healthy Eating Index (HEI), and Alternative Healthy Eating Index (AHEI) (Guenther et al., 2013; Sofi et al., 2014).

Several epidemiological studies examined the association of diet quality with morbidity and mortality of non-communicable disease, where heterogeneous outcomes of significant positive (Fung et al., 2007; Fung et al., 2016; Schwingshackl et al., 2018), inverse (Bezerra & Sichieri, 2011; Jayawardena et al., 2013), or no associations (Joyce et al., 2019) were found. The Nurses' Health Study comprising 80,029 participants reported a statistically significant association between higher AHEI and the lower risk of type 2 diabetes (Fung et al., 2007). However, no significant association was found from meta-analysis examining the association between dietary diversity score (DDS) and obesity (Salehi-Abargouei et al., 2016). Attentions on the dietary factors associated with inflammation status have been highlighted, along with the recent development of dietary index predicting inflammation levels (2004; Barbaresko et al., 2013; Galland, 2010; Kim et al., 2020). Chronic inflammation status is recognized as an underlying pathophysiological mechanism linking multiple chronic disease, including atherosclerosis (Frostegård, 2013), type 2 diabetes mellitus (T2DM) (Pradhan et al., 2001), cardiovascular disease (CVD) (Pearson et al., 2003), and several cancers (Il'yasova et al., 2005).

Nutritional epidemiology laboratory of Seoul National University developed Data Derived Inflammatory Index (DDII) regarding the C-reactive protein (hsCRP) levels (Kim et al., 2020). It is a Korean-specific index which reflects both diet and lifestyle factors with major attribute to hsCRP levels. Food and Agriculture Organization (FAO) of the United Nations developed the Minimum Dietary Diversity for Women (MDD-W), a food group based dichotomous scoring system, in order to assess the micronutrient adequacy of the women of reproductive age in developing countries (Women's Dietary Diversity Project Study Group, 2017). Despite its recent development, the scoring scheme has been investigated globally to measure the diet quality of diverse population, and further association with multiple chronic disease (Custodio et al., 2020; Fung et al., 2018; Yang et al., 2020).

Of note, the highest prevalence of obesity was reported among Filipino women from the immigrant study in Korea (Yang et al., 2012). Another immigrant study in the U.S. found that obesity prevalence of Filipinos tripled between 1992 and 2011, highest among other Asian immigrants (Singh & Lin, 2013). A previous study of the Filipino immigrants in Korea found an inverse association between obesity prevalence and higher DDS based on 11 food groups, and further suggested that the residence years and change in dietary habits may modify the association (Abris et al., 2018). Abdominal obesity is a distinct phenotype of obesity pandemic in developing countries strongly associated with metabolic comorbidities (NCD Risk Factor Collaboration, 2017; Misra & Khurana, 2008; Misra & Shrivastava, 2013). In addition, Asians may have higher body fat mass at given value of body mass index (BMI) compared to Caucasians (Dudeja et al., 2001). Based on the rationale, international institutions proposed population-specific cut-off points for the diagnosis of obesity and metabolic syndrome (2004; Alberti et al., 2006; World Health Organization, 2000). In tandem, population-specific public health intervention strategies including dietary guidelines for the non-communicable disease should be recognized, concerning both cultural and metabolic differences.

Given that Filipino immigrant women were susceptible to lower dietary diversity and risk of metabolic diseases, it would be ideal to apply two diet quality scores to identify the risk factors for obesity and chronic disease among Filipino immigrant population in the Republic of Korea. In the current analysis, the association between MDD-W, a developing country specific score, and DDII, a Korean specific score, with indicators of obesity, dyslipidemia, and insulin resistance were examined in the Filipino Women's Diet and Health Study (FiLWHEL).

II. Literature review

1. Overview of health and diet of Filipino immigrants

The immigrant population in Korea is consistently growing in recent decades, along with the increase in the proportion of multicultural family. According to the 2019 Korean population and vital statistics, the proportion of multi-cultural marriage made more than 10% of the total marriage cases in Korea (Statistics Korea, 2019). More specifically, 69.3% of the international marriages were from foreign wives. When analyzed by the country of origin, the Philippines is the 4th ranked country of marriage-based immigrant population in Korea, following the immigrants from China, Vietnam, and Japan (Korea Immigration Service Statistics, 2019). Given the growing number of immigrants and the significance of multicultural family unit, the attention towards the social and health status of the immigrants may be important for the future generation of Korean society. Moreover, the immigrants are reported to modify their dietary behaviors, known as 'dietary acculturation', as they adapt to new environment. The process involves a complex–multidimensional interaction between socioeconomic factors, with variations exist between individuals (Batis et al., 2011).

Regarding the health and disease situation in the Philippines, heart disease was the leading cause of death comprising 22.3% of the total death, followed by the vascular system disease (12.9%), and malignant neoplasm (10.1%) (Department of Health, 2013). Therefore, the attentions on the chronic disease, including cardiovascular disease among the Filipino immigrant population in Korea is important. It is noteworthy that the study examining immigrant population in Korea found the highest prevalence of obesity among the Filipino immigrant women (Yang et al., 2012). In the United States (U.S.), the Filipino population tripled between 1986 and 2006, where the prevalence of obesity also tripled concomitantly. Cardiovascular disease, malignancies, and diabetes mellitus are the top leading causes of death among Filipino American Adults over 65 years old. The U.S. study comparing the hospitalized Filipino Americans and Caucasians found higher prevalence of hypertension and diabetes among Filipino Americans (Ryan et al., 2000). Another study examining the Filipino immigrants in urban regions of New York reported that immigrants who lived in U.S. for 10 years or more had a higher risk of overweight compared to the immigrants who lived less than 5 years (Afable et al., 2016). Indeed, the study of 210 first generation Filipino Americans reported the mean Western dietary acculturation score of 6.6 (± 2.4) out of 10 points, where the participants with higher western dietary acculturation had a higher caloric intake, fat intake and increased BMI and waist circumferences (Vargas & Jurado, 2015).

Limited evidences are available in international resources regarding the dietary pattern of Filipinos in the Philippines. An analysis of pediatric data from 2013 Filipino National Nutrition Survey reported that mean (± standard deviation) of dietary diversity score (DDS) was 4.1 (±1.3) out of 9 food groups (2004). Another pediatric study found that the majority of meals are composed of refined rice or cookies, commonly recognized as unhealthy foods. On the other hand, healthy foods, such as vegetables, fruits, and meats have less contribution to daily nutrient intake (Denney et al., 2018). The previous study of Filipino immigrants reported that the Filipino women had lower dietary diversity compared to Korean women, where greater diversity was associated with lower prevalence of obesity (Abris et al., 2018).

It is suggested that the general dietary pattern of the Filipino population in the Philippines is low in dietary diversity, while the Filipino immigrants in both Korea and the U.S. may modify their dietary behaviors as part of their acculturation process. Given that Korean women in Korean society have greater variety of food consumption, the migrant population may modify their dietary pattern with adherence to the host society. Moreover, previous literatures in developing countries reported low dietary variety, along with seasonal variation concerning the food availability (Ayenew et al., 2018). The studies also found that women empowerment, including education and social activities, may yield to the improved dietary diversity in both individual and household levels (Mekuria et al., 2017; Sinharoy et al., 2018). Thus, the Filipino immigrants in Korea may possess dietary patterns low in diversity, from the country of origin, while adapting to Korean dietary patterns, generally high in dietary diversity.

On the other hand, dietary diversity may not be an adequate tool to assess the diet quality for the population in more developed countries, concerning the well established food security. Indeed, developed countries generally have less fluctuation of food supply and advanced infrastructure for the food distribution (Food and Agriculture Organization, 1985). Therefore, in order to examine the distinct characteristics of the Filipino immigrants, approaches concerning the dietary patterns of both developing and developed countries may be needed. Given the CVD is a top cause of death in the Philippines, as well as the high prevalence of overweight and obesity among the immigrant women in Korea, it is worth examining both dietary diversity and diet-related chronic inflammation status among the Filipino immigrant population.

Filipino immigrants may go through dietary acculturation as they adapt to new environment, which may potentially modify diet-related health changes, thus the public health attentions to the immigrants are recommended.

2. Dietary diversity for the prevention of chronic disease

Public health strategies have implemented multiple preventive actions towards the upsurge of chronic disease, including dietary recommendations. (Mozaffarian & Ludwig, 2010). It has been suggested that 'food-based' guidelines reflect the synergistic contributions of dietary patterns, food preparation methods, micronutrient compositions, as well as underlying socio-economic factors (Mozaffarian & Ludwig, 2010). Although there is no universal standard of dietary diversity, three major methodological approaches have been identified to build the scoring schemes; 1) count-based scores, measuring different foods or foods groups consumed over a certain period, 2) evenness, assessing the distribution of energy across foods consumed in individual's dietary pattern, and 3) dissimilarity scores, evaluating the differences of food items within a given dietary pattern (de Oliveira Otto et al., 2018). Hence, numerous dietary diversity scores have been developed using both empirical and a priori methods, including dietary diversity scores, and Minimum Dietary Diversity for Women (Women's Dietary Diversity Project Study Group, 2017; Guenther et al., 2013).

Accumulating epidemiological literatures, including cross-sectional and longitudinal studies, examined the association of the DDS with chronic disease risk factors. In South Asian population, greater dietary diversity was associated with lower prevalence of T2DM (Kapoor et al., 2018). Maternal dietary diversity was examined for the association between birth outcomes in Tanzania. Higher DDS was associated with lower risk of small for gestational age (SGA) (Madzorera et al., 2020). A previous study regarding the Filipino immigrant women in Korea found inverse association between dietary diversity and obesity (Abris et al., 2018). A case-control study in China investigated the association between maternal dietary diversity and congenital heart defects (Yang, J. et al., 2020). A U.S. study prospectively examined the association between MDD-W and risk of coronary heart disease among participants of three large cohort studies, and found lower pooled relative risk (RR) of 0.93 (95%CI=0.90-0.96) (Fung et al., 2018).

However, several studies reported inconsistent associations between dietary diversity and chronic disease, while dissimilarity of the dietary patterns due to cultural and social variations has been depicted (de Oliveira Otto et al., 2018). A recent meta-analysis of eight literatures found no significant association between DDS and obesity (Salehi-Abargouei et al., 2016). Another meta-analysis from Iran also reported no significant association between DDS and cancer mortality, while association was found regarding the high adherence to DASH, AHEI, HEI, DQI, aMED and HEI-2010 with decreased risk of cancer mortality (Milajerdi et al., 2018). A U.S. case-control study reported an association between higher DDS and increased odds of obesity (Karimbeiki et al., 2018).

Of note, several approaches were made to identify the food groups with either favorable or unfavorable effects on the health status. A meta-analysis on the association between individual food groups with the risk of T2DM reported an inverse association for fresh vegetables and fruit, whole grains, dairy products, fish, and nuts. On the other hand, the study suggested that red and processed meat, refined grains, sugar-sweetened beverages may increase the risk of T2DM (Basiak-Rasała et al., 2019). The difference in food criteria of each dietary diversity scoring system may yield to the heterogeneous outcomes between DDS and chronic disease. Therefore, development and application of adequate dietary diversity score for the target population may be essential to examine the association with chronic disease.

.

3. Dietary index related inflammation status

Excess nutrients stored in adipocytes trigger obesity-associated inflammation through multiple pathways, including increased oxidative stress and inflammatory cytokines (Ellulu et al., 2017; Kolb et al., 2016). Accumulating evidences indicate pivotal role of dietary factors in the regulation of chronic inflammation (Giugliano et al., 2006). Of note, the chronic inflammation status may yield to underlying etiology linking multiple chronic disease, including dyslipidemia, type 2 diabetes mellitus, cardiovascular disease, and certain cancers (Frostegård, 2013; Il'yasova et al., 2005; Pearson et al., 2003; Pradhan et al., 2001).

Recently, several diet quality scores were developed using the inflammatory biomarkers in order to predict the inflammation status (Barbaresko et al., 2013; Kim et al., 2020; Shivappa et al., 2014). A literature-derived dietary inflammatory index (DII®), the most widely investigated scoring, is calculated from the 45 pro- and anti-inflammatory food parameters concerning the effect on six inflammatory biomarkers; interleukin (IL) 1 beta, IL-4, IL-6, IL-10, tumor necrosis factor (TNF) alpha, and C-reactive protein (Shivappa et al., 2014). The identified food parameters that reduce the inflammation status are alchohol, vitamin B6, ß-carotene, caffeine, eugenol, fiber, folic acid, garlic, ginger, magnesium, mono unsaturated fatty acids, niacin, omega 3 fatty acids, omega 6 fatty acids, onion, poly unsaturated fatty acids, riboflavin, saffron, selenium, thiamin, turmeric, vitamins A, C, D, and E, zinc, green or black tea, flavanols, flavones, flavonols, flavonones, anthocyanidins, isoflavones, pepper, thyme or oregano, and rosemary. The food parameters proposed to enhance the inflammation status were, vitamin B12, carbohydrate, cholesterols, energy, total fat, protein, saturated fat, and *trans* fat.

Multiple literatures examined the association between DII® and morbidity and mortality of chronic disease (Garcia-Arellano et al., 2019; Phillips et al., 2019). The scoring has been investigated in various population world-wide, and found consistently positive association with colorectal cancer (Harmon et al., 2017; Niclis et al., 2018). A Japanese study also reported that the top quartile of participants with pro-inflammatory diet had higher risk of nasopharyngeal cancer compared to participants of the lowest quartile (OR=4.99, 95%CI=1.14-21.79) (Abe et al., 2018). An adjusted pooled RR from the meta-analysis of examining the association between DII® and prostate cancer found RR of 1.74 (95%CI=1.24–2.43), comparing the highest versus lowest categories of DII® (Mohseni et al., 2019). The U.S. study found the association between higher DII® scores and increased risk of all-cause, CVD, all-cancer, and digestive-tract mortality among participants from the third National Health and Nutrition Examination Survey (NHANES III) (Deng et al., 2017). Similar result was reported in the analyses of all-cause mortality and DII® from two European prospective cohort studies, "Seguimiento Universidad de Navarra" (SUN) and "PREvencion con DIeta MEDiterránea" (PREDIMED) (Garcia-Arellano et al., 2019).

Recently, a Korean-specific inflammatory index has been developed from the nutritional epidemiology laboratory, Seoul National University (Kim et al., 2020). It is composed of dietary and lifestyle factors predicting the high sensitivity C-reactive protein (hsCRP) levels, based on the data from Health Examinees (HEXA) Study in Korea. Reduced rank regression was used to determine the pro-inflammatory or anti-inflammatory factors, and scoring schemes according to each sex or combined are available. The study found that the increased levels of increased inflammatory index was positively associated with colorectal adenoma in both men and women.

III. Subjects and Methods

1. The Filipino Women's Diet and Health Study

The Filipino Women's Diet and Health Study (FiLWHEL) is an ongoing prospective cohort study of married Filipino immigrant women in Republic of Korea. The baseline data analyzed in the present analysis was collected between March 2014 and April 2016, originally by the initial members of the FiLWHEL research team from Sookmyung Women's University, and Hanyang University, Korea. A total of 504 baseline participants were recruited from various regions in Korea, encompassing Seoul, Incheon, Daejeon, and rural areas of Gyeonggi and Chung-cheong provinces. The followings were the prerequisites for study enrollment; 1) aged 19 years or over, and 2) ever been married to a Korean man.

A total of 413 participants from the 504 baseline population of Filipino Women's Health Study were included in the current analysis (Figure1), after exclusion of 91 participants due to the following reasons; 1) Participants with incomplete data of 24-h dietary records (n=7), waist circumferences (n=5), body mass index (n=3), or blood sample (n=11), 2) Participants who are currently pregnant (n=19) or breastfeeding (n= 56), and 3) Participants with implausible range of energy intake (> ±3 Standard Deviations) (n=13). Additional exclusions were made regarding the major outcomes; 413 subjects for general obesity (no. of cases = 124), 411 subjects for abdominal obesity (no. of cases = 177), and 405 subjects for dyslipidemia and insulin resistance analysis (no. of cases = 39 for TG, 28 for HDL, 76 for LDL, 109 for TC, 43 for

TG/HDL-C, 141 for HbA1c, 43 for FBG, 57 for insulin levels, and 65 for HOMA-IR).

The FiLWHEL study is designed to investigate the health, social, and dietary factors of the Filipino immigrant women in the Korean society. Detailed description of the FiLWHEL study has been mentioned elsewhere (Abris et al., 2017). Participants' data were collected by questionnaires on health-related and socioeconomic queries, anthropometric measurements, and bio-specimen collection. The respondents completed questionnaires either on-site or by phone interview. Written informed consents were collected from all study participants. The study was approved by the Institutional Review Board of Sookmyung Women's University (SMWU-1311-BR-012).

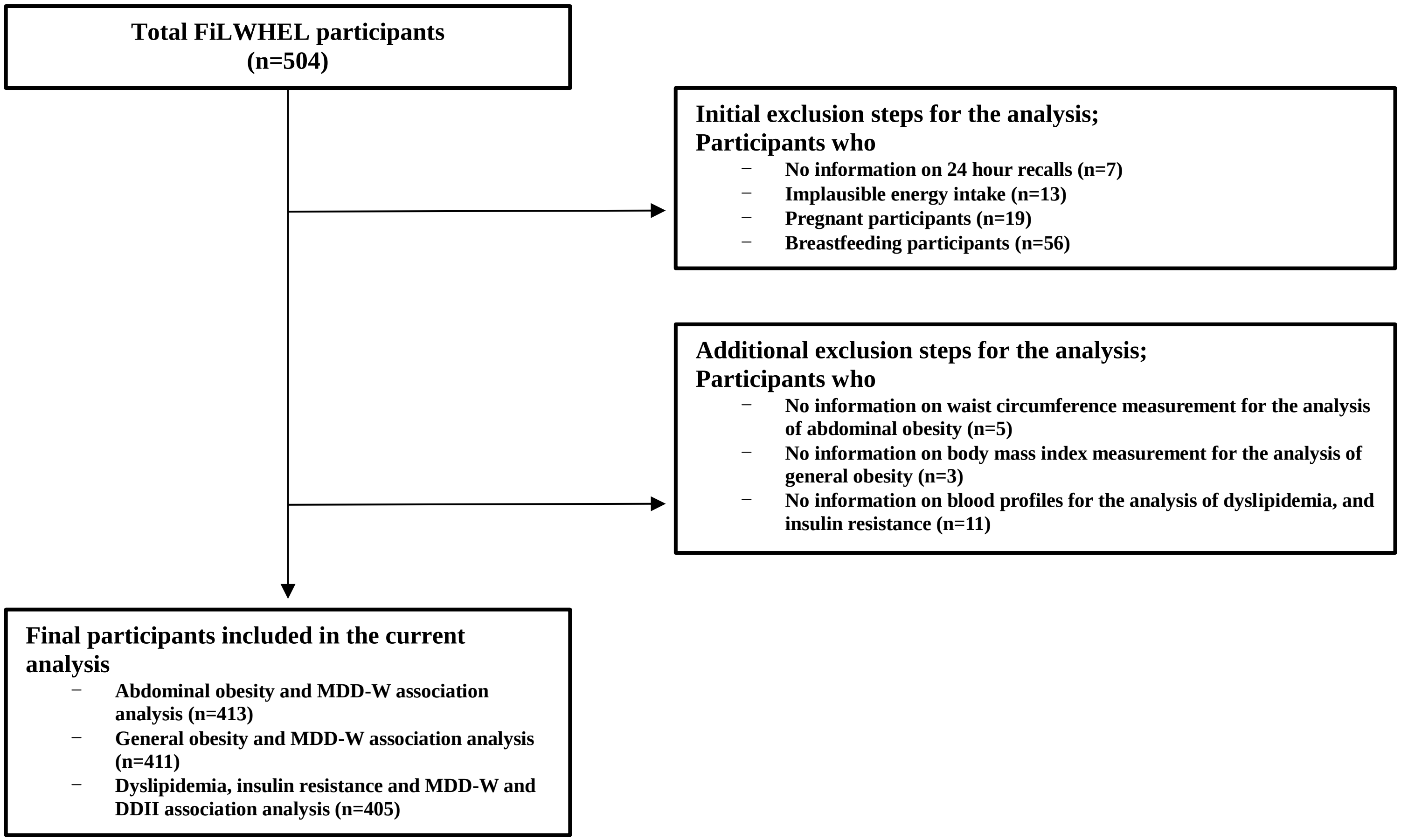

Figure 1. Flow diagram of the study population included in the analysis

2. Dietary assessment and diet quality scores computation

A single day 24-hour recall was administered at the baseline, with standard portion sizes and units provided using food miniatures, photographs, household measures, weight, and volume. The collected dietary data were computed by CAN-pro 4.0 (Computer Aided Analysis Program 4.0 for professionals, Korean Society of Nutrition, Seoul, South Korea). Absent foods from Korean database were supplemented from foreign resources; food composition Tables of the Food and Nutrition Research Institute of the Philippines (1997), Korean Rural Development Administration (2011), and US Department of Agriculture .

The Minimum Dietary Diversity for Women (MDD-W) was developed by the FAO through the Women's Dietary Diversity Project (WDDP) as a proxy indicator for micronutrient adequacy targeting the women of reproductive age in developing countries (2017). MDD-W is composed of 10 food groups, where 1 point is assigned for consuming ≥ 15g (1 serving) of each food group, and 0 point is assigned for less. The selected food groups are; 1) grains, white roots and tubers. 2) pulses (beans, peas and lentils), 3) nuts and seeds, 4) dairy, 5) meat, poultry, and fish, 6) eggs, 7) dark green leafy vegetables, 8) other vitamin A-rich fruits and vegetables, 9) other vegetables, and 10) other fruits. The total score ranges from 0 to 10 points, where 5 points is used as cut-off value to achieve the minimum micronutrient adequacy. In this study, energy adjusted MDD-W score was calculated per 1000 kcal of food consumption considering the effect of total energy intake. The energy adjusted MDD-W score was computed according to the original criteria. The Data Derived

Inflammatory Index (DDII) based on the hsCRP levels was developed by the nutritional epidemiology laboratory of Seoul National University (Kim et al., 2020). DDII is a Korean-specific predicted hsCRP score derived from dietary, lifestyle, and health-related data of 23,330 participants in the HEXA study (Kim & Han, 2017). Combined and sex-specific indices are available, and the predicted hsCRP score is calculated as a sum of multiplying beta coefficient by corresponding factor. We computed the DDII score using women-specific criteria; 1) beef, 2) processed fish, 3) age, 4) BMI, 5) smoking status (never, past, current), 6) menopausal status (premenopausal, perimenopausal, postmenopausal), 7) soup and stew with soybean paste/soybean paste, 8) sweet bread, 9) fish, and 10) education level (elementary school or below, middle school, high school, university or above). The higher DDII score indicates increased hsCRP levels and more pro-inflammatory status.

Table 1. Food components of the minimum dietary diversity for women

	Ten food groups	≥ 15g consumption
1	Grains, white roots and tubers, and plantains	Yes=1 No=0
2	Pulses (beans, peas and lentils)	Yes=1 No=0
3	Nuts and seeds	Yes=1 No=0
4	Dairy	Yes=1 No=0
5	Meat, poultry and fish	Yes=1 No=0
6	Eggs	Yes=1 No=0
7	Dark green leafy vegetables	Yes=1 No=0
8	Other vitamin A-rich fruits and vegetables	Yes=1 No=0
9	Other vegetables	Yes=1 No=0
10	Other fruits	Yes=1 No=0

Development of a Dichotomous Indicator for Population-Level Assessment of Dietary Diversity in Women of Reproductive Age. Curr Dev Nutr, 2017. 1(12).

Table 2. Food and lifestyle components of the data derived inflammatory index

	Women-specific variables	Beta coefficient
1	Beef (g/d)	0.0009
2	Processed fish (g/d)	0.0028
3	Soup and stew with soybean paste/soybean paste (g/d)	−0.0033
4	Sweet bread (g/d)	−0.0010
5	Fish (g/d)	−0.0007
6	Age (y)	0.0140
7	Body mass index (1kg/m^2)	0.0782
8	Smoking status	
	Never	reference
	Past smoker	0.1514
	Current smoker	0.1360
9	Menopausal status	
	Premenopausal	reference
	Perimenopausal	0.0587
	Postmenopausal	0.1576
10	Education level	
	Elementary school or below	reference
	Middle school	−0.0659
	High school	−0.0256
	University or above	0.0247

The association between predicted inflammatory status and colorectal adenoma. Sci Rep, 2020. 10(1): p. 2433.

3. Anthropometric measurements, blood sampling and other variables

Anthropometric data including height, and waist circumferences were directly collected on-site by a tape measure. Weight was measured using a weighing scale. BMI was calculated as ratio of weight (kg) to square of height (m^2) measurements. Blood samples were collected after a minimum of 8-hour fasting. After a professional phlebotomist drew blood under the supervision of a medical doctor, the sample was immediately centrifuged and refrigerated until the analysis within 24 hours.

The serum triglycerides (TG), total cholesterols (TC), fasting blood glucose (FBG), and high density lipoprotein cholesterols (HDL-C) levels were analyzed via Cobas 8000 C702-I. Glycated hemoglobin (HbA1c) levels were measured using Tosoh G8 by High Performance Liquid Chromatography (HPLC) principles. The intra-assay coefficient of variation (CV) of each biomarker was; 1.49-2.99% for total cholesterols, 1.48-2.33% for blood triglycerides, 0.98 – 2.11% for high density lipoprotein cholesterols; and 1.21-2.79% for fasting blood glucose. Serum low density lipoprotein cholesterols (LDL-C) levels were calculated indirectly through the Friedewald formula as follows; LDL-C = total cholesterols – high density lipoprotein cholesterols – (triglycerides/5) (Friedewald et al., 1972). The original homeostatic model assessment (HOMA) model of Matthews et al.(Matthews et al., 1985) was used to calculate homeostasis model assessment of insulin resistance

(HOMA-IR) estimates from the fasting blood glucose and insulin measurements; HOMA-IR = fasting insulin (μIU/ml) x fasting glucose (mmol/ml)/22.5.

For the obesity classification, two determinants were used with cut-off values according to joint effort of the regional office for the Western Pacific of the World Health Organization, the International Association for the Study of Obesity, and the International Obesity task force (World Health Organization, 2000) ; waist circumference ≥ 80 cm and BMI ≥ 25 kg/m^2. Lipid parameters from the 2018 Korean Guidelines for the Management of Dyslipidemia (Rhee et al., 2019) were used for the dyslipidemia classification, and levels above the normal or optimal range were considered as valid cut-off values; 1) TC ≥200 mg/dL, 2) LDL-C ≥130 mg/dL, 3) TG ≥150 mg/dL, or 4) HDL-C <40 mg/dL. The prediabetes cut-offs from the 2018 recommendations of the American Diabetes Association (ADA) was used for the analysis of insulin resistance (American Diabetes Association, 2018); HbA1c ≥5.7% or FBG ≥100 mg/dL. Other indicators related to dyslipidemia and insulin resistances such as triglycerides to high density lipoprotein cholesterols (TG/HDL-C) ratios, HOMA-IR, were also examined (Gaziano et al., 1997; Matthews et al., 1985).

Information on age (years), education level (elementary school, high school, associate/vocational, college/university, graduate school), current smoking status (no, yes), smoking cohabitants (no, yes), sleep behaviors, physical activity (vigorous, moderate, walk, sit), parity, breastfeeding (months), menopausal status, place of residence (Seoul, Incheon, Daejon, Kyeonggi, Cheongnam), migrant year, and dietary behavior change during the past year (no, yes) was obtained from the structured questionnaires. Energy (kcal), carbohydrate (g), protein (g), and fat (g) intake was calculated from the aforementioned 24-hour recall data. The overall quality of life (QOL) was assessed using World Health Organization Quality of Life-BREF (WHOQOL-BREF). Coffee intake per day was calculated by summing up all the coffee types after multiplying serving sizes by frequencies of consumption during the previous year. Current alcohol consumption was estimated by collective intake of ethanol intake from soju, beer, liquor, wine, rice wine, and refined rice wine of during the past year. The ethanol intake as grams per day was calculated using the percentage of alcohol in liquor, the mass of ethanol in 1liter of liquor, and the serving size.

4. Statistical analyses

For the descriptive analysis, the participants were ranked into tertiles of MDD-W and quintiles of DDII scores. Frequencies for the categorical variables and means with standard deviations for the continuous variables were calculated. Multiple logistic regression model was used to determine odds ratios (ORs) with 95% confidence intervals (CIs) for the association between diet quality scores and obesity and components of dyslipidemia. For this analysis, MDD-W was categorized into tertiles, while DDII was categorized into quintiles then re-categorized into three groups by assembling the 3 lowest categories to assure substantial number of cases.

For each diet quality score, model 1 was adjusted for age (years, continuous) and energy intake (kcal, continuous). Multivariable model for the MDD-W and obesity analyses was additionally adjusted for education level (high school or less, associate/vocational, college or above), employment status (yes, no), dietary behavior changes (yes, no), breastfeeding length (months, continuous), region (urban, rural), smoking cohabitant (yes, no), and alcohol intake (yes, no). The second multivariable model for the analyses of MDD-W with dyslipidemia and insulin resistance was further adjusted for BMI (<20, 20-<23, 23-<25, ≥25 kg/m^2) in addition to the aforementioned variables. Multivariable model of DDII was additionally adjusted for education level (high school or below, associate/vocational, college or above), sleep duration (<5,5-6,7-8,>8 hours), region (city, rural), vigorous activity (yes, no), dietary behavior changes (yes, no), employment status (yes, no), breastfeeding lengths (months, continuous), QOL (continuous), alcohol intake (yes, no), and coffee intake (≤1, 1-3, >3 cups/day). Multiple logistic regression was used for the stratified analysis to assess possible effect modification factor of the association between diet quality score and outcome variables. Age (<35, ≥35 years), BMI (<25, ≥25 kg/m^2), and length of residence in Korea (≤8, >8 years) were examined.

To evaluate whether DDII predicted hsCRP levels in the study population, a general linear model (GLM) analysis for least-squares means (LS-means) with 95%CIs was used to calculate the mean levels of hsCRP according to the quintiles of DDII. To improve the normality, logarithmical transformation was applied to hsCRP levels. All statistical analyses were conducted via SAS version 9.4 (SAS Institute Inc., Cary,NC, USA); all tests were two-sided, and the significance level was set at p values less than 0.05.

IV. Results

1. General characteristics of the study participants

A total of 413 participants from the 504 baseline population of Filipino Women's Health Study were included in the analysis, with variation regarding the major outcomes; 413 subjects for general obesity (no. of cases = 124), 411 subjects for abdominal obesity (no. of cases = 177), and 405 subjects for dyslipidemia and insulin resistance analysis (no. of cases = 39 for TG, 28 for HDL, 76 for LDL, 109 for TC, 43 for TG/HDL-C, 141 for HbA1c, 43 for FBG, 57 for insulin levels, and 65 for HOMA-IR). The baseline characteristics according to the tertiles of MDD-W are outlined in Table 3, and the characteristics according to the quintiles of DDII are shown in Table 4.

MDD-W scores did not vary across DDII scores, nor did DDII scores according to MDD-W scores. The individuals with greater MDD-W scores tended to have higher % energy from carbohydrate intake but lower % energy from fat intake compared to those with lower MDD-W scores. The participants with higher DDII scores tended to be older age, had higher BMI, higher % energy from carbohydrate intake but lower % energy from fat intake, and higher fasting blood glucose levels compared to those with lower DDII scores. The proportions of college graduates or above were highest in the top categories of MDD-W and DDII scores. Engagement in vigorous activity was higher among individuals with the highest MDD-W scores than the participants with lowest scores. The proportions of current alcohol consumers were the lowest in the top categories of MDD-W and DDII scores, while the proportions of participants who lived more than 8 years in Korea were the highest in the top categories of both scores.

Table 3. Baseline characteristics of participants in the FiLWHEL study according to the MDD-W scores

	MDD-W (n=413)		
	≤4	5	≥6
Total population number	179	95	139
DDII	2.34 (0.37)	2.38 (0.37)	2.32 (0.32)
Age, years	34.45 (8.06)	35.27 (8.17)	36.26 (7.69)
Body mass index, kg/m^2	23.71 (4.18)	24.17 (3.99)	23.22 (3.32)
Energy intake, kcal/day	1727.32 (702.23)	1712.81 (621.34)	1787.20 (560.68)
Carbohydrate intake, g/day	239.03 (105.19)	235.03 (96.54)	262.41 (90.89)
Protein intake, g/day	66.03 (35.08)	73.28 (29.31)	72.62 (28.86)
Fat intake, g/day	54.72 (32.28)	52.73 (31.17)	50.69 (25.96)
% Carbohydrate intake	56.55 (12.48)	55.43 (10.89)	58.71 (9.88)
% Protein intake	15.32 (4.85)	17.35 (4.32)	16.17 (4.00)
% Fat intake	28.12 (10.24)	27.22 (9.60)	25.12 (8.67)
Fasting Blood Glucose, mg/dL	88.47 (9.61)	88.79 (13.74)	88.52 (13.14)
Education level			
Associate Vocational or less	81 (45.25)	37 (38.95)	57 (41.01)
College graduate or over	98 (54.75)	58 (61.05)	82 (58.99)
Vigorous activity[1)]			
No	150 (83.80)	80 (84.21)	107 (76.98)
Yes	29 (16.20)	15 (15.79)	32 (23.02)
Alcohol intake			
No	62 (34.64)	32 (33.68)	54 (38.85)
Yes	117 (65.36)	63 (66.32)	85 (61.15)
Length of residence, years[2)]			
≤8	106 (59.22)	51 (53.68)	73 (52.52)
>8	73 (40.78)	44 (46.32)	66 (47.48)

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; DDII, Data Derived Inflammatory Index; FiLWHEL, Filipino Women's Diet and Health Study

1) Participating in a vigorous activity each week.

2) Years of residence in Republic of Korea.

Continuous variables are reported as mean ± standard deviation (SD) and categorical variables are reported as No. (%)

Table 4. Baseline characteristics of participants in the FiLWHEL study according to the DDII scores

	DDII (n=405)		
	Q1	Q3	Q5
Total population number	81	81	81
MDD-W	4.88 (1.58)	4.91 (1.57)	4.75 (1.49)
Age, years	29.57 (5.49)	34.72 (7.06)	40.56 (8.21)
Body mass index, kg/m^2	19.51 (2.73)	23.49 (1.72)	28.86 (3.68)
Energy intake, kcal/day	1749.34 (625.71)	1698.68 (601.85)	1793.88 (600.14)
Carbohydrate intake, g/day	244.52 (91.09)	229.81 (98.17)	261.66 (99.13)
Protein intake, g/day	66.51 (29.07)	72.45 (30.46)	71.60 (32.27)
Fat intake, g/day	55.71 (32.59)	53.35 (29.21)	50.43 (26.63)
% Carbohydrate intake	56.83 (10.93)	54.46 (12.98)	58.88 (10.40)
% Protein intake	15.28 (4.23)	17.21 (4.35)	16.04 (4.97)
% Fat intake	27.88 (9.57)	28.33 (10.74)	25.08 (8.97)
Fasting Blood Glucose, mg/dL	84.47 (7.06)	88.20 (12.21)	93.53 (14.03)
Education level			
Associate Vocational or less	52 (64.20)	41 (50.62)	30 (37.04)
College graduate or over	29 (35.80)	40 (49.38)	51 (62.96)
Vigorous activity[1)]			
No	65 (80.25)	62 (76.54)	66 (81.48)
Yes	16 (19.75)	19 (23.46)	15 (18.52)
Alcohol intake			
No	28 (34.57)	32 (39.51)	34 (41.98)
Yes	53 (65.43)	49 (60.49)	47 (58.02)
Length of residence, years[2)]			
≤8	63 (77.78)	50 (61.73)	25 (30.86)
>8	18 (22.22)	31 (38.27)	56 (69.14)

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; DDII, Data Derived Inflammatory Index; FiLWHEL, Filipino Women's Diet and Health Study

1) Participating in a vigorous activity each week.

2) Years of residence in Republic of Korea.

Continuous variables are reported as mean ± standard deviation (SD) and categorical variables are reported as No. (%)

2. Association between DDII and circulating levels of hsCRP

The association between DDII and circulating levels of hsCRP is presented in Table 5. A statistically significant linear trend was observed among increased hsCRP levels according to the quintiles of DDII in the age- and energy- adjusted model; LS-Means (95%CIs) were 0.79 (0.61-1.02) for quintile 1, 0.96 (0.76-1.22) for quintile 2, 1.02 (0.82-1.28) for quintile 3, 1.14 (0.90-1.45) for quintile 4, and 1.65 (1.30-2.09) for quintile 5 (p for trend<0.01). The results suggest that DDII could be implemented in Filipino immigrants in Korean society to explain the circulating levels of hsCRP.

Table 5. Least squares means (LS-Means) and 95% confidence intervals (CIs) of high sensitivity C- reactive protein according to the DDII scores

(n=371)	Q1	Q2	Q3	Q4	Q5	*p* for trend
	LS-Means (95%CI)					
High sensitivity C- reactive protein						
Age and energy adjusted	0.79 (0.61-1.02)	0.96 (0.76-1.22)	1.02 (0.82-1.28)	1.14 (0.90-1.45)	1.65 (1.30-2.09)	<0.01

Adjusted for age (years, continuous) and energy intake (kcal, continuous)

3. Association between MDD-W and prevalence of obesity, dyslipidemia, and insulin resistance

The association between the tertiles of MDD-W and obesity, dyslipidemia, and insulin resistance markers are presented in Table 6 – Table 10. A statistically significant association was observed between wider dietary variety and lower prevalence of central obesity, while higher prevalence of dyslipidemia. The multivariable adjusted ORs (95%CIs) of the top vs the bottom tertiles of MDD-W were, 0.58 (0.36-0.94) for central obesity, 2.68 (1.19-6.03) for hypertriglyceridemia, 2.13 (1.22-3.71) for hypercholesterolemia, and 3.42 (1.54-7.59) for high TG/HDL-C ratio (*p* for trend=0.03, 0.02, 0.01, and <0.01, respectively). A suggestive inverse trend was found between MDD-W and lower prevalence of general obesity but an association nor trend was not statistically significant. No statistically significant association was found between MDD-W scores and biomarkers of insulin resistance; HbA1c, FBG, Insulin, and HOMA-IR.

Table 6. Odds ratios (ORs) and 95% confidence intervals (CIs) of BMI and waist circumferences according to the MDD-W scores

	MDD-W			*p* for trend
	≤4	**5**	**≥6**	
Body Mass Index (≥25kg/m^2)				
Case/Total number	57/179	32/95	35/139	
Model 1	1	1.06 (0.62-1.81)	0.67 (0.41-1.11)	0.14
Model 2	1	1.05 (0.61-1.80)	0.65 (0.39-1.08)	0.11
Waist Circumferences (≥80cm)				
Case/Total number	82/176	43/96	52/139	
Model 1	1	0.88 (0.53-1.47)	0.60 (0.37-0.96)	0.04
Model 2	1	0.89 (0.53-1.50)	0.58 (0.36-0.94)	0.03

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; BMI, Body Mass Index

Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous)

Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), employment status (yes, no), dietary behavior changes (yes, no), breastfeeding length (months, continuous), region (urban, rural), smoking cohabitant (yes, no), and alcohol intake (yes, no)

Table 7. Odds ratios (ORs) and 95% confidence intervals (CIs) of TC, HDL-C, and LDL-C according to the MDD-W scores

	MDD-W			*p* for trend
	≤4	5	≥6	
Total Cholesterols (<40 mg/dL)				
Case/Total number	40/177	23/96	46/132	
Model 1	1	1.05 (0.57-1.91)	1.75 (1.04-2.92)	0.04
Model 2	1	1.04 (0.56-1.94)	1.87 (1.10-3.19)	0.02
Model 3	1	1.01 (0.53-1.91)	2.13 (1.22-3.71)	<0.01
High Density Lipoprotein Cholesterols (<40 mg/dL)				
Case/Total number	11/177	3/96	14/132	
Model 1	1	0.49 (0.13-1.80)	1.86 (0.81-4.27)	0.15
Model 2	1	0.47 (0.13-1.77)	1.90 (0.81-4.46)	0.15
Model 3	1	0.45 (0.12-1.71)	2.26 (0.94-5.45)	0.08
Low Density Lipoprotein Cholesterols (≥130 mg/dL)				
Case/Total number	32/177	16/96	28/132	
Model 1	1	0.87 (0.45-1.71)	1.15 (0.64-2.04)	0.67
Model 2	1	0.86 (0.42-1.75)	1.34 (0.73-2.47)	0.38
Model 3	1	0.83 (0.40-1.74)	1.57 (0.83-2.96)	0.20

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; TC, Total Cholesterols; HDL-C, High Density Lipoprotein Cholesterols; LDL-C, Low Density Lipoprotein Cholesterols; BMI, Body Mass Index

Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous)

Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), employment status (yes, no), dietary behavior changes (yes, no), breastfeeding length (months, continuous), region (urban, rural), smoking cohabitant (yes, no), and alcohol intake (yes, no).

Model 3 additionally adjusted for BMI (<20, 20-<23, 23-<25, ≥25 kg/m^2)

Table 8. Odds ratios (ORs) and 95% confidence intervals (CIs) of TG and TG/HDL-C according to the MDD-W scores

	MDD-W			*p* for trend
	≤4	**5**	**≥6**	
Triglycerides (≥150 mg/dL)				
Case/Total number	13/177	7/96	19/132	
Model 1	1	0.96 (0.37-2.52)	2.04 (0.96-4.32)	0.06
Model 2	1	0.85 (0.32-2.28)	2.16 (1.00-4.70)	0.05
Model 3	1	0.85 (0.31-2.34)	2.68 (1.19-6.03)	0.02
TG/HDL-C (≥3)				
Case/Total number	13/177	8/96	22/132	
Model 1	1	1.14 (0.45-2.86)	2.54 (1.22-5.29)	0.01
Model 2	1	1.08 (0.42-2.78)	2.57 (1.21-5.43)	0.01
Model 3	1	1.12 (0.43-2.97)	3.42 (1.54-7.59)	<0.01

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; TG, Triglycerides; TG/HDL-C, Triglycerides to High Density Lipoprotein Cholesterols ratio; BMI, Body Mass Index

Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous)

Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), employment status (yes, no), dietary behavior changes (yes, no), breastfeeding length (months, continuous), region (urban, rural), smoking cohabitant (yes, no), and alcohol intake (yes, no).

Model 3 additionally adjusted for BMI (<20, 20-<23, 23-<25, ≥25 kg/m^2)

Table 9. Odds ratios (ORs) and 95% confidence intervals (CIs) of HbA1c and FBG according to the MDD-W scores

	MDD-W			*p* for trend
	≤4	**5**	**≥6**	
HbA1c (≥5.7 %)				
Case/Total number	58/177	37/96	46/132	
Model 1	1	1.27 (0.74-2.18)	0.99 (0.60-1.63)	0.98
Model 2	1	1.22 (0.70-2.13)	1.01 (0.61-1.69)	0.92
Model 3	1	1.18 (0.67-2.09)	1.10 (0.65-1.85)	0.70
Fasting blood glucose (≥100 mg/dL)				
Case/Total number	19/177	11/96	13/132	
Model 1	1	1.02 (0.45-2.31)	0.81 (0.38-1.74)	0.60
Model 2	1	1.03 (0.44-2.39)	0.79 (0.36-1.73)	0.56
Model 3	1	0.97 (0.41-2.28)	0.86 (0.39-1.92)	0.72

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; HbA1c, Glycated hemoglobin; FBG, Fasting Blood Glucose; BMI, Body mass index
Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous)
Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), employment status (yes, no), dietary behavior changes (yes, no), breastfeeding length (months, continuous), region (urban, rural), smoking cohabitant (yes, no), and alcohol intake (yes, no).
Model 3 additionally adjusted for BMI (<20, 20-<23, 23-<25, ≥25 kg/m^2)

Table 10. Odds ratios (ORs) and 95% confidence intervals (CIs) of insulin and HOMA-IR according to the MDD-W scores

	MDD-W			*p* for trend
	≤4	5	≥6	
Insulin (≥ 15 mg/dL)				
Case/Total number	23/177	13/96	21/132	
Model 1	1	1.09 (0.52-2.28)	1.38 (0.72-2.64)	0.34
Model 2	1	1.15 (0.55-2.44)	1.40 (0.72-2.72)	0.32
Model 3	1	1.16 (0.53-2.53)	1.71 (0.84-3.49)	0.15
HOMA-IR (≥3.16)				
Case/Total number	27/177	15/96	23/132	
Model 1	1	1.04 (0.52-2.07)	1.19 (0.64-2.19)	0.59
Model 2	1	1.05 (0.52-2.12)	1.13 (0.61-2.10)	0.70
Model 3	1	1.05 (0.50-2.18)	1.37 (0.70-2.66)	0.37

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; HOMA-IR, Homeostasis Model Assessment of Insulin Resistance; BMI, Body mass index

Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous)

Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), employment status (yes, no), dietary behavior changes (yes, no), breastfeeding length (months, continuous), region (urban, rural), smoking cohabitant (yes, no), and alcohol intake (yes, no).

Model 3 additionally adjusted for BMI (<20, 20-<23, 23-<25, ≥25 kg/m^2)

4. Association between DDII and prevalence of dyslipidemia and insulin resistance

The association between the three categories of DDII and dyslipidemia, and insulin resistance markers are presented in Table 11 - Table 14. The increased DDII scores were associated with elevated prevalence of dyslipidemia and insulin resistance. The multivariable adjusted ORs (95%CIs) of the highest vs the lowest categories of DDII were 7.30 (2.76-19.36) for triglycerides, 4.28 (2.05-8.93) for LDL-cholesterols, 3.48 (1.85-6.54) for total cholesterols, 7.24 (2.79-18.76) for abnormal TG/HDL-C ratio, 3.71 (2.01-6.84) for HbA1c, 2.63 (1.09-6.33) for fasting blood glucose levels, 10.71 (4.50-25.48) for insulin levels, and 10.31 (4.64-22.93) for HOMA-IR (*p* for trend <0.01 for all, except 0.04 for fasting blood glucose).

Table 11. Odds ratios (ORs) and 95% confidence intervals (CIs) of TC, HDL-C, and LDL-C according to the DDII scores

	DDII			*p* for trend
	Q1-3	Q4	Q5	
Total Cholesterols (≥200 mg/dL)				
Case/Total number	43/247	26/77	40/81	
Model 1	1	2.02 (1.10-3.68)	3.57 (1.96-6.49)	<0.01
Model 2	1	2.08 (1.11-3.92)	3.48 (1.85-6.54)	<0.01
High Density Lipoprotein Cholesterols (<40 mg/dL)				
Case/Total number	14/247	6/77	8/81	
Model 1	1	1.67 (0.59-4.71)	2.38 (0.86-6.53)	0.09
Model 2	1	2.06 (0.68-6.26)	2.34 (0.80-6.84)	0.10
Low Density Lipoprotein Cholesterols (≥130 mg/dL)				
Case/Total number	27/247	18/77	31/81	
Model 1	1	2.16 (1.08-4.32)	4.14 (2.13-8.02)	<0.01
Model 2	1	2.28 (1.08-4.80)	4.28 (2.05-8.93)	<0.01

Abbreviations: DDII, Data Derived Inflammatory Index; TC, Total Cholesterols; HDL-C, High Density Lipoprotein Cholesterols; LDL-C, Low Density Lipoprotein Cholesterols; QOL, Quality of Life

Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous).

Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding length (months, continuous), QOL (continuous), dietary behavior change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day).

Table 12. Odds ratios (ORs) and 95% confidence intervals (CIs) of TG and TG/HDL-C according to the DDII scores

	DDII			*p* for trend
	Q1-3	Q4	Q5	
Triglycerides (≥150 mg/dL)				
Case/Total number	12/247	8/77	19/81	
Model 1	1	2.21 (0.84-5.84)	5.78 (2.44-13.70)	<0.01
Model 2	1	2.41 (0.84-6.89)	7.30 (2.76-19.36)	<0.01
TG/HDL-C (≥3)				
Case/Total number	15/247	10/77	18/81	
Model 1	1	2.58 (1.07-6.24)	5.27 (2.29-12.11)	<0.01
Model 2	1	3.32 (1.25-8.82)	7.24 (2.79-18.76)	<0.01

Abbreviations: DDII, Data Derived Inflammatory Index; TG, Triglycerides; TG/HDL-C, Triglycerides to High Density Lipoprotein Cholesterols ratio; QOL, Quality of Life

Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous).

Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding length (months, continuous), QOL (continuous), dietary behavior change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day).

Table 13. Odds ratios (ORs) and 95% confidence intervals (CIs) of HbA1c and FBG according to the DDII scores

	DDII			*p* for trend
	Q1-3	**Q4**	**Q5**	
HbA1c (≥5.7 %)				
Case/Total number	61/247	31/77	49/81	
Model 1	1	1.54 (0.87-2.74)	3.19 (1.79-5.70)	<0.01
Model 2	1	1.94 (1.06-3.57)	3.71 (2.01-6.84)	<0.01
Fasting blood glucose (≥100 mg/dL)				
Case/Total number	15/247	9/77	19/81	
Model 1	1	1.35 (0.54-3.39)	2.71 (1.19-6.16)	0.02
Model 2	1	1.13 (0.42-3.02)	2.63 (1.09-6.33)	0.04

Abbreviations: DDII, Data Derived Inflammatory Index; HbA1c, Hemoglobin A1c; FBG, Fasting Blood Glucose; QOL, Quality of Life

Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous).

Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding length (months, continuous), QOL (continuous), dietary behavior change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day).

Table 14. Odds ratios (ORs) and 95% confidence intervals (CIs) of insulin and HOMA-IR according to the DDII scores

	DDII			*p* for trend
	Q1-3	Q4	Q5	
Insulin (≥ 15 mg/dL)				
Case/Total number	21/247	16/77	20/81	
Model 1	1	5.17 (2.37-11.29)	8.70 (3.88-19.48)	<0.01
Model 2	1	5.53 (2.42-12.62)	10.71 (4.50-25.48)	<0.01
HOMA-IR (≥3.16)				
Case/Total number	23/247	15/77	27/81	
Model 1	1	3.33 (1.57-7.06)	8.38 (4.01-17.52)	<0.01
Model 2	1	3.55 (1.60-7.88)	10.31 (4.64-22.93)	<0.01

Abbreviations: DDII, Data Derived Inflammatory Index; HOMA-IR, Homeostasis Model Assessment of Insulin Resistance; QOL, Quality of Life
Model 1 adjusted for age (years, continuous) and energy intake (kcal, continuous).
Model 2 additionally adjusted for education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding length (months, continuous), QOL (continuous), dietary behavior change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day).

5. Subgroup analysis on the association between MDD-W and abdominal obesity

Table 15 presents ORs and 95%CIs for the prevalence of abdominal obesity according to the potential effect modification factor. The inverse association between MDD-W and prevalence of abdominal obesity persisted in the subgroup analyses according to age, and length of residence in Korea. When stratified by age, ORs (95%CIs) comparing the lowest category of MDD-W to the highest category of MDD-W was 0.59 (0.28-1.23) in <35 years, 0.57 (0.30-1.12) in ≥35 years. When stratified by the years of residence, ORs (95%CIs) comparing the lowest category of MDD-W to the highest category of MDD-W was 0.69 (0.35-1.37) in ≤8 years of residence, 0.46 (0.22-0.95) in >8 years of residence. However, the association between MDD-W scores and abdominal obesity was not modified by age or length of residence in Korea (*p* for interaction=0.84, and 0.53, respectively).

Table 15. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of abdominal obesity according to the MDD-W scores stratified by lifestyle factors

	MDD-W			*p* for interaction
	≤4	5	≥6	
Age, years				0.84
Case/Total number	(35/90)	(16/47)	(18/64)	
<35	1	0.78 (0.36-1.68)	0.59 (0.28-1.23)	
Case/Total number	(47/86)	(27/49)	(34/75)	
≥35	1	1.04 (0.50-2.20)	0.57 (0.30-1.12)	
Length of residence, years				0.53
Case/Total number	(40/104)	(17/52)	(25/74)	
≤8	1	0.74 (0.36-1.53)	0.69 (0.35-1.37)	
Case/Total number	(42/72)	(26/44)	(27/65)	
>8	1	1.06 (0.47-2.42)	0.46 (0.22-0.95)	

Abbreviations: MDD-W, Minimum Dietary Diversity for Women

Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), employment status (yes, no), dietary pattern change (yes, no), breastfeeding duration (months, continuous), region (urban, rural), smoking cohabitant (yes, no), and alcohol intake (yes, no).

6. Subgroup analysis on the association between DDII and dyslipidemia and insulin resistance

Whether the association between DDII and the prevalence of dyslipidemia and insulin resistance was modified by age, BMI, or length of stay in Korea was examined. Table 16 presents ORs and 95%CIs for total cholesterols according to the potential effect modification factor. The association did not vary by age, BMI or length of residence in Korea (*p* for interaction=0.10, 0.37, and 0.23, respectively). Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 4.52 (1.93-10.59) for <35 years, and 1.65 (0.83-3.31) for ≥35 years when stratified by age. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 1.42 (0.64-3.18) for ≤25kg/m^2, and 4.48 (0.77-26.13) for >25kg/m^2 when stratified by BMI. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 3.62 (1.66-7.92) for ≤8 years, and 1.91 (0.88-4.14) for >8 years when stratified by the length of residence in Korea.

Table 17 presents ORs and 95%CIs for low density lipoprotein cholesterols according to the potential effect modification factor. In the stratified analysis of DDII, more pronounced association was found for LDL-cholesterols among the participants with more than 8 years of residence in Korea compared to the more recent immigrants. Compared to the lowest category of DDII, ORs (95%CIs) with the highest category of DDII were 5.77 (2.24-14.87) in ≤8 years of residence, 1.89 (0.76-4.7) in >8 years of residence (*p* for interaction=0.04). However, the association did not differ by age or BMI (*p* for interaction=0.07, and 0.39, respectively). The

ORs (95%CIs) comparing the lowest category of DDII to the highest category of DDII were 8.11 (2.71-24.34) in <35 years, and 1.87 (0.84-4.18) in ≥35 years when stratified by age. The ORs (95%CIs) comparing the lowest category of DDII to the highest category of DDII were 1.19 (0.43-3.28) in ≤25kg/m^2, 4.74 (0.73-30.96) in >25kg/m^2 when stratified by BMI.

Table 18 presents ORs and 95%CIs for triglycerides according to the potential effect modification factor. The association did not modified by age, BMI or length of residence in Korea (*p* for interaction=0.12, 0.51, and 0.06, respectively). Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 2.35 (0.54-10.28) for <35 years, and 10.49 (2.49-44.11) for ≥35 years when stratified by age. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 7.17 (1.62-31.64) for ≤25kg/m^2, and 0.88 (0.10-7.71) for >25kg/m^2 when stratified by BMI. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 2.03 (0.57-7.22) for ≤8 years, and 16.99 (2.89-99.77) for >8 years when stratified by the length of residence in Korea.

Table 19 presents ORs and 95%CIs for TG/HDL-C according to the dichotomous categories. The association did not differ by age, BMI or length of residence in Korea (*p* for interaction=0.25, 0.40, and 0.11, respectively). Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 3.76 (1.06-13.34) for <35 years, and 8.91 (2.12-37.49) for ≥35 years when stratified by age. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 4.69 (1.11-19.82) for ≤25kg/m^2, and 1.00 (0.18-5.78) for >25kg/m^2 when stratified by BMI. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 3.25 (1.03-10.24) for ≤8 years, and 12.35 (2.29-66.58) for >8 years when stratified by the length of residence in Korea.

Table 20 shows ORs and 95%CIs for HbA1c according to the possible effect modification factor. The association did not vary by age, BMI or length of residence in Korea (*p* for interaction=0.82, 0.57, and 0.70, respectively). Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 2.67 (1.18-6.04) for <35 years, and 3.03 (1.49-6.19) for ≥35 years when stratified by age. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 1.76 (0.84-3.66) for ≤25kg/m^2, and 3.36 (0.67-16.82) for >25kg/m^2 when stratified by BMI. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 2.16 (1.03-4.55) for ≤8 years, and 3.59 (1.62-7.96) for >8 years when stratified by the length of residence in Korea.

Table 21 presents ORs and 95%CIs for fasting blood glucose according to the dichotomous categories. The association was not modified by age, BMI or length of residence in Korea (*p* for interaction=0.97, 0.20, and 0.99, respectively). Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 2.27 (0.33-15.79) for <35 years, and 2.31 (0.92-5.82) for ≥35 years when stratified by age. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 1.79 (0.56-5.79) for ≤25kg/m^2, and 0.17 (0.02-1.63) for >25kg/m^2 when stratified by BMI. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 2.02 (0.48-8.54) for ≤8 years, and 2.63 (0.89-7.73) for >8 years when stratified by the length of residence in Korea.

Table 22 presents ORs and 95%CIs for insulin according to the dichotomous categories. The association did not differ by age, BMI or length of residence in Korea (*p* for interaction=0.86, 0.77, and 0.57, respectively). Compared to the bottom category of DDII, ORs (95%CIs) for the top category of DDII were 6.87 (2.67-17.71) for <35 years, and 9.20 (2.55-33.29) for ≥35 years when stratified by age. Compared to the bottom category of DDII, ORs (95%CIs) for the top category of DDII were 3.65 (1.10-12.12) for ≤25kg/m^2, and 2.44 (0.54-11.10) for >25kg/m^2 when stratified by BMI. Compared to the bottom category of DDII, ORs (95%CIs) for the top category of DDII were 6.52 (2.61-16.30) for ≤8 years, and 12.94 (2.91-57.48) for >8 years when stratified by the length of residence in Korea.

Table 23 presents ORs and 95%CIs for HOMA-IR according to the potential effect modification factor. The association did not vary by age, BMI or length of residence in Korea (*p* for interaction=0.79, 0.96, and 0.60, respectively). Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 5.26 (2.06-13.43) for <35 years, and 7.06 (2.43-20.48) for ≥35 years when stratified by age. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 2.94 (0.93-9.34) for ≤25kg/m^2, and 2.03 (0.50-8.20) for >25kg/m^2 when stratified by BMI. Compared to Q1-3, ORs (95%CIs) for Q4 and 5 were 4.95 (2.06-11.88) for ≤8 years, and 9.66 (2.67-34.93) for >8 years when stratified by the length of residence in Korea.

Table 16. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by TC according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	**Q4,5**	
Total cholesterols			
Age, years			0.10
Case/Total number	22/159	19/43	
<35	1	4.52 (1.93-10.59)	
Case/Total number	21/88	47/115	
≥35	1	1.65 (0.83-3.31)	
Body Mass Index, kg/m^2			0.37
Case/Total number	40/227	19/58	
<25	1	1.42 (0.64-3.18)	
Case/Total number	3/20	47/100	
≥25	1	4.48 (0.77-26.13)	
Length of residence, years			0.23
Case/Total number	26/171	25/59	
≤8	1	3.62 (1.66-7.92)	
Case/Total number	17/76	41/99	
>8	1	1.91 (0.88-4.14)	

Abbreviations: DDII, Data Derived Inflammatory Index; TC, Total Cholesterols; QOL, Quality of Life

Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

Table 17. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by LDL-C according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	Q4,5	
Low density lipoprotein cholesterols			
Age, years			0.07
Case/Total number	11/159	14/43	
<35	1	8.11 (2.71-24.34)	
Case/Total number	16/88	35/115	
≥35	1	1.87 (0.84-4.18)	
Body Mass Index, kg/m^2			0.39
Case/Total number	25/227	12/58	
<25	1	1.19 (0.43-3.28)	
Case/Total number	2/20	37/100	
≥25	1	4.74 (0.73-30.96)	
Length of residence, years			0.04
Case/Total number	16/171	21/59	
≤8	1	5.77 (2.24-14.87)	
Case/Total number	11/76	28/99	
>8	1	1.89 (0.76-4.70)	

Abbreviations: DDII, Data Derived Inflammatory Index; LDL-C, Low Density Lipoprotein Cholesterols; QOL, Quality of Life
Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

Table 18. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by TG according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	**Q4,5**	
Triglycerides			
Age, years			0.12
Case/Total number	9/159	5/43	
<35	1	2.35 (0.54-10.28)	
Case/Total number	3/88	22/115	
≥35	1	10.49 (2.49-44.11)	
Body Mass Index, kg/m^2			0.51
Case/Total number	10/227	8/58	
<25	1	7.17 (1.62-31.64)	
Case/Total number	2/20	19/100	
≥25	1	0.88 (0.10-7.71)	
Length of residence, years			0.06
Case/Total number	10/171	7/59	
≤8	1	2.03 (0.57-7.22)	
Case/Total number	2/76	20/99	
>8	1	16.99 (2.89-99.77)	

Abbreviations: DDII, Data Derived Inflammatory Index; TG, Triglycerides; QOL, Quality of Life
Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

Table 19. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by TG/HDL-C according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	**Q4,5**	
TG/HDL-C			
Age, years			0.25
Case/Total number	12/159	7/43	
<35	1	3.76 (1.06-13.34)	
Case/Total number	3/88	21/115	
≥35	1	8.91 (2.12-37.49)	
Body Mass Index, kg/m^2			0.40
Case/Total number	11/227	7/58	
<25	1	4.69 (1.11-19.82)	
Case/Total number	4/20	21/100	
≥25	1	1.00 (0.18-5.78)	
Length of residence, years			0.11
Case/Total number	13/171	9/59	
≤8	1	3.25 (1.03-10.24)	
Case/Total number	2/76	19/99	
>8	1	12.35 (2.29-66.58)	

Abbreviations: DDII, Data Derived Inflammatory Index; TG/HDL-C, Triglycerides to High Density Lipoprotein Cholesterols ratio; QOL, Quality of Life
Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

Table 20. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by HbA1c according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	**Q4,5**	
HbA1c			
Age, years			0.82
Case/Total number	34/159	17/43	
<35	1	2.67 (1.18-6.04)	
Case/Total number	27/88	63/115	
≥35	1	3.03 (1.49-6.19)	
Body Mass Index, kg/m^2			0.57
Case/Total number	56/227	26/58	
<25	1	1.76 (0.84-3.66)	
Case/Total number	5/20	54/100	
≥25	1	3.36 (0.67-16.82)	
Length of residence, years			0.70
Case/Total number	41/171	28/59	
≤8	1	2.16 (1.03-4.55)	
Case/Total number	20/76	52/99	
>8	1	3.59 (1.62-7.96)	

Abbreviations: DDII, Data Derived Inflammatory Index; HbA1c, Glycated hemoglobin; QOL, Quality of Life

Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

Table 21. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by FBG according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	**Q4,5**	
Fasting blood glucose			
Age, years			0.97
Case/Total number	5/159	3/43	
<35	1	2.27 (0.33-15.79)	
Case/Total number	10/88	25/115	
≥35	1	2.31 (0.92-5.82)	
Body Mass Index, kg/ m^2			0.20
Case/Total number	12/227	9/58	
<25	1	1.79 (0.56-5.79)	
Case/Total number	3/20	19/100	
≥25	1	0.17 (0.02-1.63)	
Length of residence, years			0.99
Case/Total number	8/171	7/59	
≤8	1	2.02 (0.48-8.54)	
Case/Total number	7/76	21/99	
>8	1	2.63 (0.89-7.73)	

Abbreviations: DDII, Data Derived Inflammatory Index; FBG, Fasting Blood Glucose; QOL, Quality of Life

Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

Table 22. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by insulin according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	Q4,5	
Insulin			
Age, years			0.86
Case/Total number	(17/159)	(16/43)	
<35	1	6.87 (2.67-17.71)	
Case/Total number	(4/88)	(20/115)	
≥35	1	9.20 (2.55-33.29)	
Body Mass Index, kg/ m^2			0.77
Case/Total number	(16/227)	(7/58)	
<25	1	3.65 (1.10-12.12)	
Case/Total number	(5/20)	(29/100)	
≥25	1	2.44 (0.54-11.10)	
Length of residence, years			0.57
Case/Total number	(18/171)	(18/59)	
≤8	1	6.52 (2.61-16.30)	
Case/Total number	(3/76)	(18/99)	
>8	1	12.94 (2.91-57.48)	

Abbreviations: DDII, Data Derived Inflammatory Index; QOL, Quality of Life

Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

Table 23. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of dyslipidemia by HOMA-IR according to the DDII scores stratified by lifestyle factors

	DDII		*p* for interaction
	Q1-3	Q4,5	
HOMA-IR			
Age, years			0.79
Case/Total number	(17/159)	(15/43)	
<35	1	5.26 (2.06-13.43)	
Case/Total number	(6/88)	(27/115)	
≥35	1	7.06 (2.43-20.48)	
Body Mass Index, kg/ m^2			0.96
Case/Total number	(18/227)	(8/58)	
<25	1	2.94 (0.93-9.34)	
Case/Total number	(5/20)	(34/100)	
≥25	1	2.03 (0.50-8.20)	
Length of residence, years			0.60
Case/Total number	(19/171)	(19/59)	
≤8	1	4.95 (2.06-11.88)	
Case/Total number	(4/76)	(23/99)	
>8	1	9.66 (2.67-34.93)	

Abbreviations: DDII, Data Derived Inflammatory Index; HOMA-IR, Homeostasis Model Assessment of Insulin Resistance; QOL, Quality of Life
Adjusted for age (years, continuous), energy intake (kcal, continuous), education level (high school or less, associate/vocational, college or above), sleep hours (<5,5-6,7-8,>8 hours), region (urban, rural), vigorous activity (yes, no), employment status (yes, no), breastfeeding (months, continuous), QOL (continuous), dietary pattern change (yes, no), alcohol intake (yes, no), coffee intake (≤1, 1-3, >3 cups/day)

V. Discussion

In the present analysis of Filipino immigrant women in Korea, a statistically significant association between greater dietary diversity and decreased prevalence of abdominal obesity was observed, while increased prevalence of dyslipidemia. In addition, statistically significant association between inflammatory index and increased prevalence in components of dyslipidemia and insulin resistance was found.

Greater points of MDD-W score were inversely associated with central obesity, which corresponded to previous epidemiological evidences of the dietary diversity and chronic disease (Danquah et al., 2018; Kant & Graubard, 2005; Shan et al., 2020). A cross-sectional study examining 289 Iranian female participants found a statistically significant inverse association between quartiles of DDS and obesity and abdominal adiposity; ORs (95%CIs) were 1.00, 0.43 (0.14-1.39), 0.34 (0.11-1.29) and 0.25 (0.09-0.98) for obesity (*p* for trend=0.04), and ORs (95%CIs) were 1.00, 0.64 (0.32-1.65), 0.45 (0.21-1.09) and 0.28 (0.11-1.12) for abdominal adiposity (*p* for trend=0.04) (Azadbakht & Esmaillzadeh, 2011). A prior case-cohort study from European Prospective Investigation into Cancer and Nutrition-Norfolk study found lower risk of type 2 diabetes among participants consuming greater variety of fruit (RR=0.70, 95%CI=0.53-0.91), vegetable (RR=0.77, 95%CI=0.61-0.98), and combined (RR=0.61, 95%CI=0.48-0.78) (Cooper et al., 2012). Indeed, consuming variety of food types may play a beneficial role to sustain healthy dietary patterns and prevent non-communicable disease (de Oliveira Otto et al., 2018; Mozaffarian & Ludwig, 2010). Various international and national guidelines recommend diverse nutrient-dense food consumption across all food groups, with major emphasis on vegetable and protein sources (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015; Jessri et al., 2016; World Health Organization, 2002).

Higher dietary diversity was associated with higher prevalence of hypercholesterolemia in the present study. Despite the accumulating literatures supporting dietary diversity as an efficient assessment tool for obesity, limited evidences exist regarding the lipid profiles (Jayawardena et al., 2013; Karimbeiki et al., 2018; Otto et al., 2015; Weerasekara et al., 2020). In the cross-sectional analysis of 2016 Chinese Urban Adults Diet and Health Study (CUADHS) adherence to Chinese healthy food diversity (HFD) was not significantly associated with metabolic syndrome and its components after adjusted for potential confounders (Zhao et al., 2018). In the pooled analysis of the three U.S. cohort studies examining the risk of coronary heart disease did not observe a significant association with MDD-W (Fung et al., 2018). The results from the present analysis may owe to the characteristics of dietary patterns where the participants with higher MDD-W scores consumed more energy, compared to the participants with lower MDD-W scores. In addition, the MDD-W scores did not correlate with DDII scores in the current study population.

Recently, diet quality scores regarding the diet related inflammation status, has been developed internationally which showed decent agreement with previously established measurement schemes (Asadi et al., 2020; Kim et al., 2020; Shivappa et al., 2014; Tabung et al., 2016). A statistically significant association between pro-inflammatory DDII scores with increased prevalence of dyslipidemia and insulin resistance was found in the present analysis. Moreover, increased DDII score was associated with increased circulating hsCRP scores of the study participants. The findings align with recent epidemiological literatures investigating the association between dietary inflammation estimates and chronic disease (Phillips et al., 2018; Ruiz-Canela et al., 2016; Shivappa et al., 2017). A study examining the DII®, consisting 45 pro- and anti-inflammatory parameters, found a statistically significant association between higher DII® and metabolic syndrome (Phillips et al., 2018). A meta-analysis examining the association between DII® and prostate cancer found adjusted pooled RR of 1.74 (95%CI=1.24–2.43), comparing the highest versus lowest categories of DII®.

The inflammatory status induced from surplus energy intake may play a role in the pathophysiology linking diet, obesity, and dyslipidemia (Siri-Tarino & Krauss, 2016). The chronic inflammation state of obesity is widely acknowledged as pivotal contributor of the progression of dyslipidemia, type 2 diabetes, cardiovascular disease, and certain cancers (Calle et al., 2003; Martin-Rodriguez et al., 2015). Excess nutrients stored mainly in adipocytes trigger obesity-associated inflammation through multiple pathways, including inflammatory cytokine upregulation, increased oxidative stress, and low-grade inflammatory response (Ellulu et al., 2017;

Kolb et al., 2016). Subsequently, the inflammation status yields to development of insulin resistance and increased IGF-1 (de Rooij et al., 2009). Moreover, hypercaloric intake mainly from carbohydrate sources is linked to greater stores of intrahepatic triglycerides, resulting in atherogenic dyslipidemia (Sullivan, 2010).

Immigrants alter their dietary behaviors as part of their acculturation process, known as 'dietary acculturation' (Aljaroudi et al., 2019; Satia-Abouta et al., 2002). It involves a complex-multidimensional interaction between cultural, social, economic, and environmental factors, with variations among individuals. In our previous cross-sectional analysis, we found that the Filipino immigrants consume less variety of foods compared to the Koreans (Abris et al., 2018). A study examining the dietary diversity of Filipino children from 2013 Filipino National Nutrition Survey found that mean (± SD) DDS score was 4.1(± 1.3) out of 9 food groups (Mak et al., 2019).

The investigation of overall diet quality requires comprehensive understandings on the complexity of diverse dietary patterns. The associated nutrients, foods, food preparation methods, food availability, food security, as well as social and cultural circumstances should be considered when assessing the dietary quality of a specific population. Of note, dietary patterns of the population in developing countries are generally low in dietary diversity, where the increased diversity is associated with beneficial effects on the health status. On the other hand, the population in more economically developed countries have higher potential of food accessibility. Concerning the consistent increase in the prevalence of chronic disease, the investigation of diet quality associated with inflammatory status may impose more priority. Regarding the Filipino immigrant population in Korea, the acculturation process yield to the more sophisticated characteristics of dietary patterns. The immigrants may sustain dietary behaviors from the Philippines, as well as adapt to Korean dietary patterns to certain circumstances. In other words, the Filipino immigrant women may modify their health-related behaviors during the acculturation process, as well as holding unhealthy status from the Philippines. Thus, the investigation on the nutritional and health status of the immigrants using a proxy indicator is essential, regarding the public health burden of the host society. Furthermore, the multicultural family have play a significant role for the well-being of future generation, as well as sustainable development of the society. The nutritional screening and assessment using both MDD-W, and DDII may be useful to understand the diet-related health status of the Filipino immigrant population, encompassing both dietary diversity and dietary inflammatory status of the immigrants. With suggestions that maintaining the diet pattern low in diversity may not be an optimal choice for Filipino immigrants, favorable acculturation concerning the food diversity and anti-inflammatory food may be an option. Further epidemiological investigations are warranted regarding dietary acculturation and health outcomes among Filipino immigrants in Korea.

The strength of our findings is that this is the first study, to our knowledge, to examine the association between diet quality scores and prevalence of obesity, dyslipidemia, and insulin resistance of immigrant Filipino women in the multicultural society of South Korea. In addition, the study data collection process was standardized and sample processing was centralized. However, the following limitations should be acknowledged. First, the cross-sectional nature of the study limits our ability to examine temporal or causal relationships. In addition, dietary data was collected through a single day 24-hour recall, which may not reflect the usual daily intake. The study was limited in power due to its relatively small sample size. Moreover, although we controlled for potential confounding factors, the results are still subject to residual confounding.

In conclusion, greater dietary diversity was positively associated with lower prevalence of obesity, but higher prevalence of dyslipidemia in the present study. In addition, more pro-inflammatory diet and lifestyle patterns were associated with elevated prevalence of dyslipidemia and insulin resistance. Further epidemiological and clinical studies on the underlying mechanism are warranted.

Bibliography

Abe, M., N. Shivappa, H. Ito, I. Oze, T. Abe, Y. Shimizu, Y. Hasegawa, C. Kiyohara, M. Nomura, Y. Ogawa, J. R. Hebert & K. Matsuo. (2018). Dietary inflammatory index and risk of upper aerodigestive tract cancer in Japanese adults. Oncotarget, 9(35), 24028-24040.

Abris, G. P., S. Hong, S. M. Provido, J. E. Lee & C. B. Lee. (2017). Filipino women's diet and health study (FiLWHEL): design and methods. Nutr Res Pract, 11(1), 70-75.

Abris, G. P., N. H. Kim, S. M. P. Provido, S. Hong, S. H. Yu, C. B. Lee & J. E. Lee. (2018). Dietary diversity and nutritional adequacy among married Filipino immigrant women: The Filipino Women's Diet and Health Study (FiLWHEL). BMC Public Health, 18(1), 359.

Abris, G. P., S. M. P. Provido, S. Hong, S. H. Yu, C. B. Lee & J. E. Lee. (2018). Association between dietary diversity and obesity in the Filipino Women's Diet and Health Study (FiLWHEL): A cross-sectional study. PLoS One, 13(11), e0206490.

Afable, A., R. Ursua, L. C. Wyatt, D. Aguilar, S. C. Kwon, N. S. Islam & C. Trinh-Shevrin. (2016). Duration of US Residence Is Associated With Overweight Risk in Filipino Immigrants Living in New York Metro Area. Fam

Community Health, 39(1), 13-23.

Alberti, K. G., P. Zimmet & J. Shaw. (2006). Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. Diabet Med, 23(5), 469-480.

Aljaroudi, R., S. Horton & R. M. Hanning. (2019). Acculturation and Dietary Acculturation among Arab Muslim Immigrants in Canada. Can J Diet Pract Res, 80(4), 172-178.

American Diabetes Association. (2018, Jan). 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes. Diabetes Care. 2017/12/10.

Asadi, Z., R. Ghaffarian Zirak, M. Yaghooti Khorasani, M. Saedi, S. M. Parizadeh, R. Jafarzadeh-Esfehani, F. Khorramruz, S. Jandari, M. Mohammadi-Bajgiran, R. Zare-Feyzabadi, H. Esmaily, H. R. Rahimi, M. Tayefi, G. A. Ferns, N. Shivappa, J. R. Hébert, H. Ghazizadeh & M. Ghayour-Mobarhan. (2020). Dietary Inflammatory Index is associated with Healthy Eating Index, Alternative Healthy Eating Index, and dietary patterns among Iranian adults. J Clin Lab Anal, e23523.

Ayenew, H. Y., S. Biadgilign, L. Schickramm, G. Abate-Kassa & J. Sauer. (2018). Production diversification, dietary diversity and consumption seasonality:

panel data evidence from Nigeria. BMC Public Health, 18(1), 988.

Azadbakht, L. & A. Esmaillzadeh. (2011). Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. Public Health Nutr, 14(1), 62-69.

Barbaresko, J., M. Koch, M. B. Schulze & U. Nöthlings. (2013). Dietary pattern analysis and biomarkers of low-grade inflammation: a systematic literature review. Nutr Rev, 71(8), 511-527.

Basiak-Rasała, A., D. Różańska & K. Zatońska. (2019). Food groups in dietary prevention of type 2 diabetes. Rocz Panstw Zakl Hig, 70(4), 347-357.

Batis, C., L. Hernandez-Barrera, S. Barquera, J. A. Rivera & B. M. Popkin. (2011). Food acculturation drives dietary differences among Mexicans, Mexican Americans, and Non-Hispanic Whites. J Nutr, 141(10), 1898-1906.

Bezerra, I. N. & R. Sichieri. (2011). Household food diversity and nutritional status among adults in Brazil. Int J Behav Nutr Phys Act, 8, 22.

Calle, E. E., C. Rodriguez, K. Walker-Thurmond & M. J. Thun. (2003). Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. adults. N Engl J Med, 348(17), 1625-1638.

Cooper, A. J., S. J. Sharp, M. A. Lentjes, R. N. Luben, K. T. Khaw, N. J. Wareham & N. G. Forouhi. (2012). A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. Diabetes Care, 35(6), 1293-1300.

Custodio, E., F. Kayikatire, S. Fortin, A. C. Thomas, Y. Kameli, T. Nkunzimana, B. Ndiaye & Y. Martin-Prevel. (2020). Minimum dietary diversity among women of reproductive age in urban Burkina Faso. Matern Child Nutr, 16(2), e12897.

Danquah, I., C. Galbete, K. Meeks, M. Nicolaou, K. Klipstein-Grobusch, J. Addo, A. D. Aikins, S. K. Amoah, P. Agyei-Baffour, D. Boateng, G. Bedu-Addo, J. Spranger, L. Smeeth, E. Owusu-Dabo, C. Agyemang, F. P. Mockenhaupt, E. Beune & M. B. Schulze. (2018). Food variety, dietary diversity, and type 2 diabetes in a multi-center cross-sectional study among Ghanaian migrants in Europe and their compatriots in Ghana: the RODAM study. Eur J Nutr, 57(8), 2723-2733.

de Oliveira Otto, M. C., C. A. M. Anderson, J. L. Dearborn, E. P. Ferranti, D. Mozaffarian, G. Rao, J. Wylie-Rosett & A. H. Lichtenstein. (2018). Dietary Diversity: Implications for Obesity Prevention in Adult Populations: A Science Advisory From the American Heart Association. Circulation, 138(11), e160-e168.

de Rooij, S. R., G. Nijpels, P. M. Nilsson, J. J. Nolan, R. Gabriel, E. Bobbioni-Harsch, G. Mingrone & J. M. Dekker. (2009). Low-grade chronic inflammation in the relationship between insulin sensitivity and cardiovascular disease (RISC) population: associations with insulin resistance and cardiometabolic risk profile. Diabetes Care, 32(7), 1295-1301.

Deng, F. E., N. Shivappa, Y. Tang, J. R. Mann & J. R. Hebert. (2017). Association between diet-related inflammation, all-cause, all-cancer, and cardiovascular disease mortality, with special focus on prediabetics: findings from NHANES III. Eur J Nutr, 56(3), 1085-1093.

Denney, L., I. Angeles-Agdeppa, M. V. Capanzana, M. B. Toledo, J. Donohue & A. Carriquiry. (2018). Nutrient Intakes and Food Sources of Filipino Infants, Toddlers and Young Children are Inadequate: Findings from the National Nutrition Survey 2013. Nutrients, 10(11).

Department of Health. (2013). Mortality: Ten (10) Leading Causes. Retrieved from https://doh.gov.ph/

Dudeja, V., A. Misra, R. M. Pandey, G. Devina, G. Kumar & N. K. Vikram. (2001). BMI does not accurately predict overweight in Asian Indians in northern India. Br J Nutr, 86(1), 105-112.

Ellulu, M. S., I. Patimah, H. Khaza'ai, A. Rahmat & Y. Abed. (2017). Obesity and inflammation: the linking mechanism and the complications. Arch Med Sci, 13(4), 851-863.

Food and Agriculture Organization of the United Nations. (1985). Report of the Council of FAO. 87.

Food and Nutrition Research Institute. (1997). The Philippine Food Composition Tables. Retrieved from https://i.fnri.dost.gov.ph/fct/library

Friedewald, W. T., R. I. Levy & D. S. Fredrickson. (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem, 18(6), 499-502.

Frostegård, J. (2013). Immunity, atherosclerosis and cardiovascular disease. BMC Med, 11, 117.

Fung, T. T., S. Isanaka, F. B. Hu & W. C. Willett. (2018). International food group-based diet quality and risk of coronary heart disease in men and women. Am J Clin Nutr, 107(1), 120-129.

Fung, T. T., M. McCullough, R. M. van Dam & F. B. Hu. (2007). A prospective study of overall diet quality and risk of type 2 diabetes in women. Diabetes Care, 30(7), 1753-1757.

Fung, T. T., A. Pan, T. Hou, D. Mozaffarian, K. M. Rexrode, W. C. Willett & F. B. Hu. (2016). Food quality score and the risk of coronary artery disease: a prospective analysis in 3 cohorts. Am J Clin Nutr, 104(1), 65-72.

Galland, L. (2010). Diet and inflammation. Nutr Clin Pract, 25(6), 634-640.

Garcia-Arellano, A., M. A. Martínez-González, R. Ramallal, J. Salas-Salvadó, J. R. Hébert, D. Corella, N. Shivappa, L. Forga, H. Schröder, C. Muñoz-Bravo, R. Estruch, M. Fiol, J. Lapetra, L. Serra-Majem, E. Ros, J. Rekondo, E. Toledo, C. Razquin & M. Ruiz-Canela. (2019). Dietary inflammatory index and all-cause mortality in large cohorts: The SUN and PREDIMED studies. Clin Nutr, 38(3), 1221-1231.

Gaziano, J. M., C. H. Hennekens, C. J. O'Donnell, J. L. Breslow & J. E. Buring. (1997). Fasting triglycerides, high-density lipoprotein, and risk of myocardial infarction. Circulation, 96(8), 2520-2525.

Giugliano, D., A. Ceriello & K. Esposito. (2006). The effects of diet on inflammation: emphasis on the metabolic syndrome. J Am Coll Cardiol, 48(4), 677-685.

Guenther, P. M., K. O. Casavale, J. Reedy, S. I. Kirkpatrick, H. A. Hiza, K. J. Kuczynski, L. L. Kahle & S. M. Krebs-Smith. (2013). Update of the Healthy Eating Index: HEI-2010. J Acad Nutr Diet, 113(4), 569-580.

Harmon, B. E., M. D. Wirth, C. J. Boushey, L. R. Wilkens, E. Draluck, N. Shivappa, S. E. Steck, L. Hofseth, C. A. Haiman, L. Le Marchand & J. R. Hébert. (2017). The Dietary Inflammatory Index Is Associated with

Colorectal Cancer Risk in the Multiethnic Cohort. J Nutr, 147(3), 430-438.

Hruby, A., J. E. Manson, L. Qi, V. S. Malik, E. B. Rimm, Q. Sun, W. C. Willett & F. B. Hu. (2016). Determinants and Consequences of Obesity. Am J Public Health, 106(9), 1656-1662.

Il'yasova, D., L. H. Colbert, T. B. Harris, A. B. Newman, D. C. Bauer, S. Satterfield & S. B. Kritchevsky. (2005). Circulating levels of inflammatory markers and cancer risk in the health aging and body composition cohort. Cancer Epidemiol Biomarkers Prev, 14(10), 2413-2418.

Jayawardena, R., N. M. Byrne, M. J. Soares, P. Katulanda, B. Yadav & A. P. Hills. (2013). High dietary diversity is associated with obesity in Sri Lankan adults: an evaluation of three dietary scores. BMC Public Health, 13, 314.

Jessri, M., W. Y. Lou & M. R. L'Abbé. (2016). The 2015 Dietary Guidelines for Americans is associated with a more nutrient-dense diet and a lower risk of obesity. Am J Clin Nutr, 104(5), 1378-1392.

Joyce, B. T., D. Wu, L. Hou, Q. Dai, S. F. Castaneda, L. C. Gallo, G. A. Talavera, D. Sotres-Alvarez, L. Van Horn, J. M. Beasley, T. Khambaty, T. Elfassy, D. Zeng, J. Mattei, L. Corsino & M. L. Daviglus. (2019). DASH diet and prevalent metabolic syndrome in the Hispanic Community Health Study/Study of Latinos. Prev Med Rep, 15, 100950.

Kant, A. K. & B. I. Graubard. (2005). A comparison of three dietary pattern indexes for predicting biomarkers of diet and disease. J Am Coll Nutr, 24(4), 294-303.

Kapoor, D., R. Iqbal, K. Singh, L. M. Jaacks, R. Shivashankar, V. Sudha, R. M. Anjana, M. Kadir, V. Mohan, M. K. Ali, K. M. Narayan, N. Tandon, D. Prabhakaran & A. T. Merchant. (2018). Association of dietary patterns and dietary diversity with cardiometabolic disease risk factors among adults in South Asia: The CARRS study. Asia Pac J Clin Nutr, 27(6), 1332-1343.

Karimbeiki, R., M. Pourmasoumi, A. Feizi, B. Abbasi, A. Hadi, N. Rafie & S. M. Safavi. (2018). Higher dietary diversity score is associated with obesity: a case-control study. Public Health, 157, 127-134.

Kim, S., S. Song, Y. S. Kim, S. Y. Yang & J. E. Lee. (2020). The association between predicted inflammatory status and colorectal adenoma. Sci Rep, 10(1), 2433.

Kim, Y. & B. G. Han. (2017). Cohort Profile: The Korean Genome and Epidemiology Study (KoGES) Consortium. Int J Epidemiol, 46(2), e20.

Kolb, R., F. S. Sutterwala & W. Zhang. (2016). Obesity and cancer: inflammation bridges the two. Curr Opin Pharmacol, 29, 77-89.

Korea Immigration Service, Ministry of Justice. Korea Immigration Service

Statistics 2019.

Madzorera, I., S. Isanaka, M. Wang, G. I. Msamanga, W. Urassa, E. Hertzmark, C. Duggan & W. W. Fawzi. (2020). Maternal dietary diversity and dietary quality scores in relation to adverse birth outcomes in Tanzanian women. Am J Clin Nutr, 112(3), 695-706.

Mak, T. N., I. Angeles-Agdeppa, Y. M. Lenighan, M. V. Capanzana & I. Montoliu. (2019). Diet Diversity and Micronutrient Adequacy among Filipino School-Age Children. Nutrients, 11(9).

Martin-Rodriguez, E., F. Guillen-Grima, A. Martí & A. Brugos-Larumbe. (2015). Comorbidity associated with obesity in a large population: The APNA study. Obes Res Clin Pract, 9(5), 435-447.

Matthews, D. R., J. P. Hosker, A. S. Rudenski, B. A. Naylor, D. F. Treacher & R. C. Turner. (1985). Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia, 28(7), 412-419.

Mekuria, G., Y. Wubneh & T. Tewabe. (2017). Household dietary diversity and associated factors among residents of finote selam town, north west Ethiopia: a cross sectional study. BMC Nutr, 3, 28.

Milajerdi, A., N. Namazi, B. Larijani & L. Azadbakht. (2018). The Association of

Dietary Quality Indices and Cancer Mortality: A Systematic Review and Meta-analysis of Cohort Studies. Nutr Cancer, 70(7), 1091-1105.

Misra, A. & L. Khurana. (2008). Obesity and the metabolic syndrome in developing countries. J Clin Endocrinol Metab, 93(11 Suppl 1), S9-30.

Misra, A. & U. Shrivastava. (2013). Obesity and dyslipidemia in South Asians. Nutrients, 5(7), 2708-2733.

Mohseni, R., S. Abbasi, F. Mohseni, F. Rahimi & S. Alizadeh. (2019). Association between Dietary Inflammatory Index and the Risk of Prostate Cancer: A Meta-Analysis. Nutr Cancer, 71(3), 359-366.

Mozaffarian, D. (2016). Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity: A Comprehensive Review. Circulation, 133(2), 187-225.

Mozaffarian, D. & D. S. Ludwig. (2010). Dietary guidelines in the 21st century--a time for food. Jama, 304(6), 681-682.

National Academy of Agricultural Science. (2011). Standard food composition table 8th revision Retrieved from http://koreanfood.rda.go.kr/

NCD Risk Factor Collaboration. (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. Lancet, 390(10113), 2627-2642.

Niclis, C., S. A. Pou, N. Shivappa, J. R. Hébert, S. E. Steck & M. D. P. Díaz. (2018). Proinflammatory Dietary Intake is Associated with Increased Risk of Colorectal Cancer: Results of a Case-Control Study in Argentina Using a Multilevel Modeling Approach. Nutr Cancer, 70(1), 61-68.

Otto, M. C., N. S. Padhye, A. G. Bertoni, D. R. Jacobs, Jr. & D. Mozaffarian. (2015). Everything in Moderation--Dietary Diversity and Quality, Central Obesity and Risk of Diabetes. PLoS One, 10(10), e0141341.

Pearson, T. A., G. A. Mensah, R. W. Alexander, J. L. Anderson, R. O. Cannon, 3rd, M. Criqui, Y. Y. Fadl, S. P. Fortmann, Y. Hong, G. L. Myers, N. Rifai, S. C. Smith, Jr., K. Taubert, R. P. Tracy & F. Vinicor. (2003). Markers of inflammation and cardiovascular disease: application to clinical and public health practice: A statement for healthcare professionals from the Centers for Disease Control and Prevention and the American Heart Association. Circulation, 107(3), 499-511.

Phillips, C. M., L. W. Chen, B. Heude, J. Y. Bernard, N. C. Harvey, L. Duijts, S. M. Mensink-Bout, K. Polanska, G. Mancano, M. Suderman, N. Shivappa & J. R. Hébert. (2019). Dietary Inflammatory Index and Non-Communicable Disease Risk: A Narrative Review. Nutrients, 11(8).

Phillips, C. M., N. Shivappa, J. R. Hébert & I. J. Perry. (2018). Dietary Inflammatory Index and Biomarkers of Lipoprotein Metabolism, Inflammation and Glucose Homeostasis in Adults. Nutrients, 10(8).

Popkin, B. M., C. Corvalan & L. M. Grummer-Strawn. (2020). Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet, 395(10217), 65-74.

Pradhan, A. D., J. E. Manson, N. Rifai, J. E. Buring & P. M. Ridker. (2001). C-reactive protein, interleukin 6, and risk of developing type 2 diabetes mellitus. Jama, 286(3), 327-334.

Rhee, E. J., H. C. Kim, J. H. Kim, E. Y. Lee, B. J. Kim, E. M. Kim, Y. Song, J. H. Lim, H. J. Kim, S. Choi, M. K. Moon, J. O. Na, K. Y. Park, M. S. Oh, S. Y. Han, J. Noh, K. H. Yi, S. H. Lee, S. C. Hong & I. K. Jeong. (2019). 2018 Guidelines for the Management of Dyslipidemia in Korea. J Lipid Atheroscler, 8(2), 78-131.

Ruiz-Canela, M., M. Bes-Rastrollo & M. A. Martínez-González. (2016). The Role of Dietary Inflammatory Index in Cardiovascular Disease, Metabolic Syndrome and Mortality. Int J Mol Sci, 17(8).

Ryan, C., R. Shaw, M. Pliam, A. J. Zapolanski, M. Murphy, H. V. Valle & R. Myler. (2000). Coronary heart disease in Filipino and Filipino-American patients:

prevalence of risk factors and outcomes of treatment. J Invasive Cardiol, 12(3), 134-139.

Salehi-Abargouei, A., F. Akbari, N. Bellissimo & L. Azadbakht. (2016). Dietary diversity score and obesity: a systematic review and meta-analysis of observational studies. Eur J Clin Nutr, 70(1), 1-9.

Satia-Abouta, J., R. E. Patterson, M. L. Neuhouser & J. Elder. (2002). Dietary acculturation: applications to nutrition research and dietetics. J Am Diet Assoc, 102(8), 1105-1118.

Schwingshackl, L., B. Bogensberger & G. Hoffmann. (2018). Diet Quality as Assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: An Updated Systematic Review and Meta-Analysis of Cohort Studies. J Acad Nutr Diet, 118(1), 74-100.e111.

Shan, Z., Y. Li, M. Y. Baden, S. N. Bhupathiraju, D. D. Wang, Q. Sun, K. M. Rexrode, E. B. Rimm, L. Qi, W. C. Willett, J. E. Manson, Q. Qi & F. B. Hu. (2020). Association Between Healthy Eating Patterns and Risk of Cardiovascular Disease. JAMA Intern Med, 180(8), 1090-1100.

Shivappa, N., J. Godos, J. R. Hébert, M. D. Wirth, G. Piuri, A. F. Speciani & G. Grosso. (2017). Dietary Inflammatory Index and Colorectal Cancer Risk-A

Meta-Analysis. Nutrients, 9(9).

Shivappa, N., S. E. Steck, T. G. Hurley, J. R. Hussey & J. R. Hébert. (2014). Designing and developing a literature-derived, population-based dietary inflammatory index. Public Health Nutr, 17(8), 1689-1696.

Singh, G. K. & S. C. Lin. (2013). Dramatic Increases in Obesity and Overweight Prevalence among Asian Subgroups in the United States, 1992-2011. ISRN Prev Med, 2013, 898691.

Sinharoy, S. S., J. L. Waid, R. Haardörfer, A. Wendt, S. Gabrysch & K. M. Yount. (2018). Women's dietary diversity in rural Bangladesh: Pathways through women's empowerment. Matern Child Nutr, 14(1).

Siri-Tarino, P. W. & R. M. Krauss. (2016). Diet, lipids, and cardiovascular disease. Curr Opin Lipidol, 27(4), 323-328.

Smitasiri, S. & R. Uauy. (2007). Beyond recommendations: implementing food-based dietary guidelines for healthier populations. Food Nutr Bull, 28(1 Suppl International), S141-151.

Sofi, F., C. Macchi, R. Abbate, G. F. Gensini & A. Casini. (2014). Mediterranean diet and health status: an updated meta-analysis and a proposal for a literature-based adherence score. Public Health Nutr, 17(12), 2769-2782.

Statistics Korea. (2019). Population and Vital Statistics. Retrieved from http://kostat.go.kr/portal/korea/

Sullivan, S. (2010). Implications of diet on nonalcoholic fatty liver disease. Curr Opin Gastroenterol, 26(2), 160-164.

Tabung, F. K., S. A. Smith-Warner, J. E. Chavarro, K. Wu, C. S. Fuchs, F. B. Hu, A. T. Chan, W. C. Willett & E. L. Giovannucci. (2016). Development and Validation of an Empirical Dietary Inflammatory Index. J Nutr, 146(8), 1560-1570.

United States Department of Agriculture. USDA food composition database. Retrieved from https://fdc.nal.usda.gov/ndb/

U.S. Department of Health and Human Services and U.S. Department of Agriculture. (2015). 2015–2020 Dietary Guidelines for Americans.

Vargas, P. & L. F. Jurado. (2015). Dietary Acculturation among Filipino Americans. Int J Environ Res Public Health, 13(1), ijerph13010016.

Weerasekara, P. C., C. R. Withanachchi, G. A. S. Ginigaddara & A. Ploeger. (2020). Understanding Dietary Diversity, Dietary Practices and Changes in Food Patterns in Marginalised Societies in Sri Lanka. Foods, 9(11).

WHO Expert Consultation. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet, 363(9403), 157-163.

Women's Dietary Diversity Project Study Group. (2017). Development of a Dichotomous Indicator for Population-Level Assessment of Dietary Diversity in Women of Reproductive Age. Curr Dev Nutr, 1(12).

World Health Organization. (2002). Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases. WHO technical report series 916.

World Health Organization, Regional Office for the Western, Pacific (2000). The Asia-Pacific perspective : redefining obesity and its treatment, Sydney : Health Communications Australia.

Yang, J., Y. Cheng, L. Zeng, S. Dang & H. Yan. (2020). Maternal dietary diversity during pregnancy and congenital heart defects: a case-control study. Eur J Clin Nutr.

Yang, S. J., H. Y. Choi, Y. K. Chee & J. A. Kim. (2012). Prevalence and correlates of obesity and overweight among asian immigrant women in Korea. Asia Pac J Public Health, 24(4), 620-630.

Zhao, W., J. Zhang, A. Zhao, M. Wang, W. Wu, S. Tan, M. Guo & Y. Zhang. (2018). Using an introduced index to assess the association between food diversity and metabolic syndrome and its components in Chinese adults. BMC Cardiovasc Disord, 18(1), 189.

국문초록

필리핀 이주여성의 식사의 질과 비만, 이상지질혈증 및 인슐린 저항성과의 연관성 연구: 필리핀 여성건강연구(FiLWHEL)

서울대학교 대학원 식품영양학과

김희선

한국사회는 결혼을 통한 이민자 인구가 증가하고 있는 추세이며, 특히 이민으로 인한 식습관 및 건강 상태 변화가 중요한 관심사로 주목 받고 있다. 국내 이민자의 경우 본국에서 가지고 있던 식습관과 한국으로 이민 후 형성된 식습관을 모두 가지고 있으며, 이들의 식사요인과 만성질환 위험과의 연관성을 살펴보는 것이 건강한 삶의 질 추구에 중요할 것으로 사료된다. 필리핀 여성건강연구(Filipino Women's Diet and Health Study, FiLWHEL)는 2014-2016 기저조사 동안 구조화된 설문지를 사용해 인구사회학적 특성 및 생활습관을 조사하였다. 식사조사는 1일치 24시간 회상법을 사용해 조사하였으며 체질량지수는 수집된 몸무게와 키를 통해 계산하였다. 혈액검사는 8시간 이상 공복 후 채취하였다. 본 연구에서는 FiLWHEL 자료를 이용하여 개발도상국 여성 대상 식이 질

점수인 유엔 산하 식량농업기구(Food and Agricultural Organization, FAO)의 여성 최저식이다양성(Minimum Dietary Diversity for Women, MDD-W) 점수와, 한국인 염증 지표인 자료기반 염증지수(Data Derived Inflammatory Index, DDII)를 사용해 국내 필리핀 이주여성의 비만 및 이상지질혈증 유병률과 각 점수 간의 연관성을 살펴보았다. MDD-W는 FAO에서 개발도상국 여성의 적정 미량영양소 섭취 파악을 위해 개발되었다. DDII는 서울대학교 영양역학 연구실에서 한국인유전체역학조사 사업의 도시기반 코호트의 식이 및 생활 관련 데이터를 이용하여 만성염증지표인 고감도 C-반응성 단백질 (high sensitivity C-reactive protein, hsCRP) 수치를 예측하는 모델로서 개발되었다. 비만은 세계보건기구 아시아태평양 기준에 따라 정의하였고 이상지질혈증은 한국지질동맥경화학회 분류 기준을 따라 정의하였다. 다중 로지스틱 회귀분석을 이용해 MDD-W 삼분위수와 DDII 오분위수에 따라 비만 및 이상지질혈증 지표의 오즈비(Odds Ratios, ORs)와 95% 신뢰구간(95% Confidence Intervals, 95%CIs)을 산출하였으며 다변량 모델에서 각 식사의 질 점수에 따라 다른 보정변수가 포함되었다. 잠재적 상호작용 변수로 나이, 국내 거주기간 및 체질량지수에 따른 층화분석을 실시하였다. 또한 일반화 선형 모델을 이용해 DDII의 오분위수와 실제 hsCRP 수치의 경향성을 평가하였다. 모든 자료의 통계분석에서 SAS version 9.4를 이용하였고 유의 수준 0.05 미만으로 양측검정 하였다. MDD-W 분석결과, 5점 미만의 대상자와 비교해 5점 초과의 대상자에서 복부 비만 유병률이 42% (OR=0.58, 95%CI=0.36-0.94, *p* for trend=0.03) 감소했다. DDII 점수가 가장 낮은 집단에 비해 가장 높은 집단의 오즈비(95%CIs)는 고콜레스테롤혈증이 3.48배 (1.85-6.54), 높은 저밀도지단백질이 4.28배 (2.05-8.93), 고중성지방혈증이 7.30배 (2.76-19.36), 높은 당화혈색소가 3.71배 (2.01-6.84), 공복혈당 장애가 2.63배 (1.09-6.33), 고인슐린혈증이 10.71배 (4.50-25.48), 인슐린 저항성이 10.31배

(4.64-22.93) 높은 것으로 나타났다 (*p* for trend <0.01 for all). 층화분석을 실시한 결과, DDII 점수 하위 60% 집단과 상위 40% 집단을 비교했을 때 국내 거주기간이 8년 이하인 집단에서 상위 40% 집단의 저밀도지단백질 오즈비(95%CIs)가 5.77배로 더욱 뚜렷하게 높은 것으로 나타났다 (*p* for interaction=0.02). 본 연구를 통해 다양한 식품군을 섭취할수록 복부비만 유병률이 감소하고, DDII에 의한 염증지수가 높아질수록 이상지질혈증 및 인슐린 저항성 유병률이 증가하는 것으로 나타났다. 여성 결혼이민자는 결혼을 통해 다문화 가정 및 후속세대의 건강 및 지속 가능한 삶의 질 향상과 관련된 중요한 역할을 수행한다. 본 연구는 이민자의 본국과 이주국가의 식생활을 모두 고려할 수 있는 지표를 개발하는 것이 중요하고, 이러한 지표가 국내 이민자의 만성질환 예방에 활용되는 것이 필요하다는 것을 시사한다. 또한 본 연구 결과는 지역사회 영양관리 활동에서 이민자의 만성질환 예방을 위한 식사지침 및 식사의 질 지표의 개발과 활용에 기여할 수 있을 것으로 사료된다.

주요어: 식사의 다양성, 비만, 이상지질혈증, 인슐린 저항성, 염증, 단면연구

학번: 2019-23341