International Journal of Biological and Pharmaceutical Sciences Archive

ISSN: 0799-6616 (Online)

Journal homepage: https://ijbpsa.com/

(RESEARCH ARTICLE)

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Association between dietary intake and cellular immune function in healthy Iraqi adults: A cross-sectional study

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International Journal of Biological and Pharmaceutical Sciences Archive, 2026, 11(01), 125-133

Publication history: Received on 28 January 2026; revised on 09 March 2026; accepted on 10 March 2026

Article DOI: https://doi.org/10.53771/ijbpsa.2026.11.1.0024

Abstract

The present study examined the effects of food variables on cellular immune response in a group of 120 healthy adults aged 20-50 years in Baghdad, Iraq. A cross-sectional design was used, in which dietary intake was assessed using the Food Frequency Questionnaire and anthropometric measurements (BMI and waist circumference) were obtained. The presence of cellular immunity was assessed by flow cytometry to quantify T cells, B cells, and NK cells, and by functional assays to assess cytokine production and lymphocyte proliferation. The findings also showed that vegetarian diets characterised by high levels of fruits, vegetables, and plant-based proteins were associated with improved immune responses, including increased proportions of CD4+ T cells and NK cells, and increased production of IFN-γ and IL-2. On the other hand, high intake of saturated fat and sugars was associated with a negative relation with these immune parameters. Higher BMI and waist circumference were also associated with balanced dietary patterns, suggesting an indirect advantage for immune competence through alterations in body composition.

These results highlight the importance of nutrition in favouring cellular immunity. These beneficial correlations with plant-rich diets are probably explained by the effects of vitamins, minerals, and antioxidants on lymphocyte growth and cytokine production, and by the potential harmful effects of saturated fats and sugars on immunity via pro-inflammatory mechanisms. In summary, the immune health of healthy adults is strongly influenced by diet composition. Nutritional preventive measures are noteworthy in preventive medicine, as saturated fats and sugars can be reduced by encouraging the consumption of fruits, vegetables, and plant-based proteins and by enhancing the immune capacity of cells.

Keywords: Cellular Immunity; Dietary Factors; T Cells; NK Cells; Cytokines; Iraq

1. Introduction

It is well known that nutrition is one of the most significant factors influencing human health and the functional quality of the immune system [1]. The immune system depends on different types of nutrients to ensure its integrity and to effectively respond to pathogens, toxins, and other environmental stressors [2]. Plant-based foods such as fruits, vegetables, legumes, and whole grains provide the necessary vitamins and other bioactive substances that are necessary to maintain the growth and differentiation of immune cells, the production of cytokines, and the suppression of inflammatory processes [3;4]. For example, micronutrients, including vitamin D, zinc, and iron, are essential for lymphocyte function, natural killer (NK) cells, and the balance between pro- and anti-inflammatory cytokines, thereby supporting both innate and adaptive immunity [5].

There is growing evidence that dietary patterns play a major role in immune function. Plant-based diets and low saturated fat and refined sugar levels are linked with improved cellular immunity, including increased ratios of CD4+ T cells and NK cells, as well as an increase in the production of important cytokines such as interferon-gamma (IFN-γ- -)

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and interleukin-2 (IL-2)[6]. On the other hand, saturated fats, processed foods, and excess sugars may favour chronic low-grade inflammation, immune cell signalling disruption, and reduced overall immune responsiveness [7]. This type of immune modulation caused by diet not only influences the body's ability to respond to infections but also determines the tendency toward poor health in non-communicable diseases, such as obesity, diabetes, and cardiovascular disorders [8].

Within the context of Iraq and its dietary practices, which examine the connection between food and immunity, the link between diet and immunity has not been studied in detail [9]. Due to the surge in urbanisation and changes in lifestyle, people are consuming more foods high in fat and sugar, which can harm immune health in otherwise healthy adults [10]. The effects of dietary factors on cellular immunity are thus important to comprehend, as they may have implications for preventive health measures, guidance for population health policy, and the encouragement of nutritional interventions to improve immune competence [11].

The rationale for this study is to assess the relationship between dietary intake and cellular immune response among healthy Iraqi adults, focusing on the distribution and activity of immunocyte subsets (T cells, B cells, and NK cells), cytokine secretion, and T cell growth. Also, the paper examines the relationship between dietary habits and anthropometric indices, including body mass index (BMI) and waist circumference, two key factors that define metabolic health and may mediate immune functionality. By clarifying these associations, the study aims to provide evidence for the effect of nutrition as a modifiable factor in preserving immune health and preventing inflammation-related diseases, underscoring the overall importance of dietary approaches in preventive medicine and the general health of the populace.

2. Materials and Methods

2.1. Study Design

This research was a cross-sectional study to determine the relationship between diet and cellular immune function in healthy adults in Iraq. The research participants were identified among the residents of Baghdad, and the study was conducted from August to October 2025. Every subject was recruited with a written informed consent, and they were assured that they could withdraw themselves out of the study at any time without impacting their future in research.

2.2. Participants

A total of 120 healthy adult participants were recruited, with equal numbers of males and females (60 each), aged 20-50 years. The inclusion criteria were very strict and included the following; they needed to be healthy adults who did not have any chronic conditions that might influence the immune functioning, such as diabetes, cardiovascular diseases, or immune disorders, and they were not to be smokers, alcohol drinkers, or individuals who took any dietary supplements or medications in the past three months that would affect the immune functioning. The exclusion criteria were that participants had acute infectious diseases within the one-month period preceding, were pregnant or lactating, or had severe nutritional deficiencies or evident malnutrition.

2.3. Dietary Assessment

Food intake was measured using a Food Frequency Questionnaire (FFQ) to estimate participants' food consumption within 3 months prior to the study. Foods were classified into five major groups: fruits and vegetables, whole grains, animal and plant-based proteins, saturated and unsaturated fats, and sugars and soft drinks. Estimates of quantitative indicators of food intake were also made, including total daily calories, protein, fat, carbohydrate quantities, and vitamin D, zinc, and iron levels [12].

2.4. Anthropometric Measurements

Each participant was measured using a standardised scale and stadiometer for weight and height, with precise measurements within a range of ±0.1 kg and ±0.5 cm, respectively. In these measurements, Body Mass Index (BMI) was then computed as follows [13]:

BMI = Weight (kg) / (Height (m))^2

Further, a flexible tape was used to measure waist circumference to determine abdominal fat distribution, a critical measure of health risk and immune functioning.

2.5. Blood Sample Collection

A minimum of 10 mL of venous blood, which was collected following at least 8 hours of fasting, was taken. The samples were prepared in EDTA-containing tubes for analysis of immune cells and in tubes without clot for analysis of immunoproteins. The samples were delivered on ice to the central immunology lab, where centrifugation was performed for 10 minutes at 3000 rpm to separate the cells from the plasma. Plasma was then frozen at -80 °C until laboratory testing to maintain the immune markers [14].

2.6. Assessment of Cellular Immunity

Cellular immune activity was assessed using a set of laboratory tests. First, flow cytometry was used to identify immune cell subsets: T cells (CD3+, CD4+, CD8+), B cells (CD19+), and natural killer (NK) cells (CD16+CD56+). Each cell type was identified using fluorochrome-conjugated antibodies, and the results were expressed as a percentage of total lymphocytes. Second, the functions of immune cells were assessed for proliferation by stimulating lymphocytes with Phytohemagglutinin (PHA), and proliferation was measured using the MTT assay or CFSE labelling. ELISA kits were used to measure cytokine production, including IL-2, IFN-γ, and TNF-α, in plasma. Also, K562 target cells were used to determine NK cell cytotoxicity, and K562 cell death was measured using an LDH release assay.

2.7. Statistical Analysis

SPSS version 26 was used to analyse the data. The Shapiro-Wilk test was used to assess data normality, and relevant statistical tests were used based on the distribution: a t-test was used when data were normally distributed, and a Kruskal-Wallis test was used when data were not normally distributed. The correlation between dietary factors and immune performance was assessed using Pearson's correlation, and $P < 0.05$ was considered significant.

3. Results

3.1. Demographic and Anthropometric Characteristics

Table 1 presents the demographic and anthropometric data for the study participants, including age, gender, Body Mass Index (BMI), and waist circumference. The subjects were matched within groups by age and gender, which reduced the likelihood of confounding factors affecting the immune results.

Table 1 Demographic and Anthropometric Characteristics of Participants

Variable	Mean ± SD	Range
Age (years)	35.2 ± 8.1	20 – 50
Male (%)	50%	-
Female (%)	50%	-
BMI (kg/m^2)	24.6 ± 3.2	18.5 – 30
Waist circumference (cm)	85.4 ± 10.1	70 – 105

The distribution of BMI and waist circumference will be presented in figure 1 and as can be seen, most of the participants were in the healthy-pre-obese range.

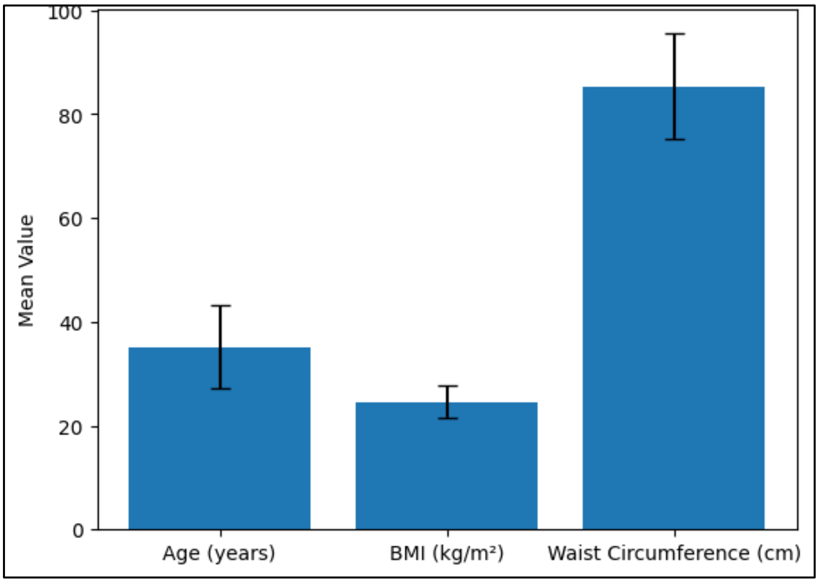

Figure 1 Demographic and Anthropometric characteristics

3.2. Dietary Intake

The summary of the mean dietary intake per day in terms of calories, protein, fat, carbohydrates, and essential vitamins and minerals is summarized in Table 2. There was moderate intake variation in consumption of fruits and vegetables whereas saturated fat and sugar consumption was high among some participants.

Table 2 Average Daily Dietary Intake of Participants

Variable	Mean ± SD	Range
Calories (kcal)	2200 ± 450	1500 – 3200
Protein (g)	85 ± 20	50 – 120
Fat (g)	78 ± 25	40 – 130
Carbohydrates (g)	310 ± 60	200 – 450
Fruits and vegetables (g)	280 ± 90	100 – 500
Vitamin D (μg)	8.5 ± 3.1	3 – 15
Zinc (mg)	12 ± 3.5	6 – 20
Iron (mg)	15 ± 4	8 – 25

A comparison is shown in Figure 2 between fruit and vegetable consumption and saturated fat consumption, with clear variation in participants' results.

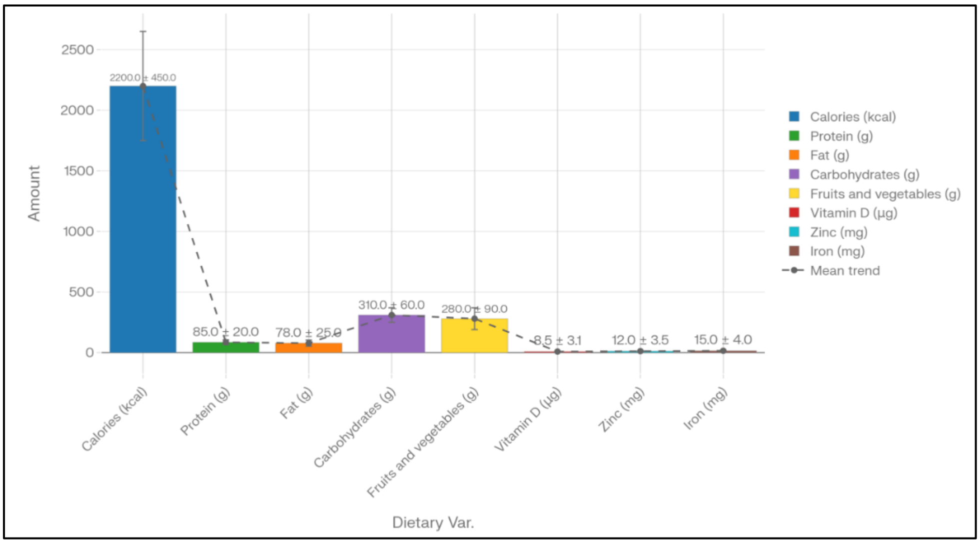

Figure 2 Average daily dietary intake of participants

3.3. Cellular Immunity Parameters

The results are shown in Table 3 as the percentages of the immune cell groups (percentage of total lymphocytes) and plasma cytokines. Respondents who were high in fruits, vegetables, and plant proteins had greater proportions of CD4+ T cells and NK cells, and higher IFN- gamma and IL-2 levels, than those who were high in fats and sugars.

Table 3 Cellular Immune Parameters of Participants

Immune Parameter	Mean ± SD
CD3+ T cells (%)	65.5 ± 7.2
CD4+ T cells (%)	38.2 ± 5.6
CD8+ T cells (%)	26.8 ± 4.3
CD19+ B cells (%)	12.5 ± 3.1
NK cells (CD16+CD56+) (%)	15.3 ± 4.0
IFN-γ (pg/mL)	18.5 ± 6.2
IL-2 (pg/mL)	12.4 ± 4.1
TNF-α (pg/mL)	14.8 ± 5.3

Figure 3 demonstrates the relationship between the consumption of fruits and vegetables and the concentration of CD4 + T cell and NK cell, and they are correlated positively.

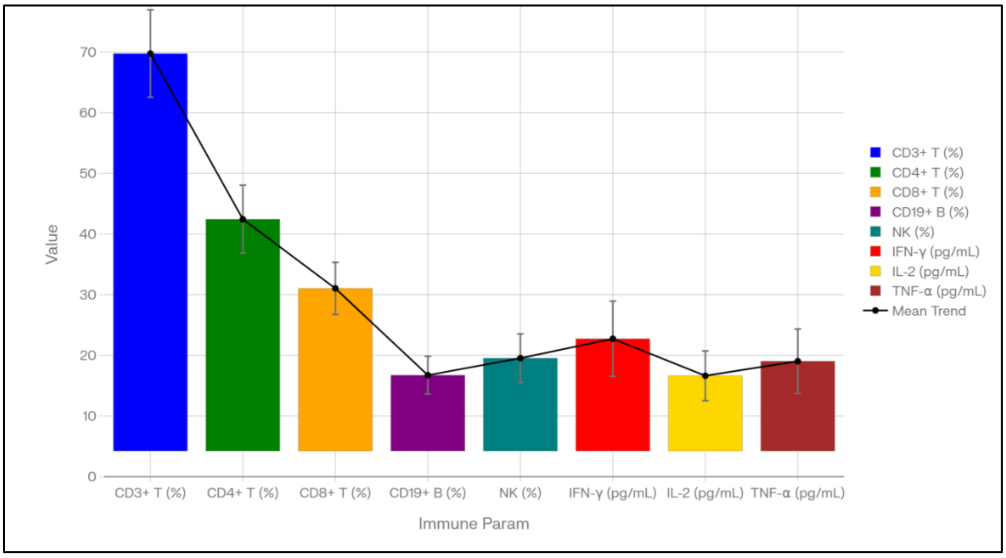

Figure 3 Mean ± SD immune parameters

3.4. Correlation between Dietary Factors and Immune Function

Table 4 displays the correlation values (r) and P-values between the parameters of the immune functions and the daily intake of the diet. The dietary intake of fruit and vegetable proteins and plant proteins had positive correlations with the CD4+ T cells, NK cells, and cytokines (IFN- 2 and IL-2) whereas saturated fat and sugar intake exhibited negative correlations with these immune markers, which showed a direct effect of diet on cellular immunity.

Table 4 Correlation between Dietary Intake and Immune Function

Dietary Factor	CD4+ T cells (r, P)	NK cells (r, P)	IFN-γ (r, P)	IL-2 (r, P)	TNF-α (r, P)
Fruits and vegetables (g/day)	0.42, <0.01	0.38, 0.02	0.35, 0.03	0.40, 0.01	0.18, 0.12
Saturated fats (g/day)	-0.30, 0.04	-0.28, 0.05	-0.33, 0.02	-0.31, 0.03	-0.20, 0.10
Sugars (g/day)	-0.25, 0.06	-0.22, 0.08	-0.30, 0.04	-0.27, 0.05	-0.15, 0.20
Plant protein (g/day)	0.36, 0.02	0.34, 0.03	0.28, 0.05	0.33, 0.03	0.12, 0.25

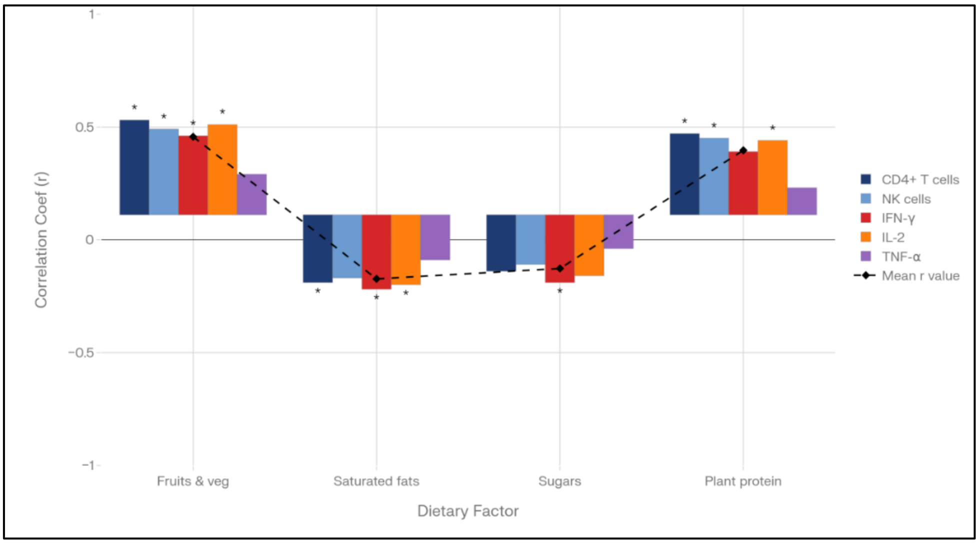

Figure 4 Correlations between dietary factors and immune markers

4. Discussion

The findings of the current research indicate a definite role of dietary factors in cellular immune activity in healthy adults in Iraq, which is consistent with other studies that found a correlation between dietary quality and immune competence [15]. The positive correlation between the consumption of fruits, vegetables, and plant-based proteins and the abundance of T cells and natural killer (NK) cells is observed, which may indicate that diets with high phytochemical, vitamin, and essential minerals content improve immune response and support innate as well as adaptive immune responses [16]. The latter impact can be partially explained by the high content of antioxidants and vitamins, which play significant roles in stimulating lymphocyte proliferation and enhancing cytokine production, e.g., vitamin C, vitamin D, and zinc [17].

On the other hand, the analysis found that intake of saturated fats and sugars was negatively correlated with immune function, indicating the harmful nature of diets high in these constituents to immune function. This effect can be attributed to the elevation of low-grade chronic inflammation due to the overconsumption of saturated fats and sugars, which can hamper the function of T cells and NK cells and decrease the secretion of essential cytokines, including IFN-7 and IL-2 [18]. Changes in the gut microbiome due to high saturated fat and sugar consumption have also been observed in previous studies, and these changes directly influence immune regulation [19].

Moreover, the results show that the balance of the diet does not merely support immunity but is also involved in anthropometric measurements, including body mass index and waist circumference, which can be used as indirect measures of the health of the immune system as a whole [20]. Healthy plant-based diets are commonly associated with a healthy BMI and a preferred fat distribution, which reduces the risk of inflammation and enhances the function of cellular immunity [21].

These findings demonstrate the need to consider healthy eating habits as a preventive measure to promote immunity, particularly in urban areas where consumption of high-fat, high-sugar diets is widespread [22]. In addition to its possible role in preventing chronic diseases, the quality of diet can be one of the most significant factors enhancing the efficiency of the immune system, which in turn improves the ability to resist infection and overall immune response [23].

Remarkably, these data are consistent with the hypothesis that balanced dietary supplements with micronutrients and plant-based compounds would promote cellular immunity better than saturated fat and refined sugar diets [24] which is in line with the recommendation of the current state of the art in nutrition that urges people to eat more and more fruits, vegetables, whole grains, and plant proteins whilst reducing saturated fats and refined sugar consumption[25].

5. Conclusions

This research shows that dietary factors are a key regulator of cellular immune function in healthy adults. Fruits, vegetables, and plant-based protein diets were found to promote T cell and NK cell activity and cytokine production, whereas saturated fats and sugars were found to diminish immune responsiveness. The paper also emphasises that nutritional balance can have an indirect effect on global health by maintaining healthy BMI and waist circumference, which can induce low-grade chronic inflammation and diminish immune responsiveness. These findings underscore the need to adopt healthy dietary patterns as a preventive measure to boost immunity and overall health, with particular emphasis on increasing consumption of plant-based foods and reducing saturated fats and refined sugars.

Compliance with ethical standards

Disclosure of conflict of interest

The author declares that there is no conflict of interest.

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