Original Article

How Combined Exercise and Vitamin D Supplementation Affect Metabolic Syndrome Risk Factors: A Clinical Trial in Menopausal Women

Najafi Nazar Abadi P[1], Etemad Z[1*], Hoseini R[2] , Moradi F[3]

1. Department of Physical Education, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran
2. Department of Exercise Physiology , Faculty of Sport Sciences, Razi University, Kermanshah, Iran
3. Department of Physical Education, Saghez Branch, Islamic Azad University, Saghez, Iran

Received: 02 Sep 2020 Accepted: 06 Oct 2020

Abstract

Background & Objective: Exercise is a well-known strategy to reduce the risk of metabolic syndrome and chronic disease. However, the concurrent effect of aerobic training with vitamin D supplementation on anthropometric indices and lipid profile are somewhat unknown. This study aimed to investigate the effect of aerobic training and vitamin D supplementation (AT+Vit D) on anthropometric indices and lipid profile in postmenopausal women with metabolic syndrome.

Materials & Methods: Forty-six postmenopausal women with metabolic syndrome were randomly assigned to four groups: AT+Vit D (n=11), AT (n=12), Vit D (n=12), and control (C; n=11). The training protocol was incrementally conducted for 8 weeks, 20-40 min of training, with 60-75% HR_{max}, 3 sessions per week. The intervention groups received capsules of 5000 IU vitamin D or placebo. The data were analyzed through paired t-tests and two-way ANOVA analysis of variance and Bonferroni post hoc test with SPSS 24 at the signification level of $P<0.05$.

Results: All three groups (AT+Vit D, AT, Vit D groups) showed a significant decrease in BW, BMI, BFP, WC, TC, TG, LDL, MAP, and glucose and an increase in HDL. Also, the results showed that AT+Vit D group compared with AT, Vit D, and C groups led to significant reductions in BW, MAP and Glucose TC, TG, and LDL and an increase in HDL ($P<0.001$ for all three variables).

Conclusions: AT+Vit D is more effective in the improvement of lipid profile in patients with NAFLD than AT or Vit D alone.

Keywords: Aerobic Training, Vitamin D, Lipid Profile, Metabolic Syndrome

Introduction

Menopause is an entirely natural phenomenon, with menstrual periods ending due to decreased ovarian activity and estrogen deficiency. During this period, physical, psychological, and hormonal changes occur (1). Hormonal changes that occur during menopause can lead to menopausal symptoms and increase the risk of metabolic syndrome (2). Metabolic syndrome is a complex of metabolic disorders , including abdominal obesity, hypertension, dyslipidemia, and hypertension (2, 3). Metabolic syndrome is associated with the prevalence of overweight and obesity and is a risk factor for cardiovascular disease and diabetes (4, 5).

The exact etiology of the metabolic syndrome is unclear (4, 6); Studies have shown that lifestyle changes due to reduced physical activity, cigarette smoking, unhealthy eating habits, high-fat diets, and high carbohydrates are directly linked to metabolic syndrome; While, consuming fruits, vegetables and dairy reduce the risk of metabolic syndrome (4, 5).

An exercise is a non-pharmacological approach to obesity-related diseases (7). Based on the results, aerobic exercise reduced blood pressure, insulin levels, body weight, blood glucose, insulin resistance, cholesterol, and triglyceride

***Corresponding Author: Etemad Zaher,** Department of Physical Education, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran.
Email: Zetemad2002@yahoo.com
https://orcid.org/0000-0001-5109-9571

deposits (7, 8). Hence in various studies, it has been suggested that regular aerobic training (AT) can be useful in treating metabolic syndrome by improving glucose uptake, insulin sensitivity, glycemic control, lipid profile, immune function, and blood pressure (9, 10).

On the other hand, new studies show that vitamin D (Vit D) deficiency is associated with an increased risk of developing metabolic syndrome; Based on the results of studies, high serum levels of Vit D are associated with a decrease in cardiac and metabolic disorders (7, 11). Studies show that obese people are more at risk for Vit D deficiency (12, 13); probably, Vit D is fat-soluble and is highly expressed in adipose tissue. Therefore, serum levels of Vit D are lower in obese people (12, 14). Accordingly, Vit D deficiency plays an essential role in the pathogenesis of metabolic syndrome and prevention and treatment of obesity (11, 13). Several mechanisms have been suggested for the protective effects of Vit D against heart disease, including impact on the renin-angiotensin system, blood pressure, parathyroid hormone levels, glucose transporter (GLUT-4) and glycemic control (15, 16); Also, Vit D has anti-inflammatory effects and prevents cholesterol uptake by macrophages and foam cell formation in the vessel wall (13, 15). Prevalence of Vit D deficiency in Iran was reported 56%. Of this percentage, 64% of women and 44 % of men have Vit D deficiency (17).

In the end, it should be noted, the beneficial effects of each of the AT+Vit D interventions have been investigated on the lipid profile. Nevertheless, more importantly, there is no convincing evidence of the simultaneous effect of aerobic exercise and Vit D on lipid profile in postmenopausal women with metabolic syndrome. Thus, the purpose of this study was to investigate the effect of a period of aerobic training and vitamin D supplementation (AT+Vit D) on lipid profile in postmenopausal women with metabolic syndrome.

Materials & Methods

Study population and design

In this semi-experimental research study, the target population of this study was postmenopausal women with metabolic syndrome (50 to 60 years old) of Kermanshah. Forty-eight Subjects were divided into four groups include: AT+Vit D (n=12); AT (n=12); Vit D (n=12); and control (C, n=12). Inclusion criteria include: Metabolic syndrome based on criteria adult Treatment Panel III (NCEP: ATP III), 25-OHD serum levels between 10 and 20 ng/ml, not having a specific diet and regular exercise program in the past year. Exclusion criteria include failure to participate in intervention program for more than one session, failure to follow recommended diet plan and other disorders (18, 19). It is worth mentioning that one subject in the AT+Vit D group and one subject in the control group refused to participate in the intervention program.

Three days prior to the start of the study, explanations about research conduction were provided for subjects and consent forms were provided and signed by all 48 subjects. Also, physical activity readiness questionnaire (PARQ), 3-day dietary questionnaire, nutritional questionnaires including food history, food frequency, habits, and dietary behaviors, and health history questionnaire (HHQ) were completed. On the first day, Height was measured to the nearest 0.5 cm using a stadiometer (DETECTO, Model 3PHTROD-WM, USA),). BW, BMI, and BFP were obtained by a bioelectric impedance body composition analyzer (Zeus 9.9 PLUS; Jawon Medical Co., Ltd., Kungsang Bukdo, South Korea) in the fasting state, with minimum clothes as possible, and without shoes.

Definition of metabolic syndrome

The revised National Cholesterol Education Program's Adult Treatment Panel III (NCEP: ATP III) defined metabolic syndrome as the presence of three or more of the following characteristics: (1) abdominal obesity: waist circumference > 88 cm in women; (2) hypertriglyceridemia: ≥150 mg/dL (≥1.69 mmol/L);(3) reduced HDL cholesterol < 50 mg/dL (< 1.29 mmol/L); (4) elevated blood pressure: systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg; and (5) elevated fasting glucose: ≥100 mg/dL (5.6 mmol/L) (20). The equations used to calculate the MS z score were as follows: {z score = [(50 - HDL)/11.8] + [(TG-150)/66.2] + [(fasting blood glucose-100)/10.4] + [(waist circumference - 88)/9.2] + [(mean arterial pressure-100)/8.7]} for subjects (21).

Blood pressure measurements

SBP and DBP were measured by standard manual sphygmomanometer. Participants were strictly prohibited from consuming any

caffeinated products and exercising, 30 min prior to the BP measurement. Throughout assessment, patients remained in a relaxed seated state for 10 min. The cuff was placed on the left arm for all patients and BP was recorded according to standard guidelines (22). A second recording was also taken after 2 min on the same arm. If the measurements had a difference of ≥5 mmHg of BP, further recordings were obtained until there were 2 consecutive stable measurements. Final recording was considered as an average of the 2 stable measurements obtained. Measurement took place each day between 8.00 a.m. and 10.00 a.m. in accordance with the protocol of the American Heart Association (22) Mean arterial pressure (MAP) was calculated as DBP + [0.333 (SBP – DBP)].

Training program

The AT program was conducted based on the ACSM's recommendation and included 8 weeks of AT including intervals of walking, jogging and running with three sessions per week. It contained 10 minutes of warming-up, 20 to 40 minutes of aerobic exercise and 10 minutes of cooling down (9, 10). In the first week, the aerobic exercise lasted 20 minutes with intensity was 60% HR_{max} and in the eighth week, it continued for 40 minutes with the intensity of 75% HR_{max} (23). Aerobic exercise intensity was 60-75% of HR_{max} and 10-13 of RPE in the 6-20 Borg scale (Table 1).

Table 1. Aerobic Training Program

Stage	Mode	Duration	Intensity
Warm-up	Stretching	15 min	HRR 45~55%
Main Exercise	1~4 week	20~30 min	HRR 60~65 %
	5~8 week	30~40 min	HRR 65-75 %
Cool-Down	Stretching	10 min	HRR 40~50%

Vitamin D supplementation

In this study, both AT+Vit D group and Vit D group received 50000 units of Vit D supplement pill once a week made by the Zahravi Pharmaceutical Company in Iran. The C and AT groups also received a weekly placebo (paraffin made by the Zahravi Pharmaceutical Company, Iran) with the same shape, color, smell and tastes to Vit D supplements pill, over a period of 8 weeks (24).

Blood sampling

After 12 hours of fasting, blood samples were collected at the pre-test and post-test (48 hours before and after the first and the last training sessions, respectively). After maintaining the subjects in a stable state for 30 minutes, 20ml of venous blood was sampled from the antecubital vein using an anticoagulant-treated syringe. The sampled blood was placed in a tube that was not treated for anticoagulation, and was then centrifuged at 3,000rpm using a centrifugal separator for 10 minutes. After extracting the serum from the cellular components, the serum was put in a storage tube and stored in the refrigerator at -70℃ until analysis. Blood lipid profile (Triglycerides (TG), Total Cholesterol (TC), High-Density Lipoprotein (HDL) and Low-Density Lipoprotein (LDL)) were measured enzymatically with Hitachi Kit, Tokyo, Japan, and Glucose with enzymatic method (Pars Azmun kit made in Iran).

Statistical analysis

The results obtained in this study were analyzed using SPSS (version 24.0). The descriptive statistics quantity was presented as the mean and the standard error of the mean (SE). The Shapiro–Wilk's test was used for evaluating the normality of distribution. In order to compare the mean hepatic risk factors between and within groups, two-way ANOVA and t-test were used, respectively. Bonferroni post hoc test was used if significant differences were found.

Results

The findings on some demographic information and anthropometric indices of the

subjects and their between-group comparison are presented in Table 2. Based on the results, there were significant differences in the mean of BW, BMI, BFP, WC, AMP and glucose between the pre-test and post-test conditions. After eight weeks, BW, BMI, BFP, WC, AMP significantly decreased in AT+Vit D, AT, Vit D groups, while in the control group, a significant increase in BW, BMI, BFP, WC, AMP levels was observed (Table 2).

Table 2. Changes in information and anthropometric indices during 8 weeks of interventions

Variables	AT + Vit D (n = 11)		AT (n = 12)	Vit D (n=12)	C (n = 11)	P Value [b]
Age (years)	56.01±2.23		45.25±2.22	55.25±2.01	56.36±1.91	P=0.651
Height	158.81±2.75		161±2.89	157.33±1.66	159.27±1.48	P=0.782
Variables	Groups	Pre	Post	P_a	P_b	
BW (kg)	AT+Vit D	87 ±1.94	83.09 ±1.30€¥µ	P=0.001*	Group	P=0.001£
	AT	87.91 ±1.92	85 ±1.34µ	P=0.002*	Test	P=0.007£
	Vit D	86.16 ±1.99	84.58±1.67µ	P=0.003*	Group * Test	P=0.001£
	C	87.27 ±1.48	89.81 ±1.25	P=0.001*		
BMI (kg/m²)	AT+Vit D	34.51 ±1.21	32.95 ±0.92¥µ	P=0.001*	Group	P=0.001£
	AT	33.94 ±1.24	32.81 ±1.20 µ	P=0.002*	Test	P=0.001£
	Vit D	34.82±1.20	34.18 ±1.26µ	P=0.003*	Group * Test	P=0.001£
	C	34.41 ±1.01	35.41 ±0.89	P=0.001*		
BFP (%)	AT+Vit D	42.90 ±1.57	37.63 ±1.36¥µ	P=0.001*	Group	P=0.001£
	AT	42.25 ±1.35	38.91 ±1.08¥µ	P=0.001*	Test	P=0.041£
	Vit D	41.50±1.44	40.58 ±1.67µ	P=0.049*	Group * Test	P=0.001£
	C	42.62±1.40	45.01 ±0.89	P=0.001*		
Waist circumference (cm)	AT+Vit D	97.63 ±1.02	95.09 ±1.86µ	P=0.002*	Group	P=0.049£
	AT	97.33 ±1.87	95.16 ±2.03 µ	P=0.001*	Test	P=0.001£
	Vit D	96.33±1.07	95.25 ±0.96 µ	P=0.001*	Group * Test	P=0.001£
	C	97.63 ±1.12	100.18 ±1.25	P=0.001*		
MAP (mmHg)	AT+Vit D	101.56 ± 1.41	96.71±0.74€¥µ	P=0.001*	Group	P=0.049£
	AT	102.23±1.31	99.37±1.31µ	P=0.001*	Test	P=0.017£
	Vit D	102.90±0.68	100.29±1.06µ	P=0.001*	Group * Test	P=0.001£
	C	101.22±1.09	103.37±0.66	P=0.002*		
Glucose (mg/dl)	AT+Vit D	143.45±1.21	125.27±1.67€¥µ	P=0.001*	Group	P=0.041£
	AT	144.83±1.52	130.83±2.97¥µ	P=0.001*	Test	P=0.031£
	Vit D	145.08±1.88	137.33±2.10µ	P=0.001*	Group * Test	P=0.001£
	C	145.36±1.50	148.45±0.93	P=0.001*		

Table 3. Changes in index lipid profile during 8 weeks of interventions

	Groups	Pre	Post	P		
TC (mg/dl)	AT+Vit D	229.81±4.30	204 ± 4.60€¥µ	P=0.001*	Group	P=0.001*
	AT	228.83±3.40	214 ± 3.21¥µ	P=0.001*	Test	P=0.045*
	Vit D	231.66 ± 3.52	223.58 ± 2.64µ	P=0.001*	Group * Test	P=0.001*
	C	230.01 ± 2.44	236.72 ± 1.79	P=0.001*		
TG (mg/dl)	AT+Vit D	191.45 ±2.38	174.54 ±2.50€¥µ	P=0.001*	Group	P=0.001£
	AT	193.08 ±2.57	182.75 ±3.88¥µ	P=0.001*	Test	P=0.041£
	Vit D	192.25±2.22	187.41 ±1.72 µ	P=0.001*	Group * Test	P=0.001£
	C	192.09 ±1.92	196.27 ±2.24	P=0.001*		
LDL (mmHg)	AT+Vit D	152.27 ± 4.36	131.45 ± 1.96€¥µ	P=0.001*	Group	P=0.001£
	AT	149.08 ± 2.27	139.58 ± 2.50¥µ	P=0.001*	Test	P=0.031£
	Vit D	150.58 ± 2.99	145.16 ± 2.28µ	P=0.001*	Group * Test	P=0.001£
	C	151.45 ± 2.11	156.90 ± 1.86	P=0.001*		
HDL (mg/dl)	AT+Vit D	34.18±1.94	45.45±1.69€¥µ	P=0.001*	Group	P=0.001£
	AT	34.08±1.88	39.91±2.42µ	P=0.001*	Test	P=0.041£
	Vit D	35.08±1.37	39.75±1.48µ	P=0.001*	Group * Test	P=0.001£
	C	34.36±1.85	31.54±1.96	P=0.001*		

AT+Vit D group, Aerobic training and vitamin D supplementation, AT group, Aerobic training; Vit D group, vitamin D supplementation; C group, that had neither aerobic training nor Vit D

P values with superscript "a" are calculated using paired t-test; superscript letter "b" indicates values are calculated using two-way ANOVA of variance test followed by post hoc Bonferroni test

*: Significantly different in comparison with pre and post -test within the groups

£: Significantly different in comparison with between the groups

¥: significantly different in comparison with pre and post -test between groups.

€: Significance different between AT+Vit D group compare to AT

¥: Significance different between AT+Vit D group compare to Vit D group

µ: Significant difference between AT+Vit D, AT, and Vit D groups compare to C group.

The results of Bonferroni post hoc test shows that the lowest anthropometric indices (BW, BMI, BFP, WC, AMP) were observed in the AT+Vit D group. No significant difference was seen in the BW, BMI and Glucose between the AT and Vit D groups; Also, the AT group showed better improvement in the PBF and AMP compared to the Vit D group. however, the mentioned variables were significantly higher in the control group than others in the post-test. (Table 2). There were significant differences in the lipid profile between the pre-test and post-test conditions, as detailed in table 3. Compared to the control group, significant differences were observed in lipid profile in all intervention groups. Significant differences were observed in lipid profile (TC, TG, LDL, and HDL) between AT+Vit D compared with other groups; Also, significant differences were observed in lipid profile (except for HDL) between AT compared with Vit D (Table 3).

Finally, two-way ANOVA showed a significant difference in Z scores for MetS between all groups (Chart 1). The co-treatment

of AT+ Vit D could improve overall Z scores of MetS compared with the other groups (P<0.001 for all three groups).

and mitochondria, and finally improves anthropometric indices (27, 28). On the other hand, Vit D may be stored in body fat mass after

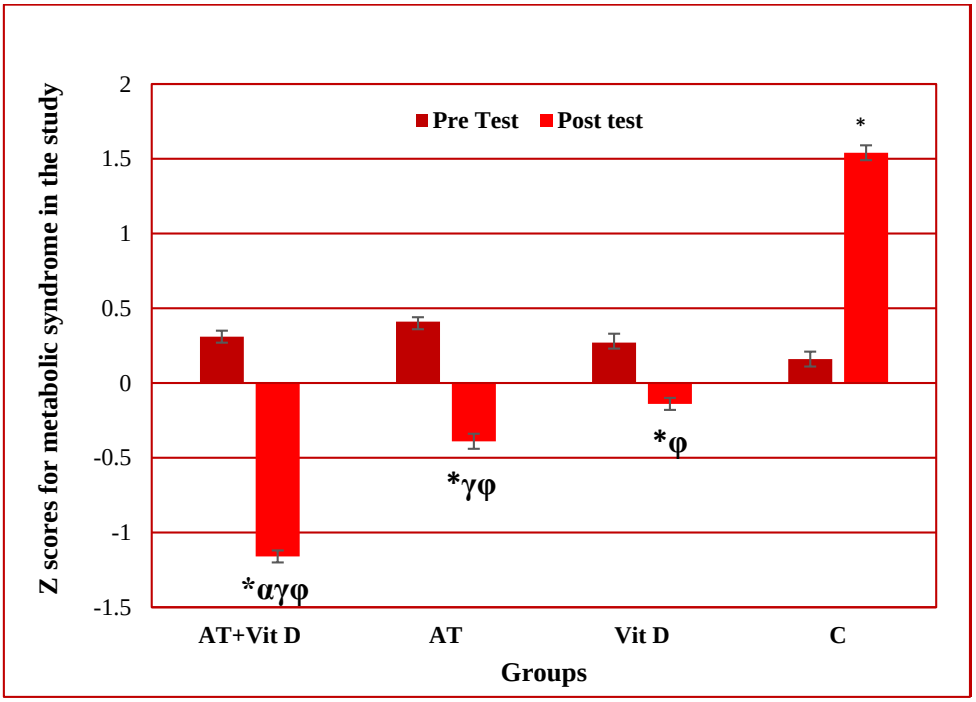

Chart 1. Z scores for metabolic syndrome in the study
AT+Vit D group, Aerobic training and vitamin D supplementation, AT group, Aerobic training; Vit D group, vitamin D supplementation; C group, that had neither aerobic training nor Vit D
P values with superscript "a" are calculated using paired t-test; superscript letter "b" indicates values are calculated using two-way ANOVA of variance test followed by post hoc Bonferroni test
*: Significantly different in comparison with pre and post -test within the groups
¥: significantly different in comparison with pre and post -test between groups.
€: Significance different between AT+Vit D group compare to AT
¥: Significance different between AT+Vit D group compare to Vit D group
µ: Significant difference between AT+Vit D, AT, and Vit D groups compare to C group.

Discussion

Based on the results of the present study, eight weeks of AT+Vit D significantly decreased anthropometric indices BW, BMI and BFP in postmenopausal women with metabolic syndrome. However, this decrement was significant in the AT and Vit D groups alone, it was greater in the AT+Vit D. Whereas, the control group showed a significant increase in anthropometric indices. These results are consistent with those of Babaei et al (2014) (25), Hoseini et al (14), Oh et al (2017) (26) and Hoseini et al (12). According to the results of studies, regular aerobic exercise induces increased daily energy consumption, improved and increased lipid oxidation in skeletal muscles

synthesis and entry into the bloodstream and then Vit D is released slowly from adipose tissue, which reduces anthropometric indices. Furthermore, Vit D deficiency may lead to a decrease in calcitriol in the hypothalamus, which induces an increase in body weight adjustment point. On the other hand, appetite is enhanced by activation of the neuronal circuit agouti-related protein and neuropeptide Y, and inhibition of Pro-Opiomelanocortin/Cocaine- and Amphetamine-Regulated (29-31).

Also, results showed that Vit D supplementation with aerobic exercise for eight weeks had a significant effect on lipid profile factors in elderly women with metabolic

syndrome. Although Vit D supplementation and aerobic exercise alone had significant effects on lipid profile, it was less effective than the simultaneous effect of AT+Vit D. These results are consistent with those of Kim et al (2014) (32), Babaei et al (2015) (25) and Hoseini et al (2020) (33).

Although the mechanism of exercise-induced lipid changes is unclear, exercise itself may increase blood lipid consumption to decrease lipids levels (34, 35). Mechanisms may involve the increased activity of lipoprotein lipase (LPL) - lipoprotein lipase responsible for chylomicrons and VLDL TAG hydrolysis in granules (36); Increase expression of ATP-binding cassette transporter A-1 (ABCA1) in macrophages - has a strong effect on RCT, plasma HDL-C formation, and protection against atherosclerosis (37); Also, Liver X receptor (LXR) is one of the transcription factors of nuclear receptor superfamily that play a key role in liver cholesterol metabolism. LXR has been proved involving in regulating the expression of ABCA1. So, exercise may by inducing higher LXR and ABCA1 to improve the RCT process, which resulting in increased plasma HDL-C levels (38, 39), and finally PCSK9 is a hot spot in the field of cardiovascular research in recent years as it is a new biomarker of LDL clearance and a new target of CVD therapy. Exercise can reduce plasma LDL-C levels, and PCSK9 plays an important role in the regulation of LDL receptor. Therefore, the investigators have considered that exercise is likely to affect LDL-C by modulating PCSK9 (38).

On the other hand, the functions of Vit D are linked to lipid profile. First, Vit D regulates calcium metabolism and increases intestinal calcium absorption, thereby reducing intestinal fatty acid absorption (40). Therefore, a reduction in intestinal fat absorption can lower the cholesterol level. Additionally, increasing the calcium concentration promotes the conversion of cholesterol into bile acids in the liver, resulting in reduced cholesterol level (41). Second, high Vit D level inhibits the parathyroid hormone (PTH). When the Vit D level is not high, Vit D may not inhibit PTH (42, 43). Increased PTH level enhancSes lipogenesis, promotes calcium influx into the adipocytes. Furthermore, a high PTH level decreases lipolytic activity, resulting in a high TG level. Therefore, in the presence of high Vit D level, a low PTH level can reduce the TG level by increasing lipolytic activity and peripheral removal. In addition, a high PTH level increases bone turnover and induces calcium release from the bone (44); Increasing the calcium concentration can affect the cholesterol level, as explained above (45). Third, Vit D can affect lipoprotein metabolism and reduce TG synthesis and secretion in the liver, increasing very-low-density lipoprotein (VLDL-C) receptor expression. Consequently, a high Vit D level induces a decrease in TG and VLDL-C levels and an increase in HDL-C level (25, 46).

Conclusion

The combined program (aerobic training with vitamin D) improves body composition, lipid profile and Metabolic Syndrome Indexes in Menopausal Women.

According to the findings of this study, it is recommended to improve the lipid profile and take steps to increase the health status of women with metabolic syndrome at menopausal age by taking benefits from AT+Vit D

Ethical issues

Informed consent was obtained for any experimentation with human subjects. The present project was approved by the ethics committee of Kurdistan University of Medical Sciences (code number: IR.MUK.REC.1398.241) and registered in the Iranian Clinical Trial Registration Center under the code IRCT20200122046217N1.

Acknowledgments

This article was part of an PhD thesis at the Department of Physical Education & Sport Science, Islamic Azad University, Sanandaj Branch, Sanandaj, Iran. The authors would like to thank the subjects for their willing participation in this study. (code number: IR.MUK.REC.1398.241) and registered in the Iranian Clinical Trial Registration Center under the code IRCT20200122046217N1.

Conflict of Interests

There was no conflict of interests in this study.

Reference

1. Schmitt EB, Nahas-Neto J, Bueloni-Dias F, Poloni PF, Orsatti CL, Nahas EAP. Vitamin D deficiency is associated with metabolic syndrome in postmenopausal women. Maturitas. 2018;107:97-102.

2. Mazloomzadeh S, Khazaghi ZR, Mousavinasab N. The prevalence of metabolic syndrome in Iran: a systematic review and meta-analysis. Iranian journal of public health. 2018;47(4):473-80.
3. You T, Nicklas BJ, Ding J, Penninx BW, Goodpaster BH, Bauer DC, et al. The metabolic syndrome is associated with circulating adipokines in older adults across a wide range of adiposity. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2008;63(4):414-9.
4. Mokhayeri Y, Riahi SM, Rahimzadeh S, Pourhoseingholi MA, Hashemi-Nazari SS. Metabolic syndrome prevalence in the Iranian adult's general population and its trend: a systematic review and meta-analysis of observational studies. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2018;12(3):441-53.
5. Liu Y-s, Liu H-y, Gu X-L, Li X-y, Luo L, Feng Q-x, et al. Relationships Between Neck Circumference and Cardiovascular Risk Factors in a Population With Hypertension and Prehypertension. American Journal of Hypertension. 2019;32(10):1039-40.
6. Deen JF, Krieger EV, Slee AE, Arslan A, Arterburn D, Stout KK, et al. Metabolic syndrome in adults with congenital heart disease. Journal of the American Heart Association. 2016;5(2):1-8.
7. Alonso-Gómez AM, Sierra LT, Frau EF, Güemez LG, Uribarri AA, Portillo MP, et al. Diastolic dysfunction and exercise capacity in patients with metabolic syndrome and overweight/obesity. IJC Heart & Vasculature. 2019;22:67-72.
8. Fenwick PH, Jeejeebhoy K, Dhaliwal R, Royall D, Brauer P, Tremblay A, et al. Lifestyle genomics and the metabolic syndrome: A review of genetic variants that influence response to diet and exercise interventions. Critical reviews in food science and nutrition. 2019;59(13):2028-39.
9. Morales-Palomo F, Ramirez-Jimenez M, Ortega JF, Mora-Rodriguez R. Effectiveness of Aerobic Exercise Programs for Health Promotion in Metabolic Syndrome. Medicine and science in sports and exercise. 2019;51(9):1876-83.
10. Slivovskaja I, Ryliskyte L, Serpytis P, Navickas R, Badarienė J, Celutkiene J, et al. Aerobic training effect on arterial stiffness in metabolic syndrome. The American journal of medicine. 2018;131(2):148-55.
11. Wimalawansa SJ. Associations of vitamin D with insulin resistance, obesity, type 2 diabetes, and metabolic syndrome. The Journal of steroid biochemistry and molecular biology. 2018;175:177-89.
12. Hoseini Z, Behpour N, Hoseini R. Vitamin D Supplementation Increases the Aerobic Training Effects on Anthropometric Indices in Elderly Women with Non-Alcoholic Fatty Liver Disease and Vitamin D Deficiency. Modern Care Journal. 2019;16(3):1-6.
13. Alkhatatbeh MJ, Abdul-Razzak KK, Khasawneh LQ, Saadeh NA. High prevalence of vitamin D deficiency and correlation of serum vitamin D with cardiovascular risk in patients with metabolic syndrome. Metabolic syndrome and related disorders. 2017;15(5):213-9.
14.Hoseini R, Damirchi A, Babaei P. Vitamin D increases PPARγ expression and promotes beneficial effects of physical activity in metabolic syndrome. Nutrition. 2017;36:54-9.
15. Mogili KD, Karuppusami R, Thomas S, Chandy A, Kamath MS, Aleyamma T. Prevalence of vitamin D deficiency in infertile women with polycystic ovarian syndrome and its association with metabolic syndrome–A prospective observational study. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2018;229:15-9.
16. Alavian SM, Mohammad-Alizadeh AH, Esna-Ashari F, Ardalan G, Hajarizadeh B. Non-alcoholic fatty liver disease prevalence among school-aged children and adolescents in Iran and its association with biochemical and anthropometric measures. Liver international. 2009;29(2):159-63.
17. Vatandost S, Jahani M, Afshari A, Amiri MR, Heidarimoghadam R, Mohammadi Y. Prevalence of vitamin D deficiency in Iran: a systematic review and meta-analysis. Nutrition and health. 2018;24(4):269-78.
18. Al-Jiffri O, Al-Sharif F, El-Kader S, Ashmawy E. Weight reduction improves markers of hepatic function and insulin resistance in type-2 diabetic patients with non-alcoholic fatty liver. African health sciences. 2013;13(3):667-72.

19. Johnson NA, Sachinwalla T, Walton DW, Smith K, Armstrong A, Thompson MW, et al. Aerobic exercise training reduces hepatic and visceral lipids in obese individuals without weight loss. Hepatology. 2009;50(4):1105-12.
20. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Circulation. 2005;112(17):2735-52.
21. Bateman LA, Slentz CA, Willis LH, Shields AT, Piner LW, Bales CW, et al. Comparison of aerobic versus resistance exercise training effects on metabolic syndrome (from the Studies of a Targeted Risk Reduction Intervention Through Defined Exercise-STRRIDE-AT/RT). The American journal of cardiology. 2011;108(6):838-44.
22. Townsend RR, Wilkinson IB, Schiffrin EL, Avolio AP, Chirinos JA, Cockcroft JR, et al. Recommendations for improving and standardizing vascular research on arterial stiffness: a scientific statement from the American Heart Association. Hypertension. 2015;66(3):698-722.
23. Heil DP. ACSM's guidelines for exercise testing and prescription. Medicine and Science in Sports and Exercise. 2001;33(2):343.
24. Targher G, Bertolini L, Scala L, Cigolini M, Zenari L, Falezza G, et al. Associations between serum 25-hydroxyvitamin D3 concentrations and liver histology in patients with non-alcoholic fatty liver disease. Nutrition, Metabolism and Cardiovascular Diseases. 2007;17(7):517-24.
25. Babaei P, Damirchi A, Hoseini R. The interaction effects of aerobic exercise training and vitamin D supplementation on plasma lipid profiles and insulin resistance in ovariectomized rats. Journal of exercise nutrition & biochemistry. 2015;19(3):173-82.
26. Oh C, Jeon BH, Storm SNR, Jho S, No J-K. The most effective factors to offset sarcopenia and obesity in the older Korean: physical activity, vitamin D, and protein intake. Nutrition. 2017;33:169-73.
27.Van Gemert WA, May AM, Schuit AJ, Oosterhof BY, Peeters PH, Monninkhof EM. Effect of weight loss with or without exercise on inflammatory markers and adipokines in postmenopausal women: the SHAPE-2 trial, a randomized controlled trial. Cancer Epidemiology and Prevention Biomarkers. 2016;25(5):799-806.
28. Smart N, King N, McFarlane JR, Graham P, Dieberg G. Effect of exercise training on liver function in adults who are overweight or exhibit fatty liver disease: a systematic review and meta-analysis. British journal of sports medicine. 2018;52(13):834-43.
29. Ebal E, Cavalie H, Michaux O, Lac G. Effect of a moderate exercise on the regulatory hormones of food intake in rats. Appetite. 2007;49(2):521-4.
30. Zhu W, Cai D, Wang Y, Lin N, Hu Q, Qi Y, et al. Calcium plus vitamin D 3 supplementation facilitated Fat loss in overweight and obese college students with very-low calcium consumption: a randomized controlled trial. Nutrition journal. 2013;12(1):2-8.
31. Salehpour A, Hosseinpanah F, Shidfar F, Vafa M, Razaghi M, Dehghani S, et al. A 12-week double-blind randomized clinical trial of vitamin D 3 supplementation on body fat mass in healthy overweight and obese women. Nutrition journal. 2012;11(1):2-8.
32. Kim H-J, Kang C-K, Park H, Lee M-G. Effects of vitamin D supplementation and circuit training on indices of obesity and insulin resistance in T2D and vitamin D deficient elderly women. Journal of exercise nutrition & biochemistry. 2014;18(3):249-57.
33. Hoseini Z, Behpour N, Hoseini R. Co-treatment with Vitamin D Supplementation and Aerobic Training in Elderly Women with Vit D Deficiency and NAFLD: A Single-blind Controlled Trial. Hepatitis Monthly. 2020;20(2):1-11.
34. Wang Y, Xu D. Effects of aerobic exercise on lipids and lipoproteins. Lipids in health and disease. 2017;16(1):2-8.
35. Igarashi Y, Akazawa N, Maeda S. Effects of aerobic exercise alone on lipids in healthy east asians: a systematic review and meta-analysis. Journal of atherosclerosis and thrombosis. 2019;26(5):488-503.
36. Tobar HE, Cataldo LR, González T, Rodríguez R, Serrano V, Arteaga A, et al. Identification and functional analysis of missense mutations in the lecithin cholesterol acyltransferase gene in a Chilean patient with hypoalphalipoproteinemia. Lipids in health and disease. 2019;18(1):2-10.
37. Tofighi A, Rahmani F, Qarakhanlou BJ, Babaei S. The effect of regular aerobic exercise on reverse cholesterol transport A1 and apo lipoprotein aI gene expression in inactive

women. Iranian Red Crescent Medical Journal. 2015;17(4):1-5.
38. Kamani CH, Gencer B, Montecucco F, Courvoisier D, Vuilleumier N, Meyer P, et al. Stairs instead of elevators at the workplace decreases PCSK 9 levels in a healthy population. European journal of clinical investigation. 2015;45(10):1017-24.
39. Rocco D, Okuda L, Pinto R, Ferreira F, Kubo S, Nakandakare E, et al. Aerobic exercise improves reverse cholesterol transport in cholesteryl ester transfer protein transgenic mice. Lipids. 2011;46(7):617-25.
40.Wang Y, Si S, Liu J, Wang Z, Jia H, Feng K, et al. The associations of serum lipids with vitamin D status. PLoS One. 2016;11(10):1-13.
41. Vaskonen T, Mervaala E, Sumuvuori V, Seppänen-Laakso T, Karppanen H. Effects of calcium and plant sterols on serum lipids in obese Zucker rats on a low-fat diet. British Journal of Nutrition. 2002;87(3):239-45.
42. Song SJ, Si S, Liu J, Chen X, Zhou L, Jia G, et al. Vitamin D status in Chinese pregnant women and their newborns in Beijing and their relationships to birth size. Public health nutrition. 2013;16(4):687-92.
43. Zittermann A, Frisch S, Berthold HK, Götting C, Kuhn J, Kleesiek K, et al. Vitamin D supplementation enhances the beneficial effects of weight loss on cardiovascular disease risk markers. The American journal of clinical nutrition. 2009;89(5):1321-7.
44. Usategui-Martín R, Pérez-Alonso M, Socorro-Briongos L, Ruiz-Mambrilla M, De Luis D, Linares L, et al. Estrogen receptor genes polymorphisms determine serum lipid profile in healthy postmenopausal women treated with calcium, vitamin D, and genistein. Journal of cellular biochemistry. 2019;120(8):13115-20.
45. Nakhl S, Sleilaty G, El Samad S, Saliba Y, Chahine R, Farès N. Association between vitamin D deficiency and lipid and non-lipid markers of cardiovascular diseases in the middle east region. European journal of clinical nutrition. 2019;73(6):850-8.
46. Kelishadi R, Farajzadegan Z, Bahreynian M. Association between vitamin D status and lipid profile in children and adolescents: a systematic review and meta-analysis. International journal of food sciences and nutrition. 2014;65(4):404-10.

مقاله پژوهشی

چگونگی اثرترکیبی تمرین هوازی و مکمل‌دهی ویتامین D بر عوامل سندرم متابولیک: یک کارآزمایی بالینی در زنان یائسه

پریوش نجفی نظرآبادی [۱]، ظاهر اعتماد[۱*]، رستگار حسینی[۲]، فتاح مرادی[۳]

۱. گروه تربیت بدنی، واحد سنندج، دانشگاه آزاد اسلامی، سنندج، ایران
۲. گروه فیزیولوژی ورزشی، دانشکده علوم ورزشی، دانشگاه رازی، کرمانشاه، ایران
۳. گروه تربیت بدنی، واحد سقز، دانشگاه آزاد اسلامی، سقز، ایران

تاریخ دریافت مقاله: ۱۳۹۹/۰۶/۱۲ تاریخ پذیرش مقاله: ۱۳۹۹/۰۷/۱۵

چکیده

زمینه و هدف: ورزش یک استراتژی شناخته شده برای کاهش خطر سندرم متابولیک و بیماری‌های مزمن است. با این حال، تأثیر هم‌زمان تمرین هوازی با مکمل‌دهی ویتامین D بر شاخص‌های تن‌سنجی و نیمرخ چربی تا حدودی ناشناخته است. هدف این مطالعه بررسی اثر تمرین هوازی و مکمل‌دهی ویتامین D (AT+Vit D) بر شاخص‌های تن‌سنجی و نیمرخ چربی در زنان یائسه مبتلا به سندرم متابولیک می‌باشد.

مواد و روش‌ها: ۴۶ زن یائسه مبتلا به سندرم متابولیک به‌طور تصادفی به چهار گروه تمرین هوازی و مکمل‌دهی ویتامین D (AT+Vit D, n=11)، تمرین هوازی (AT, n=12)، مکمل‌دهی ویتامین D (Vit D, n=12) و گواه (C, N=11) تقسیم شدند. برنامه تمرینی به صورت تدریجی و به مدت هشت هفته، ۲۰-۴۰ دقیقه تمرین با ۶۰ تا ۷۵ درصد حداکثر ضربان قلب، سه روز در هفته انجام شد. گروه‌های مداخله، کپسول ۵۰۰۰ واحدی ویتامین D یا دارونما دریافت کردند. داده‌ها با استفاده از آزمون‌های t زوجی، تحلیل واریانس (ANOVA) دو طرفه و آزمون تعقیبی بونفرونی با نرم‌افزار SPSS 24 در سطح معنی‌داری $P<۰/۰۵$ تجزیه و تحلیل شد.

نتایج: پس از هشت هفته، در هر سه گروه AT+Vit D، AT، و Vit D سطوح متغییرهای BW، BMI، BFP، WC، TC، TG، LDL، MAP و گلوکز کاهش معنی‌دار؛ همچنین HDL افزایش معنی‌دار داشت. همچنین نتایج نشان داد که در مقایسه با AT، Vit D و C، مداخله‌ی AT+Vit D منجر به کاهش معنی‌داری در BW، MAP، گلوکز، TC، TG و LDL و افزایش HDL شد ($P<۰/۰۰۱$).

نتیجه‌گیری: بکارگیری AT+Vit D در بهبود نیمرخ چربی در بیماران مبتلا به سندروم متابولیک از AT یا ویتامین D به تنهایی موثرتر است.

کلمات کلیدی: تمرینات هوازی، ویتامین D، نیمرخ چربی خون، سندرم متابولیک

***نویسنده مسئول: ظاهر اعتماد**، گروه تربیت بدنی، واحد سنندج، دانشگاه آزاد اسلامی، سنندج، ایران.
Email: Zetemad2002@yahoo.com
https://orcid.org/0000-0001-5109-9571