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Evaluation of the relationship between dietary acid load and resting energy expenditure in women: a pilot study

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Abstract

Purpose – This study aims to evaluate the effect of dietary acid load on anthropometric measurements and resting energy expenditure (REE).

Design/methodology/approach – A total of 57 women aged 18–45, with a normal body mass index and without any acute or chronic disease, were included in the study. The general characteristics of the participants were evaluated with the questionnaire, REE and body composition were measured. A three-day food consumption record was taken; potential renal acid load and net endogenous acid production were calculated.

Findings – There were no statistically significant differences in anthropometric measurements, mean oxygen consumption per minute or REE between the high and low dietary acid load groups. According to categorical regression analysis, sedentary activity level and ≥ 26% body fat percentage negatively affect REE.

Practical implications – Although no direct association was found between dietary acid load and REE, the findings suggest that higher body fat percentage and a sedentary lifestyle are significant negative predictors of REE. These results underscore the importance of promoting regular physical activity and maintaining a healthy body composition for metabolic health. Additionally, while dietary acid load may not have an immediate measurable impact on REE, its potential long-term effects on body composition warrant attention. Encouraging balanced diets rich in plant-based, healthy foods may contribute to better overall health outcomes and support metabolic efficiency in the long term.

Originality/value – To the best of the authors' knowledge, this is the first study to evaluate the effect of dietary acid load on REE in a Turkish sample.

Keywords Dietary acid load, PRAL, NEAP, Energy expenditure, Anthropometric measurements

Paper type Research paper

1. Introduction

The maintenance of acid–base equilibrium is essential to health and dietary components are an important factor that can influence this equilibrium by providing acid or base precursors. In general, foods such as meat, cheese and egg increase acid production due to their

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phosphorus and protein content (mainly sulfur-containing amino acids such as cysteine, methionine and taurine, as well as cationic amino acids such as lysine and arginine). However, fruits and vegetables increase alkali production, especially due to their potassium content (Osuna-Padilla *et al.*, 2019). Therefore, while Western diets are characterized by a high dietary acid load (DAL), due to large amounts of animal protein and processed foods, plant-based diets have a low dietary acid load (Müller *et al.*, 2021; Storz *et al.*, 2022).

Higher dietary acid load is associated with the development of diseases such as insulin resistance, diabetes, hypertension, hepatic steatosis, kidney stones and osteoporosis. Additionally, negative consequences such as increased carcinogenesis and decreased cognitive functions may be reported (Wieërs *et al.*, 2024; Han *et al.*, 2016; Iwase *et al.*, 2015; Lee and Shin, 2020). Dietary acid load is also a factor that may also be associated with obesity pathogenesis. The results of a systematic review and meta-analysis study showed that high dietary acid load is associated with obesity in adults (Abbasalizad Farhangi *et al.*, 2019). Many mechanisms have been proposed for the effect of increased dietary acid load on the development of obesity. One of these is that dietary acid load stimulates insulin resistance. Results of a prospective study show that those with high dietary acid load have a significantly higher risk of insulin resistance (Lee and Shin, 2020). Another reason may be the effect of dietary acid load on resting energy expenditure (REE). In a study conducted on healthy children, the relationship between dietary acid load and potential renal acid load (PRAL) and glucocorticoid hormone metabolism was evaluated. A significant correlation was found between PRAL and glucocorticoid hormone metabolism (Esche *et al.*, 2016). Glucocorticoid hormones play a critical role in facilitating renal adaptation to acidosis by promoting skeletal muscle catabolism and releasing glutamine. However, excessive glucocorticoid activity is associated with adverse effects such as muscle wasting, insulin resistance, altered appetite and impaired bone health. The observational nature of the study limits causal interpretation: it remains unclear whether increased glucocorticoid metabolism drives higher PRAL or whether a high dietary acid load induces hormonal changes (Weiner, 2016). Additionally, based on the results of a single study, the association between dietary acid load and hypercortisolism cannot be generalized. However, even without the influence of glucocorticoid hormone, an increase in dietary acid load may stimulate protein catabolism due to its effect on insulin resistance (Lee and Shin, 2020; Liu and Zhu, 2023). The decrease in muscle mass along with the increase in dietary acid load may also lead to a decrease in REE (Gholami *et al.*, 2023). Therefore, dietary acid load is one of the factors that should be taken into consideration, especially in the prevention of obesity and comorbid diseases. However, the number of studies on this subject is quite limited. The aim of this study was to evaluate the effect of dietary acid load on anthropometric measurements and REE.

2. Material and methods

2.1 Study design

This study was a descriptive cross-sectional study. Women aged 18–45, who had a normal body mass index (BMI) according to the World Health Organization classification (BMI: 18.5–24.9 kg/m^2), were included in the study. The reason for only including women with normal BMI in the study was to limit the effect of gender and BMI on the results. Furthermore, the gender distribution in the faculty where data were collected was also a factor in meeting sample size. Due to the effects of menstrual cycle phases on REE, participants' measurements were taken during the luteal phase. In addition, a history of any acute or chronic disease, regular medication use, pregnancy and lactation, menopause and following an energy-restricted diet were determined as exclusion criteria of the study.

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The participants of the study are Gazi University Faculty of Health Sciences students and academic staff. The study was completed with a total of 57 participants. Participants were selected using the snowball sampling method. The study was conducted by the principles of the Declaration of Helsinki. Ethical approval was received for the research from Gazi University Ethics Commission on April 16, 2024, with research code number 2024-606. Each participant was informed about the study, and an informed consent form was obtained from the participants.

The general characteristics of participants were collected with a questionnaire, and the International Physical Activity Questionnaire-short form was used to evaluate the physical activity level (Arabacı and Çankaya, 2007). Menstrual cycle phases were calculated for each participant. Women who were in the luteal phase were invited for REE measurement, body weight and body composition analysis. In addition, three-day food consumption records were taken from the participants to calculate dietary acid load and evaluate daily energy and nutrient intake.

2.2 Evaluation of resting energy expenditure

Cosmed Fitmate Pro device was used to measure REE. Fitmate is an indirect calorimeter used in clinical settings. Its validity has been shown by studies (Nieman *et al.*, 2006; Vandarakis *et al.*, 2012). Conditions for measurement were fasting for at least 10 h, not using stimulants such as cigarettes, alcohol, caffeine or medication until 4 h ago and not performing any physical activity until at least 12 h ago (Nieman *et al.*, 2006). Measurement was started after the individuals rested in a supine position for 20 min. The measurement took a total of 15 min in a quiet environment, with the room temperature at 20–25°C. For adaptation, the first 5 min of the measurement were neglected, and the middle 5-min test value of the next 10 min was used.

2.3 Evaluation of body weight and body composition

Tanita BC 418 device was used for body weight and body composition analysis. For body composition analysis, it is recommended to fast for at least 8 h and not have performed physical activity for 8 h before (Kyle *et al.*, 2004). These recommendations have already been provided prior to REE measurement. In addition, care was taken to ensure that participants did not wear metal jewelry and did not have urinary urgency (Kyle *et al.*, 2004). Height measurement was made with a stadiometer while the individual was in an upright position, with his head in the Frankfort horizontal plane, his feet together at the heels, and his back, hips and heels touching the wall (Baysal *et al.*, 2013). In waist circumference measurement, the distance between the lowest rib and the crista iliac was found, and the circumference passing through the midpoint was measured with a tape measure (Baysal *et al.*, 2013).

2.4 Evaluation of dietary acid load

Three-day food consumption records (consecutive days, two days on weekdays and one day on the weekend) were taken from participants. The energy and nutrient intake was analyzed using the "Nutrition Information Systems Package Program (BEBİS)." Dietary acid load was evaluated through two indices, PRAL (Remer and Manz, 1994) and net endogenous acid production (NEAP) (Frassetto *et al.*, 1998):

$$\mathrm{PRAL\,(mEq/day)} = 0.4888 \times \mathrm{protein\,(g)} + 0.0366 \times \mathrm{phosphorus\,(mg)} - 0.0205 \times \mathrm{potassium\,(mg)} - 0.0125 \times \mathrm{calcium\,(mg)} - 0.0263 \times \mathrm{magnesium\ (MG)}$$

$$NEAP = [54.5 \times \mathrm{protein\,(g)}/\mathrm{potassium\,(mg)}] - 10.2$$

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2.5 Statistical analysis

The data were analyzed using the SPSS 22.0 program with appropriate statistical methods. The suitability of the variables to normal distribution was examined by Shapiro–Wilk test. Descriptive values were stated as number (n), percentage (%), arithmetic mean ($\bar{x}$) and standard deviation (SD). Categorical information was represented by numbers and percentages. Median values were determined for PRAL and NEAP, and classification was made as high–low according to the median value. General characteristics of participants and daily dietary intakes were compared by independent samples *t*-test or Mann–Whitney U test for descriptive variables and Pearson chi square ($\chi 2$) or Fisher's exact tests for categorical variables. Categorical regression analysis was used to evaluate variables affecting REE. When examining the hypothesis tests, $\alpha = 0.05$ and accordingly, the confidence interval was determined as 95%, and significance was evaluated at $p < 0.05$. Bonferroni-adjusted significance values were provided below the table for relevant variables.

3. Results

Comparison of general characteristics, anthropometric measurements and indirect calorimetric measurements of participants according to dietary acid load was given in Table 1. The mean age of participants with low PRAL score was 22.5 ± 3.05 year, while the mean age of participants with a high PRAL score was 23.4 ± 3.60 year ($p > 0.05$). Similarly, the mean age of participants with low NEAP score was 22.6 ± 3.12 year, while the mean age of participants with high NEAP score was 23.3 ± 3.54 year. Based on physical activity level, most participants were classified as minimally active. No significant difference was found between dietary acid load and age, education level, working status or physical activity level. According to both PRAL and NEAP scores, body weight, waist circumference, body fat mass, fat-free mass and muscle mass were significantly higher in participants with high dietary acid load than in those with low ($p < 0.05$). Although body weight, waist circumference, body fat mass, fat-free mass and muscle mass values were significantly higher in the high dietary acid load group, after applying the Bonferroni correction for multiple comparisons (adjusted significance level $p < 0.007$), these differences were no longer statistically significant. Therefore, these results should be interpreted cautiously. In addition, mean oxygen consumption per minute and REE were significantly higher in participants with a high PRAL score (*p*-value for both variables was 0.032). However, after applying the Bonferroni correction for multiple comparisons (adjusted significance level $p < 0.0167$), these differences were also no longer statistically significant.

Comparison of daily dietary intakes of participants according to dietary acid load was given in Table 2. After applying the Bonferroni correction for multiple comparisons (adjusted significance level $p < 0.002$), in participants with a high PRAL score, dietary protein percentage was significantly higher ($p = 0.001$) compared to participants with a low PRAL score. On the contrary, in participants with a low PRAL score, vitamin C ($p = 0.002$) was significantly higher. Considered from NEAP scores, in participants with a low NEAP score, dietary fiber ($p = 0.002$) and vitamin C ($p < 0.001$) were significantly higher compared to participants with a high NEAP score.

An evaluation of variables affecting REE using categorical regression analysis was given in Table 3. The Categorical regression model was found to be statistically significant ($F = 4.066$; $p = 0.002$). When the contribution level of the variables (PRAL, body fat percentage, physical activity level, meeting energy requirement and meeting protein requirement) to the model was examined, only physical activity level ($p = 0.003$) and body fat percentage ($p < 0.001$) had a significant effect in explaining the REE change. Sedentary activity level and ≥26% body fat percentage significantly and negatively affect REE. The effect of dietary acid load on the change in REE was not found to be significant.

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Table 1. Comparison of general characteristics, anthropometric measurements and indirect calorimetric measurements of participants according to dietary acid load

Variables	PRAL			NEAP		
	Low (<5.63, $n = 29$)	High (≥5.63, $n = 28$)	p^1	Low (<−8.72, $n = 28$)	High (≥−8.72, $n = 29$)	p^2
Age (year)	22.5 ± 3.05	23.4 ± 3.60	0.250[a]	22.6 ± 3.12	23.3 ± 3.54	0.192[a]
Education status			0.468[b]			1.000[b]
High school	24 (82.8)	20 (71.4)		22 (78.6)	22 (75.9)	
Bachelor's degree	1 (3.4)	4 (14.3)		2 (7.1)	3 (10.3)	
Postgraduate	4 (13.8)	4 (14.3)		4 (14.3)	4 (13.8)	
Working status			1.000[c]			1.000[c]
Yes	4 (13.8)	4 (14.3)		4 (14.3)	4 (13.8)	
No	25 (86.2)	24 (85.7)		24 (85.7)	25 (86.2)	
Physical activity level			0.414[b]			0.852[b]
Sedentary	4 (13.8)	3 (10.7)		4 (14.3)	3 (10.3)	
Minimal active	21 (72.4)	14 (60.7)		19 (67.9)	19 (65.5)	
Active	4 (13.8)	8 (28.6)		5 (17.9)	7 (24.1)	
Anthropometric measurements						
Body weight (kg)	55.5 ± 6.42	59.5 ± 6.35	0.022[d]	55.1 ± 5.85	59.7 ± 6.70	0.008[d]
Waist circumference (cm)	67.6 ± 4.47	70.1 ± 4.82	0.047[d]	67.5 ± 4.16	70.1 ± 5.05	0.043[d]
Body fat percentage (%)	22.1 ± 5.68	24.9 ± 5.42	0.066[d]	22.1 ± 5.34	24.8 ± 5.76	0.069[d]
Body fat mass (kg)	12.6 ± 4.18	15.1 ± 4.65	0.036[d]	12.4 ± 3.83	15.2 ± 4.87	0.023[d]
Fat-free mass (kg)	42.9 ± 2.90	44.4 ± 2.30	0.040[d]	42.7 ± 2.71	44.5 ± 2.42	0.010[d]
Muscle mass (kg)	40.7 ± 2.76	42.1 ± 2.20	0.041[d]	40.5 ± 2.57	42.2 ± 2.31	0.010[d]
Body water percentage (%)	54.3 ± 3.48	52.6 ± 3.38	0.070[d]	54.3 ± 3.29	52.7 ± 3.59	0.082[d]
Indirect calorimetric measurements						
VO_2 (ml/dk)	195.4 ± 22.35	208.0 ± 20.73	0.032[d]	195.9 ± 22.36	207.1 ± 21.18	0.058[d]
Ve (l/dk)	6.6 ± 0.92	6.8 ± 0.98	0.533[a]	6.7 ± 0.99	6.8 ± 0.92	0.774[a]
REE (kcal)	1,360.5 ± 155.72	1,448.0 ± 144.93	0.032[d]	1,363.8 ± 155.63	1,441.8 ± 148.15	0.058[d]

Note(s): Medians of PRAL and NEAP scores were used in statistical analysis; PRAL = potential renal acid load; DAL, NEAP = net endogenous acid production; VO_2 = oxygen consumption; Ve = mean ventilation rate; REE = resting energy expenditure; [a]Mann–Whitney U test; [b]Pearson Chi-square test; [c]Fisher's exact test; [d]Independent samples t-test; after Bonferroni correction, the p significance value for anthropometric measurements was determined as <0.007, and the p significance value for indirect calorimetric measurements was determined as <0.0167

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Table 2. Comparison of daily dietary intakes according to dietary acid load

Nutrients	PRAL			NEAP		
	Low (<5.63, $n = 29$)	High (≥5.63, $n = 28$)	p^1	Low (<−8.72, $n = 28$)	High (≥−8.72, $n = 29$)	p^2
Energy (kcal)	1,588.1 ± 489.39	1,603.0 ± 626.83	0.823[a]	1,594.7 ± 486.71	1,596.1 ± 624.55	0.725[a]
Protein (g)	54.0 ± 15.73	64.8 ± 22.27	0.076[a]	56.1 ± 15.49	62.4 ± 23.10	0.513[a]
Protein (%)	14.3 ± 2.22	17.5 ± 4.60	0.001[a]	14.8 ± 2.48	16.9 ± 4.73	0.068[a]
Dietary fat (%)	40.0 ± 5.49	37.1 ± 4.49	0.036[b]	39.1 ± 5.45	38.1 ± 4.94	0.439[b]
Carbohydrate (%)	45.9 ± 5.14	45.4 ± 6.65	0.784[b]	46.1 ± 5.04	45.2 ± 6.65	0.538[b]
Dietary fiber (g)	18.2 ± 5.27	17.0 ± 7.81	0.185[a]	19.4 ± 4.84	15.8 ± 7.62	*0.002*[a]
Antioxidant content (mmol)	1.9 ± 0.69	3.4 ± 7.89	0.180[a]	2.0 ± 0.65	3.3 ± 7.77	0.047[a]
Vitamin A (mcg)	881.7 ± 610.44	744.0 ± 396.95	0.555[a]	917.1 ± 604.05	714.7 ± 401.91	0.202[a]
Vitamin E (mg)	17.0 ± 7.88	11.8 ± 5.87	0.006[b]	16.5 ± 7.77	12.5 ± 6.55	0.038[b]
Thiamine (mg)	0.8 ± 0.25	0.8 ± 0.27	0.694[b]	0.8 ± 0.23	0.7 ± 0.27	0.102[b]
Riboflavin (mg)	1.1 ± 0.32	1.2 ± 0.38	0.073[b]	1.1 ± 0.31	1.2 ± 0.40	0.378[b]
Niacin (mg)	11.3 ± 4.30	13.4 ± 5.71	0.238[a]	12.0±±4.20	12.7 ± 5.91	0.811[a]
Folic acid (mcg)	256.0 ± 83.45	241.1 ± 99.80	0.315[a]	266.9 ± 80.35	231.1 ± 99.02	0.046[a]
Vitamin B_{12} (mcg)	3.2 ± 1.71	3.9 ± 1.71	0.174[b]	3.4 ± 1.74	3.7 ± 1.72	0.453[b]
Vitamin C (mg)	109.9 ± 56.32	67.4 ± 31.6	0.002[a]	117.3 ± 52.56	61.8 ± 28.64	*<0.001*[a]
Potassium (mg)	2,351.2 ± 692.61	1,996.6 ± 732.50	0.066[b]	2,457.3 ± 626.92	1,906.4 ± 726.42	0.003[b]
Calcium (mg)	509.6 ± 142.18	606.6 ± 246.92	0.114[a]	524.3 ± 140.24	589.0 ± 250.39	0.453[a]
Magnesium (mg)	228.5 ± 65.60	229.3 ± 82.74	0.690[a]	239.8 ± 60.30	218.5 ± 84.67	0.085[a]
Phosphorus (mg)	884.8 ± 246.22	1,013.5 ± 319.11	0.170[a]	927.2 ± 241.17	968.1 ± 332.13	0.987[a]
Iron (mg)	9.2 ± 2.84	9.2 ± 3.14	0.992[b]	9.6 ± 2.59	8.8 ± 3.27	0.316[b]
Zinc (mg)	7.7 ± 2.55	8.7 ± 2.86	0.186[b]	8.1 ± 2.51	8.4 ± 2.96	0.658[b]

Note(s): Medians of PRAL and NEAP scores were used in statistical analysis; PRAL = potential renal acid load;; NEAP = net endogenous acid production; [a]Mann–Whitney U test; [b]Independent samples T-test; after Bonferroni correction, the p significance value for nutrients was determined as <0.002
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Table 3. Evaluation of variables affecting resting energy expenditure using categorical regression analysis

Variables	Variable categories	Categorical quantification	Standardized coefficients				
			Beta	Std. error	*F*	*p*	Model summary
PRAL	Low PRAL	−0.983	0.037	0.078	0.231	0.633	Multiple $R = 0.573$
	High PRAL	1.018					
Body fat percentage†	Normal	0.764	0.526	0.119	19.565	*<0.001*	$R^2 = 0.328$
	High	−1.309					
Physical activity level	Sedentary	−2.657	0.341	0.133	6.540	*0.003*	Adjusted $R^2 = 0.247$
	Minimal active	0.308					
	Active	0.575					
Meeting energy requirement‡	At least EAR recommendation	−0.461	0.097	0.106	0.827	0.368	$F = 4.066$
	Less than EAR recommendation	2.168					
Meeting protein requirement	At least DRI recommendation	0.625	0.134	0.109	1.513	0.224	$p = 0.002$
	Less than DRI recommendation	−1.601					

Note(s): PRAL = potential renal acid load; DRI = dietary reference intake; EAR = estimated average requirement. In the classification of resting energy expenditure, ≥1 kcal/kg/hour was considered normal in healthy adults (Mason, 2010); †For body fat percentage, 26% was determined as the cut-off point, considering the reference data of the Tanita; ‡Energy requirement was calculated with the Harris Benedict formula using mean age, body weight and height values. The physical activity level (PAL) was chosen as 1.4 for sedentary individuals, 1.6 for moderately active individuals and 1.8 for active individuals. In total, 50% was determined as the cut-off point in classifying the meeting the energy requirement; ᵠ46 g/day was determined as the cut-off point in classifying the meeting the protein requirement [National Institutes of Health (NIH), 2001]
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4. Discussion

One of the main objectives of this study was to assess the impact of dietary acid load on REE and mean oxygen consumption. Although mean oxygen consumption per minute and REE were higher in the high dietary acid load groups, no significant differences were found between the groups after Bonferroni correction. Also, the effect of dietary acid load on the change in REE was not found to be significant according to categorical regression analysis. The effect of dietary acid load on REE has been explored in only one previous study in the literature. A study conducted in Iran with 375 overweight or obese women reported that high dietary acid load was negatively associated with REE (Mirzababaei *et al.*, 2022). It is stated that an increase in dietary acid load may reduce REE, especially by stimulating insulin resistance (Akter *et al.*, 2016; Lee and Shin, 2020; Williams *et al.*, 2016a; Drabsch *et al.*, 2018). Despite the lack of statistical significance, the tendency for REE to be higher in participants with elevated PRAL and NEAP scores may be explained by several factors. One possible explanation is that the percentage of participants classified as physically active was higher in the high PRAL and NEAP groups (Table 1). Although individual variations exist, energy expenditure is closely linked to physical activity levels (Westerterp, 2008). This notion is further supported by the categorical regression analysis, which demonstrated a negative effect of sedentary behavior on REE (Table 3). Second, while total energy intake did not differ significantly between dietary acid load groups, the percentage of dietary protein was significantly greater in the high PRAL group (Table 2). Diets high in protein or rich in plant-based foods (which require more energy for fiber digestion) can increase the thermic effect of food and overall energy expenditure (Calcagno *et al.*, 2019). Finally, the tendency for higher fat-free mass and muscle mass in the high PRAL and NEAP groups (Table 1) may contribute to the observed increase in REE, as metabolically active lean tissue is a key determinant of oxygen consumption and energy expenditure (Westerterp, 2017). Correspondingly, categorical regression analysis indicated that higher fat mass has a significant negative impact on REE (Table 3).

An additional objective of this study was to investigate the impact of dietary acid load on body composition. We found that body weight, waist circumference and body fat mass tend to be higher in both high PRAL and NEAP score groups. However, after Bonferroni correction, no significant difference was found between the groups (Table 1). In a similar study involving 788 6-year-old girls, no significant association was found between anthropometric measurements and dietary acid load, as assessed by PRAL (Daneshzad *et al.*, 2021). Conversely, a study conducted among 207 university students demonstrated that individuals in the highest tertile of PRAL had significantly higher body weight compared to those in the lowest tertile. Moreover, a significant positive correlation was observed between NEAP scores and fat mass (Mansordehghan *et al.*, 2022). Supporting these findings, another study reported a positive relationship between NEAP and both BMI and waist circumference (Mozaffari *et al.*, 2019). The discrepancies between the findings of this study and those of previous research may be attributed to differences in participant characteristics, such as demographic or lifestyle factors, as well as variations in study methodology. The proposed mechanism for the association of high-acid diets with obesity may be that they cause insulin resistance and impaired secretion of insulin-like growth factor 1 (Souto *et al.*, 2011; Williams *et al.*, 2016b).

In the present study, while the differences were not statistically significant, participants in the high PRAL and NEAP groups exhibited a tendency toward higher lean body mass (Table 1). This finding appears to contrast with the general understanding that a high dietary acid load may promote muscle loss by reducing protein synthesis. Typically, an alkaline diet – rich in fruits and vegetables – is thought to support muscle mass through its micronutrient and antioxidant content, which can enhance protein synthesis and reduce inflammation

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(Welch *et al.*, 2013; Welch *et al.*, 2020). However, in our study, the tendency for higher lean body mass in the high acid load groups may be explained by their significantly higher dietary protein intake. Since dietary protein is a key driver of muscle protein synthesis, it may have counterbalanced the potential negative effects of acid load on lean tissue. This suggests that, in certain conditions, macronutrient composition – particularly protein intake – may exert a stronger influence on lean body mass than the dietary acid–base balance alone. In the study, although dietary phosphorus intake was higher in the high PRAL group, no significant result was found. Since PRAL is a composite index, the overall acid–base balance is more meaningful than any single nutrient. Thus, the nonsignificant phosphorus intake does not invalidate the findings related to high PRAL scores being associated with higher REE and body composition changes.

In conclusion, although no direct association was found between dietary acid load and resting metabolic rate, the findings suggest that higher body fat percentage and a sedentary lifestyle are significant negative predictors of REE. Additionally, although dietary acid load may not exert an immediate measurable effect on REE, its potential long-term implications for body composition deserve further consideration. In the long term, an increase in fat mass may further stimulate a decrease in REE, and this may result in the development of obesity and obesity-related chronic diseases. Therefore, it is important to follow an adequate and balanced diets that include plant-based foods and increasing physical activity.

The study examined not only dietary acid load but also physical activity levels, body composition and nutrient intakes, enabling a more comprehensive understanding of factors influencing REE. However, the study's cross-sectional design makes it difficult to draw conclusions about the relationship between dietary acid load and changes in REE or body composition. To prove causation, longitudinal research is required. The findings' generalizability is limited by the very small sample size, and their relevance to men or people who are overweight or obese is limited by the inclusion of only women with normal BMI. A question that could determine the socioeconomic level should have been added to the questionnaire; it could have been helpful in interpreting the results. Furthermore, the accuracy of dietary acid load estimations may have been impacted using self-reported food records, which are prone to recall bias and under- or over-reporting. It is important to take the mentioned limitations into consideration in future studies to obtain more generalizable and high-quality results. Future studies should also include biochemical markers of acid–base status and metabolic health to better understand physiological mechanisms.

References

Abbasalizad Farhangi, M., Nikniaz, L. and Nikniaz, Z. (2019), "Higher dietary acid load potentially increases serum triglyceride and obesity prevalence in adults: an updated systematic review and meta-analysis", *Plos One*, Vol. 14 No. 5, p. e0216547.

Akter, S., Eguchi, M., Kuwahara, K., Kochi, T., Ito, R., Kurotani, K., Tsuruoka, H., Nanri, A., Kabe, I. and Mizoue, T. (2016), "High dietary acid load is associated with insulin resistance: the furukawa nutrition and health study", *Clinical Nutrition*, Vol. 35 No. 2, pp. 453-459.

Arabacı, R. and Çankaya, C. (2007), "Beden eğitimi öğretmenlerinin fiziksel aktivite düzeylerinin araştırılması", *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, Vol. 20, pp. 1-15.

Baysal, A., Aksoy, M., Besler, T., Bozkurt, N., Keçecioğlu, S., Merdol, T., Pekcan, G., Mercanlıgıl, S. and Yıldız, E. (2013), *Diyet El Kitabı*, Ankara, Hatipoğlu Yayınevi.

Calcagno, M., Kahleova, H., Alwarith, J., Burgess, N.N., Flores, R.A., Busta, M.L. and Barnard, N.D. (2019), "The thermic effect of food: a review", *Journal of the American College of Nutrition*, Vol. 38 No. 6, pp. 547-551.

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Daneshzad, E., Dorosty-Motlagh, A., Bellissimo, N., Suitor, K. and Azadbakht, L. (2021), "Food insecurity, dietary acid load, dietary energy density and anthropometric indices among ıranian children", *Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity*, Vol. 26 No. 3, pp. 839-846.

Drabsch, T., Holzapfel, C., Stecher, L., Petzold, J., Skurk, T. and Hauner, H. (2018), "Associations between C-reactive protein, insulin sensitivity, and resting metabolic rate in adults: a mediator analysis", *Frontiers in Endocrinology*, Vol. 9, p. 556.

Esche, J., Shi, L., Sánchez-Guijo, A., Hartmann, M.F., Wudy, S.A. and Remer, T. (2016), "Higher diet-dependent renal acid load associates with higher glucocorticoid secretion and potentially bioactive free glucocorticoids in healthy children", *Kidney İnternational*, Vol. 90 No. 2, pp. 325-333.

Frassetto, L.A., Todd, K.M., Morris, R.C. and Sebastian, A. (1998), "Estimation of net endogenous noncarbonic acid production in humans from diet potassium and protein contents", *The American Journal of Clinical Nutrition*, Vol. 68 No. 3, pp. 576-583.

Gholami, F., Bahrampour, N., Samadi, M., Rasaei, N., Yarizadeh, H., Naghshi, S. and Mirzaei, K. (2023), "The association of dietary acid load (DAL) with estimated skeletal muscle mass and bone mineral content: a cross-sectional study", *BMC Nutrition*, Vol. 9 No. 1, p. 31.

Han, E., Kim, G., Hong, N., Lee, Y.-H., Kim, D.W., Shin, H.J., Lee, B.-W., Kang, E.S., Lee, I.-K. and Cha, B.-S. (2016), "Association between dietary acid load and the risk of cardiovascular disease: nationwide surveys (KNHANES 2008–2011)", *Cardiovascular Diabetology*, Vol. 15 No. 1, pp. 1-14.

Iwase, H., Tanaka, M., Kobayashi, Y., Wada, S., Kuwahata, M., Kido, Y., Hamaguchi, M., Asano, M., Yamazaki, M. and Hasegawa, G. (2015), "Lower vegetable protein intake and higher dietary acid load associated with lower carbohydrate intake are risk factors for metabolic syndrome in patients with type 2 diabetes: post-hoc analysis of a cross-sectional study", *Journal of Diabetes Investigation*, Vol. 6 No. 4, pp. 465-472.

Kyle, U.G., Bosaeus, I., DE Lorenzo, A.D., Deurenberg, P., Elia, M., Gómez, J.M., Heitmann, B.L., Kent-Smith, L., Melchior, J.-C. and Pirlich, M. (2004), "Bioelectrical impedance analysis—part II: utilization in clinical practice", *Clinical Nutrition*, Vol. 23 No. 6, pp. 1430-1453.

Lee, K.W. and Shin, D. (2020), "Positive association between dietary acid load and future insulin resistance risk: findings from the korean genome and epidemiology study", *Nutrition Journal*, Vol. 19 No. 1, pp. 1-11.

Liu, Z.-J. and Zhu, C.-F. (2023), "Causal relationship between insulin resistance and sarcopenia", *Diabetology and Metabolic Syndrome*, Vol. 15 No. 1, p. 46.

Mansordehghan, M., Daneshzad, E., Basirat, V., Gargari, B.P. and Rouzitalab, T. (2022), "The association between dietary acid load and body composition in physical education students aged 18–25 years", *Journal of Health, Population, and Nutrition*, Vol. 41.

Mason, J.B. (2010), "Chapter 4 - Nutritional assessment and management of the malnourished patient", in Feldman, M., Fnedman, L. S. and Brandt, L. J. (Eds), *Sleisenger and Fordtran's Gastrointestinal and Liver Disease*, (Ninth Edition). W.B. Saunders, Philadelphia.

Mirzababaei, A., Shiraseb, F., Setayesh, L., Tavakoli, A., Daneshzad, E., Abaj, F., Clark, C.C.T. and Mirzaei, K. (2022), "The association of dietary acid load with resting metabolic rate and metabolic components in overweight and obese women: a cross sectional study", *Clinical Nutrition ESPEN*, Vol. 47, pp. 267-276.

Mozaffari, H., Namazi, N., Larijani, B., Bellissimo, N. and Azadbakht, L. (2019), "Association of dietary acid load with cardiovascular risk factors and the prevalence of metabolic syndrome in ıranian women: a cross-sectional study", *Nutrition*, Vols 67-68, p. 110570.

Müller, A., Zimmermann-Klemd, A.M., Lederer, A.-K., Hannibal, L., Kowarschik, S., Huber, R. and Storz, M.A. (2021), "A vegan diet ıs associated with a significant reduction in dietary acid load: Post hoc analysis of a randomized controlled trial in healthy ındividuals", *International Journal of Environmental Research and Public Health*, Vol. 18 No. 19, p. 9998.

Downloaded from http://www.emerald.com/nfs/article-pdf/doi/10.1108/NFS-03-2025-0098/10054651/nfs-03-2025-0098en.pdf by Gazi Universitesi user on 04 September 2025

National Institutes Of Health (NIH) (2001), "Nutrient recommendations: Dietary reference intakes (DRI) [online]", *The National Academies Press*, available at: https://ods.od.nih.gov/HealthInformation/Dietary_Reference_Intakes.aspx (accessed 10 June 2025).

Nieman, D.C., Austin, M.D., Benezra, L., Pearce, S., Mcinnis, T., Unick, J. and Gross, S.J. (2006), "Validation of cosmed's FitMate™ in measuring oxygen consumption and estimating resting metabolic rate", *Research in Sports Medicine*, Vol. 14 No. 2, pp. 89-96.

Osuna-Padilla, I.A., Leal-Escobar, G., Garza-García, C.A. and Rodríguez-Castellanos, F.E. (2019), "Dietary acid load: mechanisms and evidence of its health repercussions", *Nefrología (English Edition)*, Vol. 39 No. 4, pp. 343-354.

Remer, T. and Manz, F. (1994), "Estimation of the renal net acid excretion by adults consuming diets containing variable amounts of protein", *The American Journal of Clinical Nutrition*, Vol. 59 No. 6, pp. 1356-1361.

Souto, G., Donapetry, C., Calviño, J. and Adeva, M.M. (2011), "Metabolic acidosis-induced insulin resistance and cardiovascular risk", *Metabolic Syndrome and Related Disorders*, Vol. 9 No. 4, pp. 247-253.

Storz, M.A., Ronco, A.L. and Hannibal, L. (2022), "Observational and clinical evidence that plant-based nutrition reduces dietary acid load", *Journal of Nutritional Science*, Vol. 11, p. e93.

Vandarakis, D., Salacinski, A.J. and Broeder, C.E. (2012), "The reliability and validity of the COSMED fitmate canopy system for assessing resting metabolic rate", *Medicine and Science in Sports and Exercise*, Lippincott Williams And Wilkins, 530 Walnut ST, Philadelphia, PA 19106-3621, p. 905.

Weiner, I.D. (2016), "Untangling the complex relationship between dietary acid load and glucocorticoid metabolism", *Kidney International*, Vol. 90 No. 2, pp. 247-249.

Welch, A., Jennings, A., Kelaiditi, E., Skinner, J. and Steves, C. (2020), "Cross-sectional associations between dietary antioxidant vitamins C, E and carotenoid intakes and sarcopenic indices in women aged 18–79 years", *Calcified Tissue International*, Vol. 106 No. 4, pp. 331-342.

Welch, A., Macgregor, A., Skinner, J., Spector, T., Moayyeri, A. and Cassidy, A. (2013), "A higher alkaline dietary load is associated with greater indexes of skeletal muscle mass in women", *Osteoporosis International*, Vol. 24 No. 6, pp. 1899-1908.

Westerterp, K.R. (2008), "Physical activity as determinant of daily energy expenditure", *Physiology and Behavior*, Vol. 93 Nos 4-5, pp. 1039-1043.

Westerterp, K.R. (2017), "Control of energy expenditure in humans", *European Journal of Clinical Nutrition*, Vol. 71 No. 3, pp. 340-344.

Wieërs, M.L., Beynon-Cobb, B., Visser, W.J. and Attaye, I. (2024), "Dietary acid load in health and disease", *Pflügers Archiv-European Journal of Physiology*, Vol. 476, pp. 427-443.

Williams, R.S., Kozan, P. and Samocha-Bonet, D. (2016b), "The role of dietary acid load and mild metabolic acidosis in insulin resistance in humans", *Biochimie*, Vol. 124, pp. 171-177.

Williams, R.S., Heilbronn, L.K., Chen, D.L., Coster, A.C., Greenfield, J.R. and Samocha-Bonet, D. (2016a), "Dietary acid load, metabolic acidosis and insulin resistance–lessons from cross-sectional and overfeeding studies in humans", *Clinical Nutrition*, Vol. 35 No. 5, pp. 1084-1090.

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