Turkish Journal of Sport and Exercise
http://dergipark.gov.tr/tsed
Year: 2016 - Volume: 18 - Issue: 3 - Pages: 92-98

ISSN: 2147-5652

The impact of resistance training with different rest intervals on plasma levels of inflammatory markers in sedentary men

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Abstract

The aim of this study was to investigate the effect of different rest intervals between two types of 8 week's resistance training with the same volume and intensity of serum levels of homocysteine and CRP In Sedentary Men. Thirty untrained subjects who voluntarily participated in this study were randomly divided into two groups: resistance training with 90 seconds rest intervalsbetween sets (n = 10), resistance training with 180 seconds rest intervalsbetween sets (n = 10) and control group (n=10). The training programs included 8 exercises, which were performed with 50% of one repetition maximum in the first session and with 85% of one repetition maximum on the last session and in 8-12 repetitions in 3 sets. Before and after 8 weeks training period blood sampling carried out. Independent and paired t-tests were used to analyze data in a meaningful level ($p<0.05$). Results showed that There is statistically significant reduction in CRP homocysteine levels after 8 weeks of resistance training with different rest intervals in the experimental group compared to the control group ($p<0.05$).In general, we can say that the difference between rest periods in resistance training can be an important factor in changes in serum levels of homocysteine and CRP are important.

Keywords: Circuit resistance training, CRP, homocysteine, rest interval.

INTRODUCTION

Nowadays, the resistance training is one of the main methods used to improve physical fitness, as well as rehabilitation programs (8). However, some reports suggest that resistance training sessions such as those seen during endurance training, increase production of free radicals, these unstable compounds make a swift chain reaction with cellular structures. Manipulate and modify any of the resistance training variables can alter the cope with the results of this exercise and create a different biochemical changes within cells or in the environment (10,23). Sedentary behaviors or lifestyle increases the risk of cardiovascular disease.Despite much progress in determining risk factors and generating mechanisms, yet these diseases are not entirely preventable (6,35). Several factors are diagnosed influencing on increasing homocysteine and CRP levels, which one of them is such lifestyle as sedentary life, alcohol intake, smoking, poor nutrition (29,38). Catabolic disorders of these factors effectively starts inflammatory and atherosclerosis process and through intensification of production of reactive oxygen species, oxidative stress increases (3,27). Physical activity causes many biochemical changes that can affect the metabolism of homocysteine and CRP. In this regard, improved body composition, to increase the absorption of vitamins in the intestine, increase in the activity of the associated enzyme (29) and perhaps above all reduce oxidative stress play significant roles. The results of some studies show that regular participation in physical exercise programs reduces levels of homocysteine and CRP (36,38). On the other hand, some studies have not reported the effects of physical activity on homocysteine and CRP level (17). For example, Hudson et al., (13). Reported the effects of two types of protocols, including resistance training, hypertrophy (90 seconds rest between sets) and strength training programs (180

seconds rest between sets), for six weeks. They found that trainings can reduce concentrations of inflammatory markers (homocysteine and CRP). Nonetheless, Mayhew et al. (20) studied the effect of resistance training, with different resting intervals (high and moderate), on inflammatory markers in sedentary students. They reported that intense workouts,compared to workouts with lower intensity, have increased levels of homocysteine and CRP. Likewise, Nikbakht et al. (24), Namazi et al. (22), have reported no change in levels of homocysteine and CRP after the regular resistance or aerobic training. Thus, the research findings indicate the dual nature of the immune system response to exercise (33). Accordingly, the increasing tendency to resistance training (41), dual nature of the immune system response to exercise, the relationship between inflammatory markers (homocysteine and CRP) with coronary heart disease, and limited and conflicting results of previous studies in this field are causes intensifying the need for further studies. Therefore, this study aimed to determine the serum levels of homocysteine, CRP after 8 weeks (24 sessions) circuit resistance training with different rest intervals (reduced intensity processing) on healthy sedentary men.

MATERIAL & METHOD

This study is in terms of semi-experimental and field research and it has been designed based on the pre-test and post-test. After calling for participation in the study, 34 interested students studying in Islamic Azad University of Sanandaj were chosen by random sampling. After an initial selection of participants, they were informed with a comprehensive and complete information about the research in writing and orally. Finally, 30 students, aged 19- 28 years with required qualifications and consent letter, were chosen. The volunteers were divided into three groups: resistance exercise with rest intervals of 90 seconds (10 subjects) and 180 seconds (10 subjects) and a control group (10 subjects). The precondition and criteria to accept the volunteers included physical health; lack of regular physical exercise, lack of special diet, no smoking and medicines intake, especially non-steroidal anti-inflammatory medicine. Groups were equaled based on physical condition, body fat percentage and body mass index. Using a caliper body density with three-point equation (14), and the formula (37) the subcutaneous fat in three points, including: the abdomen, above the aisles and triceps were measured. And, general characteristics of tests, including: age, weight, height, body mass index and body fat percentage were indirectly estimated and recorded. All measurements were performed prior to blood sampling and starting the resistance training. To determine the intensity of exercise, 1RM through the (Brzycki) formula was used (19).

$$1RM = \text{lifted weight} \div (1.0278 - (0.0278 \times \text{number of repetitions}))$$

In the beginning of each session, both resistance training groups, had 10 minutes warm-up with exactly similar training. The effects were tested to find out response to inflammatory markers. These exercises, circular in shape, include bench press; pull down curls with pulleys, biceps and triceps workout with a barbell, squat using (hack squat machine), Latpulldownsand sit-ups. The exercises were conducted based on the overload principle. Trainingduring the first week consists of 50% of 1RM, three setswith eight repetitions. One of the groups had 90 seconds rest in the round intervals while the other group had rest time for 180 seconds. 5% of 1RM per week is added to the maximum intensity exercise so that the intensity of the 8th week rose to 85% of 1RM. Also, 10-minute cool-down was included at the end of each session. Blood sampling was taken in 8, 8:30 AM in the medical laboratory in fasting state. 10 cc blood samples were taken from the right forearm brachial vein in a sitting condition. Sampling was repeated likewise before and after the training$_{P}$rogram.Immediately after blood sampling, anti-clotting agent, EDTA, was added to the samples and centrifuged at 2500 to 2700 RPM for 10 minutes to extract the blood plasma. The plasma, then, was kept in the freezer. Using HPLC technique, lab-kit manufactured by Axis-shield Diagnosticcompany in Germany was used to measure the concentration of homocysteine. And, the Diagnostic Biochem kit made in Canada was used to measure CRP by ELISA method.

The Shapiro-Wilk test was used to exam the normality of the data. Respecting the default of using the parametric test, two way independent and the paired T test was used to determine the differences within and into Two groups. All statistical analyses were performed using SPSS software, version 22 and the significance level for all statistical tests was set at $p \leq 0.05$.

RESULTS

After 8 weeks of circuit resistance training with different rest periods, physiological characteristics of

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participants and such possible changes as age, height, weight, body fat percentage, BMI and lean body mass in the pre-test and post-test stages are presented in Table 1.

The results shown in table 1 revealed that eight weeks of circuit resistance training led to significant decrease in body fat percentage and a significant increase in lean body mass in pre-test and post-test in both groups (180 seconds rest, 90 seconds rest and control). But circuit resistance training had no significant effect on body weight and body mass index.The concentration of serum levels of homocysteine and CRP and their changes in the pre-test and post-test, after 8 weeks of circuit resistance training with different rest periods, are presented in Table 2.

According to the results presented in table 4.2 and Figure 4.1, there is a significant decrease in plasma homocysteine concentration in different stages of measurement (p= 0.001). The decline in the group with 180 seconds rest intervals is about 6.97 μmol/L and in the group with 90 seconds rest period is around 3.97 μmol/L.

Table 1. Descriptive characteristics before and after 8 weeks of circuit resistance training in different groups (Mean ± SD).

Variables		180 seconds	90 Seconds	Control	p
Age (years)		23.5 ±2.64	22.7 ±2.003	23.1 ±2.23	
Height (cm)		173.8 ±3.88	174.8 ±3.49	174.5 ±4.33	
Weight (kg)	Pre-test	72.03±4.86	73.32±4.76	72.52±5.37	0.318
	Post-test	71.61±4.92	72.75±4.36	72.52±5.37	
Body fat percentage (%)	Pre-test	18.22±1.92	19.1±1.69	17.88±1.54	*0.017
	Post-test	17.05±1.76	18.11±1.64	17.91±1.4	
BMI (Kilograms per meter squared)	Pre-test	23.83±0.89	23.98±1.06	23.8±1.13	0.0113
	Post-test	23.65±0.98	23.79±0.91	23.83±1.07	
Lean body mass (kg)	Pre-test	56.88±3.66	57.35±3.77	58.04±5.02	*0.024
	Post-test	58.83±3.83	58.63±3.66	58.09±4.59	

* A significant difference with a pre - test stage in all the three groups (p<0.05).

Table 2. Physiological characteristics of different groups before and after 8 weeks of circuit resistance training (Mean ± SD).

Variables	180 seconds	90 Seconds	Control
(CRP (pg / ml			
pre-test	1.481 ± 0.19	1.580 ± 0.2	1.666 ± 0.22
Post-test	1.421 ± 0.18	1.557 ±0.18	1.664 ± 0.2
The significance level	0.025*	0.045*	NS
Homocysteine (micromoles per liter)			
Pre-test	9.05 ± 0.79	7.86 ±0.68	8.09 ± 0.58
Post-test	8.46 ± 0.81	7.56 ± 0.61	8.06 ± 0.55
The significance level	0.011*	0.032*	NS

* Significance at level (P≤ 0.05)

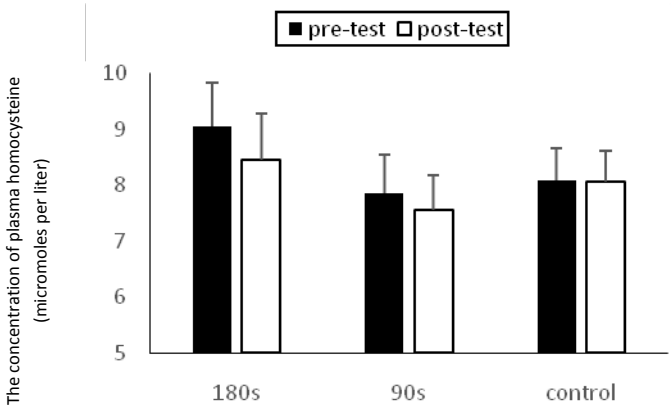

Figure 1. The comparison between plasma homocysteine concentrations in research

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groups at various stages of measurement.

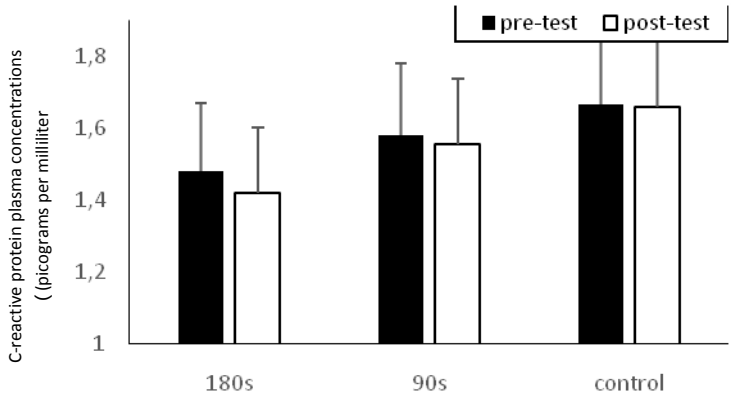

Figure 2. The comparison between plasma concentrations of C-reactive protein in research groups at various stages of measurement.

The results in table 4.2 and figure 4.2 represent that the plasma concentration of C-reactive protein was significantly decreasedat various stages of measurement (P=0.013). The decline in the group with 180 seconds rest intervals is approximately 4.22 μmol/L and in the group with 90 seconds rest period is about 1.48 μmol/L.

DISCUSSION

The results of the present study revealed that serum homocysteine levels, after 8 weeks of resistance training, in experimental groups with 90 and 180 seconds rest between sets significantly decreased, however no significant change was detected in the control group.

Several studies revealed a significant inverse relationship between physical activity and inflammatory markers. The results of the studies represent that people who are physically active and have better physical fitness have lower levels of inflammatory markers (1). Nygard et al. (25) and Gaume et al. (9) declared that one of the possible reasons for the consistency was perhaps the initial level of homocysteine, as well as the physical fitness. Since a significant reduction in homocysteine after physical training represents that the initial level of homocysteine and physical fitness effect on the exercise-induced changes (26).

The findings showed that the exercise was more significant and effective on sedentary subjects with lower physical fitness and high basic levels of homocysteine.

The findings in the following conducted studies all have reported that exercise can reduce homocysteine levels: (eight weeks of aerobic exercise in sedentary women) (12), (six-month training program) (31), (6 months of resistance training for older overweight and normal-weight adults) (43), the effects of two types of protocols, including resistance training hypertrophy (90 seconds rest between sets) and strength training programs (180 seconds rest between sets) for six weeks. In general, regular physical exercise increases the metabolic reactions required for growthand repair muscle tissue. Since high metabolic reactions increase the need for methionine to create energy and protein synthesis, and because homocysteine is an intermediate material used in methionine metabolism, its value is reduced (15). Also, regular exercise reduces the Oxygen deficit and after that body's need for Phosphagen system is reduced. Creatine is synthesized when methionine is turned into homocysteine in the body, so a reduction in the need for synthesis of creatine in the body is associated with lowering homocysteine levels (18). Hence, another possible reason for lowering homocysteine levels is perhaps the lack dependency to Phosphagen system when there is oxygen deficit. On the other hand, McAnulty et al. (21) (a triathlon competitive racing), Hammouda et al. (11) (one session of acute resistance exercise in sedentary young men) conducted a study to measure the levels of homocysteine and concluded there is no significant difference in homocysteine levels of experimental and control groups. Robinson et al. studies the effects of different rest intervals (180, 90 and 30 seconds) between sets of resistance training on the resistive index of inflammatory activity in men. They finally reported that homocysteine level

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was decreased in 180 and 90 seconds rest intervals, but no significant reduction in homocysteine level was observed in 30 seconds rest (5). Mayhew et al. (20) conducted a study to examine the effects of the rest intervals in high and medium intensity resistance training on inflammatory markers in sedentary students and reported that intense workouts compared to the lower intensity workouts shows a significant increase in homocysteine levels.

Also, McAnulty et al. (21) implemented the four-week endurance training with high intensity for active people and athletes, e Silva & da Mota (2014)and Real et al.,(2005)studied the effect of Marathon competition in athletes. They all reported that these types of exercises either cause either no significant difference or increase homocysteine serum. The findings of the present study represent no consistency with the results of the above-mentioned studies.Results of some findings represent that prolonged or heavy exercise; protein metabolism and blood concentration make changes in certain amino acids and reduces concentrations of methionine.Reducing the availability of methionine increases its synthesis. In this way, the mechanism of protein transfer increases homocysteine concentration during long or difficult training sessions(15). Another reason for the inconsistency in results are that high intensity exercise increases the transfer of methyl groups which in turn increases homocysteine levels. Increase in the methyl group transfer for any reason, including intensity exercise results in increase homocysteine levels (Joubert, 2008). The other reason is likely the increase in oxidative stress and decrease in the bodycapacity to deal with free radicals of oxygen formed after the long and intensive physical activity (18). Hence, almost certainly one of the reasons of inconsistency of the findings is that researchers conducted experimental studies with long-term, intensive and heavy exercises. Although, the present study, think to proper rest intervals, isn't categorized as intense workouts.

The results of this study showed that CRP levels, after 8 weeks of resistance training circuit in the experimental groups with different rest intervals, significantly decreased; whereas no significant change was detected in the control group. Also, comparisons between two experimentalgroups and control group represent that CRP has significantly changed.

Vidyasagar (2013), conducted a study to compare the effectiveness of three different intensities of exercise on CRP levels. The results of the study represent that CRP was significantly reduced in all three groups with different intensities. Hudson et al. (13) reported the effects of two types of protocols, including resistance training, hypertrophy (90 seconds rest between sets) and strength training programs (180 seconds rest between sets), for six weeks. They found that both trainings reduce CRP. Church et al. (4) and Phillips et al. (30) studied the effect of resistance training on levels of CRP circulating among old, obese and menopause women. The results are consistent with the findings of the present study. Various studies examined the fat weight loss and inflammation CRP reduction, the results represented that a decisive factor in reducing CRP is the diminution of the fat mass.

Fat weight loss has been observed in the experimental groups with Different rest intervals, in the present study. It is possible that fat weight loss leads to a reduction in CRP. The mechanism decreasing the CRP through fat weight loss is not totally clear (28). One of the new findingsis that macrophages absorbed from the blood circulation are the main source of inflammatory markers (7). However, it has been observed that physical activity resulted in a decrease in macrophageinfiltration into fat tissue. Therefore, it is believed that physical exercise reduces the fat mass and less macrophage infiltration by which less inflammatory markers are produced by fat tissue (2). Perhaps the training program of the present study, which results in reduction in fat mass, has actedas anti-atherogenic and risk factors in the experimental groups, and CRP has been reduced.

In general, regular physical activity and sport exercise upsurges cardiovascular protection capacity and thus improve the quality of life (16). However, the relationship between physical activity and CRP has not been verified in a few studies. Mayhew et al. (20), conducted a study to examine the effects of high and moderate intensity resistance training on inflammatory markers in sedentary students and reported thatintense workouts, compared to the moderate ones, significantly increases CRP levels.

Swift et al. (39) investigated three types of exercises including, aerobic, resistance and concurrent exercises for 9 months. The results showed that CRP values, in response to three types of exercises, did not display a significant reduction. Sheikholeslami et al. (34) also showed that CRP levels in healthy young men didn't change after six

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weeks of moderate or high intensity resistance training. The results of the mentioned studies are not consistent with the findings of this study because it has proper rest intervals to recover. This lack of consistency may be due to muscle damage caused by exercise because it stimulates the production of IL- 6, which is produced in the very beginning stage of the inflammatory response to repair the damage muscle and it is the main trigger of the CRP production (34). Thus, the muscle damage increases topical production of CRP and this increases the CRP serum after physical training (22). In addition, the production of mechanical stress and endothelial cell activation is possibly responsible for the increase in levels of CRP serum after long and heavy workouts.Therefore, interpreting the results of the CRP, such factors as the potential harms, intensity, type and volume of training (40) features of subjects such as age, sex, obesity and body mass index inflammatory and infectious diseases, baseline levels of CRP and some other factors should be considered.

It seems that cases such factors as weight loss, lose body fat levels, loss of body mass index, enough increase in muscle strength and decreasing inflammation are possible mechanisms by which exercise affects the homocysteine and CRP levels. So probably running the eight weeks of resistance exercise with different rest intervals (high and moderate intensity) in the present study can activate the mechanism so that they decrease and change the level of circulating of homocysteine and CRP. The results reveal that eight weeks of resistance trainingwith rest intervals reduce the risk of atherosclerosis disease and improve cardiovascular health through reducing the percentage of body fat, increasing the muscle strength and antioxidant defenseand reducing the risk of cardiovascular inflammatory markers (homocysteine and CRP). Also, anti-inflammatory effects of exercise training in humans play an important role in reducing inflammatory markers in human beings and resistance training with proper rest intervals (low intensity) can be a suitable method to deal with inflammation and cardiovascular risk factors. Therefore, it is recommended that resistance training with proper intensity can be used to prevent adverse effects of increased incidence of atherosclerosis disease for people with sedentary lifestyle.

REFERENCES

1. Abramson JL, Vaccarino V. Relationship between physical activity and inflammation among apparently healthy middle-aged and older US adults. Archives of Internal Medicine, 2002; 162(11): 1286–1292.
2. Bruun JM, Helge JW, Richelsen B, Stallknecht B. Diet and exercise reduce low-grade inflammation and macrophage infiltration in adipose tissue but not in skeletal muscle in severely obese subjects. American Journal of Physiology-Endocrinology and Metabolism, 2006; 290(5): E961–E967.
3. Choi JK, Moon KM, Jung SY, Kim JY, Choi SH, Kim DY, Kwon SM. Regular exercise training increases the number of endothelial progenitor cells and decreases homocysteine levels in healthy peripheral blood. The Korean Journal of Physiology & Pharmacology, 2014; 18(2): 163–168.
4. Church TS, Earnest CP, Thompson AM, Priest E, Rodarte RQ, Sanders T, Blair SN. Exercise without weight loss does not reduce C-reactive protein: the INFLAME study. Medicine and Science in Sports and Exercise, 2010; 42(4): 708.
5. Desalles BF, Simao R, Miranda F, da Silva Novaes J, Lemos A, Willardson JM. Rest interval between sets in strength training. Sports Medicine, 2009; 39(9): 765–777.
6. e Silva Ade S, da Mota MP. Effects of physical activity and training programs on plasma homocysteine levels: a systematic review. Amino Acids, 2014; 46(8): 1795–1804.
7. Fantuzzi G. Adipose tissue, adipokines, and inflammation. Journal of Allergy and Clinical Immunology, 2005; 115(5): 911–919.
8. Fleck SJ, Kraemer W. Designing Resistance Training Programs, 4E. Human Kinetics, 2014..
9. Gaume V, Mougin F, Figard H, Simon-Rigaud ML, N'guyen UN, Callier J, Berthelot A. Physical training decreases total plasma homocysteine and cysteine in middle-aged subjects. Annals of Nutrition and Metabolism, 2005; 49(2): 125–131.
10. Goldfarb AH, Garten RS, Chee PDM, Cho C, Reeves GV, Hollander DB, Kraemer RR. Resistance exercise effects on blood glutathione status and plasma protein carbonyls: influence of partial vascular occlusion. European Journal of Applied Physiology, 2008; 104(5): 813–819.
11. Hammouda O, Chaouachi A, Ferchichi S, Kallel C, Souissi N. The Effect of short-term maximal exercises on biochemical markers of muscle damage, total antioxidant status, and homocysteine levels in football players. Asian Journal of Sports Medicine, 2012; 3(4): 239.
12. Hejazi SM, Rashidlamir A, Jebelli A, Nornematolahi S, Ghazavi SM, Soltani M. The effects of 8 weeks aerobic exercise on levels of homocysteine, HS-CRP serum and plasma fibrinogen in type II diabetic women. Life Science Journal, 2013; 10 (1).
13. Hudson MB, Hosick PA, McCaulley GO, Schrieber L, Wrieden J, Mcanulty SR, Quindry JC. The effect of resistance exercise on humoral markers of oxidative stress. Medicine and Science in Sports and Exercise, 2008; 40(3): 542.
14. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. British Journal of Nutrition, 1978; 40(3): 497–504.
15. Joubert LM. Exercise, nutrition, and homocysteine. ProQuest, 2008.
16. LaMonte MJ, Durstine JL, Yanowitz FG, Lim T, DuBose KD, Davis P, Ainsworth BE. Cardiorespiratory fitness and C-

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reactive protein among a tri-ethnic sample of women. Circulation, 2002; 106(4): 403–406.

17. Lee YH, Song YW, Kim HS, Lee SY, Jeong HS, Suh SH, Noh CI. The effects of an exercise program on anthropometric, metabolic, and cardiovascular parameters in obese children. Korean Circulation Journal, 2010; 40(4): 179–184.
18. Mann DL, Zipes DP, Libby P, Bonow RO. Braunwald's heart disease: a textbook of cardiovascular medicine. Elsevier Health Sciences, 2014.
19. Maud PJ, Foster C. Physiological assessment of human fitness. Human Kinetics, 2006.
20. Mayhew DL, Thyfault JP, Koch AJ. Rest-interval length affects leukocyte levels during heavy resistance exercise. The Journal of Strength & Conditioning Research, 2005; 19(1): 16–22.
21. McAnulty SR, McAnulty LS, Nieman DC, Morrow JD, Shooter LA, Holmes S, Henson DA. Effect of alpha-tocopherol supplementation on plasma homocysteine and oxidative stress in highly trained athletes before and after exhaustive exercise. The Journal of Nutritional Biochemistry, 2005; 16(9): 530–537.
22. Namazi A, Aghaalinejad H, Peeri M, Rahbarizadeh F. The effects of short term circuit resistance training on serum homocysteine and CRP concentrations in active and inactive females. Iranian Journal of Endocrinology and Metabolism, 2010; 12(2): 169–176.
23. Neuman JC, Albright KA, Schalinske KL. Exercise prevents hyperhomocysteinemia in a dietary folate-restricted mouse model. Nutrition Research, 2013; 33(6): 487–493.
24. Nikbakht HA, Amirtash AM, Gharouni H, Zafari A. Correlation of physical activity with serum fibrinogen and homocysteine concentration in active, sedentary and with CAD males, 2007.
25. Nygard O, Vollset SE, Refsum H, Stensvold I, Tverdal A, Nordrehaug JE, Kvåle G. Total plasma homocysteine and cardiovascular risk profile: the HordalandHomocysteine Study. Jama, 1995; 274(19): 1526–1533.
26. Okura T, Rankinen T, Gagnon J, Lussier-Cacan S, Davignon J, Leon AS, Bouchard C. Effect of regular exercise on homocysteine concentrations: the heritage Family Study. European Journal of Applied Physiology, 2006; 98(4): 394–401.
27. Panic N, Leoncini E, de Belvis G, Ricciardi W, Boccia S. Evaluation of the endorsement of the preferred reporting items for systematic reviews and meta-analysis (PRISMA) statement on the quality of published systematic review and meta-analyses. Plus One, 2013; 8(12): e83138.
28. Patrick L, Uzick M. Cardiovascular disease: C-reactive protein and the inflammatory disease paradigm: HMG-CoA reductase inhibitors, alpha-tocopherol, red yeast rice, and olive oil polyphenols. A review of the literature. Alternative Medicine Review, 2001; 6(3): 248–248.
29. Paziraei M, Azadmanesh M, Mogharnasi M, Rezaei M. (N.d.). The Interactive Effect of Aerobic Exercise and Omega-3 Fatty Acids Supplement on Plasma Homocysteine Concentration and sICAM-1 in Elderly Men.
30. Phillips MD, Patrizi RM, Cheek DJ, Wooten JS, Barbee JJ, Mitchell JB. Resistance training reduces subclinical inflammation in obese, postmenopausal women. MEDSci Sports Exerc, 2012; 44(11): 2099–2110.
31. Randeva HS, Lewandowski KC, Drzewoski J, Brooke-Wavell K, O'Callaghan C, Czupryniak L, Prelevic GM. Exercise decreases plasma total homocysteine in overweight young women with polycystic ovary syndrome. The Journal of Clinical Endocrinology & Metabolism, 2002; 87(10): 4496–4501.
32. Real JT, Merchante A, Gomez JL, Chaves FJ, Ascaso JF, Carmena R. Effects of marathon running on plasma total homocysteine concentrations. Nutrition, Metabolism and Cardiovascular Diseases, 2005; 15(2): 134–139.
33. Schneeberg A. Investigation Into the Relationship Between Physical Activity and Total Plasma Homocysteine. In Masters Abstracts International, 2007; 46.
34. SheikholeslamiVatani D, Ahmadi S, Ahmadi Dehrashid K, Gharibi F. Changes in cardiovascular risk factors and inflammatory markers of young, healthy, men after six weeks of moderate or high intensity resistance training. The Journal of Sports Medicine and Physical Fitness, 2011; 51(4): 695–700.
35. Shi Z, Guan Y, Huo YR, Liu S, Zhang M, Lu H, Ji Y. Elevated total homocysteine levels in acute ischemic stroke are associated with long-term mortality. Stroke, 2015; 46(9): 2419–2425.
36. Shih KC, Janckila AJ, Kwok CF, Ho LT, Chou YC, Chao TY. Effects of exercise on insulin sensitivity, inflammatory cytokines, and serum tartrate-resistant acid phosphatase 5a in obese Chinese male adolescents. Metabolism, 2010; 59(1): 144–151.
37. Siri WE. Body composition from fluid spaces and density: analysis of methods. Techniques for Measuring Body Composition, 1961; 61: 223–44.
38. Stefani GP, Nunes RB, Dornelles AZ, Alves JP, Piva MO, Di Domenico M, Dal Lago P. The Effects of creatine supplementation associated with resistance training on oxidative stress in different tissues of rats. Journal of the International Society of Sports Nutrition, 2014; 11(1): 1.
39. Swift DL, Johannsen NM, Earnest CP, Blair SN, Church TS. The Effect of Exercise Training Modality ofC-reactive Protein in Type-2 Diabetes. Medicine and Science in Sports and Exercise, 2012; 44(6): 1028.
40. Talebi-Garakani E, Safarzade A. Resistance training decreases serum inflammatory markers in diabetic rats. Endocrine, 2013; 43(3): 564–570. http://doi.org/10.1007/s12020-012-9786-9.
41. Uchida MC, Bacurau RFP, Navarro F, Pontes Jr FL, Tessuti VD, Moreau RL, Aoki MS. Alteration of testosterone: cortisol ratio induced by resistance training in women. RevistaBrasileira de Medicina Do Esporte, 2004; 10(3): 165–168.
42. Vidyasagar S. Dose response relationship between exercise intensity and C reactive protein in healthy individuals, 2013.
43. Vincent HK, Bourguignon C, Vincent KR. Resistance training lowers exercise-induced oxidative stress and homocysteine levels in overweight and obese older adults. Obesity, 2006; 14(11): 1921–1930.

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