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Original Research Article

IMPACT OF HIGH INTENSITY INTERVAL VERSUS MODERATE INTENSITY CONTINUOUS TRAINING ON MODULATING CARDIOVASCULAR DISEASE RISK FACTORS IN POSTMENOPAUSAL WOMEN

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ABSTRACT

Background: Estrogen has protective effects on the cardiovascular system due to which there is an increase in the prevalence of cardiovascular diseases in postmenopausal women.

Objective: This study was conducted to determine the effect of high intensity interval training versus moderate intensity continuous training on modulating cardiovascular disease risk factors in postmenopausal women.

Participants and methods: Sixty obese hypertensive postmenopausal women participated in this study, their age ranged from 45-55 years. They were divided into two groups equal in number,(group- A; n=30) high intensity interval training group (HIT group) received high intensity interval training for 3 sessions per week for 12 weeks and (group-B; n=30) Moderate intensity continuous training group (MIT group) received moderate intensity continuous training for 3 sessions per week for 12 weeks and. Nitric oxide, blood pressure and BMI were measured before and after the study.

Results: The results of this study revealed a non-statistical significant difference ($P>0.05$) between both groups (A&B) in nitric oxide, blood pressure and BMI before the treatment, While, there was a highly statistical significant difference ($P<0.01$) after treatment in favor of group (A).

Conclusion: It could be concluded that HIT is more effective than MIT in improving levels of nitric oxide, blood pressure and BMI.

KEY WORDS: High intensity interval training, Moderate intensity continuous training, postmenopausal, hypertension.

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INTRODUCTION

Estrogen withdrawal in menopause is considered a risk factor for cardiovascular disease (CVD) as it has a detrimental effect on cardiovascular function and metabolism. Other risk factors for CVD include; increased blood pressure, changes in body fat distribution, abnormal plasma lipids, reduced glucose tolerance, increased sympathetic tone, endothelial dysfunction and vascular inflammation. Treatment of arterial hypertension and glucose intolerance should be priorities for postmenopausal women [1-3]. The cause for this increased CVD risk is due to decline in the apparent cardio-pro-tective effects of estrogen in postmenopausal women [4].

At the begining of the menopausal period; a woman reaches her maximum body weight, accompanied by a rise in body fat percentage and abdominal fat percentage associated with a consequent increase in body weight linearly with age [5].

The prevalence of hypertension is higher in young adult and middle aged males compared with females. However, after middle age, women are more prone to be hypertensive than men, particularly increased systolic blood pressure [6]. Cross-sectional data show a fourfold higher incidence of hypertension in post-menopausal women than pre-menopausal women [7, 8].

It is well established that post-menopausal status is accompanied by a significantly reduced arterial NO activity [9]. Estrogen is of utmost importance due to its strong and valuable effect on endothelial function by increasing secretion and declining degradation of NO [10]. Other risk factors of postmenopausal hypertension are endothelial dysfunction, sympathetic nervous system overtone and rennin-angiotensin-aldosterone system, oxidative stress, body mass index and sedentary life [11,12].

It has been conventionally recommended to practice Continuous moderate-intensity exercise for 30 min or more for hypertension prevention and treatment [13,14]. However, several studies have shown that high intensity interval training, which consists of several bouts of high-intensity exercise (~85%to 95% of HRMAX and/or VO2MAX) lasting 1 to 4min interspersed with intervals of rest or active recovery [15,17,18], is superior to CMT for improving cardiorespiratory fitness [16-18].

A frequently mentioned obstacle to exercise is shortage of time [19]. Substituting some vigorous exercise for some moderate-intensity exercise in order to improve fitness in a more time-efficient manner. According to the 2008 Physical Activity Guidelines [20].

One minute of vigorous activity counts for two minutes of moderate-intensity activity, although presently there is not adequate verification to support this assert for many health outcomes. Yet, including vigorous activity as part of an exercise program could offer a more time-efficient approach to achieve specific health goals for some individuals [21].

High intensity interval training has been used for several decades by athletes and coaches to enhance exercise performance [22]. But its cabability to improve health outcomes in non-athletes has recently aroused new interest [23].

PARTICIPANTS AND METHODS

Participants: Sixty obese hypertensive post-menopausal women vol-unteered for this study and were recruited from El Mataria Hos-pital, Cairo-Egypt. Their ages ranged from 45 to 55 years, BMI ranged from 30 to 35 kg/cm^2, stage 1 hypertension where systolic blood pressure ranged from 140-159 and diastolic blood pressure ranged from 90-99mmHg, classified according to the fifth Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure JNC V [24].

Inclusion criteria were: Post menopausal, defined as amenorrhea for a minimum of 1year and or serum follicle stimulating hormone FSH concentration 40 mIUml, or having had a prior hysterectomy and bilateral oophorectomy; sedentary, non-smoking, non-diabetic, no more than one antihypertensive medication is taken.

Exclusion criteria were: Taking hormone replacement therapy or medications that affect cardiovascular hemodynamics and history or evidence of CVD, renal disease, or orthopedic conditions that affect the ability to participate in exercise program.

Randomization: The participants were randomly assigned to group (A) (HIT) (n=30) or group (B) (MIT) (n=30) by an independent person who selected blindly from sealed envelopes containing numbers created by a random number generator. The randomization was restricted to permuted blocks to ensure that equal numbers were allocated to each group A and group B. The sequences assigned to the participants were placed in envelopes containing the allocation to each group A and group B.

The aim and procedures of the study were informed to eligible patients. All patients signed a written informed consent. The study was approved by the ethical Committee of Faculty of Physical Therapy, Cairo University.

Evaluation: Every patient was assessed by a physician to select eligi-ble patients. Before patient inclusion in this study, a com-plete medical history and drug history were used for the patients. .All tests were performed before the training (pre-) and after (post-) training period for each participant including demographic data, blood pressure assessment and laboratory analysis for se-rum NO. To control the acute effects of exer-cise on hemodynamic and biochemical variables, all final testing was measured at least 24 to 36 hours after the last exercise session.

Anthropometric and cardiovascular parameters: The height bare feetwere measured by a clinical stadiometer (made in china) and body weight was measured with a dig-ital calibrated precision scale (Thinner MS-7400, Fairlfiled NJ, made in china). Body mass index (BMI) was measured by weight (Kg) divided by the height square in meters.

Resting BP was measured with a calibrated mercury sphygmomanometer following the American Heart Association guidelines [25]. Participants were requested not to ingest caffeine within 30 min prior to measurement. During BP measurements, participants were seated in an uprightchair with feet flat on the floor. For consistency, the same sphygmomanometer, with an appropriately sized attachable cuff, was used during the entire studyperiod for each participant. SBP was determined by the first Korotkoff sound, and diastolic blood pressure DBP was determined by the disappearance of the fifth Korotkoff sound. Three readings were recorded within a 5-min period taking the average of these three readings to record as the BP measurement for that visit.

Resting heart rate was identified after 5 minutes position using a pulse oximeter.

Plasma endothelial function markers:

Blood samples were drawn into EDTA tubes in the morn-ing following a 12-hour overnight fast. Total NO was de-termined spectrophotometrically by using kits (Total Ni-tric Oxide kit used in ELISA, R & D systems, Minneapolis, USA), concentration was given in µmol/L.

Five milliliters of fasting blood was collected by venous arm puncture under aseptic conditions. Serum was obtained by centrifugation at 2 000*g* for 5 min of blood samples taken without anticoagulant. Serum was kept at 20 °C until the analysis date.

Determination of total NO (NO_3^-/NO_2^-) concentration in serum: Nitrite (NO_2^-) and nitrate (NO_3^-) are stable final products of NO metabolism and may be used as indirect markers of NO presence. Total NO concentration is commonly determined as a sum of nitrite and nitrate concentrations. NO concentration was determined using an indirect method based on measurement of nitrite concentration in serum according to Griess's reaction. In the samples analyzed, nitrate were reduced to nitrite in the presence of cadmium (Sigma-Aldrich, Steinheim, Germany), and then converted to nitric acid that gave a color reaction with Griess's reagent (Sigma-Aldrich, Stainheim, Germany). Nitrite concentrations were determined by spectrophotometric analysis at 540 nm (UVN-340 ASYS Hitech GmbH microplate reader; Biogenet, Eugendorf, Austria) with reference to a standard curve. NO products were expressed as ìmoles.

Treatment procedures: Electronic treadmill (Vegamax, made in Taiwan) was used for training for both groups (A&B). HIT consisted of walking on a treadmill 3 sessions/week for 12 weeks. HIT duration consisted of warm-up for 10 min at 70% of maximal heart rate (HRmax) and 4x4 min intervals at 80-85% of HRmax, with 3-min active recovery at 70% of HRmax between inter-vals, and finally 5min cool-down period. Whereas for MIT, the participant of this group had undergone warming up for 10 min, then performed treadmill walking three times per week (on non consecutive days). The duration of exercise was increased from 20 min per session (at 60% of maximum heart rate) to 30 min (at 75% of maximum heart rate) per session.

Aerobic exercise intensity was determined by the Karvonen formula in which target heart rate = [(maxHR"resting HR)´% intensity]+resting HR, All the participants willingly adhered to and completed the training programs. No serious adverse effects were reported in either training group. The total exercise time was 40 min. Maximum heart rate is estimated accord-ing to the following formula: HRmax = 206 – 0.88*age. A heart rate and the Borg scale of perceived exertion were monitored during the interval training to ensure that all subjects were exercising on their corresponding intensity of exercise. Continuous adjustment of the speed of the treadmill was used to avoid training adaptations to ensure training at the desired heart rate along the whole 12-week training program.

Statistical analysis:

Statistical analysis was performed using SPSS software, version 16.0 (SPSS, Inc., Chicago, IL). Data were expressed as mean ± standard deviation (SD). The results were ana-lyzed by using the Student's *t*-test. Statistical significance was set at P<0.05.

RESULTS

A total of 60 hypertensive postmenopausal women were recruited, including 30 in group A (HIT group) and 30 in group B (MIT group). Subjects in group (A) performed 12-weeks high intensity interval training while, group (B) performed 12-weeks moderate intensity continuous training.

Table 1 represents the age, BMI, Blood pressure and plasma nitric oxide in both groups (A & B). There was a non-statistical significant difference (P>0.05) between groups (A&B) in BMI, Blood pressure and plasma nitric oxide before the treatment, While, there was a highly statistical significant difference (P<0.01) after treatment in favor of group (A)

Table 1: Age, BMI, Blood pressure and plasma nitric oxide in both groups (A&B).

		Pre-treatment	Post-treatment	% of improvement	T-value	P-value
Age	Group (A)	49.30 ±3.24				
	Group (B)	50.00 ±0.59				
	T value	0.83				
	p value	0.40 (NS)				
BMI (kg/cm^2)	Group (A)	33.32 ±1.14	31.62 ±2.25	5.10%	4.97	0.0001(HS)
	Group (B)	33.56 ±1.16	32.62 ±1.05	2.80%	12.99	0.0001(HS)
	T value	0.81	2.2			
	p value	0.41 (NS)	0.031(S)			
SBP (mmHg)	Group (A)	149.17±5.43	137.5±5.37	7.80%	13.85	0.0001(HS)
	Group (B)	146.83±7.48	141.83±7.25	3.40%	9.32	0.0001(HS)
	T value	1.83	2.63			
	P value	0.17(NS)	0.01(HS)			
DBP (mmHg)	Group (A)	92.33±2.54	84.33±3.41	8.60%	12.98	0.0001(HS)
	Group(B)	92.17±2.52	89.17±2.96	3.30%	6.59	0.0001(HS)
	T value	0.25	5.86			
	P value	0.79 (NS)	0.0001(HS)			
NO(µmol/L)	Group (A)	25.42±1.89	28.87±1.94	13.50%	11.24	0.0001(HS)
	Group(B)	25.9±1.37	27.27±1.46	5.20%	10.59	0.0001(HS)
	T value	1.12	3.57			
	P value	0.26 (NS)	0.0001(HS)			

Data presented as mean and ± standard deviation; BMI= Body mass index; SBP = Systolic blood pressure; DBP = Diastolic blood pressure; NO = Nitric oxide; NS= non-significant; HS= Highly significant

DISCUSSION

The risks related to post-menopause are mainly due to the abrupt interruption of estrogen, which has indirect protective effects on lipid, glycidic metabolism and direct effects on vessel function. Post-menopause is also frequently associated with hypertension, the most frequent related factor to coronary artery disease. Hyper tension is due to increased body mass index, with insulin-resistance, sodium retention, increased blood viscosity and estrogen deficiency with increased smooth muscle cell proliferation which determines an increase in systemic vascular resistance. Age and estrogen deficiency are together the most important cause of cardiovascular risk in post-menopause [26].

Obesity and adipose tissue redistribution are leading problems in Post-menopause, there is definite positive relationship between body weight and all cause morbidity and mortality. Obesity is ''by itself." a risk factor because of the effect on glicidic metabolism, insulin resistance, blood pressure and lipid profile. All risk factors moreover are responsible of endothelial dysfunction which may represents the mean through which hypertension induces hypertension associated disease and determines target organ damage. Hypertension is an important risk factor associated with all-cause and cardiovascular mortality, as well as a greater life expectance without cardiovascular disease [27,28]. Moreover, BP is strong and linearly associated with coronary heart disease and stroke, which are the most common causes of mortality among women [29]. Preventing or delaying the onset of hypertension may therefore have a large impact on public health, mainly in individuals at high risk for hypertension [30].

The principle of using HIT in both healthy and clinical populations is that the vigorous activity promote greater adaptations via increased cellular stress, yet their short length, and the consequent recovery intervals, allow even untrained individuals to work harder than would otherwise be possible at steady state intensity [21].

This study aimed to compare between the impact of HIT and MIT on some of the cardiovascular risk factors that accompany postmenopausal status, like obesity, hypertension and decreased NO levels.

The findings of this comparative study ; showed that after a program of 12 weeks; both moderate intensity continuous training (MIT) and HIT were effective in decreasing both systolic and di-astolic blood pressure as well decreasing BMI and increasing the serum levels of NO. However HIT shows a higher percentage of improvement compared to MIT group.

These findings were supported by Schjerve et al, who demonstrated that after 12-week study of obese, middle-aged adults with baseline elevated diastolic blood pressure (DBP) showed improvement in DBP in both the HIT and continuous moderate aerobic groups [31].

Moreover, Ciolac et al showed that Lower levels of resting diastolic BP, exercise diastolic BP, and recovery systolic and diastolic BP were observed in aerobic interval training (AIT) . In the continuous moderate training (CMT) group, only exercise diastolic BP and recovery systolic BP were reduced in CMT. The greater improvements in the norepinephrine, endothelin-1 (ET-1) and NOx response to exercise observed after AIT are possible explanations for the differences in BP response to exercise between groups [16]. They suggested that the reason for these differences in ET-1 and NOx response to exercise between groups may be due to the different effects of the low and high intensity training exercise programs on the shear stress in the arterial wall during exercise training and that this may capitulate differences in molecular responses[16].

On the other hand; In a study with metabolic syndrome subjects, resting BP was reduced after a 16-wk HIT or CMT exercise program with no significant difference between programs [18]. Tjønna et al found that exercise intensity appears to affect exercise induced improvements of endothelial function in hypertension, and that HIT was more effective than continuous moderate training for improving endothelial function in metabolic syndrome subjects with hypertension as nitric oxide (NO) availability was improved and several factors that influence nitric oxide bioavailability (blood glucose, insulin sensitivity and oxidized low-density lipoprotein) were normalized after HIT only [18]. Padilla et al., confirmed that there is a significant dose response relationship between aerobic exercise intensity and Flow-mediated dilation which may be because of the more release of NO due to the higher exercise intensity caused greater shear stress on the endo-thelium [3].

These results support the new evidence that high-intensity exercise training can be more useful for cardiovascular health than low-intensity exercise training .[33]

The American College of Sports Medicine pub-lished the physical activity guidelines that emphasize the advantage of high-intensity exercise training for preserv-ing and promoting cardiovascular health [13]. For each MET increment in exercise intensity, cardiovascular and all-cause mortality are diminished by 8–17 % [34].

Fur-thermore, high-intensity exercise training was better than moderate-intensity exercise in improving cardiorespira-tory fitness [35].

Moreover, it could be suggested that the higher exercise intensity could have produced changes in BMI which result in a greater improvement in microvas-cular function [36].

Recent studies suggest that HIIT caused more blood flow and consequently shear stress which is better in improving most cardio metabolic diseases including NO bioavailability, endothelial func-tion, insulin sensitivity, glucose metabolism, high density lipoproteins, oxidized low-density lipoproteins and left ventricular dysfunction and enhances compliance [37,38,18].

Although regular aerobic exercise appears to attenuate age associated arterial stiffness and to reduce established arterial stiffness in normotensive subjects [39].

In a study by Guimarães et al showed a reduction in arterial stiffness of hypertensive subjects after 16 weeks of HIT, but not CMT [15]. All these findings are in accordance with a systematic review carried by Ramos et al, which suggests that 4 × 4 HIIT, three times per week for at least 12 weeks, is a powerful form of exercise to enhance vascular function [40].

Trapp and colleagues reported that a 15-week maximal effort HIT intervention was more effective than moderate-intensity continuous exercise at reducing whole body fat mass and in particular, intra-abdominal adiposity in young healthy women [41].

On consequence Gillen et al, reported that 6-week low volume HIT, consisting of only 30-min exercise within a 1-h time commitment per week, improved body composition and skeletal muscle oxidative capacity in overweight and obese women. These adaptations were realized regardless of when food was ingested around the acute training sessions and provide evidence to suggest that HIT is a time efficient and effective exercise strategy to improve fitness in overweight women [42].

Although, HIT may not be appropriate for everyone. High intensity interval training is highly structured and requires at least initial supervision in untrained individuals. Also, it may require medical clearance due to the high-intensity nature of the exercise. However, the authors of two studies that compared HIT to CME incidentally noted that participants in the HIT group reported that they found the varying intensities of exercise to be motivating. The participants in the CME group, in contrast, found the exercise training to be quite boring [43,18].

Future researches are required to investigate the effect of different in-terval training protocols among different age population.

CONCLUSION

Our study findings show that high intensity interval train-ing for 12 weeks promotes the reduction of risk factors of cardiovascular diseases in postmenopausal obese hypertensive women. The reduction in BMI and blood pressure, which occurs together with an increase in endothelial NO level. So, high intensity interval training could be used instead traditional continuous training in enhancing endothelial function for modulating cardiovascular disease risk factors in postmenopausal hypertensive women.

ABBREVIATIONS

HIT- High intensity interval training
MIT- Moderate intensity training
NO- Serum nitric oxide

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Conflicts of interest: None

REFERENCES

[1]. RosanoC,Vitale C,Marazzi G,Volterrani M, Menopause and cardiovascular disease: the evidence.JournalClimacteric 2007;10(1):19-24.
[2]. Huang G, Wang D, Zeb I, Budoff MJ, Harman SM, Miller V, Brinton EA, Khoudary SR, Manson JE, Sow-ers MR, et al. Intra-thoracic fat, cardio-metabolic risk factors, and subclinical cardiovascular disease in healthy, recently menopausal women screened for the Kronos Early Estrogen Prevention Study (KEEPS). Atherosclerosis. 2012 Mar;221(1): 198-205.

[3]. Armeni E, Stamatelopoulos K, Rizos D, Georgiopou -los G, Kazani M, Kazani A, Kolyviras A, Stellos K, Panoulis K, Alexandrou A, et al. Arterial stiffness is increased in asymptomatic non-diabetic postmeno-pausal women with a polycystic ovary syndrome phe-notype. J Hypertens. 2013 Oct;31(10):1998-2004.

[4]. Leuzzi C, Marzullo R, Modena MG. Is menopause a risk factor for ischemic heart disease in women? ItalCardiol (Rome).2012 June;13(6):401-6.

[5]. Ley CJ, B. Lees, JC Stevenson. Sex- and menopause-as-sociated changes in body-fat distribution. Am. J. Clin. Nutr.1992;55:950-954.

[6]. Burt VL, Whelton P, Roccella EJ, Brown C, Culter JA, Higgins M, et al. Prevalence of hypertension in the US population: results from the third national health and nutrition examination survey, 1988–1991.Hy-pertension 1995;25:305–313.

[7]. Staessen JA, Celis H, Fagard R. The epidemiology of the association between hypertension and meno-pause. J Hum Hypertens1998;12:582–592.

[8]. Staessen J, Bulpitt CJ, Fagard R, Lijnen P, Amery A. The influence of menopause on blood pressure. J Hum Hypertens1989; 3:427–433.

[9]. Majmudar NG, Robson SC, Ford GA. Effects of the menopause, gender, and estrogen replacement therapy on vascular nitric oxide activity. J ClinEndocrinolMetab 2000;85:1577-83.

[10]. Colditz GA, Willett WC, Stampfer MJ, Rosner B, Speizer FE, Hennekens CH. Menopause and the risk of coronary heart disease in women. N Engl J Med1987; 316:1105–10.

[11].Posnik-Urbanska A and Kawecka-Jaszcz K. Hyperten-sion in postmenopausal women—se-lected pathomech-anisms. Przegladlekarski. 2006;63(12):1313-7.

[12]. Vincent HK, Vincent KR, Bourguignon C ,Braith RW. Obesity and postexercise oxidative stress in older women. Medicine and science in sports and exer-cise 2005;37(2):213-9.

[13]. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, ThompsonPD, Bauman A. Physical activity and public health: Up-dated recommendation for adults from the Ameri-can College of Sports Medicine and the American Heart Association. Circulation 2007;116:1081-1093.

[14]. American College of Sports Medicine. Position stand: exercise and hypertension. Med Sci Sports Exerc 2004;36:533-553.

[15]. Guimarães GV, Ciolac EG, Carvalho VO, D'Ávila VM, Bortolotto LA, Bocchi EA. Effects of continuous vs interval exercise training on blood pressure and arterial stiffness in treated hypertension.Hypert Res 2010;33:627-632.

[16]. Ciolac EG, Bocchi EA, Bortolotto LA, CarvalhoVO, Greve JMD, Guimarães GV. Effects of highintensity aerobic interval training vs. moderate exercise on hemodynamic, metabolic and neuro-humoral ab-normalities of young normotensive women at high familial risk for hypertension. Hypert Res 2010;33:836-843.

[17]. Ciolac EG, Bocchi EA, Greve JMD, Guimarães GV. Heart rate response to exercise and cardiorespira-tory fitness of young women at high familial risk for hypertension: effects of interval vs continuous training. Eur J CardiovPrevRehabil 2011;18:824-830.

[18]. Tjønna AE, Lee SJ, Rognmo Ø, Stølen TO, Bye A, Haram PM, Loennechen JP, Al-Share QY, SkogvollE, Slørdahl SA, Kemi OJ, Najjar SM, Wisløff U. Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome. A pilot study. Circulation 2008.

[19]. Reichert FF, Barros AJ, Domingues MR, et al. The role of perceived personal barriers to engagement in leisure-time physical activity. Am J Public Health 2007 Mar;97(3):515–9.

[20]. USDHHS. Physical activity guidelines for Americans. Hyattsville (MD): U.S. Department of Health and Human Services; 2008 [online]. Available from URL: http://www.health.gov/paguidelines/guide-lines/chapter4.aspx[Accessed 2008 Jul 10]

[21]. Kessler, H.S., Sisson, S.B. & Short, K.R. The Potential for High-Intensity Interval Training to Reduce Cardiometabolic Disease Risk . Sports Med 2012;42:489.

[22]. Laursen PB, Jenkins DG. The scientific basis for high-intensity interval training: optimising training programmes and maximising performance in highly trained endurance athletes. Sports Med 2002;32(1):53–73.

[23]. Gibala MJ, McGee SL. Metabolic adaptations to short-term high-intensity interval training: a little pain for a lot of gain? Exerc Sport Sci Rev 2008 Apr; 36 (2):58–63.

[24]. JNC V. The Fifth Report of the Joint National Commit-tee on Detection, Evaluation, and Treatment of High Blood Pressure. Arch Intern Med 1993;153:154–183.

[25]. Perloff D, Grim C, Flack JM, Frohlich E, Hill M, McDonald M, et al. Human blood pressure determi-nation by sphygmomanometry. Circulation 1993;88:2460–2470.

[26]. Rossi R, T. Grimaldi, G. Origliani, G. Fantini, F. Coppi, M.G. Modena Cattedra di Cardiologia, Università di Modena e Reggio Emilia . Menopause and car-diovascular risk Pathophysiol Haemost Thromb, 2002;32:325-328.

[27]. Chobanian AV, Bakris GL, Black HR, Cushiman WC, Green LA, Izzo JI, Jones DW, Materson BW, Oparil S, Wright Jr JT, Rochella EJ. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 2003;42:1206–1252.

[28]. Franco OH, Peeters A, Bonneux L, Laet C. Blood pres-sure in adulthood and life expectancy with cardio-vascular disease in men and women: life course analysis. Hypertension 2005;46:1–7.

[29]. Barrios V, Escobar C, Echarri R, Matalí A. Gender and blood pressure control. Hypertension 2008;51:e58.

[30]. Mosca L, Appel LJ, Benjamin EJ, Berra K, Chandra-

-Strobos N, Fabunmi RP, Grady D, Haan CK, Hayes SN, Judelson DR, Keenan NL, McBride P, Oparil S, Ouyang P, Oz MC, Mendelsohn ME, Pasternak RC, Pinn VW, Robertson RM, Schenck-Gustafsson K, Sila CA, Smith Jr SC, Sopko G, Taylor AL, Walsh BW, Wenger NK, Williams CL. Evidence-based guidelines for cardiovascular disease prevention in women. Circulation 2004;109:672–6930.

[31]. Schjerve IE, Tyldum GA, Tjonna AE, et al. Both aerobic endurance and strength training programmes improve cardiovascular health in obese adults. Clin Sci (Lond) 2008 Nov; 115(9):283–93.

[32]. Padilla J, Harris RA, Rink LD, et al. Characterization of the brachial artery shear stress following walking exer-cise. Vasc Med. 2008;13(2):105–11.

[33]. Whyte LJ, Ferguson C, Wilson J, et al. Effects of sin-gle bout of very high-intensity exercise on metabol-ic health biomarkers in overweight/obese sedentary men. Metabolism. 2013;62(2):212–9.

[34].Swain DP and Franklin BA. Comparison of cardio-protective benefits of vigorous versus moderate inten-sity aerobic exercise. Am J Cardiol. 2006;97(1):141–7. doi:10.1016/j.amjcard. 2005. 0 7 130

[35]. Smart NA, Dieberg G, Giallauria F. Intermittent versus continuous exercise training in chronic heart failure: a meta-analysis. Int J Cardiol. 2013;166(2):352–8.

[36]. Sprung VS, Cuthbertson DJ, Pugh CJ, et al. Nitric ox-ide mediated cutaneous microvascular function is impaired in polycystic ovary sydrome but can be im-proved by exercise training. J Physiol. 2013 Mar 15;591(Pt 6):1475-87.

[37]. Gibala MJ, Little JP, Macdonald MJ & Hawley JA . Physiological adaptations to low-volume, high-inten-sity interval training in health and disease. J Physiol .2012; 590(pt5):1077-1084

[38].Shepherd SO, Cocks M, Tipton KD, et al. Sprint in-terval and traditional endurance training increase net intramuscular triglyceride breakdown and expression of perilipin 2 and 5. J Physiol .2013;591(pt3):657-675.

[39]. Tanaka H, Dinenno FA, Monahan KD, Clevenger ,CM, DeSouza CA, Seals DR. Aging, habitual exercise, and dynamic arterial compliance.Circulation 2000;102:1270-1275.

[40]. Ramos J S, Dalleck L C, Tjonna A E, Beetham K S., Coombes J S .The Impact of High-Intensity Interval Training Versus Moderate-Intensity Continuous Training on Vascular Function: a Systematic Review and Meta-Analysis , Sports Medicine 2015;45(5):679–692.

[41]. Trapp EG, Chisholm DJ, Freund J, Boutcher SH. The effects of high-intensity intermittent exercise training on fat loss and fasting insulin levels of young women. Int J Obes 2008;32:684-691

[42].Gillen J B, Percival M E, Ludzki A, Tarnpolskly MA,Gibala M J Interval training Interval training in the fed or fasted state improves body composition and muscle oxidative capacity in overweight women. OBESITY 2013;21(11):2249–2255.

[43]. Wisloff U, Stoylen A, Loennechen JP, et al. Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. Circulation 2007 Jun 19;115(24):3086–94.

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