doi:10.22100/ijhs.v5i2.610
Original Article

IJHS 2019;5(2):25-30
ijhs.shmu.ac.ir

IJHS
International Journal of Health Studies

Cardiovascular Effects of Circular Training (Resistance-Interval) Combined with Berberine on Overweight Elderly Men

Sayed Alireza Ghorashi[1], Shirin Zilaei Bouri[2*], Mohammad Ali zarbayjani[3]

[1] Department of Physical Education and Sport Sciences, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran.
[2] Department of Physical Education and Sport Sciences, Masjed Soleyman Branch, Islamic Azad University, Masjed Soleyman, Iran.
[3] Department of Exercise Physiology, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

Received: 1 July 2019
Accepted: 17 July 2019

Abstract

Background: *Obesity and overweight, along with inactive lifestyle, have been introduced as the most important risk factors of cardiovascular diseases, especially among elderly. This study aimed to determine the effect of circular training (resistance-interval) combined with berberine on cardiovascular risk factors and C reactive protein (CRP) in overweight elderly men.*

Methods: *40 sedentary healthy elderly male with the ages ranged from 50 to 55 years old were divided into 4 groups as following: circular training (resistance-interval, 8 weeks, 3 times/weekly) (CT), berberine supplementation (BS), circular training combined with berberine (CT-BS), and control (CON) groups (n = 10 each group). The duration of Intervention was 8 weeks. Fasting blood samples were collected before and 48 hours after the last training session to determine the cardiovascular risk factors (TG, TC, LDL, HDL) and serum CRP for all groups. Multivariate analysis of covariance (MANCOVA) was used to compare the groups' results.*

Results: *All interventions (CT, BS, and CT-BS) resulted in significant decrease in TG, TC, and LDL, and also an increase in DL. Serum CRP was significantly decreased in CT and CT-BS groups, but not in BS. In addition, significant difference was observed in cardiovascular risk factors and CRP within groups with emphasizing more on cardiovascular effects of CT-BS.*

Conclusions: *Based on the results, it is concluded that circular trainings combined with berberine supplementation is associated with more cardiovascular effectiveness than each one alone in overweight elderly men.*

Keywords: Cardiovascular risk factor, Circular exercise, Berberine, Elderly, Overweight
***Corresponding to:** SH Zilaie Bouri, **Email:** shirinzilaei@iau.ac.ir.
Please cite this paper as: Ghorashi SA, Zilaei Bouri S, Azarbayjani MA. Cardiovascular effects of circular training (resistance-interval) combined with berberine on overweight elderly men. Int J Health Stud 2019;5(2):25-30.

Introduction

Over recent years, the prevalence of obesity and overweight in both developed and developing countries has been remarkably increased as some experts have recognized it as a "hidden epidemic".[1] Nowadays, obesity is not only taken into consideration due to its association with chronic diseases such as cardiovascular diseases, diabetes, hypertension, hyperlipidemia, and cancer, but is also accentuated as a risk factor for mortality.[2] Obesity is associated with an increase in TG, TC, and LDL levels and a decrease in HDL level, in response to which the resistance of the peripheral vessels decreases, which is accompanied with coronary artery disease and hypertension.[3] Moreover, the increased levels of pre-inflammatory cytokines such as CRP have also been reported in the presence of obesity and overweight.[4] The mentioned inflammatory marker has been introduced as one of the most significant clinical markers for the diagnosis of inflammation and cardiovascular diseases by the Centers for disease control and prevention (CDC) in the united states.[2] The findings obtained from the clinical trials have accentuated the higher levels of this inflammatory marker in patients with coronary artery disease, type 2 diabetes, obesity, and sedentary lifestyle.[5] The prevalence of peripheral vascular diseases and sudden cardiac death can also be regarded as the consequences of the increased levels of CRP.[6] However, some studies have suggested that CRP is not associated with LDL, as another risk factor for cardiovascular diseases.[7] Considering the presented discussion, for the diagnosis of cardiovascular diseases, researchers propose that simultaneous evaluation of both CRP and LDL along with other cardiovascular risk factors are more appropriate than measuring each factor alone.

Hence, presentation of appropriate strategies employing intrinsic or extrinsic stimuli for reducing the body fat tissue in obese or overweight subjects with various age ranges, has always grasped the attention of health and wellness researchers. In this regard, scientific resources have acknowledged the role of exercise in reducing the levels of pro-inflammatory mediators in healthy or patient populations.[8] It has been mentioned that weight loss programs proposed for obese subjects result in a reduction in the level of CRP along with an increase in adiponectin.[9] Moreover, the findings of a study conducted by Kadoglou et al. (2007) indicated that aerobic training for three sessions per week for the period of six months not only resulted in a significant decrease in insulin resistance and lipid profile markers such as TG, TC, and LDL, but also caused an increase in the level of HDL in obese subjects.[10] However, some studies have reported that the levels of CRP and other cardiovascular risk factors have not been changed following the long-term exercise training programs.[11] The findings presented by Bouchonville et al. (2013) indicated that 12 months of aerobic training resulted in no significant changes in the levels of lipid profile, glucose, and some inflammatory or anti-inflammatory markers.[12] Boroujeni et al. (2014) reported that eight weeks of resistance training in obese men caused no any significant changes in lipid profile markers such as TG, TC, and LDL.[13]

In addition to studies addressing the effects of exercise training on cardiovascular function, some studies have evaluated the effectiveness of nutritional or herbal supplements on cardiovascular function or other metabolic factors in different populations. In this respect, berberine has been

introduced as herbal alkaloid with a very long history of use in medicine. The origin of recognizing its therapeutic effects dates back to 2500 years ago in India and China. The compounds of this effective alkaloid substance are mostly found in the roots, rhizome, and cortex of stems in Berberis vulgaris and Berberis aristata.[14] Moreover, it has been reported to affect the influential factors in diabetes, cancer, depression, hypertension, and lipids in the serum.[15] In addition, by consuming that the absorption rate of TC in dietary intake reduced by 40- 51%.[16] The combined effects of berberine with Policosanols and red yeast rice on reducing the levels of LDL-C and TG in hypercholesterolemic mice have been presented in the literature.[17] However, its combined effect with field stimuli such as exercise training on cardiovascular function, especially in the presence of obesity and overweight, in elderly subjects, has not been reported so far.

Briefly, although most studies have acknowledged the effectiveness of exercise training and berberine consumption on cardiovascular risk factors, no study has addressed the concurrent effects of berberine consumption and exercise training, particularly circular training, on cardiovascular function, especially among overweight elderly subjects. Therefore, the present study aimed at investigating the effect of combined circular trainings (interval-resistance) along with berberine consumption on CRP and cardiovascular risk factors in overweight elderly men.

Materials and Methods

At first, 40 sedentary age-matched overweight males (50 - 55 years, BMI 25 - 30 kg / m^2) were elected through purposive sampling in this semi-experimental study with pre and post-training design. Then, they were divided into circular training (resistance-interval, 8 weeks, 3 times/weekly) (CT), berberine supplementation (BS), circular training combined with berberine (CT-BS), and control (CON) groups (n = 10 each group) based on random allocation using a table of random numbers. The duration of the whole intervention lasted 8 weeks. Main objective of this study was to determine cardiovascular risk factors (TG, TC, LDL, and HDL) and CRP responses to each intervention, and also to compare them with each other. An informed consent was obtained from all participants before study was carried out, and the Ethics Committee of Islamic Azad University approved this study.

All subjects were non-smoker and non-alcoholics. Subjects participated in no regular exercise/diet programs for the preceding 6 months. None of the subjects used drugs or therapies for obesity, and none had a history of disease or injury that would prevent daily exercise. The exclusion criteria were as follows: Patients with known history of respiratory infections, neuromuscular disease, cardiopulmonary disease and type II diabetes, or other chronic diseases.

Anthropometric measurements of height, weight, body fat percent, and circumference measurements were taken study. Overweight was measured by body mass index (BMI). Body mass index (BMI) was calculated by dividing body mass (kg) by height in meters squared (m^2). Body weight and height were measured with the subject wearing light clothes. Abdominal circumference (WC) was measured at the superior border of the iliac crest, and was taken to the nearest 0.1 cm after a normal expiration. Body fat Percentage was measured using body composition monitor (OMRON, Finland).

As it was mentioned above, subjects were assigned into 4 separate groups as follows: circular training (CT), berberine supplementation (BS), CT-BS, and control (CON) groups (n = 10 each group).

Training protocol for CT group was performed 3 times per week consisting of combined interval and resistance exercise in each exercise session. In each exercise session, they performed warm-up for 5 - 10 min, followed by interval, and then resistance exercise. Interval exercise was in the form of running on a smooth surface without a gradient in the specified intensity range. The intensity distribution of interval training was adapted from the practice protocol of some previous studies on elderly people, [18,19,20] (modified). After completing the interval section, the subject performed stretching for 5 minutes, especially muscles involved in resistance training. Tensile movements were performed with two purposes, one was the recovery of the subsequent interval exercise, and the other one was warming up the muscles and joints for resistance training. After the tensile moves, circular resistance training was performed. For the purpose of the principle of training variation and reduction of exercise uniformity, as well as strengthening muscles at different angles, resistance training was performed in a fixed (circular) manner and at each training station, a muscle with a different station was different to follow the principle of the overload of exercise diversification experienced by the subject. Applying the intensity distribution of resistance training divided by week was adapted from some similar studies in this age range,[21,22] (modified).

In BS group, subjects received 0.4 of berberine at 3 consecutive times daily (totally 1200g, daily) for 8 weeks. In CT-BS group, subjects completed a circular training (CT) along with berberine supplementation (BS) according to what was mentioned above for 8 weeks. However, in control group, the subjects continued their usual life pattern before studying and there was no intervention or medication on them.

Fasted blood samples (10 - 12-hour overnight fasting) were collected at pre and post (48 h after lasted exercise session) intervention with regard to measure TG, TC, LDL, HDL and serum CRP of all 4 groups. The subjects performed no exercise for 48 hours before the blood collection. Serums were immediately separated and stored at -80° until the assays were performed. TG, TC, HDL and LDL-cholesterol as cardiovascular risk factors were measured by enzymatic methods (Randox direct kits) using Kobas Mira auto-analyzer made in Germany. Serum CRP was determined using ELISA method (Diagnostics Biochem Canada Inc. High sensitivity C reactive protein (Hs-CRP)). The Intra- assay coefficient of variation and sensitivity of the method were 8.3% and 10 pg / ml for CRP, respectively.

All statistical analyses were performed using a statistical software package (SPSS, Version 15.0, SPSS Inc., IL, USA). Normality of distribution was assessed by Kolmogorov-

Smirnov. Independent sample T-test was used to compare all variables between two groups at baseline. Multivariate analysis of variance was used to examine baseline differences between groups. Paired t-test was used to determine the mean differences between pre and post-intervention values on all clinical and anthropometric variables. Significant level was set at 0.05.

Results

Pre and post intervention of anthropometrical indexes of two groups are shown in table 1. No significant difference was observed in all anthropometrical markers between groups at baseline level (Pvalue > 0.05). Compared to pre-intervention, a significant decrease was observed for anthropometrical indexes by CT, BS and CT-BS groups; however, these variables remained without changed in control subjects (data by Paired T test, see table 1).

Clinical characteristics of pre and post intervention for the subjects are described in table 2. No significant difference was observed in these variables between groups at baseline (Pvalue > 0.05).

Based on Multivariate analysis variance, significant changes were observed for all cardiovascular risk factors (TG, TC, LDL, and HDL) between groups. On the other hand, data obtained by post-hoc LSD indicated significant change between CT-BS with CT and BS. These data demonstrated that CT-BS intervention resulted in significant decrease in TG, TC and LDL and increase in HDL as compared with each CT or BS alone (table 3).

Multivariate analysis variance also showed significant change in CRP between groups (Pvalue = 0.001). However, during comparing the groups together by post-hoc LSD, differences between CON with CT and CT-BS were significant. On the other hand, CT and CT-BS intervention resulted in significant decrease in serum CRP compared to control group; however, the difference between CON and BS was not significant. Significant difference was also observed between BS with CT-BS. On the other hand, serum CRP was significantly decreased in CT-BS compared to BS alone. In addition, no significant difference was observed in serum CRP between CT-BS with CT alone (see table 4).

Table 1. Pre and post intervention of anthropometrical indexes for all groups (M ± SD)

Variable	Time	CON	CT	BS	CT-BS
Weight (kg)	pre	84.70 ± 2.82	83.90 ± 3.07	83.90 ± 2.89	85 ± 3.27
	post	84.80 ± 2.75	82.10 ± 2.97	82.60 ± 3.08	81.2 ± 2.53
	sig	0.213	< 0.001	0.004	< 0.001
AC (cm)	pre	94.60 ± 2.63	93.50 ± 3.50	92.60 ± 4.43	93.5 ± 2.51
	post	94.90 ± 2.89	90.80 ± 2.97	90.90 ± 4.77	88.3 ± 1.83
	sig	0.279	< 0.001	< 0.001	< 0.001
HC (cm)	pre	96.10 ± 2.73	94.90 ± 3.28	98.50 ± 4.05	95.7 ± 2.71
	post	96.10 ± 2.96	92.30 ± 3.34	94.10 ± 3.99	91.8 ± 2.44
	sig	0.998	< 0.001	< 0.001	< 0.001
BF (%)	pre	28.17 ± 1.22	27.74 ± 0.81	28.25 ± 0.77	27.67 ± 0.73
	post	28.07 ± 0.97	26.60 ± 0.75	27.58 ± 0.61	26 ± 0.34
	sig	0.476	< 0.001	< 0.001	< 0.001
BMI (k/m^2)	pre	28.59 ± 0.78	28.24 ± 0.74	28.16 ± 0.84	28.51 ± 0.70
	post	28.66 ± 0.72	27.60 ± 0.77	27.70 ± 1.00	27.3 ± 0.54
	sig	0.209	< 0.001	0.004	< 0.001

AC; abdominal circumference, HC; hip circumference, BF; body fat percentage, BMI; body mass index

Table 2. Pre and post intervention of anthropometrical indexes for all groups (mean ± SD)

Variable	Sampling time	CON	CT	BS	CT-BS
TG (mg/dL)	pre	165 ± 27	169 ± 10	162 ± 32	170 ± 80
	Post	161 ± 20	152 ± 14	142 ± 24	147 ± 50
TC (mg/dL)	pre	181 ± 30	183 ± 13	177 ± 22	187 ± 15
	Post	180 ± 25	163 ± 10	154 ± 13	159 ± 10
LDL (mg/dL)	pre	154 ± 15	165 ± 11	158 ± 22	160 ± 10
	Post	152 ± 12	150 ± 16	144 ± 23	141 ± 80
HDL (mg/dL)	Pre	42.0 ± 1.81	41.5 ± 1.35	41.8 ± 1.93	41.6 ± 1.84
	Post	42.4 ± 1.90	45.5 ± 2.22	44 ± 1.83	47 ± 1.56
CRP (pg/mL)	pre	6234 ± 943	6072 ± 725	6021 ± 845	6013 ± 864
	Post	6253 ± 918	55/3 ± 848	5498 ± 791	5154 ± 1156

AC; abdominal circumference, HC; hip circumference, BF; body fat percentage, BMI; body mass index

Table 3. Results of multivariate analysis variance for cardiovascular risk factors

Variables	Sum of Squares	df	Mean Square	F	Pvalue
TG	1712	3	428	1.174	< 0.001
TC	2818	3	705	2.10	< 0.001
LDL	1720	3	430	1.743	< 0.001
HDL	114	3	28.6	6.590	< 0.001

Table 4. Results of post-hoc LSD for serum CRP for studied groups

Group	Group	Difference mean	standard error	Pvalue
Control	CT	660.6	272.83	0.018
	BS	1484.1	272.83	0.080
	CT-BS	1089.2	272.83	0.001
CT	BS	176.5	272.83	0.521
	CT-BS	428.6	272.83	0.121
BS	CT-BS	605.1	272.83	0.030

Discussion

The findings of the present study revealed the effectiveness of combined exercise training along with berberine consumption on cardiovascular health condition among overweight elderly men. Moreover, the findings indicated an improvement in the cardiovascular risk factors (TG, TC, LDL, and HDL) and the level of CRP in response to the combination of berberine with circular trainings as compared with each one alone. In other words, 8 weeks of combined circular training (interval-resistance) along with berberine consumption resulted in a significant reduction in the levels of TG, TC, and LDL and a significant increase in the level of HDL in overweight elderly men, who had a sedentary lifestyle, previously. In line with the findings of the present study, Racil et al. (2013) expressed that 4 weeks of moderate and high intensity interval training could significantly lead to a reduction in the anthropometric indices and insulin resistance as well as a significant increase in HDL in obese subjects.[23] Jorge et al. (2011) in their study addressed the effect of various training methods on metabolic factors in diabetic obese subjects, and expressed that 12 weeks of aerobic, resistance, and combined trainings reduced the fasting glucose levels and improved the lipid profile markers (TG, TC, LDL, and HDL).[24] Similarly, Riesco et al. (2013) reported a significant increase in HDL as well as improvements in other lipid profile markers following a 16-week brisk walking program in obese or overweight subjects.[25]

However, in contrast with the findings of this study and the presented piece of evidence, Nazari et al. (2015) reported no significant changes in the metabolic syndrome factors such as fasting glucose, TG, systolic and diastolic blood pressure, waist-hip ratio, and the level of HDL and LDL in obese and overweight subjects with type 2 diabetes after 8 weeks of circular-resistance training.[26] In the study conducted by Colombo et al. (2013), no changes were observed in the level of TG, TC, and LDL in patients with metabolic syndrome after 12 weeks of brisk walking.[27] Usefipour et al. (2015) found that 8 weeks of aerobic training resulted in no changes in HDL and TC as compared with that of the control group.[28] Moreover, the findings of a study by Afshon Pour et al. (2016) revealed that although 8 weeks circular-resistance training led to a significant increase in HDL in male patients with type 2 diabetes, no significant changes were observed in the levels of TG, TC, and LDL.[29]

In spite of improvements in the cardiovascular risk factors in response to combined circular training, the levels of the mentioned risk factors were also improved in a group that received only supplementary berberine. In other words, an 8-week berberine supplementation led to a decrease in the levels of TG, TC, and LDL, and an increase in HDL. The presented findings clarify the fact that each of the combined circular training and berberine consumption are capable of improving the cardiovascular risk factors amongst overweight elderly subjects. In addition, the findings revealed that the improvement of the cardiovascular risk factors following the circular training along with berberine consumption was remarkably higher than the improvements provided by each of the interventions alone. In this regard, although the presented evidence is limited, some clinical studies have supported the effectiveness of berberine on cardiovascular risk factors in both human and animal samples. Berberine could lead to a reduction in the level of TC in blood circulatory system by negative regulation of LDL-C, inhibition of TC absorption, and acceleration of its excretion. In this regard, the available evidence reveals that Berberine consumption is associated with a 50% reduction in the TC absorption rate from the diet.[16] Furthermore, reduction of TC absorption in intestinal absorption cells and excretion of TC from the liver to the bile, can be considered as the other beneficial effects of berberine on the level of blood lipids.[30] Based on the presented evidence, it seems that in the combined circular training and Berberine group, decreased TC absorption rate or increased liver excretion by berberine consumption, along with the reducing effect of circular training (interval-resistance) concurrently paves the way for a significant improvement in the cardiovascular risk factors, as compared with each of the training and berberine groups alone.

In addition to the effectiveness of circular training and berberine consumption on the cardiovascular risk factors in the present study and some other studies, their anti-inflammatory effects have also been reported several times.[10,24] Kadoglou et al. (2007) reported a significant increase in serum IL-10, decrease in CRP and IL-18, and improvement in the cardiovascular risk factors and insulin resistance in response to aerobic training, for 3 sessions per week during six months in obese patients10. In a study conducted by Jorge et al. (2011), 12 weeks of aerobic, resistance, and combined trainings led to a decrease in fasting blood glucose, blood pressure, and CRP in diabetic obese subjects.[24] In this regard, the findings of the present study revealed the anti-inflammatory effect of combined circular trainings in obese male subjects. Eight weeks of combined circular training in the form of resistance and interval trainings could cause a reduction in the serum level of CRP in overweight elderly men.

In this respect, although there are few studies that merely examined the effects of combined circular training (interval -

resistance), some studies have reported the effects of other training methods on CRP. In line with the present study and in addition to the findings of the studies presented by Kadoglou (2007) and Jorge (2011), Etemad et al. (2016) revealed that two circular-resistance training programs with different rest intervals lasting for 8 weeks would result in a significant reduction in homocysteine and CRP in a group of healthy men.[31] Abbasi Delui et al. (2016) also indicated a significant reduction in CRP along with the weight and body fat tissue loss following eight weeks of resistance training in obese or overweight women.[32] Olson et al. (2007) reported a significant reduction in the serum level of CRP by passing one year from resistance training in obese subjects.[33] However, in contrast with the presented findings, in a recently conducted study, six months of aerobic training led to no significant changes in the level of CRP and some other inflammatory mediators such as TNF-α and IL-6 in obese or overweight subjects.[34] In another study, despite a significant improvement in TNF-α and IL-6, 12 weeks of aerobic and resistance training had no effect on the level of CRP levels in middle-aged obese men.[35] The observed contradiction in the findings can be attributed to the type, intensity, duration of the training program, the baseline levels of the inflammatory mediators, and the type of studied population.

Despite the findings of the present study and majority of the mentioned studies that acknowledged the anti-inflammatory properties of regular exercise training, significant changes in the level of CRP were not observed in the berberine group in comparison with the control group. The mentioned finding demonstrated that 8 weeks of berberine consumption can lead to no significant changes in the serum level of CRP. Lack of changes in the berberine group in the present study is in contrast with a recent study, in which berberine consumption in laboratory mice with induced hypertension led to a reduction in inflammatory mediators such as IL-6 and TNF-α in aortic endothelial cells.[36] In another study, as compared with the placebo consumption, 45 days of berberine consumption by STZ-induced diabetic rats resulted in a significant reduction in the TNF-α and NF-kB inflammatory mediators and apoptotic proteins such as caspase-8 as well as an increase in the anti-inflammatory mediators such as IL-10.[37] Based on the available evidence that supports the anti-inflammatory effects of berberine, insignificant changes in the level of CRR in response to berberine supplementation may be attributed to the small sample size, distribution of scores, or dosage and manner of berberine consumption during the intervention period. However, Li et al. (2016) have expressed that 28 days of berberine consumption with 100 or 200 mg per kg of body weight reduces the IL-1β, IL-4, IL-5, IL-6, IL-13, and IL-17 inflammatory markers, the level of pulmonary inflammation index, the activity of NF-κB signaling pathways, and the production of IgE in bronchoalveolar lavage fluid (BALF) in rats with ovalbumin-induced asthma.[38]

In conclusion, the results of the present study revealed that the level of CRP decreased in the training group; however, it had no change in the berberine group as compared with the control group. Moreover, there was no significant difference in the level of CRP between the training and the combined (berberine + training) groups. Meanwhile, there was a significant difference between the berberine and the combined (berberine + training) groups. The mentioned findings indicated that berberine supplementation with the mentioned dose and duration in the present study could not cause a significant change in the level of CRP in overweight elderly men. Based on the clinical evidence regarding this supplement, these results are somewhat controversial, and suggest the necessity of conducting further studies by manipulating the dose or duration of berberine consumption. In addition, it should be taken into account that Hu et al. (2012), in line with the earlier mentioned findings, have expressed that in comparison with the placebo group, taking 500 mg of berberine three times per day for 12 weeks by obese subjects resulted in a significant decrease in TG and TC; however, no significant changes were observed in the inflammatory mediators of IL-6, CRP, and TNF-α.[39]

Considering the available evidence, the implementation of circular trainings (interval + resistance) along with berberine consumption has more cardiovascular and anti-inflammatory effects, in comparison with application of each one alone. An eight-week circular training along with berberine supplementation has more positive effects on the cardiovascular risk factors along with reduced level of CRP in overweight elderly men. However, the recognition and understanding of the interactive effects of exercise training and berberine consumption on the factors of cardiovascular function require further research, especially over the elderly period.

Acknowledgement

We thank to all individuals for participating in study, and also to Islamic Azad university for financial support and cooperation in implementing this study(Research plan code: IR.SSRC.REC.1398.453).

Conflict of Interest

The authors declare that they have no conflict of interest.

References

1. Hersoug LG, Linneberg A. The link between the epidemics of obesity and allergic diseases: does obesity induce decreased immune tolerance? Allergy 2007;62:1205-13. doi:10.1111/j.1398-9995.2007.01506.x

2. Pearson TA, Mensah GA, Alexander RW, Anderson JL, Cannon RO 3rd, Criqui M, et al. Markers of inflammation and cardiovascular disease: application to clinical and public health practice: a statement for healthcare professionals from the Centers for Disease Control and Prevention and the American Heart Association. Circulation 2003;107:499-511. doi:10.1161/01.cir.0000052939.59093.45

3. Armstrong N, van Mechelen W. Pediatric exercise science and medicine. 2nd ed. London: Oxford University Press; 2000: p. 323-28.

4. Nicklas BJ, You T, Pahor M. Behavioural treatments for chronic systemic inflammation: effects of dietary weight loss and exercise training. CMAJ 2005;172:1199-209. doi:10.1503/cmaj.1040769

5. Bruun JM, Lihn AS, Verdich C, Pedersen SB, Toubro S, Astrup A, et al. Regulation of adiponectin by adipose tissue-derived cytokines: in vivo and in vitro investigations in humans. Am J Physiol Endocrinol Metab 2003;285:E527-33. doi:10.1152/ajpendo.00110.2003

6. Albert CM, Ma J, Rifai N, Stampfer MJ, Ridker PM. Prospective study of C-reactive protein, homocysteine, and plasma lipid levels as predictors of sudden cardiac death. Circulation 2002;105:2595-9. doi:10.1161/01.cir.0000017493.03108.1c

7. Verma S, Szmitko PE, Ridker PM. C-reactive protein comes of age. Nat Clin Pract Cardiovasc Med 2005;2:29-36. doi:10.1038/ncpcardio0074

8. Julia W, Karen C, Javier R, Ascension M. Role of physical activity on immune function Physical activity, exercise and low-grade systemic inflammation. Proceedings of the Nutrition Society 2010; 69: 400–406. doi:10.1017/ S0029665110001928.

9. Ouchi N, Kihara S, Funahashi T, Nakamura T, Nishida M, Kumada M ,et al. Reciprocal association of C-reactive protein with adiponectin in blood stream and adipose tissue. Circulation 2003;107:671-4. doi:10.1161/01.cir.0000055188.83694.b3

10. Kadoglou NP, Iliadis F, Angelopoulou N, Perrea D, Ampatzidis G, Liapis CD, et al. The anti-inflammatory effects of exercise training in patients with type 2 diabetes mellitus. Eur J Cardiovasc Prev Rehabil 2007;14:837-43. doi:10.1097/HJR.0b013e3282efaf50

11. Kim SK, Jung I, Kim JH. Exercise reduces C-reactive protein and improves physical function in automotive workers with low back pain. J Occup Rehabil 2008;18:218-22. doi:10.1007/s10926-007-9120-1

12. Bouchonville M, Armamento-Villareal R, Shah K, Napoli N, Sinacore DR, Qualls C, et al. Weight loss, exercise or both and cardiometabolic risk factors in obese older adults: results of a randomized controlled trial. Int J Obes 2013;38:423-31. doi:10.1038/ijo.2013.122

13. Eatemady-Boroujeni A, Kargarfard M, Mojtahedi H, Rouzbehani R, Dastbarhagh H. Comparison of the effects of 8-weeks aerobic training and resistance training on lipid profile in patients with diabetes type 2. J Isfahan Med Sch 2014;32:524-33.

14. Vuddanda PR, Chakrabory S, Singh S. Berberine: a potential phytochemical with multispectrum therapeutic activities. Expert Opin Investig Drugs 2010;19:1297-307. doi:10.1517/13543784.2010.517745

15. Zhou J, Zhou S, Tang J, Zhang K, Guang L, Huang Y, et al. Protective effect of berberine on beta cells in streptozotocin- and high-carbohydrate/ high-fat diet-induced diabetic rats. Eur J Pharmacol 2009;606:262-8. doi:10.1016/j.ejphar.2008.12.056

16. Wang Y, Yi X, Ghanam K, Zhang S, Zhao T, Zhu X. Berberine decreases cholesterol levels in rats through multiple mechanisms, including inhibition of cholesterol absorption. Metabolism 2014;63:1167-77. doi:10.1016/ j.metabol.2014.05.013

17. Affuso F, Ruvolo A, Micillo F, Saccà L, Fazio S. Effects of a nutraceutical combination (berberine, red yeast rice and policosanols) on lipid levels and endothelial function randomized, double-blind, placebo-controlled study. Nutr Metab Cardiovasc Dis 2010;20:656-61. doi:10.1016/ j.numecd.2009.05.017

18. Sharifi GR, Banihashemi M, Rahnema N, Babaei AR. Comparison of the effect of 8 weeks aerobic exercise with resistance exercise on brain-derived neurotrophic factor in elderly men. Iranian Journal of Ageing 2015;10:148-54.

19. Lang UE, Hellweg R, Seifert F, Schubert F, Gallinat J. Correlation between serum brain-derived neurotrophic factor level and an in vivo marker of cortical integrity. Biological Psychiatry 2007;62:530-5. doi:10.1016/ j.biopsych.2007.01.002

20. Gomez-Pinilla F, Ying Z, Opazo P, Roy RR, Edgerton VR. Diffrential regulation by exercise of BDNF and NT-3 in rat spinal cord and skeletal muscle. Eur J Neurosci 2001;13:1078-84. doi:10.1046/ j.0953-816x.2001.01484.x

21. Abdul-Hameed U, Rangra P, Yakub Shareef M, Ejaz Hussain M. Reliability of 1-repitition maximum estimation for upper and lower body muscular strength measurement in untrained middle aged type 2 diabetic patients. Asian J Sports Med 2012;3:267-73. doi:10.5812/asjsm.34549

22. Saghebjoo M, Shabanpoor O, Fathi R. Effects of 8 weeks high intensity circuit resistance training on plasma chemerin levels and glycemic control in male patients with type 2 diabetes. Olympic 2013;21:99-115.

23. Racil G, Ben Ounis O, Hammouda O, Kallel A, Zouhal H, Chamari K, et al. Effects of high vs. moderate exercise intensity during interval training on lipids and adiponectin levels in obese young females. Eur J Appl Physiol 2013;113:2531-40. doi:10.1007/s00421-013-2689-5

24. Jorge ML, de Oliveira VN, Resende NM, Paraiso LF, Calixto A, Diniz AL, et al. The effects of aerobic, resistance, and combined exercise on metabolic control, inflammatory markers, adipocytokines, and muscle insulin signaling in patients with type 2 diabetes mellitus. Metabolism 2011;60:1244-52. doi:10.1016/j.metabol.2011.01.006

25. Riesco E, Tessier S, Lacaille M, Pérusse F, Côté M, Després JP, et al. Impact of a moderate-intensity walking program on cardiometabolic risk markers in overweight to obese women: is there any influence of menopause? Menopause 2013;20:185-93. doi:10.1097/gme.0b013e31826f7ebf

26. Nazari M, Gholamrezaei SH, Shabani R. Effect of a period circuit resistance training on components of the metabolic syndrome in females with type II diabetes. Iranian Journal of Endocrinology and Metabolism 2015;17:362-70.

27. Colombo CM, de Macedo RM, Fernandes-Silva MM, Caporal AM, Stinghen AE, Costantini CR, et al. Short-term effects of moderate intensity physical activity in patients with metabolic syndrome. Einstein (Sao Paulo) 2013;11:324-30. doi:10.1590/s1679-45082013000300011

28. Usefipour P, Tadibi V, Behpour N, Parno A, Delbari MA, Rashidi S. Effects of aerobic exercise on glucose control and cardiovascular risk factor in type 2 diabetes patients. Medical Journal of Mashhad University of Mashhad Science 2015;57:976-84.

29. Afshon Pour MT, Habibi A, Ranjbar R. The impact of circuit resistance exercise training on metabolic parameters in type 2 diabetics men. Jundishapur Sci Med J 2016;15:125-38.

30. Li XY, Zhao ZX, Huang M, Feng R, He CY, Ma C, et al. Effect of berberine on promoting the excretion of cholesterol in high-fat diet-induced hyperlipidemic hamsters. J Transl Med 2015;13:278. doi:10.1186/s12967-015-0629-3

31. Etemad Z, Nikbakht H, Azarbaijani MA, Gholami M. Concentrations of homocysteine and CRP after 8 weeks of resistance training circle with different rest intervals. Scientific Journal of Kurdistan University of Medical Sciences 2017;87:107-119. [Persian].

32. Abbasi Delui N, Mogharnasi M. The effect of 8-week circular resistance training on plasma levels of vaspin, high sensitivity c-reactive protein in overweight and obese young wom. Qom Univ Med Sci J 2016;10:38-46.

33. Olson TP, Dengel DR, Leon AS, Schmitz KH. Changes in inflammatory biomarkers following one-year of moderate resistance training in overweight women. Int J Obes (Lond) 2007;31:996-1003. doi:10.1038/sj.ijo.0803534

34. Lebon J, Riesco E, Tessier D, Dionne IJ. Additive effects of isoflavones and exercise training on inflammatory cytokines and body composition in overweight and obese postmenopausal women: a randomized controlled trial. Menopause 2014;21:869-75. doi:10.1097/GME.0000000000000177

35. Li XX, Li CB, Xiao J, Gao HQ, Wang HW, Zhang XY, et al. Berberine attenuates vascular remodeling and inflammation in a rat model of metabolic syndrome. Biol Pharm Bull 2015;38:862-8. doi:10.1248/bpb.b14-00828

36. Wang Y, Ding Y. Berberine protects vascular endothelial cells in hypertensive rats. Int J Clin Exp Med 2015;8:14896-905.

37. Chandirasegaran G, Elanchezhiyan C, Ghosh K, Sethupathy S. Berberine chloride ameliorates oxidative stress, inflammation and apoptosis in the pancreas of Streptozotocin induced diabetic rats. Biomed Pharmacother 2017;95:175-85. doi:10.1016/j.biopha.2017.08.040

38. Li Z, Zheng J, Zhang N, Li C. Berberine improves airway inflammation and inhibits NF-κB signaling pathway in an ovalbumin-induced rat model of asthma. J Asthma 2016;53:999-1005. doi:10.1080/02770903.2016.1180530

39. Hu Y, Ehli EA, Kittelsrud J, Ronan PJ, Munger K, Downey T, et al. Lipid-lowering effect of berberine in human subjects and rats. Phytomedicine 2012;19:861-7. doi:10.1016/j.phymed.2012.05.009