NATURALISTA CAMPANO
ISSN: 1827-7160
Volume 28 Issue 1, 2024

Effects of Exercise Training on Components of Metabolic Syndrome in Postmenopausal Diabetic Women: A Systematic Review

D.Varalakshmi[1], Dr.K.Rekha[2]

[1]Ph D Scholar, Saveetha college of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai

Email ID: vara31.lakshmi@gmail.com

[2]Associate Professor, Saveetha College of Physiotherapy, Institute of Medical and Technical Sciences, Thandalam, Chennai

Abstract

Background: The metabolic syndrome is highly prevalent in postmenopausal women and is associated with higher risk of diabetes and cardiovascular events. Individuals who are physically active are less likely to develop metabolic syndrome. An appropriate exercise program which considers the needs of postmenopausal diabetic women should be selected.

Objective: The purpose of this review was to systematically review the effects of exercise training and the type of exercise training on the components of metabolic syndrome.

Methods: Literature search was conducted in the PubMed, CINAHL, Medline, Scopus and Web of Science for all articles published up to December 2020. RCTs that investigated the effect of exercises on components of metabolic syndrome in postmenopausal diabetic women were eligible for this review.

Results: Four studies involving 88 participants were selected for analysis. The components of the metabolic syndrome significantly improved were BMI (1/3 studies), Diastolic blood pressure (1/3 studies), HbA1c (1/3 studies), Fasting glucose (1/1 study) Triglycerides (1/2 studies), and high-density lipoprotein cholesterol (1/3 studies).

Conclusion: exercise programs result in a modest improvement in some components of metabolic syndrome. Exercise benefits are associated with exercise mode, frequency, duration and total length of study.

Keywords: Exercise training, Metabolic syndrome, Postmenopausal diabetic women

Introduction

In Indian female population, menopause occurs at an average age of 46 years,[1-3] which is much earlier as compared to the developed countries.[4,5]When menopause starts, there may be a rapid phase of decrease in muscle strength, bone mineral density, aerobic fitness and most importantly increase in body fat. Fall in estrogen level after menopause increases the risk of metabolic syndrome.[6,7]Metabolic syndrome is basically a lifestyle disease. It is a constellation of metabolic abnormalities that confer an increased risk of cardiovascular disease and diabetes mellitus[8]. Many cross-sectional studies have shown an increased risk of metabolic syndrome in postmenopausal women, which varies from 32.6% to 41.5%[9,10]. Although the mechanisms are poorly understood, it is believed to be related to the increased visceral adipose tissue deposition seen in relation to menopause.[11-13]The etiology of the effect of menopause on cardiovascular and metabolic diseases may be linked with changes in body fat. Thus, this increase in the abdominal visceral adipose tissue is associated with the metabolic diseaseslike type-2 diabetes, hypertension and dyslipidemia.[14,15]An increase in both total fat mass and visceral adipose tissue mass were associated with a more pronounced increase in ectopic lipid deposition and insulin resistance (IR) in postmenopausal women compared with premenopausal women.[11]studies also show a strong correlation between estrogen deficiency and metabolic dysfunction.[16,17] The reduction of estrogen in postmenopausal women accelerates the development of insulin resistance.[18]The clinical and economic burden associated with diabetes mellitus and its management remain an enduring challenge to the healthcare community.[19,20]

Various exercise recommendations are available for postmenopausal women that focus on various aspects of health including diabetes.Evidence suggests that individuals who are physically active are less likely to develop

metabolic syndrome.[21,22]Although physical exercises are recognized as a most important aspect for the prevention and treatment of components of metabolic syndrome, it is necessaryto selectan appropriate exercise program which considers the special needs of postmenopausal diabetic women.To our knowledge, many reviews studying the effects of physical exercise in postmenopausal women have been published and no review was conducted exclusively for finding out these effects in postmenopausal diabetic women.The objective of this reviewis to provide an analysis of published data pertaining to the effects of physical exercise on health in postmenopausal diabetic women.

Methods

The current systematic review followed the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).Studies included in this review followed the recommendations from the PICOS (population, intervention, comparison, outcome, and setting) framework.[23]

Inclusion and Exclusion Criteria:

Studies were included when they met the following inclusion criteria: (1)Randomized controlled protocols; (2) one exercise group versus a control group; (3) postmenopausal women; (4) any type of aerobic or anaerobic exercise training for at least 8 weeks, with two or more sessions every week performed by the experimental group; (5) control group without exercise intervention or conventional therapy or home-based low level recreational exercise intervention with only stretching and relaxation exercises; (6) Studies that assessed insulin resistance,obesity, dyslipidemia, and hypertension were included.

Review papers, literature reviews, conference, abstracts, editorial and study protocols have been excluded. Case series and case reports are excluded from the review owing to the high potential for bias in these study designs. Case–control studies and economic evaluations,Duplicate studies or preliminary data from the subsequently published studies were also excluded. Studies in which the patients engaged in an exercise program during the last 6 months have also been excluded. The studies were limited to English language publications and to studies with human participants.

Information Sources and Search Strategy:

A systematic literature search was conducted in the PubMed, CINAHL, Medline, Scopus, Web of Science and Google Scholar for all articles published up to December 2020.The following keywords were used to search the databases: “exercise”OR “exercises” OR “training” OR “physical activity” OR “walking” AND “postmenopausal” OR “post-menopausal” OR “menopause”. The last search was conducted on 30 September 2021. Duplicate publications were identified by comparing author names, treatment comparisons, publication dates, sample sizes, intervention, and outcomes. In the case of unclear eligibility criteria or when the confirmation of any data or additional information was needed, the authors were contacted by e-mail.

Study Selection and Data Extraction:

Duplicate articles were discarded followed by screening of titles and abstracts to exclude items that did not meet the eligibility criteria as described above. Finally, full-text articles were examined to verify whether they met the inclusion criteria. Data extraction was carried out independently by two reviewers and disagreements were resolved through discussion with assistance of a third reviewer. Details of the study design, participants’ characteristics (sex, age and sample size), outcomes, intervention procedures, measurement time points and dropout rates were considered in data extraction.

Risk of bias assessment:

The included studies were assessed for risk of bias by 2 reviewers using revised Cochrane risk-of-bias tool for randomized trials (RoB 2)[24].The RoB 2.0 tool provides five domains to assess risk of bias in studies; (1) risk of bias arising from the randomization process, (2) risk of bias due to deviations from the intended interventions, (3) risk of bias due to missing outcome data, (4) risk of bias in measurement of the outcome, and (5) risk of bias in selection of the reported result. The risk of bias for each domain is determined as low, high, or some concerns as suggested in RoB 2.0. Finally, the overall study was considered to have a low risk of bias if all quality criteria

Ident

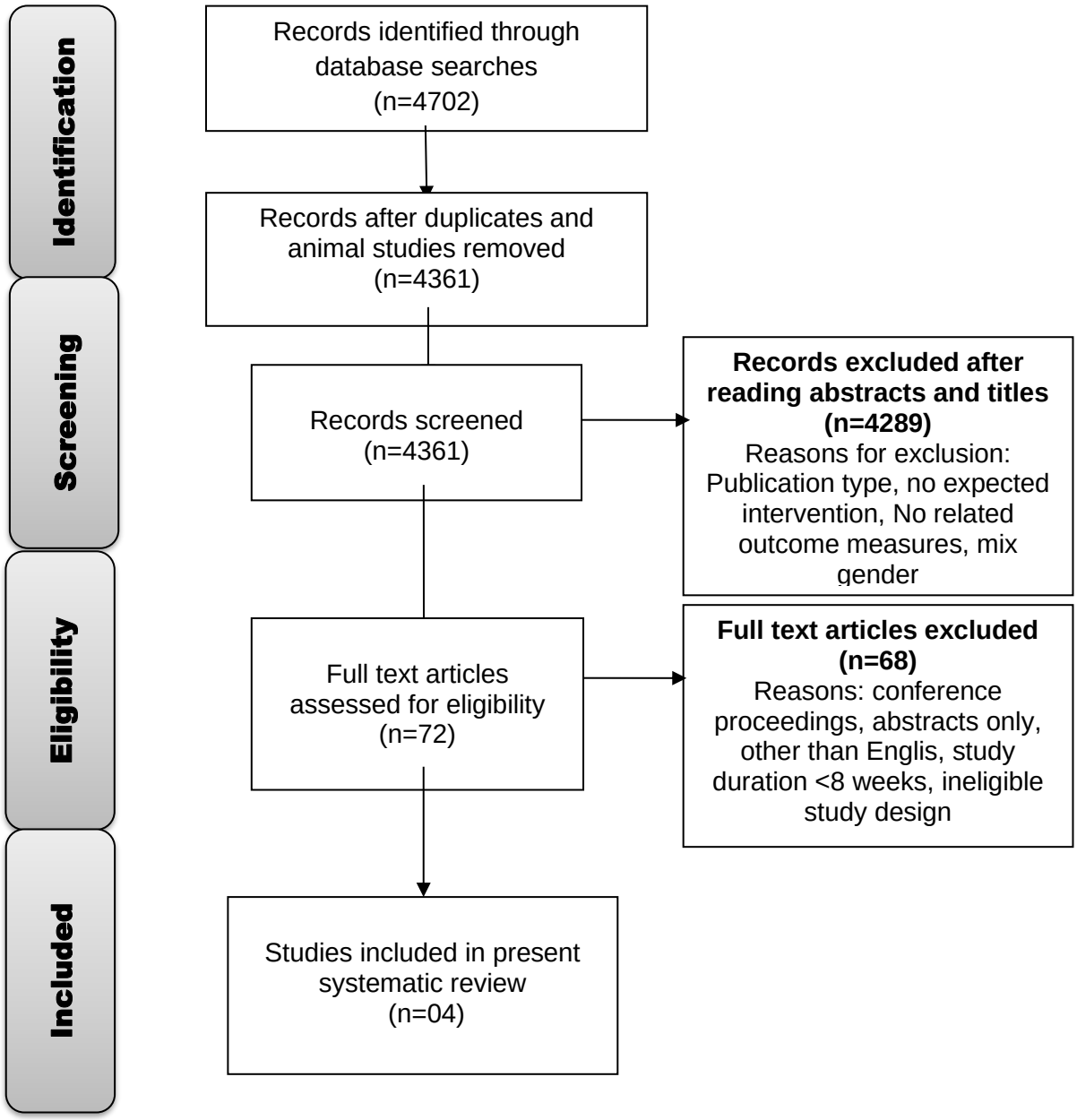

Figure-1: PRISMAflow diagram of search strategies

were met; high risk of bias if one or more of the criteria were not included or not met; the study is judged to raise some concern if one or more of the quality criteria were unclear or no information provided.Any disagreements between the two reviewers were resolved by discussion.

Results

A total of 4702 studies were extracted from the databases, of which 4361 studies remainedafter removing duplicates.After title and abstract screening, 72 full-text papers were assessed for eligibility, of which only 4 studies met the inclusion criteria and were included in this review (Figure-1).

Characteristics of the studies:

Characteristics of the included studies are presented in Table-1. Participants in the 4 included articles were postmenopausal women with type-II diabetes mellitus. Mean age of all patients was 62.45. Interventions in the studies lasted between 10 to 16 weeks. Participants performed exercise training 2-4 days per week with each session lasting 20 to75 minutes. The included studies had 88 participants who completed the prescribed intervention. Three studies[25-27] included a combination of aerobic and resistance exercises. The type of aerobic exercises utilized werefolk dances[25], cycle ergometer[26] and treadmill walking[27].One study[28] utilized high-intensity interval training (HIIT) to exercise group and moderate-intensity continuous training (MICT) to another group which can be considered as control group.Exercise intensity for aerobic exercises was assessed through rate of perceived exertion(RPE)[25], heart rate reserve (HRR)[26],$HR_{max}$and target heart rate[27]. For resistance exercises, intensity was assessed through RPE[25] and 1RM[26,27].

Risk of bias in the included studies:

Risk of bias in the included studies is summarized in Table-2. All the included studies did not clearly report the randomization method. The overall judgment for two studies[25,28]raise 'some concern' and two studiesare judged to have high risk of bias[26,27].

Effects of exercises:

The effects of exercise interventions are summarized in Table-1.

Effects of exercises on blood pressure:

The effect of combined aerobic and resistance training on systolic and diastolic blood pressure levels was measured in three studies[25-27], of which two studies[25,26]reported no significant change in both SBP and DBP following exercise intervention. Another study that incorporated both aerobic and resistance exercises demonstrated significant decrease in SBP in the exercise group, while no change was noted in DBP.

Effects of exercises on lipid profile:

Three studies[25-27] examined the effects of exercises on cholesterol levels. Of the three studies, one study did not include triglycerides test.One study[27] demonstrated a significantly lower post-intervention level of triglycerides and a significant increase in HDL in the exercise group compared to the control group. However, no change was found in total cholesterol and LDL levels following 16 weeks of aerobic (treadmill walk) and strength training. No significant change was seen in the post-intervention levels of total cholesterol, triglycerides, HDL and LDL in the study[25] that utilized a combination of folk dances (aerobic) and resistance exercises. Another study[26] in which a combination of cycle ergometer (aerobic) and resistance exercises were used, did not report a significant change in the post-intervention levels of total cholesterol, HDL and LDL.

Effects of exercises on Blood sugar:

Effect of exercises on blood sugar levels was measured by three studies[25-27]. All the three studies incorporated combined aerobic and resistance training. One study[27] reported significant reduction in the levels of HbA1c and fasting glucose in exercise group after 16 weeks of aerobic and resistance training. The other two studies[25,26], found no significant change in post-intervention levels of HbA1c.

Effects of exercises on abdominal/central obesity:

The Effects of exercises on BMI was investigated by three studies[25,26,28] of which two studies[25,28] also included waist circumference (WC). Both the high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) did not show any effect on BMI and WC[28]. The combined effect of aerobic (folk dances) and resistance training in one study demonstrated no change in BMI and WC[25], whereas, another study[26] that utilized aerobic exercises on cycle ergometer along with resistance training reported significant decrease in BMI.

Table-1: Characteristics and results of the studiesincluded in this systematic review

Study	Mean age (years)	n (E/C)	Type of Intervention	Study duration	Frequency, duration, and intensity of training	Findings
Jeon et al. 2020	E: 62.1 C: 61.1	20/14	E: combined aerobic and resistance training, C: No exercise	12 w	(1) Aerobic: Folk dances, 3 time/week, 20 min. RPE-light (1-4 w), RPE-somewhat hard (5-12 w) (2) Resistance: 3 time/week, 30 min. RPE-light (1-4 w), RPE-somewhat hard (5-12 w)	↔SBP,DBP,HbA1c,TC, LDL, HDL, Triglycerides, BMI, WC in both E and C.
Maillard et al. 2016	E: 68.2 C: 70.1	08/08	E: HIIT C: MICT	16 w	HIIT: 2 times/week, 20 min, 80% HR_{max} MICT: 2 times/week,40min, 55-60% of THR	↔BMI,WC in both E and C
McGavock et al. 2004	E: 58 C: 59	11/07	E: combined aerobic and resistance training C: No exercise	10 w	3 time/week, (1) Aerobic: cycle ergometer, 30-55 min., 65 and 75% of HRR. (2) Resistance: 50-65% of 1RM, 3 sets, 10-15 repetitions.	↔SBP,DBP,HbA1c,TC, LDL, HDL, in both E and C. ↓BMI in EG
Zois et al. 2009	E: 55 C: 59.4	10/10	E: Aerobic and strength training. C: No exercise	16 w	4 time/week (2 days aerobic and 2 days resistance on alternate days). (1) Aerobic: Walking on tread mill, 75 min including warm up and cool down, 60–70% of HRmax (first 2 months), 70-80% of HRmax (after 2 months).	↓ HbA1c,FG,SBP ↔TC, LDL,DBP ↓Triglycerides in E compared to C ↑HDL in E compared to C

					(2) Strength training: 6 exercises, 3 sets of 12 repetition. Intensity: 60% of 1-RM	

E-exercise group; C-control group; n-number of subjects; w-weeks; HIIT-high intensity interval training; MICT-moderate intensity continuous training; RPE-rate of perceived exertion; THR-target heart rate; HRR-heart rate reserve; SBP-systolic blood pressure; DBP-diastolic blood pressure; TC-total cholesterol; LDL-low density lipoprotein; HDL-high density lipoprotein; BMI-body mass index; WC-waist circumference; FG-fasting glucose; ↓-significant reduction; ↑-significant increase; ↔- no change;

Table-2: Risk of bias analysis of the included studies

	Risk of bias domains					**Overall**
	D1	**D2**	**D3**	**D4**	**D5**	
Jeon et al. 2020	?	+	+	+	+	?
Maillard et al. 2016	?	+	+	+	+	?
McGavock et al. 2004	X	?	+	+	?	X
Zois et al. 2009	?	+	+	?	?	X

Domains:
D1: Bias arising from the randomization process
D2: Bias due to deviations from intended interventions
D3: Bias due to missing outcome data
D4: Bias in measurement of the outcome
D5: Bias in selection of the reported result
Overall judgment:
High Low Some concern

Discussion

Majority of postmenopausal women present with higher risk of gaining weight. The weight gain and redistribution of body fat increase the chances of developing metabolic syndrome. Menopause is considered a predictor of metabolic syndrome independent of women's age. This systematic review of four RCTs involving 88 participants indicates that exercise training may yield beneficial effects on metabolic abnormalities like insulin resistance, obesity, blood pressure and hyperlipidemia.Many RCTs have consistently shown that increased physical activity can improve components of metabolic syndrome and recommended a variety of exercise protocols[29-32]. Although it is well known that exercise training is very important for the management of metabolic syndrome, the role of exercise training in improving health of postmenopausal women has not been systematically evaluated in Indian postmenopausal women who are at risk of developing metabolic syndrome.Moreover, there is no sufficient literature regarding the different effects of the type of exercise training in postmenopausal women with metabolic syndrome. It remains uncertainabout the impact of exercise intensity whether high ormoderate,and mode of exercise, i.e., aerobic or resistance trainingon the components of metabolic syndrome. It is difficult to isolate the benefits of exercise alone because many intervention protocols include both dietary and physical activity components.

Our systematic review suggests that exercise training may be helpful in treating some components of metabolic syndrome. In the included studies,only few of the metabolic components could be altered with exercise interventions. The main problem in the included studies in this review is that the sample size is considerably smaller. A smaller sample size reduces the power of the study and increases the margin of error thus may produce inconclusive results[33].Although the sample size is small, insulin resistance measured by serum plasma glucose and HbA1c were shown to decrease following exercise training in a study that incorporated aerobic (tread mill walk) and strength training on alternate days, at a frequency of 4 days in a week (2 days aerobic and 2 days strength training) for 16 weeks[27]. Conversely, HbA1c did not show significant lower post-intervention levels in the other two included studies[25,26] which incorporated combined aerobic and resistance training.One of these studies used folk dances[25] and other study used cycle ergometer[26]. These differences in the results may be due to type of aerobic exercises that they used. These findings suggest that aerobic exercises performed on tread mill generated constructive results compared to the aerobic exercises performed as folk dances or cycle ergometer. Other characteristics of the studies like exercise duration, frequency and intensity might have also influenced the results.It is thus suggested that interventions of lesser duration and frequency, and insufficient exercise intensity may determine the outcome of a particular study.

Another frequently observed component of metabolic syndrome is central obesity.Although positive impact of exercise training on obesity has been well-established, two of the three included articles in this review has reported no changes in BMI and Waist circumference after exercise training[25,28]. Such results might be partially explained by the characteristics of the exercise training. Conversely, BMI was reduced in exercise group in a study that employed combined aerobic and resistance training[26]. These studies with contrasting results indicate that exercise frequency <3 times per week with relatively lesser exercise duration might not be enough to produce beneficial effects.Significant differences in blood pressure after exercise training were not detected among the included studies except one study[27] in which exercise frequency, duration and total length of study are relatively more, reported post-intervention lower levels in systolic blood pressure.

Study characteristics also influenced the results of lipid profile among the included studies. Significant changes were reported in triglycerides and HDL levels following exercise training in the study in which the exercises were performed 4 times per week for 16 weeks[27]. However, total cholesteroland LDL remained same after the training. Two other studies also measured total cholesterol, triglycerides, HDL and LDL but no significant changes were noted from baseline to post-intervention[25,26]. These variations in results among the included trials may be explained by substantial differences in exercise characteristics. In general, more frequent exercise trainingis considered to be more effective, and is in agreement with general recommendations for exercise by the United States Preventive Task Force[34]

Limitations of the review:

There are few potential limitations of this review to note. Sample size in theincluded studies of this systematic review was substantially smaller. The studies did not have a component of long-term follow-up.So it is unclear about the effects of exercise training on metabolic syndrome over time. The number of studies eligible for the review was inadequate, confiningthe ability tofind out the impact of different characteristics of exercise interventions. Future studies are required with relatively larger sample and long-term follow up to identify an appropriate training protocol for postmenopausal women with diabetes mellitus.

Conclusion:

In conclusion, in postmenopausal women with diabetes mellitus, exercise programs compared to usual care result in a modest improvement in some componentsof metabolic syndrome. Exercises with more frequent sessions and longer duration were associated with the better improvements.Benefits are also associated with the total length of study.

References

1. Kakkar V, Kaur D, Chopra K, Kaur A, Kaur IP. Assessment of the variation in menopausal symptoms with age, education and working/non-working status in north-Indian sub population using menopause rating scale (MRS). Maturitas. 2007 Jul 20;57(3):306-14. doi: 10.1016/j.maturitas.2007.02.026. Epub 2007 Apr 3. PMID: 17408889.
2. Borker SA, Venugopalan PP, Bhat SN. Study of menopausal symptoms, and perceptions about menopause among women at a rural community in Kerala. J Midlife Health. 2013 Jul;4(3):182-7. doi: 10.4103/0976-7800.118997. PMID: 24672192; PMCID: PMC3952411.
3. Kriplani A, Banerjee K. An overview of age of onset of menopause in northern India. Maturitas. 2005 Nov-Dec;52(3-4):199-204. doi: 10.1016/j.maturitas.2005.02.001. PMID: 16257611.
4. Palacios S, Henderson VW, Siseles N, Tan D, Villaseca P. Age of menopause and impact of climacteric symptoms by geographical region. Climacteric. 2010 Oct;13(5):419-28. doi: 10.3109/13697137.2010.507886. PMID: 20690868.
5. Gold EB. The timing of the age at which natural menopause occurs. ObstetGynecolClin North Am. 2011 Sep;38(3):425-40. doi: 10.1016/j.ogc.2011.05.002. PMID: 21961711; PMCID: PMC3285482.
6. Appiah D, Winters SJ, Hornung CA. Bilateral oophorectomy and the risk of incident diabetes in postmenopausal women. Diabetes Care. 2014;37(3):725-33. doi: 10.2337/dc13-1986. Epub 2013 Nov 5. PMID: 24194507.
7. Rocca WA, Grossardt BR, de Andrade M, Malkasian GD, Melton LJ 3rd. Survival patterns after oophorectomy in premenopausal women: a population-based cohort study. Lancet Oncol. 2006 Oct;7(10):821-8. doi: 10.1016/S1470-2045(06)70869-5. PMID: 17012044.
8. Huang PL. A comprehensive definition for metabolic syndrome. Dis Model Mech. 2009 May-Jun;2(5-6):231-7. doi: 10.1242/dmm.001180. PMID: 19407331; PMCID: PMC2675814.
9. Chedraui P, Hidalgo L, Chavez D, Morocho N, Alvarado M, Huc A. Quality of life among postmenopausal Ecuadorian women participating in a metabolic syndrome screening program. Maturitas. 2007 Jan 20;56(1):45-53. doi: 10.1016/j.maturitas.2006.05.008. Epub 2006 Jun 23. PMID: 16797890.
10. Ponholzer A, Temml C, Rauchenwald M, Marszalek M, Madersbacher S. Is the metabolic syndrome a risk factor for female sexual dysfunction in sexually active women? Int J Impot Res. 2008 Jan-Feb;20(1):100-4. doi: 10.1038/sj.ijir.3901605. Epub 2007 Sep 20. PMID: 17882275.
11. Abildgaard J, Danielsen ER, Dorph E, Thomsen C, Juul A, Ewertsen C, Pedersen BK, Pedersen AT, Ploug T, Lindegaard B. Ectopic Lipid Deposition Is Associated With Insulin Resistance in Postmenopausal Women. J ClinEndocrinolMetab. 2018 Sep 1;103(9):3394-3404. doi: 10.1210/jc.2018-00554. PMID: 29889238.
12. Abildgaard J, Pedersen AT, Green CJ, Harder-Lauridsen NM, Solomon TP, Thomsen C, Juul A, Pedersen M, Pedersen JT, Mortensen OH, Pilegaard H, Pedersen BK, Lindegaard B. Menopause is associated with

decreased whole body fat oxidation during exercise. Am J PhysiolEndocrinolMetab. 2013 Jun 1;304(11):E1227-36. doi: 10.1152/ajpendo.00492.2012. Epub 2013 Apr 2. PMID: 23548615.

13. Lovejoy JC, Champagne CM, de Jonge L, Xie H, Smith SR. Increased visceral fat and decreased energy expenditure during the menopausal transition. Int J Obes (Lond). 2008 Jun;32(6):949-58. doi: 10.1038/ijo.2008.25. Epub 2008 Mar 11. PMID: 18332882; PMCID: PMC2748330.
14. Rendell M, Hulthén UL, Törnquist C, Groop L, Mattiasson I. Relationship between abdominal fat compartments and glucose and lipid metabolism in early postmenopausal women. J ClinEndocrinolMetab. 2001 Feb;86(2):744-9. doi: 10.1210/jcem.86.2.7260. PMID: 11158040.
15. Wilcox G. Insulin and insulin resistance. ClinBiochem Rev. 2005 May;26(2):19-39. PMID: 16278749; PMCID: PMC1204764.
16. Salpeter SR, Walsh JM, Ormiston TM, Greyber E, Buckley NS, Salpeter EE. Meta-analysis: effect of hormone-replacement therapy on components of the metabolic syndrome in postmenopausal women. Diabetes ObesMetab. 2006 Sep;8(5):538-54. doi: 10.1111/j.1463-1326.2005.00545.x. PMID: 16918589.
17. Misso ML, Murata Y, Boon WC, Jones ME, Britt KL, Simpson ER. Cellular and molecular characterization of the adipose phenotype of the aromatase-deficient mouse. Endocrinology. 2003 Apr;144(4):1474-80. doi: 10.1210/en.2002-221123. PMID: 12639931.
18. Louet JF, LeMay C, Mauvais-Jarvis F. Antidiabetic actions of estrogen: insight from human and genetic mouse models. CurrAtheroscler Rep. 2004 May;6(3):180-5. doi: 10.1007/s11883-004-0030-9. PMID: 15068742.
19. Danaei G, Finucane MM, Lu Y, Singh GM, Cowan MJ, Paciorek CJ, Lin JK, Farzadfar F, Khang YH, Stevens GA, Rao M, Ali MK, Riley LM, Robinson CA, Ezzati M; Global Burden of Metabolic Risk Factors of Chronic Diseases Collaborating Group (Blood Glucose). National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2·7 million participants. Lancet. 2011 Jul 2;378(9785):31-40. doi: 10.1016/S0140-6736(11)60679-X. Epub 2011 Jun 24. PMID: 21705069.
20. Miller BR, Nguyen H, Hu CJ, Lin C, Nguyen QT. New and emerging drugs and targets for type 2 diabetes: reviewing the evidence. Am Health Drug Benefits. 2014 Nov;7(8):452-63. PMID: 25558307; PMCID: PMC4280522.
21. Helmrich SP, Ragland DR, Leung RW, Paffenbarger RS Jr. Physical activity and reduced occurrence of non-insulin-dependent diabetes mellitus. N Engl J Med. 1991 Jul 18;325(3):147-52. doi: 10.1056/NEJM199107183250302. PMID: 2052059.
22. Eriksson KF, Lindgärde F. Prevention of type 2 (non-insulin-dependent) diabetes mellitus by diet and physical exercise. The 6-year Malmö feasibility study.Diabetologia. 1991 Dec;34(12):891-8. doi: 10.1007/BF00400196. PMID: 1778354.
23. Centre for reviews and dissemination: Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care. York: University of York; 2006.
24. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, Cates CJ, Cheng HY, Corbett MS, Eldridge SM, Emberson JR, Hernán MA, Hopewell S, Hróbjartsson A, Junqueira DR, Jüni P, Kirkham JJ, Lasserson T, Li T, McAleenan A, Reeves BC, Shepperd S, Shrier I, Stewart LA, Tilling K, White IR, Whiting PF, Higgins JPT. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019 Aug 28;366:l4898. doi: 10.1136/bmj.l4898. PMID: 31462531.
25. Jeon YK, Kim SS, Kim JH, Kim HJ, Kim HJ, Park JJ, Cho YS, Joung SH, Kim JR, Kim BH, Song SH, Kim IJ, Kim YK, Kim YB. Combined Aerobic and Resistance Exercise Training Reduces Circulating Apolipoprotein J Levels and Improves Insulin Resistance in Postmenopausal Diabetic Women. Diabetes Metab J. 2020 Feb;44(1):103-112. doi: 10.4093/dmj.2018.0160. PMID: 32097999; PMCID: PMC7043986.
26. McGavock J, Mandic S, Lewanczuk R, Koller M, Muhll IV, Quinney A, Taylor D, Welsh R, Haykowsky M. Cardiovascular adaptations to exercise training in postmenopausal women with type 2 diabetes mellitus. CardiovascDiabetol. 2004 Mar 15;3:3. doi: 10.1186/1475-2840-3-3. PMID: 15023235; PMCID: PMC400749.

27. Zois C, Tokmakidis SP, Volaklis KA, Kotsa K, Touvra AM, Douda E, Yovos IG. Lipoprotein profile, glycemic control and physical fitness after strength and aerobic training in post-menopausal women with type 2 diabetes.Eur J Appl Physiol. 2009 Aug;106(6):901-7. doi: 10.1007/s00421-009-1078-6. Epub 2009 May 21. Erratum in: Eur J Appl Physiol. 2009 Aug;106(6):909. Christos, Zois E [corrected to Zois, Christos E]. PMID: 19458961.
28. Maillard F, Rousset S, Pereira B, Traore A, de Pradel Del Amaze P, Boirie Y, Duclos M, Boisseau N. High-intensity interval training reduces abdominal fat mass in postmenopausal women with type 2 diabetes. Diabetes Metab. 2016 Dec;42(6):433-441. doi: 10.1016/j.diabet.2016.07.031. Epub 2016 Aug 24. PMID: 27567125.
29. Kemmler W, Von Stengel S, Engelke K, Kalender WA. Exercise decreases the risk of metabolic syndrome in elderly females. Med Sci Sports Exerc. 2009 Feb;41(2):297-305. doi: 10.1249/MSS.0b013e31818844b7. PMID: 19127197.
30. Verrusio W, Andreozzi P, Renzi A, Martinez A, Longo G, Musumeci M, Cacciafesta M. Efficacy and safety of spinning exercise in middle-aged and older adults with metabolic syndrome: randomized control trial. Ann Ist Super Sanita. 2016 Apr-Jun;52(2):295-300. doi: 10.4415/ANN_16_02_24. PMID: 27364407.
31. Liu YL, Lu CW, Shi L, Liou YM, Lee LT, Huang KC. Low intensive lifestyle modification in young adults with metabolic syndrome a community-based interventional study in Taiwan. Medicine (Baltimore). 2015 Jun;94(22):e916. doi: 10.1097/MD.0000000000000916. PMID: 26039125; PMCID: PMC4616347.
32. Tran VD, James AP, Lee AH, Jancey J, Howat PA, Thi Phuong Mai L. Effectiveness of a Community-Based Physical Activity and Nutrition Behavior Intervention on Features of the Metabolic Syndrome: A Cluster-Randomized Controlled Trial. MetabSyndrRelatDisord. 2017 Mar;15(2):63-71. doi: 10.1089/met.2016.0113. Epub 2016 Dec 20. PMID: 27997282.
33. Faber J, Fonseca LM. How sample size influences research outcomes. Dental Press J Orthod. 2014 Jul-Aug;19(4):27-9. doi: 10.1590/2176-9451.19.4.027-029.ebo. PMID: 25279518; PMCID: PMC4296634.
34. Patnode CD, Evans CV, Senger CA, Redmond N, Lin JS. Behavioral Counseling to Promote a Healthful Diet and Physical Activity for Cardiovascular Disease Prevention in Adults Without Known Cardiovascular Disease Risk Factors: Updated Systematic Review for the U.S. Preventive Services Task Force [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2017 Jul. Report No.: 15-05222-EF-1. PMID: 29364620.