Original article

Effect of Alkaline Diet with 8-week Step Aerobic Exercise on Body Composition and Aerobic Exercise Performance of Sedentary Women

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Summary. *Study Objectives:* The aim of this study was to investigate the effect of an alkaline diet with step aerobic exercises for 8-week in sedentary women on their body composition and aerobic exercise performances. *Methods:* 22 sedentary women (age = 49.18 ± 6.28) voluntarily participated in the study (n = 11 alkaline diet group; n = 11 acidic diet group). Alkaline diet and acidic diet programs were applied to the sedentary women together with step aerobic exercises for 8 weeks. This research was designed as a randomized controlled trial model. Body composition (total body weight, fat mass, and free-fat mass), aerobic exercise performance indicators (Bruce treadmill test, lactate accumulation, estimated VO_{2Max}, and rating of perceived exertion) were measured before and after diet and exercise programs. *Results:* The results of the body weight, fat mass, lactate accumulation, and rating of perceived exertion levels of the group consuming an alkaline diet together with the eight-week step aerobic exercises showed a higher decrease and aerobic exercise performance duration and VO_{2Max} levels indicated a higher increase than acidic diet group. *Conclusion:* The alkaline diet with reduced acid value together with 8-week step aerobic exercises in sedentary women, has a high rate of positive effects on body composition and aerobic exercise performances.

Key words: Alkaline Diet, Aerobic Exercise performance, Body Composition, Lactate accumulation, Rating of Perceived Exertion

Introduction

In order for organisms and cells to survive in the world for a long time, the pH value of the environment they live in must be appropriate. This value should be at pH 7.4 (7.35-7.45) alkaline level in human serum (1). With the development of industrialization in the last 100 years, the amount of CO_2 in the universe has increased and the pH level in the oceans has decreased from 8.2 to 8.1 (2). This drop in the pH of the oceans results in the disappearing of coral reefs and negatively affecting the mineral content of the plants grown in the soil (3). The pH value in the human body consists of numerical values between 1 (most acidic) and 14 (most basic); While pH 7 is neutral, the optimal pH in the blood is slightly alkaline in the range of 7.2-7.4. Even if the pH range in the blood drops in a very low rate of 0.2 units towards the acidic level, the pH takes minerals from the blood to reach the neutralized level (4). While diet types and exercises positively affect the body's acid-base balance, this interaction also increases the efficiency of exercise (5). Today's modern western diets have an acidic diet feature (6), and mostly consist of animal foods with high protein, high fat, high cholesterol content and fall into a diet type including fewer vegetables and fruits are consumed (7). Disruption of the acid-base balance of the body is directly related to universal diseases such as metabolic acidosis, obesity, diabetes, cardiovascular diseases (8,9).

The basic nutrients are divided into two as acidic and alkaline (basic). Alkali foods contain potassium (K), magnesium (Mg), iron (Fe), and manganese (Mn), while acidic foods mostly contain sulfur (S), phosphorus (P) and copper (Cu) (10). Alkaline foods are balanced with acidic foods, but most people do not prefer alkaline foods and not participate in activities such as exercises to cope with stress and to reduce acidosis (8). Apart from exercise, the alkalinity of the body is provided by electrons, and the important sources that provide these electrons are seeds, spices, vegetable oils, vegetables, fruits, and fish containing healthy oils, alkaline water and clean oxygen (11). Vegetable proteins are richer than animal proteins in terms of glutamate and neutralize hydrogen ions, while animal proteins and grains increase the body's acidic ratio due to the amino acids such as methionine, homocysteine, and cysteine (6). In general, the alkaline diet aims to increase consumption of whole grains, fruits, and vegetables, which are accepted as basic foods and reduce fried and processed foods (animal and dairy products, eggs), which are accepted as acidic foods (4). By increasing the alkaline (basic) environment with an alkaline diet, it contributes to the reduction of protons in the acidic environment and the reduction of acidosis occurring in the muscles throughout the exercise and thus contributing to the development of aerobic exercise performance (5). In addition, aerobic exercises increase the blood circulation of the muscles and remove acids from our cells and benefit the alkalization of the body (9).

Although acid-base balance plays a major role in nutrition and exercise, there are limited studies in the literature that investigate the effect of diets containing alkaline or acidic foods on performance components (2,4,12). Ball et al. (13) reported that a diet containing high acid (high-PRAL), low carbohydrate, high fat, and high protein decreased performance capacity in exercises. The acute study of Limmer et al. (2018) stated that the 4-day alkaline diet decreases 400-m sprint times in individuals who do active sports for moderate recreational purposes (14). Rios Enriquez et al. (2010) stated that the alkaline diet in combination with anaerobic exercises provides an improvement on exhaustion time (from 60 sec to 2 mins) in extreme anaerobic stress test to exhaustion (15). In a cross-study about High-PRAL (High-Potential Renal Acid Load) and Low-PRAL (Low-Potential Renal Acid Load) diets, Caciano et al. (2015) report that Low-PRAL diet increases anaerobic exercise performance by 21% (16).

When the experimental and review studies conducted in the literature are examined, it is seen that the Low-PRAL diets increase aerobic and anaerobic performances and also have positive effects on physiological parameters. However, they are mostly acute experimental studies and less chronic. Additionally, short-term diet programs have been applied in most of the previous researches. To strengthen the generalizations on this subject, further studies are required that investigate the chronic effects of the exercises with the long-term alkaline diet program. In this context, this study aimed to examine the effects of the 8-week alkaline diet together with the step-aerobic exercise on body composition and aerobic exercise performances.

Material and Method

Participants

The sample of the study initially consisted of 24 volunteer sedentary women. The study was completed with 22 sedentary women (age = 49.18±6.28) since 2 participants did not participate in post-test measurements during the research. All participants passed medical control before starting the research. Sedentary women who have not received any medication, skeletal-muscle system injuries, and moderately healthy women in the last six months have been included in the study. Also, it was questioned that the participants did not apply a personal diet program prepared by experts in the last six months. All participants were given detailed information about the content and purpose of the study by the researchers and an informed voluntary consent form was signed. Ethics committee approval was received for this research from Sakarya University of Applied Sciences with the number 26428519/044.

Experimental Design

A randomized controlled trial model was used to comparing the effect of two different diet types. The sedentary women were randomly divided into two as Low-PRAL (alkaline) and High-PRAL (acidic) diet groups. All participants were informed about diets but not hypotheses. At the beginning of the study, the body weight, fat mass, and free-fat mass of the sedentary women were measured with bioelectrical impedance analyzer and their aerobic exercise performances were determined using the Bruce treadmill test. During treadmill tests, lactate accumulation and Rating of Perceived Exertion (RPE) were measured for each session. After the first measurements, the participants performed to the step-aerobic exercises 3 times a week for 8 weeks. During the exercises, the subject groups applied their alkaline and acidic diets. At the end of the 8-week exercise and diet period, the tests applied in the first measurement week of the study were repeated as a post-test. During the tests, individuals were kept under control without much intervention to their normal diet and were warned not to consume any alcohol or energy drinks on the test days.

Collection of Data

Measurement of Body Composition

Body composition (body weight, fat mass, and free-fat mass) of the participants were measured with the bioelectric impedance analyzer TANITA BC-418 (Tanita Corp., Tokyo, Japan) when they hungry at the morning. All sedentary women were wearing only shorts and T-shirts during body composition measurements. From the body weights obtained, 250 g tare was removed for accurate estimation of body weight.

Sub-maximal Bruce Treadmill Test

Sub-maximal Bruce treadmill test was used to determine the aerobic exercise performances of the sedentary women. Because the participants were sedentary and their high average age a submaximal test was preferred. The test was performed on the treadmill in three-minute steps up to 85% of the participants' estimated age-based Maximum Heart Rate (HR_{Max}). Submaximal Bruce treadmill test starts at 2.7 km/h with a 10% incline after a general warm-up and increases speed and slope every 3 minutes. Bruce's treadmill test was finished when the heart rate of the participants' was reached 85% of the estimated HR_{Max}. The duration of the test was recorded and the estimated VO_2max was calculated by a formula using the test ending time (17). The sub-maximal heart rate (85% HR_{Max}) of the participants was calculated using the formula [208-(0.7 × Age) × 85%] (18). In the calculation of estimated VO_{2Max} (For women: Estimated VO_{2Max} = 4.38 x (Test duration) - 3.90) formula was used (19).

Calculation of Lactate Accumulation

To determine the blood lactate accumulation of the participants during the Bruce treadmill test, blood samples taken from the participants' fingers 1 min. before and after the test. Lactate accumulation level was calculated by subtracting before and after the lactate levels of the participants. In the last tests, lactate measurement was taken again at the same ending time of the participants as the first test. The lactate accumulation differences between the two measurements were analyzed. Blood lactate measurements were measured with Lactate Scout (LS, SensLab GmbH, Germany) brand lactate analyzer.

Determination of RPE

To determine the Session RPE (sRPE) scores of the participants during the Bruce treadmill test, the CR10 scale was used, developed by Foster, (1998). At the end of each minute of the test, participants were asked about the level of exertion on the scale, which depicts the perception of exertion between 0-10. The sRPE is calculated as the arbitrary unit by multiplying the RPE scores and the exercise duration (min) (20). In the pre and post-tests, sRPE scores were obtained for the two tests using the same method.

Dietary Intervention

The PRAL is a value that indicates the acid-base status of the nutrients we take by mouth after passing into the stomach (12,17). The protein content of the PRAL formula is based on Cl^-, PO43–, SO42–, Na +, K +, Ca 2+, and Mg 2+ (21). The PRAL value of foods (mEq / 100 g) is calculated as: 0.49 × protein (g / 100 g) + 0.037 × phosphorus (mg / 100 g) - 0.021 × potassium (mg / 100 g) - 0.026 × magnesium (mg / 100 g) - 0.013 × calcium (mg / 100 g) (22). A German PRAL list published by the Institute for Prevention and Nutrition, Ismaning, Germany, was distributed to the participants (23). In the PRAL list, participants are given advice on how to make food alkaline or acidic.

The participants in the alkaline diet group consumed animal proteins like fish, chicken, and turkey meat for eight weeks in their main menu only three days a week (exercise days). They consumed animal proteins for breakfast seven days a week as curd cheese and powder egg white. For eight weeks, animal proteins were reduced and mostly vegetable proteins (soyabeans, lentils, beans, peas, chickpeas, etc.) were emphasized. The alkaline diet group, which is considered to be acidic drinks during the research, was not allowed to consume coffee, cola, milk, instant juices, and black tea for eight weeks, but herbal teas were allowed (green tea, white tea, fennel, mint-lemon tea, and rosehip). As a result, individuals in the experimental group kept animal proteins limited for eight weeks (fish, chicken and turkey meat, curd cheese, egg whites), mostly vegetable-fruit, starchy vegetables (sweet potatoes) vegetable oils (almonds, avocados, walnuts, nuts), dried fruits (black raisins, dried apricots, dried figs, dried dates).

Animal proteins were included in the diet programs of the acidic diet group for eight weeks every day of the week [only red meat, eggs, milk, yogurt, and cheese (cheddar, cream, and parmesan)]. In addition to consuming cereals (oats, bread, pasta, and rice), they were also allowed to drink black tea, coffee, milk, acidic drinks (e.g. cola), ready-made juices. High-sugar fruits and dried fruits were also included, and eight-week diet programs were completed for both groups.

Exercise Plan

In the study, the sedentary women participated in 90-min. step aerobic exercise programs for three weeks a week (Monday, Wednesday, Friday), between 10:00 and 12:00 a.m for 8 weeks. An exercise consisted of 4 phases. In the first phase of the exercise, subjects performed low-rhythm exercises without using a step board, and warm-up exercises involving aerobic movements along with heart rate controls with music for about 20 minutes (120-125 BPM). In the second phase, 10-minute dynamic stretching exercises were performed for the basic muscle groups. In the third phase, which is the main phase of the exercise, the basic movements (Basic step, Wide Step, Tap Up, Tap Down, Knee Up, Leg Curl, Leg Lif, Kick, Across The Top, Over The Top, Straddle Up-Down, Turn Step, Turn Travel Tip, A Step, L Step, T Step, Z Step, Corner To Corner, Reverse Step, Lunge, and Turn Mambo) of step aerobic exercise were performed at the speed of 130-135 BPM using a step board with a height of 70 cm, a width of 30 cm and a height of 10 cm. In the last phase of the exercise, 10 minutes of static flexibility exercises were applied for recovery and cool-down.

Statistical Analysis

IBM SPSS Statistics 24 package program was used to analyze the obtained data. Descriptive statistics of the obtained data were given as mean and standard deviation. Besides, a two-way repeated analysis of variance was used to determine the difference between the body composition, athletic performance, and biochemical parameters according to the time points (Pre-test and Post-test) of alkaline (Low-PRAL) and acidic (High-PRAL) diet types. Moreover, percentage differences of time points according to diet types were calculated with the formula "% Δ = (Post-test - Pre-test) / Pre-test *100". The confidence interval was chosen as 95% and values below $p < 0.05$ were considered statistically significant.

Results

When table 1 was examined, it was found that the pre-test and post-test averages of the body weight (F=75.606), fat mass (F=58.935), and free-fat mass (F=9.285) of sedentary women were statistically different according to the measurement times ($p < 0.01$). These results show that the decrease in body weight and the fat mass of sedentary women who consume an alkaline diet with an eight-week step aerobic exercise was higher than women who consume an acidic diet. In addition, body weight, fat mass, and free-fat mass were not statistically different according to diet types (p> 0.05). Moreover, the interaction between diet types and measurement times for body weight (F = 10.514) and fat mass (F = 14.435) ratio was found to be statistically significant (p <0.01), whereas the interaction for the free-fat mass was not significant (p > 0.05). According to these results, it was seen that sedentary women who consume an alkaline diet have higher body weight (5.22%) and fat mass (10.90%) reduction than women who consume an acidic diet.

When Table 2 was examined, it was found that the pre-test and post-test averages of the Bruce treadmill test duration (F= 177.397), blood lactate level (F= 67.606), VO_{2Max} (F= 31.587), and sRPE (F= 80.234) of sedentary women were statistically different according to the measurement times (p <0.01). These results show that the increase in Bruce treadmill test duration and VO_{2Max} levels and the decrease in blood lactate level and sRPE of sedentary women who consume an alkaline diet with an eight-week step aerobic exercise was higher than women who consume an acidic diet. In addition, it was found that Bruce treadmill test duration, blood lactate, and VO_{2Max} levels were not statistically different according to diet types (p> 0.05), whereas the sRPE was statistically different (p <0.05). In addition, the interaction between diet types and measurement times for Bruce treadmill test duration (F = 51.747), blood lactate level (F = 43.667) and VO_{2Max} levels (F = 22.199), was statistically significant (p <0.01), whereas the interaction for sRPE (F = .180) was not significant (p> 0.05). According to these results, Bruce treadmill test duration (33.66%) and VO_{2Max} levels (35.67%) of sedentary women who consume an alkaline diet with eight-week step aerobic exercise increased, and blood lactate levels (81.71%) decreased.

Discussion

In this study, the effects of an alkaline diet with 8-week step aerobic exercises on body composition and aerobic exercise performances of sedentary women were investigated. According to the findings of the

Table 1. Comparison of variables related to body composition according to diet type and measurement times of sedentary women

Variables	Diet Type	N	Pre-test $\bar{X}$± S.D.	Post-test $\bar{X}$± S.D.	Total $\bar{X}$± S.D.	%Δ	F	p
Body Weight kg	Alkaline (Low-PRAL)	11	78.48±14.32	74.38±12.93	76.43±13.63	-5.22	1.079	.311
	Acidic (High-PRAL)	11	84.39±17.99	82.52±17.67	83.46±17.83	-2.22		
	Total	22	81.44±16.15	78.45±15.67		Interaction		
			F= 75.606; p= .001**			F= 10.514; p= .004**		
Fat Mass kg	Alkaline (Low-PRAL)	11	30.55±8.98	27.22±8.52	28.89±8.75	-10.90	2.015	.171
	Acidic (High-PRAL)	11	36.00±12.68	34.87±12.49	35.44±12.58	-3.14		
	Total	22	33.28±11.08	31.05±11.15		Interaction		
			F= 58.935; p= .001**			F= 14.435; p= .001**		
Free-Fat Mass kg	Alkaline (Low-PRAL)	11	47.95±6.07	47.16±5.32	47.56±5.70	-	.001	.975
	Acidic (High-PRAL)	11	47.76±7.26	47.17±7.18	47.47±7.22	-		
	Total	22	47.85±6.53	47.17±6.17		Interaction		
			F= 9.285; p= .006**			F= .180; p= .676		

**p<0.01; $\bar{X}$: Mean; S.D.: Standard Deviation; PRAL: Potential Renal Acid Load

Table 2. Comparison of variables related to performance outputs according to diet type and measurement times of sedentary women

Variables	Diet Type	N	Pre-test	Post-test	Total	%Δ	F	p
			X̄± S.D.	X̄± S.D.	X̄± S.D.			
Bruce Treadmill Test Duration min.	Alkaline (Low-PRAL)	11	9.21±1.29	12.31± .85	10.76±1.07	33.66	.030	.865
	Acidic (High-PRAL)	11	10.40±1.71	11.33±1.73	10.86±1.72	8.94		
	Total	22	9.81±1.60	11.82±1.42			Interaction	
			F= 177.397; p= .001**				F= 51.747; p= .001**	
Blood Lactate μL	Alkaline (Low-PRAL)	11	1.64± .64	.30± .25	.97± .45	-81.71	3.481	.077
	Acidic (High-PRAL)	11	1.54± .86	1.39± .85	1.46± .86	-9.74		
	Total	22	1.59± .68	.85± .83			Interaction	
			F= 67.606; p= .001**				F= 43.667; p= .001**	
VO_{2Max} $ml.kg^{-1}.dk^{-1}$	Alkaline (Low-PRAL)	11	37.34±5.75	50.66±3.48	44.00±4.62	35.67	.715	.408
	Acidic (High-PRAL)	11	45.12±7.15	46.29±5.43	45.71±6.29	2.52		
	Total	22	41.23±7.48	48.48±4.98			Interaction	
			F= 31.587; p= .001**				F= 22.199; p= .001**	
sRPE	Alkaline (Low-PRAL)	11	15.35±4.99	3.44±3.12	9.39±4.06	-	8.051	.010*
	Acidic (High-PRAL)	11	17.32±3.23	9.26±4.87	13.29±4.05	-		
	Total	22	16.34±4.23	6.35±4.98			Interaction	
			F= 80.234; p= .001**				F= 2.983; p= .100	

*p<0.05; **p<0.01; X̄: Mean; S.D.: Standard Deviation; PRAL: Potential Renal Acid Load

study, it was found that the alkaline diet with step aerobic exercise provides a greater reduction in body weight and fat mass and less lactate accumulation as well as higher aerobic exercise time, the level of VO_{2Max} and reduction in the sRPE compared to the acidic diet.

In our study, it is observed that the alkaline diet with step-aerobic exercises provides a higher rate of decrease in total body weight and fat mass compared to the acidic diet in women (total body weight = 5.22%, fat mass = 10.90%). In the free-fat mass of sedentary women, no significant difference was found between diet types. Massiera et al. (2010) report that the Western-type diet causes a gradual increase in fat mass and thus the spread of obesity in humans (24). In contrast, the meta-analysis study of Ballor and Keesey (1991) states that aerobic exercises are effective on body mass, fat mass, and free fat mass values, and the numbers of the week and duration of exercise sessions can be important predictors especially in women (25). In the present study, the free-fat mass data which did not differ significantly (p> 0.05) could be accepted as an indicator that lean muscle mass is preserved. However, researchers state that physical activity, age, and protein intake, as well as long-term nutritional habits, are effective in preserving muscle mass (26, 27). In the literature, no longitudinal study investigating the effect of an alkaline diet with exercise on body composition parameters and comparing it with other diet programs has been encountered. Therefore, our findings indicated that the alkaline diet together with the aerobic exercise program was more effective than the acidic diet in reducing the total body mass and fat mass ratio.

When the physiological and psychological responses to Bruce treadmill test were analyzed, participants who were on an alkaline diet had a higher increase in test termination durations and estimated

VO_{2Max} data (test duration = 33.66% and VO_{2Max} = 35.67%), and a higher decrease in the level of lactate accumulation (blood lactate accumulation = 81.71%) than an acidic diet. A significant difference was found in the sRPE in terms of diet types ($p < 0.05$). In studies investigating the effect of diet-related acid load on performance during exercise, they assume that reducing the acid load of the diet and creating a more alkaline environment can increase the cleansing of protons and inhibitor molecules that affect muscles that perform during acid-induced acidosis, thereby improving aerobic and anaerobic exercise performance. However, the benefit of diets with a reduced acid load on performance has not been demonstrated (28). In the literature, different results have been reached in the studies investigating the effect of diets with the low acid load on performance. Greenhaff, Gleeson, and Maughan (1987) report that individuals who performed a 4-day low-protein and high-carbohydrate diet exhibit higher exhaustion times in their cycling test compared to those who applied high-protein and low-carbohydrate-acid diet (29). However, the study of Ball et al. (1996) state that the alkaline high carbohydrate diet does not increase the cycling test performance acutely compared to other diet types (13). Limmer et al. (2018) investigate the effect of short-term (4 days) alkaline and acidic diet on 400-meter sprint performance, blood lactate, blood gas parameters, and urine pH in adults with moderate exercise. They demonstrate that the alkaline diet improves 400 m sprint performance and increases the blood level of lactate concentration (14). When the studies examining the relationship between VO_{2Max} and alkaline diet are examined, the respiratory exchange ratio used in the correct determination of VO_{2max} is higher in Low-PRAL diets in treadmill tests (30,31).

Our findings indicated that the sRPE during exercise varied according to diet types, and the sRPE after the diet program was less in the applied test to the alkaline diet group. No study examined the sRPE, which is a valid subjective marker of internal load during exercise. Moreover, it is seen that the alkaline diet processes applied are short in the previous studies according to the relationship between alkaline diet and performance. The use of short-term diet programs and measurements on mainly anaerobic performance restricts the generalizations about the subject. Applegate et al. (2017) emphasize the lack of studies involving a long diet intervention program in the studies on the alkaline diet and suggest that further studies are required for investigating the efficacy of long diet programs (5). In this context, our findings will contribute to the literature by revealing the longitudinal results of the alkaline diet that includes a long diet program.

Conclusion

The results of this study reveal that the alkaline diet with aerobic exercises has a positive effect on the body composition and aerobic exercise performance of sedentary women. To increase the quality of life, it should be considered to choose alkali-derived diets instead of western diets that are high in acid density a diet with regular physical activities. Furthermore, more longitudinal studies involving long diet and exercise programs are needed to generalize the effects of low acid density alkaline diets on physical and physiological parameters.

Conflicts of interest

The authors declare that there is no conflict of interest in this manuscript.

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