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Original Article

The Effects of Moderate-Intensity Aerobic Exercise on Serum Vitamin D and Albumin Levels in Patients with Type 2 Diabetes

Alireza Babaei Mazreno [1] Ph.D., Farzaneh Taghian [1*] Ph.D., Khosro Jalali Dehkordi [1] Ph.D., Esmaeil Babaei [2] M.D.

[1] Department of Sports Physiology, Isf.C., Islamic Azad University, Isfahan, Iran
[2] Faculty of Ophthalmology, Faculty of Medicine, Shahid Sadoughi University of Medical Science, Yazd, Iran

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A B S T R A C T

Introduction: Vitamin D and albumin are important biochemical markers in diabetes management. This study examined the effect of moderate-intensity aerobic exercise on serum vitamin D and albumin levels in women with type 2 diabetes in Yazd, Iran.

Materials and Methods: In this experimental study with a pretest-posttest control design, 30 women aged 40–50 years were randomly assigned to an exercise or control group (15 each). The exercise group performed treadmill aerobic exercise at 35–75% of maximum heart rate, three times per week for eight weeks. Serum vitamin D and albumin levels were measured before and after the intervention. Paired and independent t-tests were used for analysis.

Results: Post-intervention, vitamin D levels slightly increased in the exercise group, but changes were not statistically significant ($p = 0.155$), nor were between-group differences ($p = 0.190$). Albumin levels showed a significant within-group increase in the exercise group ($p = 0.009$), while between-group differences remained non-significant ($p = 0.273$).

Conclusion: Eight weeks of moderate-intensity aerobic exercise significantly improved albumin levels within the exercise group, but vitamin D changes and between-group differences were not significant. These findings suggest that longer-duration interventions or combination with dietary strategies may be necessary to elicit significant changes in biochemical markers in women with type 2 diabetes.

[*] **Corresponding Author:** Department of Sports Physiology, Isf.C., Islamic Azad University, Isfahan, Iran
Email: f.taghian@gmail.com, **Tel:** +989133080241

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Introduction

Type 2 diabetes is one of the most common chronic metabolic disorders worldwide, characterized by elevated blood glucose levels resulting from insulin resistance and impaired insulin secretion [1]. According to the International Diabetes Federation (IDF), the global prevalence of type 2 diabetes is increasing at an alarming rate, with the number of affected individuals expected to exceed 780 million by 2045 [2, 3]. In Iran, type 2 diabetes has emerged as a significant public health challenge, particularly in regions such as Yazd Province, where unique dietary habits, lifestyles, and climatic conditions may influence disease prevalence and progression. In recent years, attention has shifted toward the role of nutritional and inflammatory biomarkers in the prevention and management of type 2 diabetes [4]. Among these, vitamin D and serum albumin have been identified as key indicators potentially involved in the disease's pathophysiological mechanisms [5]. In addition to its well-known role in calcium and phosphorus metabolism, vitamin D possesses anti-inflammatory, immunomodulatory, and insulin-sensitizing properties [6]. Several studies have reported associations between vitamin D deficiency and increased insulin resistance, impaired pancreatic β-cell function, and poor glycemic control [7-10].

Albumin, the most abundant plasma protein, plays essential roles in maintaining oncotic pressure and transporting various endogenous and exogenous substances. It is also considered a marker of nutritional status, systemic inflammation, and oxidative stress [11]. Low serum albumin levels in patients with diabetes are associated with an increased risk of cardiovascular complications, nephropathy, and mortality [12].

Regular physical activity, especially moderate-intensity aerobic exercise, is widely recognized as an effective non-pharmacological intervention for managing type 2 diabetes [13]. In addition to improving glycemic control, enhancing insulin sensitivity, and reducing inflammation, some evidence suggests that aerobic exercise may positively influence vitamin D status and albumin levels. These effects may result from improved metabolic function, increased exposure to sunlight, reduced systemic inflammation, and changes in body composition [14].

Several studies have explored the relationship between aerobic exercise and changes in vitamin D and albumin levels in diabetic populations. Yousefipoor et al. found that eight weeks of aerobic training led to reductions in hemoglobin A1c (HbA1c) and fasting glucose levels and improvements in lipid profiles, though no significant changes were observed in blood pressure, body weight, or BMI [15]. Naderyan et al. reported significant increases in total plasma proteins, albumin, and globulin following endurance exercise in both athletes and non-athletes, with levels returning to baseline 24 hours post-exercise [16]. Dixit et al. demonstrated that moderate-intensity aerobic exercise over eight weeks significantly reduced HbA1c in elderly patients with type 2 diabetes and peripheral neuropathy [17]. In another study, Hossein et al. showed that diabetic patients who

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engaged in regular physical activity had significantly lower rates of micro- and macroalbuminuria, improved glycemic control, lower triglyceride levels, and higher high-density lipoprotein cholesterol compared to sedentary patients [18]. Regular moderate-intensity aerobic exercise has been suggested to positively influence serum levels of vitamin D and albumin in patients with type 2 diabetes. Mechanistically, aerobic exercise may enhance vitamin D status through increased sunlight exposure during outdoor activity, improved metabolic efficiency, and reduction of systemic inflammation. Similarly, exercise can elevate albumin levels by promoting protein synthesis, improving nutritional status, and mitigating oxidative stress. Several studies support these effects: Naderyan et al. reported significant increases in plasma proteins, including albumin, following endurance exercise [16], while Dixit et al. and Yousefipoor et al. observed improvements in glycemic and metabolic markers through moderate-intensity aerobic training [15, 17]. These findings highlight the potential of aerobic exercise not only to improve classical diabetes outcomes but also to modulate important biochemical markers such as vitamin D and albumin, providing a rationale for investigating these effects in Iranian populations with a high prevalence of deficiency. [11, 12]. Despite these findings, limited scientific evidence exists regarding the effects of aerobic exercise on vitamin D and albumin levels in Iranian populations, particularly in regions like Yazd that receive abundant sunlight yet report high rates of vitamin D deficiency. Contributing factors may include cultural clothing practices, limited outdoor activity, and inadequate dietary supplementation [19].

Given the crucial role of vitamin D and albumin in the overall health of patients with type 2 diabetes, and the potential benefits of physical activity in modulating these biomarkers, the present study aimed to investigate the effects of an eight-week moderate-intensity aerobic exercise program on serum vitamin D and albumin levels in women with type 2 diabetes living in Yazd Province. The findings may help clarify the metabolic impact of aerobic exercise and support the development of effective non-pharmacological strategies in diabetes management.

Materials and Methods

This study was designed as a pretest-posttest quasi-experimental study with a control group. Thirty women with type 2 diabetes, aged between 40 and 50 years, and with at least three years of membership in the Yazd State Diabetes Center, were selected through purposive and convenience sampling. Considering the limited target population and based on the sample sizes used in similar studies, 30 participants were deemed sufficient to detect the potential effects of moderate-intensity aerobic exercise.

After eligibility confirmation, participants were randomly assigned to either the exercise group or the control group, with 15 individuals in each group. The objective was to assess the effects of exercise on serum levels of vitamin D and albumin. Inclusion criteria were as follows: age between 40 and 50 years, confirmed diagnosis of type 2 diabetes for at least three years, fasting blood sugar level over 126 mg/dL, use of similar

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medication regimens to control blood glucose, adherence to the dietary recommendations of the Diabetes Center, non-smoking status, no history of cardiovascular, hepatic, or infectious diseases affecting inflammatory markers, and no regular or intense physical activity during the previous three months. Exclusion criteria included unwillingness to continue participation, failure to adhere to the exercise protocol, development of serious complications during the intervention, unplanned changes in medication or treatment regimen, diagnosis of a new disease or condition, or any physical or psychological limitations preventing continued participation. Participants who missed sessions or blood sampling appointments were also excluded. All participants were fully informed about the study objectives and procedures, and voluntarily signed an informed consent form. Ethical considerations, including confidentiality and the right to withdraw at any time, were strictly observed throughout the study.

Biochemical measurements

Serum levels of vitamin D were measured using enzyme-linked immunosorbent assay or chemiluminescence methods. Serum albumin concentrations were assessed using standard protein assays.

Exercise intervention

One week prior to the intervention, participants attended an orientation session where safety protocols for treadmill use were explained. The exercise group performed progressive aerobic training on a treadmill for eight weeks, three sessions per week. Each session lasted 50 minutes and included a 10-minute warm-up, 30 minutes of continuous aerobic activity, and a 10-minute cool-down period.

Table 1 shows the details of the eight-week aerobic exercise program, including how the intensity, duration, and frequency of sessions progressed over time.

The intensity of exercise was gradually increased throughout the program, as follows:

- Weeks 1–2: 35–45% of maximum heart rate (HRmax)
- Weeks 3–4: 45–55% of HRmax
- Weeks 5–6: 55–65% of HRmax
- Weeks 7–8: 65–75% of HRmax

Statistical analysis

Data were analyzed using SPSS software (version 26). The normality of data distribution was assessed using the Kolmogorov-Smirnov test. Paired t-tests were applied to compare pre- and post-test values within each group, while independent t-tests were used to compare mean values between the exercise and control groups. A p-value of less than 0.05 was considered statistically significant.

Results

The mean age of participants in both the exercise and control groups was 45 years (SD = 3). The average body weight was 60 kg (SD = 5), and the mean height was 160 cm (SD = 4). The mean BMI was 23.4 kg/m² (SD = 1.2). These findings indicate that the two groups were relatively homogeneous in terms of baseline demographic characteristics. Table 2 presents the descriptive statistics of participants' serum vitamin D and albumin levels before and after the intervention in both exercise and control groups.

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Comparative analysis of vitamin D levels

To evaluate the effect of moderate-intensity aerobic exercise on serum vitamin D levels in women with type 2 diabetes, a paired t-test was used to compare pre- and post-test values within the exercise and control groups. Additionally, independent t-tests were used to assess between-group differences at each stage. Table 3 shows the results of paired and independent t-tests for vitamin D levels, indicating the changes from pre- to post-test in both exercise and control groups.

Exercise group: In the exercise group, the mean difference in vitamin D levels before and after the aerobic exercise intervention was 0.22 ng/mL, indicating a slight increase. The standard deviation of the difference was 0.58, with a standard error of 0.15. The 95% confidence interval ranged from –0.10 to 0.54, including zero, indicating that this increase was not statistically significant. The t-value was 1.51, and the p-value was 0.155.

Control group: In the control group, the mean difference in vitamin D levels was –0.06 ng/mL, showing a slight decrease that was also not statistically significant. The standard deviation was 0.59, and the standard error was 0.15. The 95% confidence interval ranged from –0.38 to 0.26, including zero. The t-value was –0.40 and the p-value was 0.695, suggesting that the observed changes were likely due to chance.

Table 1 summarizes the specifications of the aerobic exercise program.

Week	Exercise intensity (HRmax%)	Session duration (minutes)	Sessions per week
Week 1	35–45	40–50	3
Week 2	35–45	40–50	3
Week 3	45–55	40–50	3
Week 4	45–55	40–50	3
Week 5	55–65	40–50	3
Week 6	55–65	40–50	3
Week 7	65–75	40–50	3
Week 8	65–75	40–50	3

Table 2. Descriptive statistics of participants' physical characteristics

Variable	Group	Stage	Mean	SD	Min	Max
Vitamin D (ng/mL)	Exercise	Pre-test	20.072	5.975	10.21	27.93
	Exercise	Post-test	20.297	5.714	10.83	28.25
	Control	Pre-test	16.669	5.292	10.20	26.38
	Control	Post-test	16.609	5.405	9.49	26.25
Albumin (g/dL)	Exercise	Pre-test	4.242	0.487	3.61	4.93
	Exercise	Post-test	4.276	0.497	3.60	4.99
	Control	Pre-test	4.235	0.381	3.59	4.71
	Control	Post-test	4.251	0.394	3.60	4.71

Table 3. Results of paired and independent t-tests for vitamin D levels in exercise and control groups

Group	Mean difference (Post – Pre)	Standard deviation	Standard error of mean	95% Confidence interval for the difference	t-value	df	p-value (two-tailed)
Exercise	0.22	0.58	0.15	-0.10 to 0.54	1.51	14	0.155
Control	-0.06	0.59	0.15	-0.38 to 0.26	-0.40	14	0.695

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Between-group comparison of vitamin D changes

Table 4 presents the independent t-test results comparing the changes in vitamin D levels between the exercise and control groups.

Levene's test and independent t-test for vitamin D

Levene's test for equality of variances showed a significance value of 0.962. Therefore, the null hypothesis of equal variances was accepted, and the results from the "Equal variances assumed" section were used for analysis.

The independent t-test revealed a t-value of 1.342 with a p-value of 0.190. Thus, there is no significant difference in vitamin D level changes between the exercise and control groups. The mean difference between groups was 0.285 (95% CI: –0.150 to 0.721), which includes zero, further confirming the lack of a statistically significant difference.

Effect of moderate-intensity aerobic exercise on albumin levels

This section examines changes in serum albumin levels in type 2 diabetic patients following an eight-week moderate-intensity aerobic exercise program. Table 5 shows the results of paired t-tests for albumin levels, indicating within-group changes from pre- to post-test in both exercise and control groups.

Albumin changes in exercise and control groups

Exercise group: In the exercise group, the mean difference in albumin levels before and after aerobic exercise was 0.03 g/dL, indicating a significant increase. The standard deviation of this difference was 0.04, with a standard error of 0.01. The 95% confidence interval ranged from 0.01 to 0.06, which does not include zero, confirming the statistical significance of the increase. The t-value was 3.01, and the p-value was 0.009, indicating a significant change in albumin levels following the exercise intervention.

Control group: In the control group, the mean difference in albumin levels was 0.02 g/dL, representing a slight increase that was not statistically significant. The standard deviation was 0.05, and the standard error was 0.01. The 95% confidence interval ranged from –0.01 to 0.04, which includes zero, indicating the change was not statistically significant. The t-value was 1.25, and the p-value was 0.233, suggesting that the observed change was likely due to chance.

Between-group comparison of albumin changes

An independent t-test was conducted to determine whether there was a significant difference in albumin level changes between the exercise and control groups. Table 6 presents the independent t-test results comparing the changes in albumin levels between the exercise and control groups.

Levene's test for equality of variances showed a significance value of 0.932 (F = 0.007), which is greater than 0.05; therefore, the null hypothesis of equal variances is accepted. Hence, the "Equality of variances assumed" section was used for analysis.

The independent t-test showed that the t-value was 1.118 with a significance p-value of

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0.273, which is greater than 0.05. Thus, there was no significant difference in albumin levels between the exercise and control groups. These results indicate that changes in albumin between the two groups were not statistically significant. The mean difference between groups was 0.01867. The 95% confidence interval for this mean difference ranged from –0.01553 to 0.05287 under the assumption of equal variances. Since this interval includes zero, it confirms that there is no significant difference in albumin levels between the two groups.

Discussion

This study aimed to investigate the effect of moderate-intensity aerobic exercise on serum vitamin D and albumin levels in women with type 2 diabetes living in Yazd province. The findings showed that although the mean vitamin D levels in the exercise group increased slightly after the intervention compared to the pre-test, this change was not statistically significant.

Table 4. Independent t-test comparing vitamin D changes between exercise and control groups

Test	t-value	df	p-value (two-tailed)	Mean difference	Standard error of difference	95% Confidence interval
Equal variances assumed	1.342	28	0.190	0.285	0.213	–0.150 to 0.721
Equal variances not assumed	1.342	27.994	0.190	0.285	0.213	–0.150 to 0.721

Table 5. Results of paired t-test comparing albumin levels in exercise and control groups

Group	Mean difference (Post – Pre)	Standard deviation	Standard error	95% Confidence interval	t-value	df	p-value (two-tailed)
Exercise	0.03	0.04	0.01	0.01 to 0.06	3.01	14	0.009
Control	0.02	0.05	0.01	–0.01 to 0.04	1.25	14	0.233

Table 6. Independent t-test comparing albumin changes between exercise and control groups

Group	F	Sig.	t	df	Sig. (two-tailed)	Average difference	Difference criterion error	95% Confidence interval for the difference
Equality of variances assumed	0.007	0.932	1.118	28	0.273	0.01867	0.01670	–0.01553 up to 0.05287
Equality of variances not assumed	—	—	1.118	27.796	0.273	0.01867	0.01670	–0.01554 up to 0.05288

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Regarding albumin, although a significant within-group increase was observed in the exercise group, the comparison between exercise and control groups revealed no significant difference. These results suggest that moderate-intensity aerobic exercise over eight weeks may induce slight changes in some biochemical markers, but these changes do not necessarily reach statistical significance. Interpreting these findings requires consideration of several factors. First, vitamin D synthesis primarily depends on sunlight exposure [21]. Since the aerobic exercise in this study was conducted indoors on a treadmill, the positive effects of sunlight on vitamin D levels were likely minimal or absent. Additionally, participants' baseline vitamin D status, dietary intake, supplement use, and environmental factors such as clothing, timing of exercise, and season may have influenced the outcomes [22]. Previous studies reporting significant increases in vitamin D often involved outdoor exercise or included nutritional interventions [23, 24].

Concerning serum albumin, the significant within-group increase might reflect positive effects of aerobic exercise on reducing chronic inflammation, improving liver function, and regulating protein balance in diabetic patients. Aerobic exercise can enhance albumin synthesis by improving hepatic blood flow, increasing insulin sensitivity, and lowering inflammatory cytokines such as tumor necrosis factor-alpha and Interleukin-6 [25, 26]. However, since between-group differences were not statistically significant, caution is warranted when attributing definitive effects to the exercise intervention. This aligns with previous research indicating that short-term exercise has a limited impact on albumin unless combined with nutritional changes or longer intervention periods.

Another consideration is the intervention duration and exercise volume. Eight weeks of moderate-intensity aerobic exercise, although physiologically beneficial and safe, may be insufficient to produce significant changes in biomarkers like vitamin D, which are heavily influenced by environmental and nutritional factors. Serum albumin, as a relatively stable biomarker, may also require longer interventions to show meaningful changes.

Limitations of this study include a relatively small sample size, a lack of strict control over diet and supplements, and conducting exercise indoors. The absence of measurement for other inflammatory markers and active vitamin D (25-OH-D3) might have limited the analysis. Strengths include the experimental design, adherence to exercise protocols, and focus on the indigenous population of Yazd, which has been understudied.

Conclusion

The present study showed that eight weeks of moderate-intensity aerobic exercise in women with type 2 diabetes resulted in a slight, non-significant increase in vitamin D levels and a significant within-group increase in albumin levels. However, no significant differences were found between exercise and control groups in either marker. These results suggest

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that longer-term interventions, outdoor exercise, nutritional modifications, and stricter control of confounding factors may be necessary to achieve meaningful changes in vitamin D and albumin levels.

Future studies with larger sample sizes, longer durations, examination of inflammatory and oxidative stress markers, and combined exercise and nutritional interventions are recommended to better understand the role of aerobic exercise in managing type 2 diabetes.

Ethical Considerations

This study was approved by the Ethics Committee of Islamic Azad University, Khorasgan Branch (Approval Number: IR.IAU.KHUISH.1403.511). Ethical standards, including informed consent, privacy, and confidentiality, were strictly observed. Participants were free to withdraw at any time.

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Conflicts of Interests

The authors declared no conflict of interest.

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Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Authors' Contributions

A. B: Collection of materials and sources; F. T: Research management and scientific editing; K. J: Research consultant; E. B: Data analysis; All authors have read, approved the final manuscript, and accept responsibility for the research.

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