

# The Effects of Two Different Exercise Training Protocols on Metabolic Syndrome Components in Non-athlete, Middle-Aged Women

Faegheh Dehganipour,<sup>1</sup> and Mohsen Salesi<sup>1\*</sup>

<sup>1</sup>Department of Physical Education and Sport Sciences, Shiraz University, Shiraz, IR Iran

\*Corresponding author: Mohsen Salesi, Department of Physical Education and Sport Sciences, Shiraz University, Shiraz, IR Iran. E-mail: msalesi@shirazu.ac.ir

Received 2015 August 04; Revised 2015 October 19; Accepted 2016 January 25.

## Abstract

**Background:** Metabolic syndrome is considered a risk factor for many chronic diseases, such as type II diabetes and cardiovascular diseases (CVD). The syndrome is the result of various factors, including poor nutritional diets, sedentary lifestyles, and genetic predisposition. Physical activity and good nutrition can prevent metabolic syndrome.

**Objectives:** The aim of the present study was to compare the effects of continuous and discontinuous training on metabolic syndrome components in non-athlete, middle-aged woman.

**Patients and Methods:** Forty-five non-athlete women who met the study criteria voluntarily participated in this study. The participants were divided randomly into three groups: continuous, discontinuous, and control (n = 15 in each group). Twenty-four hours before the beginning of the training program, a blood sample was obtained from each participant in the fasting state. The two training groups participated in sports activities designed to produce a heart rate of 50 - 70 beats/minute for 8 weeks, three times a week, for 60 - 90 minutes. The continuous training group performed the activities in one session, and the discontinuous training group performed them in two sessions, for the same time and intensity. Twenty-four hours after the completion of the 8-week program, all the measurements were performed similar to the pretest phase. The data were analyzed using a one-way analysis of variance (ANOVA).

**Results:** The discontinuous training significantly decreased each participant's weight (P = 0.04) and systolic blood pressure (BP) (P < 0.01), whereas it significantly increased their triglyceride (TG) (P < 0.01) and high-density lipoprotein cholesterol (HDL-c) levels (P < 0.01). However, there was no significant change in diastolic BP, low-density lipoprotein cholesterol (LDL-c), or glucose. In the continuous training group, the TG level decreased significantly (P < 0.01).

**Conclusions:** This study demonstrated that a regular physical activity program in the form of discontinuous training improved metabolic syndrome indexes in non-athlete, middle-aged women. Discontinuous training seems to be an efficient, safe, and inexpensive way to reduce and prevent metabolic syndrome.

**Keywords:** Exercise, Women, Metabolic Syndrome

## 1. Background

Metabolic syndrome is a cluster of abnormal metabolic, lipid, and nonlipid variables (1). The national cholesterol education program adult treatment panel III (NCEP ATP III) has defined metabolic syndrome as meeting three of the following risk factors: i, elevated triglycerides (TGs); ii, low high-density lipoprotein cholesterol (HDL-c); iii, abdominal obesity; iv, high fasting glucose; and v, hypertension (2). Individuals with metabolic syndrome have a threefold increased risk of cardiovascular disease (CVD)-related mortality (3). To curb the progression of CVD, it is paramount to find effective treatments to reverse metabolic syndrome. Lifestyle interventions are the initial therapies recommended for the prevention and treatment of metabolic syndrome (4). One of the most

important lifestyle interventions is exercise. Exercise programs, especially aerobic exercise, can improve several components of metabolic syndrome (5, 6) and decrease its incidence (7). Aerobic exercise training has been shown to be an effective intervention to improve lipid profiles and other CVD-related risk factors. However, only a few studies have examined the impact of exercise alone on the components of metabolic syndrome, and the results of those studies are not consistent. Previous studies also examined the effect of exercise training in populations with a single metabolic risk factor (hypercholesterolemia, obesity, or hypertension) (8, 9). A 12-month resistance and aerobic training program reduced some risk factors for metabolic syndrome in females older than 65 years (10). In men and women older than 60 years, a 12-week exercise program reduced TGs, blood pressure (BP), obesity, and

insulin resistance (11). In contrast, another study found no statistically significant metabolic effects of 12-week exercise training in older women and men compared with controls (12).

Overall, there is concordance among these studies that exercise interventions are likely to exert a protective effect against metabolic syndrome by reducing related risk factors. However, the results of those studies are contradictory, depending on the different training modes.

## 2. Objectives

The aim of this study was to investigate the effects of continuous vs. discontinuous training on metabolic syndrome-related risk factors and to determine which training protocol promoted health levels in a sedentary female population.

## 3. Patients and Methods

This study has been approved by the ethical committee of Shiraz university. Forty-five non-athlete women between the ages of 45 and 60 years volunteered to participate in this study. The subjects were selected first through convenience and purposive sampling and then divided into three groups based on random sampling using a table of random numbers. None of the subjects had overt CVDs, and none were taking diabetes or hypertension medication. They were all nonsmokers and had a sedentary lifestyle for the previous 6 months. Based on clinical identification, all the subjects were required to have at least three or more of the components of metabolic syndrome, as defined by the NCEP ATP III, which states that someone with metabolic syndrome must have three of the following: i, a waist circumference greater than 102 cm in men and 88 cm in women; ii, a TG level greater than 150 mg/dL; iii, HDL-c less than 40 mg/dL for men and 50 mg/dL for women; iv, BP over 130/85 mmHg; and v, fasting glucose over 100 mg/dL (2). Subjects were ineligible to participate in the study if they reported uncontrolled hypertension, adverse cardiac events, chronic inflammatory disease, peripheral vascular disease, or musculoskeletal conditions that would make participation in regular exercise difficult or dangerous and/or make it difficult to perform the exercise protocol.

After receiving information about the exercise protocol and procedures, the subjects gave written informed consents, and they were randomly divided into three groups: a continuous exercise group, discontinuous exercise group, and control group, in which the participants were instructed not to change their daily patterns

of physical activity during the study period. Both training groups participated in aerobic rhythmic training activities and were designed to produce a heart rate of 50 - 70 beats/minute for 8 weeks, three times a week, for 60 - 90 minutes. Each training session began with a light warm-up, followed by a light stretching routine. The continuous training group performed one continuous cardiovascular steady-state training bout per day, and the discontinuous training group performed two sessions for the same time and intensity, with each session lasting 30 - 45 minutes. Blood was collected in the morning and 24 hours before and after the intervention program. Prior to the blood tests, each subject was asked to maintain a 12-hour fasting period and not to participate in vigorous activity for at least 24 hours to reduce the possibility of dietary and physical activity interference.

Body weight and height were measured while wearing light clothing and shoes off to obtain the best estimate of the subject's true height and weight. The body mass index (BMI) was calculated by dividing the subject's body weight in kilograms by their height squared (kg/ms). Waist circumference was measured to the nearest 0.1 cm using a plastic tape measure at the narrowest circumference of the torso. The resting BP was manually taken, using a sphygmomanometer and a stethoscope, with the subject in a sitting position.

### 3.1. Statistical Analyses

A one-way analysis of variance (ANOVA) was used to test for differences between groups. If significant differences were observed, Turkey's post hoc test was used to detect possible sources of the differences. To compare the pre- and post-test results in each group, a paired t-test was used. All the statistical analyses were performed with SPSS software (version 19) at a significance level of 0.05.

## 4. Results

In the baseline evaluation, no significant differences were observed between the study groups in any of the studied variables. Table 1 shows the physiological and anthropometric characteristics of the subjects.

The ANOVA revealed no significant differences in the age, height, weight, BMI, waist circumference, systolic BP, or diastolic BP at baseline between the groups. As shown in Table 1, the weights and systolic BP of the groups were significantly different. The results of Tukey's post hoc test showed that the systolic BP decreased significantly in the discontinuous exercise group compared with that of the control group and that the weight decreased significantly in the two exercise groups compared with that of the control group. The paired t-test results showed that there was

**Table 1.** Characteristics of the Subjects Before and After the 8-Week Training Program in the Three Study Groups<sup>a</sup>

Variable	Continuous		Discontinuous		Control		P Value
	Baseline	8 Weeks	Baseline	8 Weeks	Baseline	8 Weeks	
Age, y	50.3 ± 7.9		48.8 ± 5.1		52.5 ± 3.3		0.36
Height, cm	168.2 ± 5.2		176.1 ± 7.6		170.7 ± 4.4		0.47
Weight, kg	72.9 ± 6.3	70.8 ± 7.2	74.1 ± 3.2	70.3 ± 4.1	73.8 ± 4.7	73.1 ± 5.2	At baseline: 0.23, At 8 weeks: 0.04 <sup>b</sup>
BMI, kg/m <sup>2</sup>	24.7 ± 2.1	24.1 ± 3.7	25.8 ± 3.6	24.5 ± 3.8	25.6 ± 2.4	25.5 ± 2.1	At baseline: 0.37, At 8 weeks: 0.41
Waist circumference, cm	94.1 ± 7.5	93.4 ± 8.1	96.3 ± 5.1	91.1 ± 6.2	95.2 ± 8.3	94.6 ± 7.8	At baseline: 0.71, At 8 weeks: 0.59
Systolic BP, mmHg	138 ± 12	131 ± 13	140 ± 17	128 ± 15	142 ± 11	140 ± 9	At baseline: 0.78, At 8 weeks: 0.01 <sup>b</sup>
Diastolic BP, mmHg	87 ± 8	82 ± 7	85 ± 7	82 ± 6	88 ± 7	83 ± 6	At baseline: 0.25, At 8 weeks: 0.32

<sup>a</sup>Values are expressed as mean ± SD.

<sup>b</sup>Significantly different between the groups:  $P \leq 0.05$ .

a significant improvement in the waist circumference ( $P = 0.001$ ) and weight ( $P = 0.001$ ) compared to baseline values in the discontinuous exercise group. Although the waist circumference and diastolic BP of the continuous exercise group improved after the 8 weeks, the improvements were not significant compared to the baseline values ( $P > 0.05$ ).

The ANOVA revealed no significant between-group differences in any of the study variables at baseline. As shown in Table 2, the post hoc test showed that the TG level decreased in both exercise groups compared with that of the control group. HDL-c also increased in the discontinuous exercise group compared with that of the control group. The paired t-test revealed that the levels of TG significantly decreased after 8 weeks in the discontinuous ( $P = 0.001$ ) and continuous ( $P = 0.001$ ) exercise groups compared with the baseline. The blood glucose and total cholesterol levels of both groups improved after 8 weeks, but the improvements were not significant compared with the baseline values ( $P > 0.05$ ).

## 5. Discussion

This study found statistically significant improvements in the HDL-c, TG, weight, and systolic BP of the discontinuous exercise group compared with these parameters in the control group following 8 weeks of exercise training. The continuous exercise group also showed decreased TG levels and systolic BP compared with those of the control group.

The results of the present study are in line with those of an earlier study, which demonstrated that exercise training reduced the risk of metabolic syndrome in elderly females (10). However, in a recent randomized controlled study of elderly men and women, 12 weeks of aerobic exercise did not significantly change a composite of metabolic

risk factors (12).

The results of this study revealed some improvements in the lipid profiles of the exercise training groups, especially those of the discontinuous exercise group. The blood HDL-c increased in the discontinuous training group compared to that of the control group. In common with the findings of this study, most research has reported significant changes in HDL-c after exercise training (13). To increase the HDL-c concentration by exercise, many enzymes should be considered. Increased lipoprotein lipase (LPL) activity hydrolyzes TGs from LDL and transfers excess surface cholesterol to HDL particles. This process aids the formation of HDL-c, therefore, increasing the plasma HDL-c concentration (14).

In the current study, the TG levels of the subjects in the two exercise groups fell compared with those of the control group. An increase in energy expenditure might explain the reductions in the concentrations of these lipids. During exercises lasting for 1 - 2 hours, intramuscular TGs are consumed, and lipolysis is activated in fatty tissue that supplies carbon skeletons for physical exercises. TGs stored within skeletal muscle cells are considered a potentially large energy source. It has been estimated that during exercises, intramuscular TG could provide as much as 20% - 25% of the energy for muscles to work. Enhanced epinephrine and glucagon during exercise activate adenylate cycles, thereby increasing cyclic adenosine monophosphate (cAMP) (15). Increased cAMP phosphorylates activates hormone-sensitive LPL, which hydrolyzes intracellular TGs in skeletal muscle and the myocardium, as well as in adipose tissue, during exercise, to provide free fatty acids as an energy source. After exercise, endogenous TGs that were oxidized needs to be replenished from exogenous TGs (16). This may cause rapid uptake of free fatty acids from the circulation, thus increasing the clearance rate of TGs

**Table 2.** Blood Parameters in the Groups Before and After the 8-Week Training Program<sup>a</sup>

Variable	Continuous		Discontinuous		Control		P Value
	Baseline	8 Weeks	Baseline	8 Weeks	Baseline	8 weeks	
<b>TG, mg/dL</b>	216.7 ± 9.5	192.3 ± 8.4	212.3 ± 10.1	190.7 ± 12.6	213.9 ± 9.9	209.2 ± 14.3	At baseline: 0.44 At, 8 weeks: 0.01 <sup>b</sup>
<b>TC, mg/dL</b>	201.6 ± 14.2	195.5 ± 12.7	195.7 ± 7.7	191.4 ± 9.6	190.2 ± 11.6	193.7 ± 10.4	At baseline: 0.21, At 8 weeks: 0.87
<b>HDL-c, mg/dL</b>	46.8 ± 4.4	47.4 ± 3.7	45.9 ± 7.1	49.8 ± 8.3	42.4 ± 5.4	43.1 ± 6.6	At baseline: 0.16, At 8 weeks: 0.01 <sup>b</sup>
<b>Glucose, mg/dL</b>	105 ± 7.2	100 ± 6.4	114 ± 12.3	107 ± 9.5	108 ± 10.1	104 ± 8.1	At baseline: 0.51 At 8 weeks: 0.55

<sup>a</sup>Values are expressed as mean ± SD.

<sup>b</sup>Significantly different between the groups:  $P \leq 0.05$ .

from the circulation. The elevated LPL activity in muscle after exercise may play an important role in increasing concentrations of TGs (14).

During discontinuous exercise, there might be an increase in energy expenditure and basal metabolism due to the frequent exposure to muscular contraction which is developed by this type of training. Several studies have suggested that exercise improved the lipid profiles of men and female.

Exercise is considered vital in the prevention and management of hypertension (17). The results of the present study showed that 8 weeks of discontinuous exercise training significantly decreased systolic BP but did not have an impact on diastolic BP. Potential explanations for this finding are increased endothelial nitric oxide synthase activity and increased insulin sensitivity (18). Epidemiological studies indicated that greater physical activity was associated with a lower BP, and an interventional study showed that chronic dynamic aerobic endurance training reduced BP (17). Other studies demonstrated that exercise had an antihypertensive effect in humans (19) and that regular exercise training reduced the heart rate, improving the sensitivity of aortic baroreceptors, thereby contributing to more efficient regulation of BP (20). Research also suggested that the beneficial BP lowering effects of exercise were due to decreased activity of both the sympathetic nervous system and rennin-angiotensin system. Other mechanisms responsible for the antihypertensive effect of training include a decrease in peripheral arterial resistance caused by vasodilatation (21).

In summary, metabolic syndrome is a constellation of elevated metabolic, lipid, and nonlipid factors, which tend to cluster in an individual. The exact mechanisms responsible for the pathogenesis of this syndrome remain unknown, and the mechanisms by which increased exercise reduces metabolic syndrome are also largely unknown. Early perspectives on the mechanisms involved in metabolic syndrome included insulin resistance (22) and obesity (23). Recent studies of metabolic syndrome

have implicated chronic inflammation, gene-environment interactions, sympatho-adrenal irregularities, endothelial dysfunction, and lifestyle (24). It has been hypothesized that exercise reduces metabolic syndrome by inducing changes in individual components of the syndrome, such as TGs, HDL-c, BP, glucose, and abdominal obesity. The present study showed that exercise training, especially discontinuous training, appeared to be beneficial in preventing and improving the risk factors of metabolic syndrome relative to any other current interventions. This finding may have important implications for exercise training in rehabilitation programs for middle-aged women. Exercise is inexpensive and has relatively few negative side effects when performed properly. If exercise programs were effectively implemented among the metabolic syndrome population, there would most likely be improvements in health, as well as reductions in health care costs associated with the disease.

### Acknowledgments

The authors thank all the women who participated in this study.

### Footnotes

**Authors' Contribution:** Mohsen Salesi developed the original idea and the protocol, abstracted and analyzed the data, and wrote the manuscript; Faegheh Dehganipour contributed to the development of the protocol and the statistical analysis and provided administrative, technical, and material support.

**Financial Disclosure:** This study was approved by the committee at Shiraz University and IRCT. This study was financially supported by the investigators and scientific team at Shiraz university.

## References

- Huang PL. A comprehensive definition for metabolic syndrome. *Dis Model Mech.* 2009;2(5-6):231-7. doi: [10.1242/dmm.001180](https://doi.org/10.1242/dmm.001180). [PubMed: [19407331](https://pubmed.ncbi.nlm.nih.gov/19407331/)].
- Expert Panel on Detection E, Treatment of High Blood Cholesterol in A. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA.* 2001;285(19):2486-97. [PubMed: [11368702](https://pubmed.ncbi.nlm.nih.gov/11368702/)].
- Malik S, Wong ND, Franklin SS, Kamath TV, L'Italien GJ, Pio JR, et al. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. *Circulation.* 2004;110(10):1245-50. doi: [10.1161/01.CIR.0000140677.20606.0E](https://doi.org/10.1161/01.CIR.0000140677.20606.0E). [PubMed: [15326067](https://pubmed.ncbi.nlm.nih.gov/15326067/)].
- Grundy SM, Cleeman JJ, 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. doi: [10.1161/CIRCULATIONAHA.105.169404](https://doi.org/10.1161/CIRCULATIONAHA.105.169404). [PubMed: [16157765](https://pubmed.ncbi.nlm.nih.gov/16157765/)].
- Joseph LJ, Prigeon RL, Blumenthal JB, Ryan AS, Goldberg AP. Weight loss and low-intensity exercise for the treatment of metabolic syndrome in obese postmenopausal women. *J Gerontol A Biol Sci Med Sci.* 2011;66(9):1022-9. doi: [10.1093/gerona/glr093](https://doi.org/10.1093/gerona/glr093). [PubMed: [21653990](https://pubmed.ncbi.nlm.nih.gov/21653990/)].
- Villareal DT, Miller B3, Banks M, Fontana L, Sinacore DR, Klein S. Effect of lifestyle intervention on metabolic coronary heart disease risk factors in obese older adults. *Am J Clin Nutr.* 2006;84(6):1317-23. [PubMed: [17158411](https://pubmed.ncbi.nlm.nih.gov/17158411/)].
- Stewart KJ, Bacher AC, Turner K, Lim JG, Hees PS, Shapiro EP, et al. Exercise and risk factors associated with metabolic syndrome in older adults. *Am J Prev Med.* 2005;28(1):9-18. doi: [10.1016/j.amepre.2004.09.006](https://doi.org/10.1016/j.amepre.2004.09.006). [PubMed: [15626550](https://pubmed.ncbi.nlm.nih.gov/15626550/)].
- Ferrier KE, Waddell TK, Gatzka CD, Cameron JD, Dart AM, Kingwell BA. Aerobic exercise training does not modify large-artery compliance in isolated systolic hypertension. *Hypertension.* 2001;38(2):222-6. [PubMed: [11509480](https://pubmed.ncbi.nlm.nih.gov/11509480/)].
- Seals DR, Tanaka H, Clevenger CM, Monahan KD, Reiling MJ, Hiatt WR, et al. Blood pressure reductions with exercise and sodium restriction in postmenopausal women with elevated systolic pressure: role of arterial stiffness. *J Am Coll Cardiol.* 2001;38(2):506-13. [PubMed: [11499745](https://pubmed.ncbi.nlm.nih.gov/11499745/)].
- Kemmler W, Von Stengel S, Engelke K, Kalender WA. Exercise decreases the risk of metabolic syndrome in elderly females. *Med Sci Sports Exerc.* 2009;41(2):297-305. doi: [10.1249/MSS.0b013e31818844b7](https://doi.org/10.1249/MSS.0b013e31818844b7). [PubMed: [19127197](https://pubmed.ncbi.nlm.nih.gov/19127197/)].
- Yassine HN, Marchetti CM, Krishnan RK, Vrobel TR, Gonzalez F, Kirwan JP. Effects of exercise and caloric restriction on insulin resistance and cardiometabolic risk factors in older obese adults—a randomized clinical trial. *J Gerontol A Biol Sci Med Sci.* 2009;64(1):90-5. doi: [10.1093/gerona/gln032](https://doi.org/10.1093/gerona/gln032). [PubMed: [19164269](https://pubmed.ncbi.nlm.nih.gov/19164269/)].
- Finucane FM, Sharp SJ, Purslow LR, Horton K, Horton J, Savage DB, et al. The effects of aerobic exercise on metabolic risk, insulin sensitivity and intrahepatic lipid in healthy older people from the Hertfordshire Cohort Study: a randomised controlled trial. *Diabetologia.* 2010;53(4):624-31. doi: [10.1007/s00125-009-1641-z](https://doi.org/10.1007/s00125-009-1641-z). [PubMed: [20052455](https://pubmed.ncbi.nlm.nih.gov/20052455/)].
- Thompson PD, Crouse SF, Goodpaster B, Kelley D, Moyna N, Pescatello L. The acute versus the chronic response to exercise. *Med Sci Sports Exerc.* 2001;33(6 Suppl):S438-45. [PubMed: [11427768](https://pubmed.ncbi.nlm.nih.gov/11427768/)] discussion S452-3.
- Kiess B, Lithell H, Mikines KJ, Richter EA. Effects of insulin and exercise on muscle lipoprotein lipase activity in man and its relation to insulin action. *J Clin Invest.* 1989;84(4):1124-9. doi: [10.1172/JCI114275](https://doi.org/10.1172/JCI114275). [PubMed: [2677048](https://pubmed.ncbi.nlm.nih.gov/2677048/)].
- Zhang JQ, Thomas TR, Ball SD. Effect of exercise timing on postprandial lipemia and HDL cholesterol subfractions. *J Appl Physiol (1985).* 1998;85(4):1516-22. [PubMed: [9760349](https://pubmed.ncbi.nlm.nih.gov/9760349/)].
- Annuzzi G, Jansson E, Kaijser L, Holmquist L, Carlson LA. Increased removal rate of exogenous triglycerides after prolonged exercise in man: time course and effect of exercise duration. *Metabolism.* 1987;36(5):438-43. [PubMed: [3574133](https://pubmed.ncbi.nlm.nih.gov/3574133/)].
- Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA, et al. American College of Sports Medicine position stand. Exercise and hypertension. *Med Sci Sports Exerc.* 2004;36(3):533-53. [PubMed: [15076798](https://pubmed.ncbi.nlm.nih.gov/15076798/)].
- Roberts CK, Vaziri ND, Barnard RJ. Effect of diet and exercise intervention on blood pressure, insulin, oxidative stress, and nitric oxide availability. *Circulation.* 2002;106(20):2530-2. [PubMed: [12427646](https://pubmed.ncbi.nlm.nih.gov/12427646/)].
- Chrysohoou C, Pitsavos C, Panagiotakos DB, Kokkinos PF, Stefanadis C, Toutouzas P. The association between physical activity and the development of acute coronary syndromes in treated and untreated hypertensive subjects. *J Clin Hypertens (Greenwich).* 2003;5(2):115-20. [PubMed: [12671323](https://pubmed.ncbi.nlm.nih.gov/12671323/)].
- Brum PC, Da Silva GJ, Moreira ED, Ida F, Negrao CE, Krieger EM. Exercise training increases baroreceptor gain sensitivity in normal and hypertensive rats. *Hypertension.* 2000;36(6):1018-22. [PubMed: [11116118](https://pubmed.ncbi.nlm.nih.gov/11116118/)].
- Zinman B, Ruderman N, Campaigne BN, Devlin JT, Schneider SH, American Diabetes A. Physical activity/exercise and diabetes mellitus. *Diabetes Care.* 2003;26 Suppl 1:S73-7. [PubMed: [12502622](https://pubmed.ncbi.nlm.nih.gov/12502622/)].
- Ford ES, Giles WH, Mokdad AH. Increasing prevalence of the metabolic syndrome among u.s. Adults. *Diabetes Care.* 2004;27(10):2444-9. [PubMed: [15451914](https://pubmed.ncbi.nlm.nih.gov/15451914/)].
- Grundy SM. What is the contribution of obesity to the metabolic syndrome?. *Endocrinol Metab Clin North Am.* 2004;33(2):267-82. doi: [10.1016/j.ecl.2004.03.001](https://doi.org/10.1016/j.ecl.2004.03.001). [PubMed: [15158519](https://pubmed.ncbi.nlm.nih.gov/15158519/)] table of contents.
- Fowler SB, Moussouttas M, Mancini B. Metabolic syndrome: contributing factors and treatment strategies. *J Neurosci Nurs.* 2005;37(4):220-3. [PubMed: [16206549](https://pubmed.ncbi.nlm.nih.gov/16206549/)].