

## Research Article

# Effect of Aerobic Training along with Garlic on Oxidative Stress Index in Obese Women with High Blood Pressure

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### Abstract

**Background:** A large amount of evidence shows that oxidative stress plays a central role in hypertension pathophysiology. The aim of this study was to examine effect of aerobic training along with Garlic on oxidative stress index in obese women with high blood pressure.

**Materials and Methods:** In this clinical trial study, 36 postmenopausal obese women with hypertension were purposefully and accessibly selected from Sari and were simple randomly divided into four groups Control (C), Aerobic Training (AT), Garlic (G) and Aerobic Training +Garlic (ATG). The training groups participated in a progressive aerobic training for eight weeks, three sessions a week (55% to 65% of the reserved heart rate and for 30 to 55 min). The groups of G and ATG were provided 1000 mg of garlic supplement for eight weeks (After breakfast and dinner). Two days before and after the protocol, blood samples were taken in fasting state. SPSS 16.0 software was used for statistical analysis. Data were analyzed using ANCOVA at  $p < 0.05$ .

**Results:** The results showed that the levels of malondialdehyde (MDA) ( $P = 0.0001$ ) decrease significantly in the experimental groups. Also, superoxide dismutase (SOD) ( $P = 0.001$ ), glutathione peroxidase (GPX) ( $P = 0.000$ ) and catalase (CAT) ( $P = 0.001$ ) in the experimental groups increased significantly compared to the C group. The amount of SOD, GPx and CAT in the ATG group was significantly higher than the AT and G group ( $p \leq 0/05$ ).

**Conclusion:** It seems that AT and G has interactive effects on reducing Oxidative Stress in obese women with high blood pressure.


### Keywords:

Aerobic exercise, Garlic, Oxidative Stress, Hypertension, Obese Women

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## 1. Introduction

Hypertension is an important modifiable risk factor for premature cardiovascular disease (CVD), however, 43% of adult women have hypertension (1). Blood pressure (BP) increases with age in both sexes, but blood pressure is higher in women after middle age than in men. It has also been shown that after menopause, the prevalence of high blood pressure in women increases (2). Oxidative stress has been implicated as a mediator of hypertension, as most studies have shown that individuals with lower blood pressure also have higher levels of endogenous antioxidants such as vitamins E and C (3). Chronic inflammation and oxidative stress are factors in endothelial dysfunction (4) that are directly involved in increasing systemic vascular resistance and thus increasing blood pressure (BP). Oxidative stress is caused by a systemic imbalance between the production of reactive oxygen species (ROS) and antioxidant capacity (5). ROS levels may be increased due to decreased antioxidant enzyme activity in hypertensive individuals, while reduced oxidative stress may reduce blood pressure (6). Exercise training has a positive effect on blood pressure by reducing lipid peroxidation and oxidative stress (7). Previous studies have reported that although a single bout of exercise increases ROS production, long-term exercise can also regulate the expression of antioxidant defense systems (8). Epidemiological studies have also shown that regular physical exercise performed at low to moderate intensity per week is more suitable for middle-aged and elderly people (9).

Therefore, aerobic training (AT) can be a suitable way for these people by improving the state of oxidative stress in obese women with high blood pressure. AT has been shown to be effective in a decrease of the occurrence of ROS-associated hypertension (10) and exerts a protective effect on oxidative damage, the exact mechanism of the effect of exercise training on cardiovascular function is not well known. In this regard, da Silva et al. (2022) showed that 16 weeks of AT was associated with blood pressure improvement in women with hypertension (11). Several other studies have shown that AT is an important non-pharmacological strategy for the prevention and treatment of hypertension (12). AT reduces sympathetic tone, arterial blood pressure, oxidative stress (13) and inflammation (14). However, Ruangthai et al. (2019) showed that endurance exercise does not have a significant effect on plasma MDA (15). On the other hand, studies have shown that some plants also play a role in controlling blood pressure by modulating oxidative stress. Garlic (*Allium sativum L.*) is a nutrient that has beneficial cardiovascular properties and effects and contains various compounds including organosulfur compounds, amino acids, vitamins and minerals. Some sulfur-containing compounds are responsible for the healing properties of garlic, including Allicin, S-allyl Cysteine, and Diallyl Disulfide (16). It has been shown that daily consumption of 1200 mg of garlic significantly reduces systolic and diastolic pressure, decreases arterial wall resistance and lowers total cholesterol level (17).

Also, consuming garlic improves the performance of the antioxidant defense system by increasing superoxide dismutase, catalase and glutathione peroxidase (18). By introducing this trend, blood pressure can be lowered in hypertensive patients with antioxidant measures, and it is possible that one of the mechanisms to reduce cardiovascular diseases caused by high blood pressure is performing endurance sports and using antioxidant supplements. Considering the role of sports activities in reducing and adjusting oxidative stress indicators and the role of oxidative stress in the development of blood pressure, as well as the inhibitory effect of garlic on oxidative stress indicators, the researcher assumes that the simultaneous effect of aerobic exercise with garlic consumption has a better effect on oxidative stress in obese women with high blood pressure. Therefore, this study intends to study the simultaneous effect of garlic consumption and AT on oxidative stress in obese women with hypertension.

## 2. Materials and Methods

### Subjects

In this clinical trial study, 36 inactive postmenopausal women with hypertension (blood pressure higher than 140/90 mmHg) and obesity (body mass index  $\leq 30$ ) from Sari city (summer 2018) aged 50 to 65 were included in the study. Sampling was done among hypertensive people voluntarily, purposefully and available. After completing the number of subjects for the research, by making a phone call and obtaining their consent, 36 eligible people were randomly divided into four groups Control (C), Training (AT), Garlic (G) and Training+Garlic (ATG). The criteria for entering the study include: confirmation of hypertension by a doctor, absence of other underlying diseases (structural diseases and skeletal muscle abnormalities, no fractures and sprains in different body tissues, no history of any fractures and surgeries in the last 1 year, disease heart and liver problems), not participating in a regular exercise program in the last six months, being allowed to participate in the exercise program with the doctor's opinion and consenting to participate in the study. The exclusion criteria from the study included not taking supplements and not doing exercise, diagnosis of other underlying diseases during the implementation of the protocol, change in the pattern of drug consumption, feeling the risk of exercising or taking supplements, and not having a phone call from the researcher for follow-up. In this study, the subjects also participated in an exercise familiarization program. Subjects were asked not to change their diet during the study period.

## Exercise protocol

The AT group trained for 8 weeks (24 sessions, 3 sessions per week). The duration of the activity was 30 to 55 minutes and the intensity of the activity was considered to be 55 to 65% of the maximum reserve heart rate (Table 1) (4). It should be noted that the training program in the gyms was standardized and implemented with safety precautions, and a Polar heart rate monitor was used to control the intensity of the training.

**Table 1: Aerobic training protocol for menopausal women with high blood pressure and obesity**

week	1	2	3	4	5	6	7	8
Time (minutes)	30	35	40	45	50	50	55	55
Intensity (HR reserve)	55	55	60	60	60	65	65	65

## Supplement preparation and consumption

The garlic supplement was purchased under the brand name (Natural Made) made in the United States. 500 mg of the supplement was placed in gelatin capsules. The subjects were asked to take one capsule after breakfast and dinner. The subjects of the C and AT groups also used the placebo (starch capsule) twice a day in the same amount and volume as the G group. Capsules containing garlic supplement and placebo (capsule containing starch) were given to the subjects in a double-blind manner. The dosage (960 mg) has previously been used in hypertensive patients (systolic blood pressure above 140 mmHg) (20).

**Blood sampling and laboratory analysis**

Two days before and after the training session, blood samples were taken from the brachial vein in a fasting state (12 hours). MDA serum levels were measured based on the reaction with thiobarbituric acid and using a fluorimetric device. SOD was measured using a commercial kit made by RANDOX company, and GPX and CAT levels were measured by spectrophotometric method.

**3. Results**

Table 2 show the mean changes in weight, height, BMI, WHR, systolic blood pressure (SBP) and diastolic blood pressure (DBP) in different groups (Tab 2).

**Statistical analysis**

Shapiro-Wilk test was used to ensure normal distribution of data and Levin test was used to ensure homogeneity of variances. Descriptive statistics were used to describe the data and draw graphs, and ANCOVA was used to compare the groups in the studied variables. Significant level was considered  $P \leq 0.05$ . All statistical analysis was performed using 26 SPSS software.

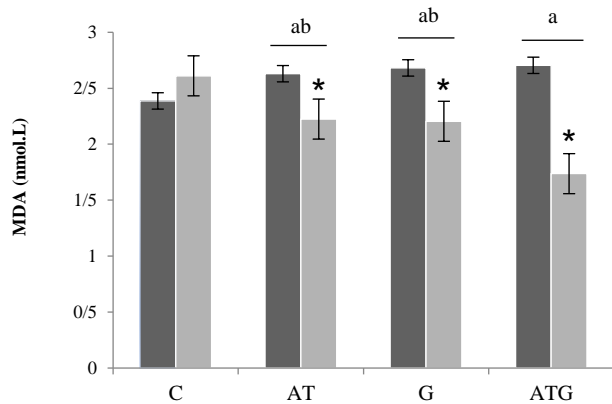
**Table 2: Results related to subjects' characteristics and SBP and DBP**

		C	AT	G	ATG	P Between-group
Age (years)	Pre-test	59.89 ± 4.45	61.89 ± 4.85	61.89 ± 4.70	62.56 ± 4.66	0.652
	Post-test	59.89 ± 4.45	61.89 ± 4.85	61.89 ± 4.70	62.56 ± 4.66	
Height(meters)	Pre-test	1.56 ± 0.049	1.55 ± 0.037	1.55 ± 0.032	1.56 ± 0.040	0.840
	Post-test	1.56 ± 0.049	1.55 ± 0.037	1.55 ± 0.032	1.56 ± 0.040	
Weight (kg)	Pre-test	72.78 ± 8.24	74.00 ± 6.22	69.67 ± 7.64	72.33 ± 6.42	0.009 β
	Post-test	72.44 ± 9.04	69.44 ± 4.47	65.56 ± 6.48	66.56 ± 6.12	
	P within-group	0.700	0.004*	0.001*	0.005*	
BMI (Kg/m <sup>2</sup> )	Pre-test	29.70 ± 3.99	30.68 ± 3.54	28.96 ± 3.14	29.75 ± 2.89	0.010 β
	Post-test	29.57 ± 4.28	28.76 ± 2.55	27.27 ± 2.81	27.33 ± 2.05	
	P within-group	0.692	0.005*	0.001*	0.006*	
WHR	Pre-test	0.860±0.051	0.878 ± 0.05	0.882 ± 0.11	0.856 ± 0.087	0.0001 β
	Post-test	0.922±0.058	0.853 ± 0.067	0.891±0.107	0.893 ± 0.093	
	P within-group	0.000	0.061	0.421	0.042	
SBP (mmHg)	Pre-test	140.67±10.05	143.11 ± 9.06	147.11±8.55	144.67 ± 9.24	0.0001 β
	Post-test	141.56 ± 9.36	30.36±131.78 <sup>a</sup>	135.78±8.84 <sup>a</sup>	130.22±15.63 <sup>a</sup>	
	P within-group	0.362	0.0001*	0.002*	0.001*	
DBP (mmHg)	Pre-test	84.33 ± 6.40	82.89 ± 5.08	83.22 ± 7.29	84.89 ± 3.98	0.032 β
	Post-test	85.11 ± 5.13	81.33 ± 2	82.67 ± 5.14	80.44±14.2 <sup>a</sup>	
	P within-group	0.432	0.270	0.714	0.003*	

\* significance of within-group, a: difference with control group β: difference between groups ( $P \leq 0.05$ )

After confirming the normality of the data using the Shapiro-Wilk test; The results of within-group comparison showed a significant decrease in the average MDA levels in groups AT (P=0.008), G (P=0.009) and ATG (P=0.0001) (Fig 1). Data analysis using covariance test showed that there is a significant difference in the amount of MDA changes between different groups (P=0.0001). The results of Benferroni's post hoc test showed that there is a significant difference between group C with AT (P=0.015), G (P=0.007) and ATG (P=0.0001); and also, between ATG group with AT (P=0.018) and G (P=0.042) (Fig 1).

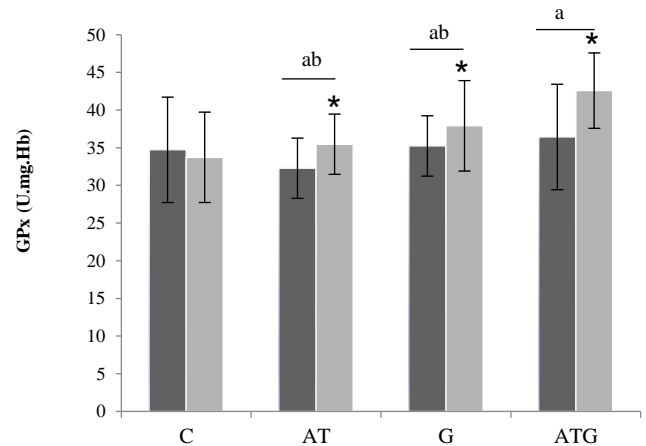
The results of within-group comparison showed a significant increase in the mean levels of GPx in groups AT (P=0.0001), G (P=0.012) and ATG (P=0.001) (Fig 2). Data analysis using covariance test showed that there is a significant difference in the amount of GPx changes between different groups (P=0.0001). The results of Benferroni's post hoc test showed that there is a significant difference between group C with AT (P=0.01509 G (P=0.012) and ATG (P=0.0001); and also, between ATG group with AT (P=0.031) and G (P=0.016) (Fig 2).



**Figure 1:** Changes in serum MDA levels in different groups using t test and ANCOVA test (p<0.05 level).

\*Difference with pre-test, a Difference with C group, b Difference with ATG group.

Control (C), Aerobic Training (AT), garlic (G) and Aerobic Training-garlic (ATG).



**Figure 2:** Changes in serum GPx levels in different groups using t test and ANCOVA test (p<0.05 level).

\*Difference with pre-test, a Difference with C group, b Difference with ATG group.

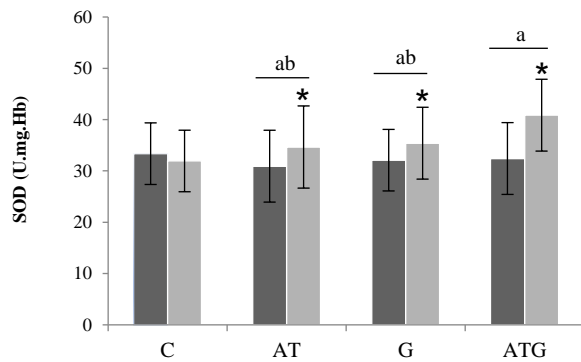
Control (C), Aerobic Training (AT), garlic (G) and Aerobic Training-garlic (ATG).

\*Difference with pre-test, a Difference with C group, b Difference with ATG group.

Control (C), Aerobic Training (AT), garlic (G) and Aerobic Training-garlic (ATG).

In addition, the results of within-group comparison showed a significant increase in the average SOD levels in AT ( $P=0.036$ ), G ( $P=0.031$ ) and ATG ( $P=0.0001$ ) groups (Fig 3). Data analysis using covariance test showed that there is a significant difference in the amount of SOD changes between different groups ( $P=0.0001$ ). The results of Benferroni's post hoc test showed that there is a significant difference between group C with AT ( $P=0.027$ ), G ( $P=0.045$ ) and ATG ( $P=0.0001$ ); and also, between ATG group with AT ( $P=0.042$ ) and G ( $P=0.023$ ) (Fig 3).

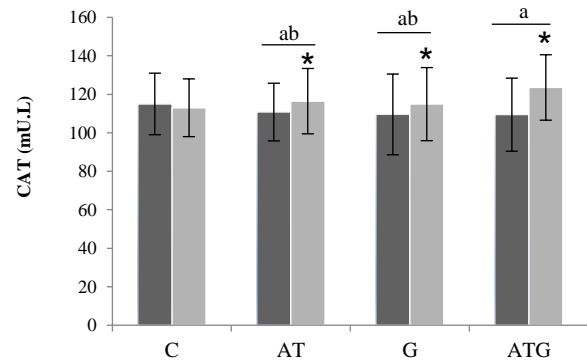
Among the other results of this research, using the within-group test, there was a significant increase in the average CAT levels in groups AT ( $P=0.015$ ), G ( $P=0.014$ ) and ATG ( $P=0.0001$ ) (Fig 4). Data analysis using covariance test showed that there is a significant difference in the amount of CAT changes between different groups ( $P=0.0001$ ). The results of Benferroni's post hoc test showed that there is a significant difference between group C with AT ( $P=0.027$ ), G ( $P=0.022$ ) and ATG ( $P=0.001$ ); and also, between ATG group with AT ( $P=0.006$ ) and G ( $P=0.003$ ) (Fig 4).



**Figure 3:** Changes in serum SOD levels in different groups using t test and ANCOVA test ( $p<0.05$  level).

\*Difference with pre-test, a Difference with C group, b Difference with ATG group.

Control (C), Aerobic Training (AT), garlic (G) and Aerobic Training-garlic (ATG).



**Figure 4:** Changes in serum CAT levels in different groups using t test and ANCOVA test ( $p<0.05$  level).

\*Difference with pre-test, a Difference with C group, b Difference with ATG group.

Control (C), Aerobic Training (AT), garlic (G) and Aerobic Training-garlic (ATG).

## 4. Discussion

The results of the present study showed that AT in women with high blood pressure was associated with a decrease in the serum level of MDA and an increase in SOD, GPx and CAT. Oxidative stress plays a key role in the pathophysiology of hypertension (10). The importance of redox imbalance in hypertension has also been demonstrated in many population-based studies. Persistent accumulation of free radicals due to impaired redox homeostasis negatively affects vascular function, thus contributing to the initiation and progression of hypertension (21). Clinical studies of hypertensive patients showed that SBP and DBP were positively correlated with oxidative stress biomarkers and negatively correlated with antioxidant levels. Decreased antioxidant activity (SOD) and increased levels of lipid peroxidation (MDA) may contribute to oxidative stress in human hypertension (22). Naregal et al. (2017) found that plasma MDA levels were significantly increased and SOD antioxidant activity was decreased in elderly hypertensive subjects compared to healthy subjects (23). In addition, some studies have shown that exercise may be able to reduce oxidative damage and increase the clearance of reactive aldehydes in patients with hypertension (23). In line with the present study, Wu et al. (2021) showed that 12 weeks of AT in adult women increased SOD, TCA and decreased MDA (24). Park et al. (2017) also stated that 15 sessions of AT with low to moderate intensity led to positive effects on blood lipid profile, blood pressure, level of blood inflammatory markers and oxidative stress in women over 70 years old (25).

Also, Dantas et al. (2016) showed that exercise increases TAC levels and decreases MDA and mean blood pressure in elderly hypertensive women (26). In the present study, the decrease in MDA concentration was associated with an increase in GPx. GPx, an antioxidant enzyme responsible for the degradation of lipid peroxides, protects the cell membrane against peroxidative damage. Therefore, the decrease in MDA concentration is probably due to the increase in GPx activity (15). Previous studies have shown that AT is effective in reducing ROS and increasing adaptation to oxidative stress by increasing the level of antioxidants in hypertensive subjects (10). It has also been reported that by increasing the frequency of exercise to four days a week or more, markers of oxidative stress improve in people with high blood pressure who participate in walking (27).

Among the other results of the current study, there was a significant decrease in MDA and an increase in SOD, GPx and MDA following the consumption of garlic in obese adult women. In a study, Seo et al. (2012) showed that a 12-week diet of garlic extract combined with regular exercise reduced body weight, body mass index, total cholesterol, LDL-C, malondialdehyde and homocysteine levels reduced cardiovascular risk factors in menopause (28). Ahmadian et al. (2017) found that daily supplementation of 800 mg garlic tablets for four weeks, compared to placebo, resulted in increased TAC concentrations and decreased MDA levels in postmenopausal women with osteoporosis (29).



In agreement with our study, some previous studies reported that garlic supplementation could increase TAC and decrease MDA levels (29, 30). Allicin, diallyl disulfide, and S-allylcysteine derived from garlic contain redox-active sulfhydryl (SH) groups that act as radical scavengers. Also, the mechanism of the antioxidant effect of garlic may be involved in regulating the Nrf2-ARE pathway and increasing the activity of antioxidant enzymes (31). Nrf2 trans-activation promotes the up-regulation of antioxidant genes responsible for the expression of antioxidant enzymes (32). In addition, in vitro studies have shown that garlic can protect endothelial cells against ROS damage by up-regulating cellular inhibitory enzymes such as catalase, glutathione peroxidase, and superoxide dismutase (33). However, in the study of Atkin et al. (2016), no significant effect on oxidative stress markers was observed in the garlic group compared to the placebo group (34). Maybe the difference in the type of subjects caused the difference in the results.

Another finding of the present study was the greater effect of combining AT with garlic on oxidative stress indices in women with high blood pressure. In this regard, Ghyasi et al. (2019) showed in an animal study that six weeks of exercise combined with garlic consumption significantly increased the levels of GPx, SOD, CAT and TAC (35). It was also shown that AT with garlic consumption improves inflammatory indices along with reducing systolic blood pressure and body composition in hypertensive and obese women (14). It seems that in the current research, the combination of exercise and garlic has a synergistic effect and has led to better results than exercise and garlic alone.

Since high blood pressure disease leaves its effects in the long term, perhaps the length of the research period in the present study is another important limitation for the detailed examination of the effects of AT and garlic consumption on this disease. Therefore, it is recommended to use longer periods in subsequent protocols. Also, the gender and age of the subjects was one of the limitations of this study, so the results of this protocol cannot be generalized to other people. Finally, the generalizability of the results is limited due to the small sample size. Therefore, the results should be interpreted with caution.

## 5. Conclusion

The results of the present study showed that AT and garlic consumption improved oxidative stress in hypertensive and obese women, however, the effect of combining AT and garlic on oxidative stress was better. Therefore, the combination of these two can be used as a strategy to control blood pressure and oxidative damage caused by it in obese hypertensive adult women.

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This study did not have any funds.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** the research was conducted with regard to the ethical principles (IR.SSRI.REC.1398.039), and it was registered in the clinical trial system under number IRCT20140415017288N5.

**Informed consent** Informed consent was obtained from all participants.

## Author contributions

Conceptualization: GH.T., M.K. A.A., A.A.D., M.A.M; Methodology: A.A., M.K.; Software: GH.T.; Validation: A.A.D., M.K.; Formal analysis: A.A., GH.T.; Investigation: A.A., A.A.D.; Resources: A.A.D., M.K., A.A.; Data curation: A.A., GH.T.; Writing - original draft: GH.T., M.K. A.A., A.A.D., M.A.M; Writing - review & editing: A.A., GH.T.; Visualization: A.A.D., M.K.; Supervision: A.A.; Project administration: M.K.; Funding acquisition: A A M K

## References

1. Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, et al. Heart disease and stroke statistics—2020 update: a report from the American Heart Association. *Circulation*. 2020;141(9):e139-e596. doi: [10.1161/CIR.0000000000000757](https://doi.org/10.1161/CIR.0000000000000757). PMID: 31992061
2. Coylewright M, Reckelhoff JF, Ouyang P. Menopause and hypertension: an age-old debate. *Hypertension*. 2008;51(4):952-9. doi: [10.1161/HYPERTENSIONAHA.107.105742](https://doi.org/10.1161/HYPERTENSIONAHA.107.105742). PMID: 18259027.
3. Kuwabara A, Nakade M, Tamai H, Tsuboyama-Kasaoka N, Tanaka K. The association between vitamin E intake and hypertension: results from the re-analysis of the National Health and Nutrition Survey. *J Nutr Sci Vitaminol*. 2014;60(4):239-45. doi: [10.3177/jnsv.60.239](https://doi.org/10.3177/jnsv.60.239). PMID: 25297612.
4. Rodríguez-Mañas L, El-Assar M, Vallejo S, López-Dóriga P, Solís J, Petidier R, et al. Endothelial dysfunction in aged humans is related with oxidative stress and vascular inflammation. *Aging cell*. 2009;8(3):226-38. doi: [10.1111/j.1474-9726.2009.00466.x](https://doi.org/10.1111/j.1474-9726.2009.00466.x). PMID: 19245678.
5. Higashi Y, Maruhashi T, Noma K, Kihara Y. Oxidative stress and endothelial dysfunction: clinical evidence and therapeutic implications. *Trends Cardiovasc Med*. 2014;24(4):165-9. doi: [10.1016/j.tcm.2013.12.001](https://doi.org/10.1016/j.tcm.2013.12.001). PMID: 24373981.
6. Pedro-Botet J, Covas M, Martin S, Rubies-Prat J. Decreased endogenous antioxidant enzymatic status in essential hypertension. *J Hum Hypertens*. 2000;14(6):343-5. doi: [10.1038/sj.jhh.1001034](https://doi.org/10.1038/sj.jhh.1001034). PMID: 10878691.
7. Xu T, Liu S, Ma T, Jia Z, Zhang Z, Wang A. Aldehyde dehydrogenase 2 protects against oxidative stress associated with pulmonary arterial hypertension. *Redox Biol*. 2017;11:286-96. doi: [10.1016/j.redox.2016.12.019](https://doi.org/10.1016/j.redox.2016.12.019). PMID: 28030785.
8. Rowiński R, Kozakiewicz M, Kędziora-Kornatowska K, Hübner-Woźniak E, Kędziora J. Markers of oxidative stress and erythrocyte antioxidant enzyme activity in older men and women with differing physical activity. *Exp Gerontol*. 2013;48(11):1141-6. doi: [10.1016/j.exger.2013.07.010](https://doi.org/10.1016/j.exger.2013.07.010). PMID: 23911531.
9. de Freitas Brito A, do Socorro Brasileiro-Santos M, de Oliveira CVC, da Cruz Santos A. Postexercise hypotension is volume-dependent in hypertensives: autonomic and forearm blood responses. *J Strength Cond Res*. 2019;33(1):234-41. doi: [10.1519/JSC.0000000000001735](https://doi.org/10.1519/JSC.0000000000001735). PMID: 27930451.
10. Larsen MK, Matchkov VV. Hypertension and physical exercise: the role of oxidative stress. *Medicina*. 2016;52(1):19-27. doi: [10.1016/j.medic.2016.01.005](https://doi.org/10.1016/j.medic.2016.01.005). PMID: 26987496.
11. da Silva Almeida I, de Souza Andrade L, de Sousa AMM, Junior GC, Turri-Silva N, Cunha Nascimento Dd, et al. The Effect of Mat Pilates Training Combined With Aerobic Exercise Versus Mat Pilates Training Alone on Blood Pressure in Women With Hypertension: A Randomized Controlled Trial. *Phys Ther*. 2022;102(2):pzab258. doi: [10.1093/ptj/pzab258](https://doi.org/10.1093/ptj/pzab258). PMID: 35084038.
12. Cornelissen VA, Smart NA. Exercise training for blood pressure: a systematic review and meta-analysis. *J Am Heart Assoc*. 2013;2(1):e004473. doi: [10.1161/JAHA.112.004473](https://doi.org/10.1161/JAHA.112.004473). PMID: 23525435.
13. Irigoyen M-C, De Angelis K, Dos Santos F, Dartora DR, Rodrigues B, Consolim-Colombo FM. Hypertension, blood pressure variability, and target organ lesion. *Curr Hypertens Rep*. 2016;18(4):1-13. doi: [10.1007/s11906-016-0642-9](https://doi.org/10.1007/s11906-016-0642-9). PMID: 27002717.
14. khatami saravi L, abdi A, barari A. Protective Effect of Aerobic Training along with Garlic on Lipocalin-2 and IL-1 $\beta$  in Obese Women with High Blood Pressure. *Iranian J Nutr Sci Food Technol*. 2020;15(1):25-34. URL: <http://nsft.sbmu.ac.ir/article-1-2881-en.html>
15. Ruangthai R, Phoemsapthawee J. Combined exercise training improves blood pressure and antioxidant capacity in elderly individuals with hypertension. *J Exerc Sci Fit*. 2019;17(2):67-76. doi: [10.1016/j.jesf.2019.03.001](https://doi.org/10.1016/j.jesf.2019.03.001). PMID: 30949214. PMID: [PMCID: PMC6430041](https://pubmed.ncbi.nlm.nih.gov/30949214/).
16. Rivlin RS. Historical perspective on the use of garlic. *J Nutr*. 2001;131(3):951S-4S. doi: [10.1093/jn/131.3.1027S](https://doi.org/10.1093/jn/131.3.1027S). PMID: 11238810.
17. Ried K, Travica N, Sali A. The effect of aged garlic extract on blood pressure and other cardiovascular risk factors in uncontrolled hypertensives: The AGE at Heart trial. *Integr Blood Press Control*. 2016 27;9:9-21. doi: [10.2147/IBPC.S93335](https://doi.org/10.2147/IBPC.S93335). PMID: 26869811.

18. Islam F, Khadija JF, Harun-Or-Rashid M, Rahaman M, Nafady MH, Islam M, et al. Bioactive compounds and their derivatives: an insight into prospective phytotherapeutic approach against alzheimer's disease. *Oxid Med Cell Longev.* 2022;11;2022:5100904. doi: [10.1155/2022/5100904](https://doi.org/10.1155/2022/5100904). PMID: [35450410](https://pubmed.ncbi.nlm.nih.gov/35450410/). PMCID: [PMC9017558](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC9017558/).
19. Braz NF, Carneiro MV, Oliveira-Ferreira F, Arriero AN, Amorim FT, Lima MM, et al. Influence of aerobic training on cardiovascular and metabolic parameters in elderly hypertensive women. *Int J Prev Med.* 2012;3(9):652. PMID: [23024855](https://pubmed.ncbi.nlm.nih.gov/23024855/). PMCID: [PMC3445282](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC3445282/).
20. Ried K, Frank O, Stocks N. Aged garlic extract reduces blood pressure in hypertensives: a dose-response trial. *Eur J Clin Nutr.* 2013;67(1):64. doi: [10.1038/ejcn.2012.178](https://doi.org/10.1038/ejcn.2012.178). PMID: [23169470](https://pubmed.ncbi.nlm.nih.gov/23169470/). PMCID: [PMC3561616](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC3561616/).
21. Campos JC, Fernandes T, Bechara LRG, Paixão NAd, Brum PC, Oliveira EMd, et al. Increased clearance of reactive aldehydes and damaged proteins in hypertension-induced compensated cardiac hypertrophy: impact of exercise training. *Oxid Med Cell Longev.* 2015;2015. doi: [10.1155/2015/464195](https://doi.org/10.1155/2015/464195). PMID: [25954323](https://pubmed.ncbi.nlm.nih.gov/25954323/). PMCID: [PMC4411445](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC4411445/).
22. Montezano AC, Dulak-Lis M, Tsiropoulou S, Harvey A, Briones AM, Touyz RM. Oxidative stress and human hypertension: vascular mechanisms, biomarkers, and novel therapies. *Can J Cardiol.* 2015;31(5):631-41. doi: [10.1016/j.cjca.2015.02.008](https://doi.org/10.1016/j.cjca.2015.02.008). PMID: [25936489](https://pubmed.ncbi.nlm.nih.gov/25936489/).
23. Naregal GV, Devaranavadagi BB, Patil SG, Aski BS. Elevation of oxidative stress and decline in endogenous antioxidant defense in elderly individuals with hypertension. *J Clin Diagn Res: JCDR.* 2017;11(7):BC09. doi: [10.7860/JCDR/2017/27931.10252](https://doi.org/10.7860/JCDR/2017/27931.10252). PMID: [28892880](https://pubmed.ncbi.nlm.nih.gov/28892880/). PMCID: [PMC5583849](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC5583849/).
24. Wu X, Wu H, Sun W, Wang C. Improvement of anti-Müllerian hormone and oxidative stress through regular exercise in Chinese women with polycystic ovary syndrome. *Hormones.* 2021;20(2):339-45. doi: [10.1007/s42000-020-00233-7](https://doi.org/10.1007/s42000-020-00233-7). PMID: [32725588](https://pubmed.ncbi.nlm.nih.gov/32725588/).
25. Park S-A, Lee A-Y, Park H-G, Son K-C, Kim D-S, Lee W-L. Gardening intervention as a low-to moderate-intensity physical activity for improving blood lipid profiles, blood pressure, inflammation, and oxidative stress in women over the age of 70: A pilot study. *HortScience.* 2017;52(1):200-5.
26. Dantas FFO, Brasileiro-Santos MdS, Batista RMF, do Nascimento LS, Castellano LRC, Ritti-Dias RM, et al. Effect of strength training on oxidative stress and the correlation of the same with forearm vasodilatation and blood pressure of hypertensive elderly women: a randomized clinical trial. *PloS one.* 2016;11(8):e0161178. doi: [10.1371/journal.pone.0161178](https://doi.org/10.1371/journal.pone.0161178). PMID: [27529625](https://pubmed.ncbi.nlm.nih.gov/27529625/). PMCID: [PMC4986983](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC4986983/).
27. Yu Y, Gao Q, Xia W, Zhang L, Hu Z, Wu X, et al. Association between physical exercise and biomarkers of oxidative stress among middle-aged and elderly community residents with essential hypertension in China. *Biomed Res Int.* 2018; 3;2018:4135104. doi: [10.1155/2018/4135104](https://doi.org/10.1155/2018/4135104). PMID: [30065938](https://pubmed.ncbi.nlm.nih.gov/30065938/). PMCID: [PMC6051290](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC6051290/).
28. Seo DY, Lee SR, Kim HK, Baek YH, Kwak YS, Ko TH, et al. Independent beneficial effects of aged garlic extract intake with regular exercise on cardiovascular risk in postmenopausal women. *Nutr Res Pract.* 2012;6(3):226-31. doi: [10.4162/nrp.2012.6.3.226](https://doi.org/10.4162/nrp.2012.6.3.226). PMID: [22808347](https://pubmed.ncbi.nlm.nih.gov/22808347/). PMCID: [PMC3395788](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC3395788/).
29. Ahmadian F, Mozaffari-Khosravi H, Azaraein MH, Faraji R, Zavar-Reza J. The effect of consumption of garlic tablet on proteins oxidation biomarkers in postmenopausal osteoporotic women: A randomized clinical trial. *Electron Physician.* 2017;9(11):5670. doi: [10.19082/5670](https://doi.org/10.19082/5670). PMID: [29403603](https://pubmed.ncbi.nlm.nih.gov/29403603/). PMCID: [PMC5783112](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC5783112/).
30. Avcı A, Atlı T, Ergüder İB, Varlı M, Devrim E, Aras S, et al. Effects of garlic consumption on plasma and erythrocyte antioxidant parameters in elderly subjects. *Gerontology.* 2008;54(3):173-6. doi: [10.1159/000130426](https://doi.org/10.1159/000130426). PMID: [18463427](https://pubmed.ncbi.nlm.nih.gov/18463427/).
31. Shang A, Cao S-Y, Xu X-Y, Gan R-Y, Tang G-Y, Corke H, et al. Bioactive compounds and biological functions of garlic (*Allium sativum* L.). *Foods.* 2019;8(7):246. doi: [10.3390/foods8070246](https://doi.org/10.3390/foods8070246). PMID: [31284512](https://pubmed.ncbi.nlm.nih.gov/31284512/). PMCID: [PMC6678835](https://pubmed.ncbi.nlm.nih.gov/pmc/articles/PMC6678835/).

32. Ma L, Chen S, Li S, Deng L, Li Y, Li H. Effect of allicin against ischemia/hypoxia-induced H9c2 myoblast apoptosis via eNOS/NO pathway-mediated antioxidant activity. *Evid Based Complement Alternat Med.* 2018;16;2018:3207973. doi: [10.1155/2018/3207973](https://doi.org/10.1155/2018/3207973). PMID: 29849702. PMCID: [PMC5926492](https://pubmed.ncbi.nlm.nih.gov/PMC5926492/).
33. Oboh G, Ademiluyi AO, Agunloye OM, Ademosun AO, Ogunsakin BG. Inhibitory effect of garlic, purple onion, and white onion on key enzymes linked with type 2 diabetes and hypertension. *J Diet Suppl.* 2019;16(1):105-18. 10.1080/19390211.2018.1438553. PMID: 29522359.
34. Atkin M, Laight D, Cummings MH. The effects of garlic extract upon endothelial function, vascular inflammation, oxidative stress and insulin resistance in adults with type 2 diabetes at high cardiovascular risk. A pilot double blind randomized placebo controlled trial. *J Diabetes Complications.* 2016;30(4):723-7. doi: [10.1016/j.jdiacomp.2016.01.003](https://doi.org/10.1016/j.jdiacomp.2016.01.003). PMID: 26954484.
35. Ghyasi R, Moslehi A, Naderi R. Combination Effect of Voluntary Exercise and Garlic (*Allium sativum*) on Oxidative Stress Biomarkers and Lipid Profile in Healthy Rats. *Pharmaceutical Sciences.* 2019;25(3):268-73. doi: [10.15171/PS.2019.26](https://doi.org/10.15171/PS.2019.26).