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The Association between Dietary Acid Load and Non-Communicable Diseases: A Cohort Study in Shahrekord

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ABSTRACT

Background and aim: It has recently been suggested that acid-base imbalances may play a role in some types of cardiovascular diseases and metabolic disorders. The aim of this study is to investigate the association between dietary acid load and common non-communicable diseases (NCDs). **Methods:** In this cross-sectional study, 1800 participants were enrolled in a cohort study in Shahrekord. Data were collected using a Food Frequency Questionnaire (FFQ). The potential renal acid load (PRAL) was calculated using the intestinal absorption of five nutrients including protein, potassium, phosphorus, magnesium, and calcium. The association of dietary acid load with NCDs was investigated in two models. Then, the raw model was adjusted by including calorie intake and age; after adjusting the effect of the two variables, the association between dietary acid load and the studied NCDs was not statistically significant. **Results**: The mean age of the participants was 51.49±9.27 years, and 941 (52.27%) of them were female. Mean±SD acid load score was -6.88±23.23. The results showed that there was a significant association between dietary acid load and age (*P*=0.005), weight (*P*=0.0001), waist circumference (*P*=0.016), hip circumference (*P*=0.0001)**,** waist-to-hip ratio (*P*=0.01), body mass index (*P*=0.004), and triglyceride (*P=0.012*). In the raw model, a significant association was observed between dietary acid load and hypertension (OR=0.57, 0.39-0.8). **Conclusion**: In this study, no significant association was observed between dietary acid load and NCDs, but the variable was associated with weight and body mass index as the most important risk factors for NCDs.

Keywords: *Diet; Dietary acid load; Noncommunicable diseases; Cohort studies; Diabetes mellitus; Hypertension; Myocardial Infarction; Stroke.*

Introduction

The continuing increase in non-communicable diseases (NCDs) across the world is a major challenge facing global health (Ahmadi *et al.*, 2021). NCDs including cardiovascular disease, diabetes, chronic lung disease, allergies, some types of cancer, and osteoporosis are the most important cause of mortality in the world (Hanson *et al.*, 2011). NCDs reduce productivity, capital, and economic growth (Simpson and Camorlinga, 2017). Global status report *on NCDs in 2010*

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reported care and monitoring of risk factors as being the first priority in fighting the growing prevalence of NCDs in low-income areas (Hosseinpoor *et al.*, 2012).

NCDs are not diagnosed early due to their hidden symptoms or are treated when the patient has already manifested the symptom (Tapia-Conyer *et al.*, 2015). According to the World Health Organization (WHO), NCDs are responsible for 70% deaths in world and 76.4% of all the deaths in Iran (Ahmadi *et al.*, 2021).

NCDs are directly correlated with risk factors such as smoking, nutrition, and inadequate physical activity, which are also preventable. These factors have increased due to adverse changes in diet and lifestyle as well as industrialization (Goli *et al.*, 2018).

Cost-effective and sustainable method of controlling these diseases includes reducing risk factors that can be fulfilled through lifestyle changes (Azizi *et al.*, 2009). Dietary patterns have changed substantially over time. With globalization, urbanization, and the consumption of processed foods, sugar, salt, and unhealthy fats are readily available, which result in obesity and health problems (Bloom *et al.*, 2012).

Because of its high animal protein content such as red meat, meat products, eggs, processed foods such as high energy drinks, in recent years, the Western diet affect the body's acid-base balance and finally human health (Reeds *et al.*, 2016) .

Dietary acid load is a variable to assess the quality of the diet which has recently been suggested as a risk factor for cardiovascular disease and metabolic disorders, hypertension, hyperglycemia, and insulin problems (Larijani and Azadbakht, 2017). Due to poor diet and calcium-citrate imbalance and cortisol-induced acidosis, metabolic acidosis have been identified as risk factors for obesity, lipid disorder, and subsequently cardiovascular disease (Murakami *et al.*, 2008).

Acidosis refers to a decrease in the level of extracellular fluid bicarbonate and the blood pH of acidic range (<7). The potential renal acid load (PRAL) and the net endogenous acid production (NEAP) are two scores to assess dietary acid load using dietary information (Ferraro *et al.*, 2016). Dietary acid load can be estimated by calculating PRAL, which indicates the excretion of pure renal acid from a type of food or the whole diet. The calculation of the PRAL in the diet is one of the approaches to examine the diet regarding base-acid balance (Scialla and Anderson, 2013).

NEAP equals total proteins divided by potassium, which are important determinants of metabolic acidosis (Stroup *et al.*, 2017). In this study, PRAL will be used. This index is calculated by considering the intestinal absorption of minerals and protein intake. This model has been experimentally validated in children, adolescents, and adults (Fagherazzi *et al.*, 2014).

Acidic foods positively affect dietary acid load, and alkaline foods negatively affect it. Foods such as meat, grains, and some dairy products increase the body's acidity, and fruits and vegetables that contain organic anions reduce pure acid (Ferraro *et al.*, 2016).

Few studies have so far examined the association between dietary acid load and risk factors for NCDs, and the result of some studies are contradictory (Chen *et al.*, 2019, Han *et al.*, 2016). In previous studies, acid load was positively associated with waist circumference (Murakami *et al.*, 2008) triglyceride low-density lipoprotein cholesterol (Bahadoran *et al.*, 2015), and total cholesterol (Murakami *et al.*, 2008).

Therefore, given the importance of NCDs and the effect of research in detecting and controlling risk factors for these diseases, we decided to investigate the association between dietary acid load and diabetes, hypertension, cardiovascular disease and related risk factors.

Materials and Methods

Study design: This was a cross-sectional and prospective cohort study regarding health status and NCDs in Chaharmahal and Bakhtiari province [Shahrekord cohort study (SCS)], which was performed on the study population using the data collected in 2017-2020.

Selection and description of participants: SCS was population-based, and its sample size included at least 10075 people. The study was aimed to

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assess general health status, chronic and NCD (cardiovascular diseases, cancers, hypertension, diabetes, fatty liver, multiple sclerosis, mental disorders, kidney diseases, asthma and lung diseases and causes of death) and their risk factors in people aged 35 to 70 in Shahrekord (sample size: 7034), and in urban and rural areas of Ardal County (sample size: 3041) in Chaharmahal and Bakhtiari province, southwest Iran.

Data collection: To conduct the present study, a sample of 1800 individuals was randomly selected. The study population of SCS consisted of 7000 individuals. First, a cumulative list of eligible individuals was prepared and after their invitation and referral, the list was finalized. Then, informed consent to participate in the study was received, and the questionnaires were completed and examinations were performed (Ahmadi *et al.*, 2021).

Data on demographics, disease, exposure to risk factors, food intake, place of residence, smoking, ethnicity, alcohol consumption, anthropometric indices and blood factors were drawn from SCS data. Diet assessment was performed by a trained nutritionist using Food Frequency Questionnaire (FFQ).

To calculate dietary acid load, the information on food intake, which had already been collected using the 168-item FFQ, was calculated in grams and included in the relevant formula.

All the questionnaires were filled out using face-to-face interviews conducted by a nutrition consular. Eventually, the proportion of each of the identified foods consumed was estimated to calculate energy and nutrients intake. The validity and reliability of the FFQ used in the SCS were investigated and were considered acceptable (Hosseini Esfahani *et al.*, 2010) .

In this study, Spearman correlation coefficient was obtained at 0.79 after adjusting the effect of age for relative validity of FFQ, and it was 0.91 after adding the effect of age and energy for relative reliability of the instrument.

Potential participants were enrolled by coding, and people who did not complete the FFQ or did not fill out all the items, people who had to follow special diets (such as vegetarianism or celiac diet) due to disease, people with calorie level of below 800 and above 4200, and those with very high or very low acid load scores were excluded from the study.

The PRAL was calculated using the intestinal absorption of five nutrients including protein, potassium, phosphorus, magnesium, and calcium:

PRAL (mEq/d) = [protein (g/d) × 0.49] + [P (mg/d) × 0.37] – [K (mg/d) × 0.021] – [Ca (mg/d) × 0.013] – [Mg (mg/d) ×0.026]

In this study, dietary acid load was calculated by PRAL method. Dietary acid load scores were divided into four classes (less than 14, between 14 to 3, between 3 and 7, and greater than 7 (Ahmadi *et al.*, 2021), and data analysis was performed on the basis of categorized quartiles and was evaluated in statistical analyses to investigate its association with NCDs and risk factors.

In order to investigate the relationship between dietary acid load and the studied diseases, in the first step, only demographic variables were entered into the model. In the second step, demographic variables along with anthropometric indices and other risk factors for NCD were entered into the model. In the third step, the variables of the second model in addition to food intake were entered into the third model and were modeled and correlated. In this study, the first quartile of acid load was used as a reference. In the first step, raw logistic regression was significant only for hypertension.

Ethical approval: The protocol of the present study was approved by Shahrekord University of Medical Sciences with the reference code: IR.SKUMS.REC.1399.225

Data analysis: SPSS version 16 software was used for analysis. For modeling the risk factors for NCDs, variables affecting the studied NCDs were correlated using logistic regression. Next, the effects of age, gender and calorie intake were adjusted, and the final result was reported.

Results

In this study, 941 (52.27%) women and 850

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(47.72%) men were enrolled. The mean±SD age of the participants was 51.49±9.27 (35-70), and 84.8% of the study population was in the age group of under 60. Moreover, 67% of the participants lived in urban areas, and 33% were in rural areas. Regarding ethnicity, 48.9% participants were *Lors*, and least 4.3% were *Kurds* (**Table 1**).

Table 1. Demographic information table.

Variables	**n(%)**
Gender	
Female	941(52.8)
Male	850(47.2)
Residency	
Urban	1220(67.7)
Rural	571(31.7)
Age (y)	
35-59	1526(84.8)
60≤	265(14.7)
Current smoker	387(21.5)
Alcohol abstainers	301(16.7)
Blood group	
A	509(28.3)
B	102(5.7)
AB	350(19.4)
O	761(42.3)
Ethnicity	
Fars	721(40.0)
Turkish	112(6.2)
Kurds	77(4.3)
Lors	881(48.9)
Diabetes	168(9.3)
High blood pressure	296(16.4)
Cardiovascular disease	106(5.9)
Heart failure	20(1.1)
Stroke	13(0.7)

Mean±SD dietary acid load calculated by the PRAL was obtained at -6.88±23.23 mEq/d. The results showed that the mean±SD dietary acid load was -2.25±10.24 mEq/d in men and was statistically higher than that of women -11.07±59.59 mEq/d (P≤0.0001).

The mean difference in dietary acid load was higher in men 8.83 mEq/d compared with women. Regarding ethnicity, the highest mean±SD dietary acid load was obtained for *Lor*s -4.92±22.88 and the lowest for *Kurd*s -13.57±30.03 mEq/d, the difference of which was statistically significant (P≤0.001). The LSD post-hoc test was used to investigate intergroup differences, and the results showed that the mean dietary acid load of *Lor*s was 3.57 mEq/d, which was higher than that of *Fars* (P≤0.005). In addition, the mean dietary acid load of *Lor*s was 8.65 mEq/d, which was higher than *Kurds* (P≤0.02).

The one-way ANOVA results indicated that there was a significant association between categorized dietary acid load, and age, weight, waist circumference, hip circumference, waist-to-hip ratio (WHR), body mass index (BMI), triglyceride, and HDL cholesterol. The LSD was used to investigate intergroup differences (**Table 2**).

Regarding age, the mean age at the first and second quartiles was significantly different to that of the fourth quartile, so that the mean age at the two quartiles was lower than the fourth quartile by 2.4 and 2 years, respectively (P≤0.05).

Regarding hip circumference, the mean hip circumference at fourth quartile 100.88±7.1 cm was significantly higher than the second quartile 99.78±8.00 cm, and also there was a significant difference between the third and second quartiles, so that the mean hip circumference at third quartile was 1.02 cm and less than that at fourth quartile (P≤0.05). Regarding WHR, the mean WHR at first quartile was significantly higher than the second and fourth quartiles (P≤0.05), but no significant difference was observed compared to the third quartile. Regarding BMI, the mean BMI at first quartile was significantly lower than the second and third quartiles (P≤0.05).

Regarding triglyceride, a significant difference was observed between the mean triglyceride levels at second and fourth quartiles, so that the mean triglyceride level at fourth quartile was 17.9 mg/dl and higher than that the second quartile (P≤0.05). In addition, an inverse correlation was observed between the mean HDL cholesterol and dietary acid load, so that the mean HDL cholesterol at the first quartile was 2.58 mg/dl and higher than the fourth quartile (P≤0.05).

To investigate the association between dietary acid load and NCDs, first, all the studied diseases were subjected to two models. In the first model,

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each disease was entered into the logistic regression model alone with the categorized dietary acid load, and then, age, gender, and calorie intake were entered into the model to adjust the effect. Thus, the probability of developing blood pressure was lower at the second quartile of dietary acid load compared with the first quartile of dietary acid load by 0.37 mmHg ($P≤0.01$), i.e. in the raw model, a protective effect for blood pressure was observed; moreover, people at the fourth quartile of dietary acid load were less likely to develop hypertension than those at the reference quartile by 0.43 mmHg ($P≤0.02$).

After adjusting for the effects of age, gender, and calorie intake, the observed association for hypertension also disappeared. In other words, the association was explained by age, gender, and calorie intake, and after the inclusion of these variables, dietary acid load was not associated with NCDs (**Table 3**).

Table 2. Characteristics of the participants by quartiles of potential renal acid load (PRAL) score.

Variables	PRAL score quartiles (mEq/d)				P-value[b]
	< −14(n=16,622)	−14 to −3(n=16,621)	−3 to 7(n=16,621)	≥ 7(n =16,621)	
Age (y)	50.70±9.30[a]	50.30±9.30	49.15±9.50	48.30±8.80	0.005
Weight (kg)	70.11±30.20	70.32±13.70	72.95±13.30	75.48±12.60	0.0001
Waist circumference(cm)	95.57±11.50	93.25±11.90	94.59±11.00	94.84±10.50	0.016
Hip circumference(cm)	100.99±7.60	99.8±78.00	100.80±7.60	100.88±7.10	0.0001
Waist-to-hip ratio	0.94±0.07	0.93±0.07	0.94±0.07	0.93±0.07	0.01
Body mass index (kg/m^2)	27.33±4.50	27.02±4.70	27.45±4.30	28.05±4.40	0.004
Physical activity (MET-h/week)	40.47±7.90	40.49±9.10	41.28±8.90	41.70±10.30	0.762
Cholesterol(mg/dl)	189.67±39.80	180.90±42.40	183.10±64.10	181.64±40.3	0.223
Triglyceride(mg/dl)	149.30±77.90	137.94±77.20	145.29±84.80	155.80±80.20	0.012
HDL-C (mg/dl)	51.56±11.00	50.92±12.90	50.47±11.50	48.98±10.50	0.004
LDL-C (mg/dl)	105.39±32.20	103.24±36.60	102.01±32.90	101.70±32.40	0.305
LDL-C/HDL-C	2.04±0.69	2.13±0.89	2.07±0.80	2.09±0.78	0.15
Meat (g/day)	102.00±64.30	87.00±110.60	70.0±100.60	65.00±112.50	0.15
Dairy (g/d)	571.10±33.20	605.78±476.33	573.56±409.70	581.90±427.80	0.78
Vegetables and Fruit (g/day)	915.03±505.30	848.10±451.30	890.50±998.90	877.90±479.00	0.44
Protein (% of energy)	99.70±36.50	87.50±32.90	96.30±41.03	132.30±47.20	0.0001
Fat (% of energy)	97.52±46.33	83.59±44.22	84.06±46.52	96.90±60.85	0.0001
Carbohydrates (% of energy)	535.58±209.10	450.57±188.63	482.71±198.91	677.52±266.09	0.0001
Energy (kcal/day)	3356.84±1257.04	2875.83±1128.12	3056.03±1233.27	4114.84±1559.65	0.0001
Fiber (g/day)	37.80±14.09	26.67±10.68	26.21±11.83	32.85±12.84	0.0001
Calcium (mg/day)	1298.06±519.26	1050.13±464.76	1133.94±984.42	1382.65±660.54	0.0001
Magnesium (mg/day)	453.69±165.30	335.33±132.78	341.97±157.04	433.86±167.25	0.0001
Phosphorus (mg/day)	1516.95±565.82	1211.95±489.05	1303.37±829.04	1684.83±709.21	0.0001
Potassium (mg/day)	5186.11±1716.56	3514.23±1212.34	3345.71±1631.25	3694.06±1407.74	0.0001

[a]:Mean±SD; [b]: ANOVA test.

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Table 3. Multivariate associations between potential renal acid load and non-communicable diseases.

Variables	Crude		Adjustment[a]	
	Odds ratio	P-value	Odds ratio	P-value[b]
Diabetes				
<-14	1	0.52	1	0.35
-14 to -3	0.74(0.45 – 1.12)[c]	0.14	0.70(0.44 – 1.33)	0.14
-3 to 7	0.94(0.64 -1.44)	0.78	1.02(0.65–1.52)	0.92
≥7	0.91(0.59 – 1.40)	0.67	1.09(0.69 – 1.72))	0.70
Hypertension				
<-14	1	0.001	1	0.17
-14 to -3	0.80(0.58-1.11)	0.19	0.77(0.54-0.97)	0.14
-3 to 7	0.63(0.45-0.90)	0.01	0.67(0.46-0.97)	0.13
≥7	0.57(0.39-0.80)	0.02	0.79(0.53-1.17)	0.24
Stroke				
<-14	1	0.42	1	0.52
-14 to -3	2.15(0.51-9.01)	0.29	1.99(0.46-8.58)	0.35
-3 to 7	1.7(0.39-7.79)	0.45	1.70(0.37-7.77)	0.48
≥7	0.43(.04-4.20)	0.47	0.45(0.04-4.48)	0.49
Myocardial infarction				
<-14	1	0.89	1	0.83
-14 to -3	0.85(0.24-3.00)	0.81	0.75(0.22-29.00)	0.67
-3 to 7	0.88(0.24-3.10)	0.85	0.81(0.22-0.29)	0.75
≥7	1.30(0.42-4.10)	0.62	1.33(0.40-4.20)	0.64
Cardiovascular disease				
<-14	1	0.14	1	0.31
-14 to -3	1.08(0.66-1.70)	0.74	1.05(0.62-1.76)	0.85
-3 to 7	0.59(0.32-1.07)	0.08	0.60(0.33-1.11)	0.10
≥7	0.70(0.40-1.20)	0.21	0.83(0.46-1.50)	0.55

[a]: Effects of age, gender and calorie intake were adjusted; [b]: Logistic regression; [c]: Odds (lower %95 confidence interval-upper confidence interval).

Discussion

In this study, the association between dietary acid load and demographic variables, common NCDs and related risk factors was investigated in 35 to 70 years old participants in SCS.

According to a study on diet, there was a high dietary acid load. This may be due to the differences in the consumption of food groups affecting dietary acid load, such as higher intake of meat and meat products and less consumption of fruits and vegetables in SCS population compared to the Tehran Lipid and Glucose Study (TLGS's); the finding indicated the difference in food culture between the residents of the two areas (Bahadoran *et al.*, 2015).

In this study, to investigate the relationship between dietary acid load and NCDs, a significant association was observed only in the raw model between dietary acid load and hypertension, which after adjusting the model for age, gender, and calorie intake, the relationship disappeared. In general, no significant association was observed between dietary acid load and the studied diseases, including diabetes, hypertension, cardiovascular disease, myocardial infarction, and stroke. Murakami et al. reported a significant association between acidosis and hypertension (Murakami *et al.*, 2008). In one study in Iran, a significant relationship was observed between blood pressure and the acid load of food diet (Haghighatdoost *et al.*, 2015). This study did not show a significant association between dietary acid load and diabetes. This lack of association remained after adjusting for the effects of age, gender, and calorie intake. In a study on blood sugar levels and diabetes with respect to dietary acid load, a significant association between dietary acid load and the incidence of diabetes was observed. However, the

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study was performed only on nurses and the confounding variables were not controlled (Akter *et al.*, 2015). The reason for lack of relationship between dietary acid load and NCDs in this study could be the observed association between age and dietary acid load. This study was a retrospective study, and previous prospective cohort studies were population based**.**

According to the results, with aging, dietary acid load decreased, which can be due to diet modification as aging and the incidence of NCDs (high acidic foods, high fatty acids and cholesterol, consumption of which was restricted in people with underlying disease, could partly explain the possible concealment of the relationship).

Furthermore, NCDs have not yet developed in young people who are likely to have diets with the highest dietary acid load, which may also hide a possible association. In a study regarding risk factors for NCDs, a significant relationship was observed between age and acid load, so that the mean age of people at the first quartile of acid load was 2.4 years more than those at the fourth quartile, which suggested that younger people had a more acidic diet. This difference could be due to the high consumption of fast foods and meat products and high consumption of sugary drinks in younger people. In one study in Iran, an inverse correlation was observed between age and dietary acid load so that the dietary acid load decreased with aging (Mousavi *et al.*, 2019).

Regarding anthropometric indices, a direct and significant correlation was observed between weight, waist circumference, hip circumference, WHR and BMI. People at the fourth quartile of dietary acid load had a higher average weight than those at the first quartile by 5.37 kg, and the corresponding difference in BMI was 0.55 kg/m^2.

There was a significant and direct correlation between dietary acid load, and serum creatinine and triglyceride levels in terms of the studied blood factors. Besides, people at the first quartile of dietary acid load had higher mean HDL cholesterol, which is a protective factor for the incidence of cardiovascular disease. Regarding triglycerides, people at the fourth quartile showed a higher mean triglyceride level compared with those at the first quartile by 8.62 mg/dl. In a study in Iran, a positive and significant correlation was reported between dietary acid load and triglyceride, and an inverse correlation was found between dietary acid load and creatinine level.

In this research, men consumed a more acidic diet than women, which could be due to the higher intake of meat and meat products in men and more consumption of fruits and vegetables in women. The urban population also had a less acidic diet than the rural population, which could be due to the lower consumption of fruits and vegetables, as well as higher intake of dairy products and thus calcium (alkali precursor) in rural populations. Intake of dairy products was almost twice higher in the rural population than in the urban population in this study.

It was the first time the authors compared diets of different ethnicities and reported a significant relationship. In this study, *Kurd*s had the lowest dietary acid load and the *Lor*s had the highest dietary acid load due to their high consumption of meat and meat products and less consumption of fruits and vegetables. Moreover, a direct and significant correlation was observed between dietary acid load and alcohol consumption and smoking, which may be due to inappropriate lifestyle.

In this study, smokers consumed more meat and fat and less fiber, and alcohol consumers had higher levels of energy, fat, and protein compared with others. These foods contain acid precursors and reduce the quality of diet, which along with the risk due to alcohol consumption and smoking, can intensify the risk of NCDs. Modeling the factors affecting acid load showed an inverse correlation between fat and fiber intake and acid load level, and also a direct correlation between carbohydrate intake and dietary acid load after adjusting for gender and calorie intake.

Bahadoran *et al*.'s research showed a direct and significant correlation between dietary acid load and fat and meat intake, and an inverse correlation between carbohydrate and fiber intake and dietary acid load (Bahadoran *et al.*, 2015). The study by Murakami *et al*. showed a direct and significant

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correlation between dietary acid load and meat, egg, and protein intake, and an inverse correlation with fruit and vegetable intake (Murakami *et al.*, 2008).

Inconsistencies in the results of these studies can be due to differences in the dietary pattern of different populations, different methods of measuring and estimating dietary acid load, different methods of estimating food intake, and the variety of controlled variables as confounding variables. One of the most important reasons for the inconsistency of the results can be cohort studies with high sample size. More clearly, many cohort studies had reported a significant association between acid load and the incidence of NCDs, while the current study did not show a significant association between acid load and NCDs.

Inconsistencies in the results of this and other studies may be due to differences in the dietary pattern of different populations, the use of different methods in estimating dietary acidity, study design, the number of samples studied in the study, different measurement methods and estimates of food intake as well as variability in adjusted confounders. Dietary acid load may also have different effects on the risk of chronic diseases in different regions of the world and in different cultures.

One of the strengths of this study was its proper sampling and the possibility of generalizing the results to the community, which in many studies, was not observed because they selected samples from a specific population of professionals, residents of a city, or either women or men, which makes it impossible to generalize the results to the community. In addition, due to the established effect of demographic factors on both acid load and the incidence and prevalence of NCDs, this limitation could undermine the results of those studies. Another strength of this study was the adjustment of confounding factors including age, sex, and calorie intake.

Due to the diet of the people in the province under study and their high average protein intake, which was the main factor for increased dietary acid load, the result was far from expected. This result may be due to the study type (cross-sectional study) and the simultaneous study of the risk factor and the studied outcome‛ this was because the presence of meat and its products in diets prescribed for patients with hypertension and cardiovascular disease was somewhat controlled, which can affect the observed association.

Given the effect of acid load on the incidence of diabetes and hypertension in cohort studies and also the results of the current study on the relationship between dietary acid load and risk factors for NCDs, it is necessary to conduct prospective studies to investigate the relationship, so when necessary, modifications should be made to the diets of healthy people to prevent the occurrence of NCDs, as well as to the diets of patients with these diseases to reduce the associated complications and disability.

Conclusions

Dietary acid load is affected by residence status, gender, and age. Men, have a more acidic diet, and in general, rural people have a higher acidic diet which is because of the higher consumption of meat and meat products and less consumption of fruits and vegetables due to cultural problems and health literacy regarding the appropriate division of food basket and rural people's access to fruits and vegetables. The average acid load decreases with aging, which can be due to the increased risk of NCDs and lifestyle modifications and treatment regimens. According to the results of this study, although dietary acid load is not associated with NCDs, it is related to the main risk factors for these diseases such as weight, waist circumference, hip circumference, BMI, and triglyceride.

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Conflict of interests

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Authors' contributions

Mousavi MS and Ghorbani M conceived the study; Mousavi MS, Ghorbani M and Ahmadi A designed the study; Mousavi MS, Ghorbani M and Ahmadi A collected data: Mousavi MS, Ghorbani M and Fazelian S analyzed the data; Mousavi MS, Ghorbani M and Fazelian S drafted the manuscript; and Mousavi MS, Ghorbani M, Ahmadi A and Fazelian S were involved with the manuscript's final edition.

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