Published by SET Publisher

Journal of Pharmacy and Nutrition Sciences

ISSN (online): 1927-5951

A Survey of Relationship between Dietary Diversity Score and Metabolic Syndrome

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Article Info:

Keywords:
Metabolic Syndrome,
Dietary Quality Indices,
Dietary Diversity Score,
Food Frequency Questionnaire.

Timeline:
Received: July 12, 2026
Accepted: August 15, 2026
Published: September 03, 2026

Citation: Mohtashami A. A survey of relationship between dietary diversity score and metabolic syndrome. J Pharm Nutr Sci 2026; 16: 46-52.

Abstract:

Background: Dietary intake is increasingly recognized as a pivotal factor in the etiology of metabolic syndrome. A substantial body of evidence suggests a significant correlation between dietary quality indices—such as the Dietary Diversity Score (DDS)—and the occurrence of metabolic syndrome.

Objective: This study aims to rigorously evaluate the impact of the Dietary Diversity Score and demographic variables on the manifestation of metabolic syndrome.

Materials and Methods: This case-control study included 175 individuals diagnosed with metabolic syndrome and an equal number of age-matched healthy controls (comprising both genders), aged between 20 and 65 years. Participants were recruited from various laboratories and the general population in Chalous, northern Iran. Dietary intake data were meticulously collected using a comprehensive Food Frequency Questionnaire (FFQ). Additionally, dietary quality indices, specifically the Dietary Diversity Score (DDS), were assessed using standardized methodologies.

Results: A difference in the likelihood of metabolic syndrome morbidity was observed when comparing the highest quartile (Quartile 4) of Dietary Diversity Score to the lowest (Quartile 1). However, after adjusting for confounding variables—including age, sex, dietary energy intake, education, occupation, and marital status—this difference did not reach statistical significance. No substantial variations were observed in the odds ratios across quartiles or models (P-trend ≥ 0.05) for the Dietary Diversity Score.

Conclusion: No significant associations were found between the Dietary Diversity Score and the occurrence of metabolic syndrome.

DOI: https://doi.org/10.29169/1927-5951.2026.16.05

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INTRODUCTION

Metabolic syndrome (MetS) is a cluster of metabolic risk factors that increase the likelihood of developing chronic diseases [1]. Although the origins of metabolic syndrome can be traced back historically, its modern conceptualization began with Reaven's description in 1980 [2]. According to the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), MetS is defined by the simultaneous presence of obesity, dyslipidemia, elevated blood pressure, and glucose intolerance [3].

This syndrome significantly increases the risk of developing diabetes mellitus, cardiovascular disease (CVD), stroke, and even certain types of cancer [4-6]. Reports indicate that the prevalence of MetS varies both globally and within the Iranian population [7,8], with moderately high rates observed in various regions of Iran—often exceeding 25% [9,10].

Although the precise etiology of MetS remains unclear, it is widely suggested that a combination of genetic, metabolic, and environmental factors plays a pivotal role in its development [11,12]. Among environmental factors, dietary habits have garnered considerable attention from researchers in relation to MetS, particularly the effects of dietary fiber [13], fruits and vegetables [14], and dairy consumption [15].

Dietary quality indices have emerged as valuable tools for assessing overall diet and nutrient intake, offering key insights into the relationship between nutrition and the risk of chronic diseases [16,17]. Among these, the Dietary Diversity Score (DDS) is especially instrumental in evaluating overall diet quality and the variety of consumed food groups [18].

Numerous studies have investigated dietary quality indices, revealing associations such as lower scores in individuals with type 2 diabetes and an increased risk of coronary heart disease [19]. Additionally, research has highlighted the adverse effects of low-quality diets in women on cardiometabolic risk factors, including abdominal obesity [20]. In some cases, the Dietary Diversity Score (DDS) has demonstrated an inverse relationship with cardiovascular risk factors [21] and metabolic syndrome [22].

However, conflicting findings have emerged from cohort studies examining the relationship between dietary quality indices and chronic diseases. For example, a study conducted among French adults found that higher dietary quality index scores were only weakly associated with lower BMI and blood pressure in men, with no significant associations observed with plasma lipid profiles [23].

Given the inconsistencies in the existing literature , presence a little studies regarding relationship between Dietary Diversity Score(DDS) and metabolic syndrome and the need for a comprehensive assessment of dietary quality indices within a single study, this research aimed to investigate the association between the Dietary Diversity Score (DDS) and metabolic syndrome.

MATERIALS AND METHODS

Study Design

A case-control study design was employed for this investigation. After screening and identifying individuals who met the inclusion criteria, eligible participants were invited to take part in the study. At this stage, the required sample size (using the formula of sampling and given the 95% confidence level, the power of the test is 0.8, and the maximum acceptable error in the estimate), a total of 175 patients diagnosed with metabolic syndrome and an equal number of healthy controls (both male and female), aged between 20 and 65 years, were enrolled. Participants were recruited using data from various laboratories and general outreach efforts in Chalous, northern Iran.

The research project, assigned the approval number 393636, received ethical clearance from the Medical Ethics Committee of Isfahan University of Medical Sciences and was conducted in accordance with the principles of the Declaration of Helsinki.

Criteria for Diagnosis of Metabolic Syndrome

Subjects were diagnosed with metabolic syndrome based on the criteria defined by the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III). According to these guidelines, the presence of three or more of the following five components constitutes a diagnosis of metabolic syndrome:

- **Waist circumference (WC):** ≥88 cm for females and ≥102 cm for males
- **Blood pressure (BP):** ≥130/85 mmHg or current use of antihypertensive medication

- **High-density lipoprotein cholesterol (HDL-C):** <50 mg/dL for females and <40 mg/dL for males
- **Triglycerides (TG):** ≥150 mg/dL or current use of lipid-lowering medication
- **Fasting blood sugar (FBS):** ≥100 mg/dL or current use of medication for glycemic control

Individuals meeting at least three of these criteria were classified as having metabolic syndrome, while those meeting fewer than three were considered healthy controls.

Exclusion Criteria

Participants were excluded if they had undergone recent changes in medication or supplement use; were pregnant or lactating; had chronic diseases such as hepatic, renal, muscular, or neurological disorders; or adhered to an atypical or medically prescribed diet.

Data Collection

For participants undergoing new laboratory testing for high-density lipoprotein (HDL), triglycerides (TG), and fasting blood sugar (FBS), measurements of waist circumference (WC) and blood pressure (BP) were also performed. For those who had recent test results available, laboratory testing was verified, and only WC and BP measurements were conducted. All participants were fully informed about the objectives of the study and provided written informed consent after receiving comprehensive information.

Demographic and Biographical Data

Demographic and biographical information—including age, gender, marital status, educational level, and occupation—was collected using a structured questionnaire completed by all participants.

Assessment of Dietary Intake

Dietary intake for both groups was meticulously recorded using a validated 168-item Food Frequency Questionnaire (FFQ), a tool widely used in Iranian populations [24]. The reported quantities of each food item were converted into grams per day to ensure precise measurement. Dietary data were then analyzed using NUTRITIONIST IV (N4) software. Based on the software output, dietary quality indices were calculated and further analyzed using the Statistical Package for the Social Sciences (SPSS). This comprehensive methodology ensured accuracy and reliability in assessing the dietary habits of study participants.

Dietary Diversity Score (DDS)

The Dietary Diversity Score (DDS) was calculated based on the methodology proposed by Kant [25]. This index evaluates dietary diversity across five primary food groups derived from the food guide pyramid: bread and grains, fruits, vegetables, meats, and dairy products. These groups were further divided into 23 subgroups to better capture diversity within each category. Specifically:

- **Bread and grains:** 7 subgroups (refined bread, biscuits, macaroni, whole bread, corn flakes, rice, and refined flour)
- **Fruits:** 2 subgroups (whole fruits and fruit juices)
- **Vegetables:** 7 subgroups (potato, tomato, starchy vegetables, legumes, yellow vegetables, green vegetables, and other vegetables)
- **Meats:** 4 subgroups (red meats, poultry, fish, and eggs)
- **Dairy:** 3 subgroups (milk, yogurt, and cheese)

An individual was considered a consumer of a subgroup if they consumed at least half a serving of that subgroup. The maximum score for each food group was capped at two points, yielding a total possible DDS ranging from 2 to 10. A higher DDS score indicates greater dietary diversity, reflecting a more varied and potentially more nutritionally adequate diet.

Measuring Waist Circumference

Waist circumference was measured using a stretchable tape measure. The measurement was taken at the narrowest point between the lower rib cage and the umbilicus [26]. Accurate measurement of waist circumference is a vital anthropometric indicator, providing valuable information about central adiposity and contributing to the overall assessment of metabolic health.

Measuring Blood Pressure

Prior to blood pressure assessment, subjects were instructed to rest for ten minutes. Trained personnel measured blood pressure using a standard sphygmomanometer on the participant's left arm. The measurement was performed twice, and the average value was recorded as the participant's blood pressure [27]. This meticulous approach ensures accuracy and reliability in determining blood pressure, a critical parameter in evaluating cardiovascular health.

Assessment of Biochemical Parameters

To assess fasting blood sugar (FBS), triglycerides (TG), and high-density lipoprotein (HDL), subjects were instructed to visit the laboratory after fasting for 10–12 hours. Venous blood samples were collected and centrifuged at 3000 g for 5–7 minutes at 37°C within 20–30 minutes of collection.

Serum levels of FBS and TG were quantified using commercial kits, while HDL levels were measured using an enzymatic kit (Pars Azmoon Co., Tehran, Iran). This standardized approach ensures accuracy and consistency in biochemical parameter measurements, providing essential data for the comprehensive evaluation of metabolic health.

Assessment of other Variables

Additional variables, including medication use, disease status, dietary characteristics, and other relevant information, were collected via questionnaire. Comprehensive documentation of these factors contributes to a holistic understanding of participants' health and lifestyle, enabling a more thorough analysis of the relationships between dietary habits, metabolic syndrome, and overall well-being. This inclusive approach enhances the study's ability to identify potential confounders and strengthens the reliability of the findings.

Statistical Analysis

Data analysis was performed using SPSS software (version 21). Logistic regression was employed to examine the relationship between dietary quality and the occurrence of metabolic syndrome. Participants' scores were categorized into quartiles to assess adherence to dietary quality indices. The odds ratios (ORs) for metabolic syndrome were estimated across four models: the crude model (unadjusted), Model 1 (adjusted for age and sex), Model 2 (further adjusted for energy intake), and Model 3 (additionally adjusted for job, income, education, and marital status).

Quartile 1 served as the reference category, and ORs for metabolic syndrome were calculated for quartiles 2 through 4 relative to quartile 1. To assess the trend (P trend), the mean dietary diversity scores were calculated for each quartile within each model, and P trend was determined by treating the quartile means as a continuous variable.

This rigorous statistical approach enhances the study's ability to discern associations between dietary quality and metabolic syndrome while controlling for potential confounding variables, ultimately providing a robust foundation for drawing meaningful conclusions.

RESULTS

Among the Metabolic Syndrome (MetS) patients (cases), there were 80 males and 95 females, while the healthy subjects (controls) included 86 males and 89 females. The mean age of MetS patients was 50.8 ± 8.85 years, compared to 43.2 ± 11.16 years in healthy subjects. In the case group, 96% were married, whereas 80.6% were married in the control group. Education levels were higher in the control group than in the case group. The primary occupation for subjects in both groups was staff membership. Energy intake was similar between the two groups (2709 ± 1030 kcal in MetS patients vs. 2697 ± 958 kcal in healthy subjects) (Table **1**).

Although some demographic factors differed between the groups, these variables were adjusted for in the subsequent analysis of dietary diversity score.

In Table **2**, the likelihood of developing metabolic syndrome across quartiles of dietary diversity score (DDS) is presented. The crude model represents unadjusted values, while Model 1 adjusts for age and sex, Model 2 adjusts for energy intake, and Model 3 further adjusts for job, income, education, and marital status. Quartile 1 serves as the reference category. The odds ratios and confidence intervals are reported based on the study's findings. The P trend was not significant in any model ($P \geq 0.05$).

DISCUSSION

The objective of this study was to assess the association between dietary diversity score (DDS) and the occurrence of metabolic syndrome. However, based on the results obtained, no significant relationship was observed. Although the likelihood of metabolic syndrome decreased after adjusting for confounding variables such as age, sex, dietary energy, education, income, occupation, and marital status, the difference in morbidity between quartile 4

Table 1: Demographic Characteristics and Status of Energy Intake of the Two Groups

Variable	MetS patients (N = 175)	Healthy subjects (N = 175)	Comparison (P-Value)
Ag (Mean ± SD)	50.8 ±8.85	43.2±11.16	0.00
Sex Male (%)	80 (45.7)	86 (49.1)	0.52
Female (%)	95 (54.3)	89 (50.9)	
Marriage single (%)	7 (4)	34(19.4)	0.00
status married (%)	168(96)	141(80.6)	
Education Illiterate (%)	2(1.1)	0(0)	0.00
Under diploma (%)	61(34.9)	27(15.4)	
Diploma (%)	48(27.4)	37(21.1)	
Over diploma (%)	8(4.6)	9(5.1)	
Bachelor (%)	36(20.6)	61(34.9)	
Master science (%)	18(10.3)	39(22.3)	
PhD (%)	2(1.1)	2(1.1)	
Job Housekeeper (%)	63(36)	33(18.8)	0.00
Staff (%)	69(39.4)	109(62.3)	
Worker (%)	2(1.1)	0(0)	
Business (%)	21(12)	12(6.9)	
Unemployed (%)	20(11.4)	21(12)	
Energy intake (Mean ± SD)	2709±1030	2697±958	0.91

Table 2: Odds Ratio for Metabolic Syndrome in Quartiles of Dietary Diversity Score (DDS)

Models	Quartile 1	Quartile 2 OR (95% CI)	Quartile 3 OR (95% CI)	Quartile 4 OR (95% CI)	P-trend
Stock	1	1.32(0.73-2.40)	1.1(0.61-1.98)	0.81(0.49-1.47)	0.40
1	1	0.93(0.49-1.77)	1.44(0.76-2.75)	1.06(0.56-2.01)	0.93
2	1	1.22(0.60-2.50)	1.78(0.89-3.58)	1.20(0.62-2.34)	0.42
3	1	1.42(0.66-3.04)	2.09(1.00-4.32)	1.30(0.64-2.64)	0.23

*Odds Ratio; **Confidence interval.

and quartile 1 of DDS lost statistical significance after these adjustments.

No significant difference (P ≥ 0.05) was found in the odds ratios across quartiles and models (P trend) for dietary diversity score. These results contrast with previous studies, including those by Niazi [28], Esmaillzadeh [29], Travido [30], and Azadbakht [22], which reported an inverse relationship between dietary quality or its indices and the occurrence of metabolic syndrome. Conversely, Frazier [31] reported no correlation between diet quality and the risk of cardiovascular disease in females. Additionally, McCullough's studies [32, 33] demonstrated that high dietary quality had no significant effect on preventing chronic diseases in both males and females.

Several reasons may explain the weak association between dietary quality and chronic diseases such as metabolic syndrome. Dietary quality indices like DDS may not fully capture the overall quality of a diet, as similar scores can result from different dietary patterns. Higher scores on dietary quality indices do not always correlate with improvements in biomarkers or reductions in the risk of chronic diseases, highlighting the need to consider other factors such as age and sex.

It is noteworthy that DDS does not specifically align with the dietary recommendations of the Dietary Approaches to Stop Hypertension (DASH) diet. Therefore, assuming that the score of this index or other dietary quality indices influences blood pressure, a key component of metabolic syndrome, may not be warranted.

One potential explanation for the lack of association between dietary quality or its indices and the occurrence of metabolic syndrome in this study is the prevalence of chronic diseases such as diabetes mellitus, hypertension, or hyperlipidemia, as well as the use of various medications by the subjects. These factors were not controlled for or excluded in the study, which may have influenced dietary patterns and lifestyle prior to participants entering the study. Consequently, we cannot definitively assert a relationship between dietary quality, as measured by the dietary diversity score, and the incidence of metabolic syndrome.

CONCLUSION

In summary, the findings of this study indicate no significant difference in dietary quality between individuals diagnosed with metabolic syndrome and their healthy counterparts. Consequently, no notable association was observed between dietary diversity score and the incidence of metabolic syndrome.

CONFLICT OF INTEREST

The author declare no conflict of interest.

ACKNOWLEDGEMENTS

The author would like to express their appreciation to the personnel of the School of Medical Sciences, Azad University of Chalous, Iran, for their invaluable collaboration and support in conducting this study.

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