ORIGINAL ARTICLE

Comparing between the effect of energy-restricted diet and yoga on the resting metabolic rate, anthropometric indices, and serum adipokine levels in overweight and obese staff women

Farideh Yazdanparast[1,2], Sima Jafarirad[2,3], Fatemeh Borazjani[2,3], Mohammad Hossein Haghighizadeh[4], Alireza Jahanshahi[1]

[1]Diabetes Research Center, Health Research Institute, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, [2]Nutrition and Metabolic Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, [3]Department of Nutrition, School of Para-Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, [4]Department of Biostatistics, School of Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Background: Weight management is an important strategy to prevent the consequences of obesity. The aim of the study was to compare the effect of yoga practice and energy-restricted diet on resting metabolic rate (RMR), anthropometric indices, and serum adiponectin and leptin in overweight and obese women. **Materials and Methods:** Obese or overweight women were divided into two groups: yoga practicing and energy-restricted diet. Exercise trials consisted of 60-min Hatha yoga equal to 200 kilocalories (kcal) combined with 300 kcal restriction per day, and an energy-restricted diet consisted of 500 kcal restriction per day. The intervention period for both the groups was 8 weeks. RMR, anthropometric indices, and serum adiponectin, leptin, and lipid profiles were measured at baseline and at the end of the study. **Results**: RMR was increased in yoga but not in the diet group ($P = 0.001$). The level of adiponectin was increased in the yoga group compared with the diet ($P = 0.035$). The concentration of high-density lipoprotein-cholesterol was decreased in the diet group significantly but not in yoga ($P = 0.006$). The level of leptin was decreased in both the groups ($P = 0.001$), and there were no significant differences between the two groups. **Conclusion:** The findings of the study demonstrated the effect of yoga practicing on RMR, and serum adiponectin, in overweight and obese women. It seems yoga practice with less energy restriction compared with a common energy restriction diet and is more effective in weight management for those who are in weight loss programs.

Key words: Adiponectin, anthropometry, caloric restriction, leptin, resting metabolic rate, yoga

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INTRODUCTION

Obesity is a problem affecting the whole world[1] and a risk factor for different health problems such as hypertension, type 2 diabetes, dyslipidemia, metabolic syndrome, fatty liver, and cardiovascular diseases.[2,3] In Iran, the prevalence of overweight and obesity is 41% and 13%, respectively.[4]

Limiting daily energy intake has been suggested as an admissible method of treatment of obesity; however, the amount of exercise to achieve weight loss goals is still subject of disagreement among researchers. Resting metabolic rate (RMR) is significantly related to the amount of exercise, energy consumption, weight loss, and energy balance. Exercise not only contributes to metabolism during workout sessions but also improves RMR after exercise.[5] With its roots deep in ancient India, yoga is a both mental and physical exercise and can actually be considered as an alternative way for physical activity.[6,7]

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Address for correspondence: Dr. Sima Jafarirad, Nutrition and Metabolic Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. E-mail: jafarirad-s@ajums.ac.ir, sjafarirad@gmail.com

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Adipokines such as leptin and adiponectin, which are secreted by adipose tissue, play a major role in regulating appetite.[8,9] There is a relationship between serum leptin and total body fat mass.[9] In addition, there is a correlation between following exercise weight loss and reduction of plasma leptin among obese women.[10]

Plasma levels of adiponectin (secreted from adipose tissue) have an inverted relation with fat mass.[11] According to independent studies, doing yoga in postmenopausal women and an 8-week resistance-training program in sedentary men, elevated adiponectin and decreased leptin levels.[12,13]

Most previous investigations studied the effect of yoga training merely on adipokines[14-16] or anthropometric indices,[17,18] but to the best of our knowledge, the effect of a balanced and varied energy-restricted diet along with yoga practicing on RMR, anthropometric indices, and levels of leptin and adiponectin in overweight and obese women has not been studied before. Yoga in addition to being a physical activity affects the mind[19] and may be effective in the weight loss management. Therefore, this study was performed to consider the effect of Hatha yoga along with an energy-restricted diet compared with a common energy-restricted diet on the mentioned variables.

MATERIALS AND METHODS

Subjects and study design

This study was a randomized clinical trial. The sample size was calculated based on Lee *et al*. who evaluated the effect of yoga exercise on serum adiponectin levels in obese postmenopausal women.[12] For estimating sample size, a standard formula suggested for clinical trials by considering type 1 error (α) of 0.05 (95% confidence) and type 2 error (β) of 0.10 (90% power) was used. Nineteen participants were calculated in each group. Considering the loss of samples during the study, 22 participants were included in each group. The inclusion criteria were female gender, age range between 30 and 50 years and body mass index (BMI) more than 25 kg/m2. Subjects who suffered from cardiovascular diseases, hypertension, thyroid disorders, diabetes, polycystic ovary syndrome and menopause were not included. In addition, the other criteria such as smoking, pregnancy or lactation, taken any herbal, vitamin and mineral supplements or other medicines (such as statins, beta-blockers, and psychoactive drugs), difficulties for doing exercise, weight loss over 5% in the past 6 months, and following a special diet prior to the study, were not included to participate in the study. Based on the inclusion criteria, 44 overweight and obese women who were employee at the Ahvaz Jundishapur University of Medical Sciences participated in the study. Exclusion criteria were poor following the diet and yoga practicing.

All participants completed a general questionnaire, the International Physical Activity Questionnaire, and the Dutch Eating Behavior Questionnaire. Metabolic equivalents preweek were calculated by the International Physical Activity Questionnaire. The Dutch Eating Behavior Questionnaire was used to determine the participants' eating behavior and for an appropriate dietary recommendation.

Intervention

Energy-restricted diet intervention

Eligible participants were randomly divided (by computer-generated random numbers) into two groups: the first group – yoga practicing along with a balanced and varied energy-restricted diet (-300 kcal) and the second group (control group) – a balanced and varied energy-restricted diet (-500 kcal). First, a food record questionnaire (for two normal days and a weekend) was filled to determine the average energy intake of participants. The amount of energy and macronutrient intakes was determined using Nutritionist 4 software (Version 3.5.1, San Bruno, CA: First DataBank, USA). Total energy expenditure was calculated based on the Harris–Benedict equation by considering thermogenesis effect of food and activity coefficients. After that, a diet, which reduced 500 kcal/day, was considered as an energy-restricted diet group and participants followed this diet for 8 weeks. The macronutrient distribution of the diet was 15% of energy from protein, 55% from carbohydrate, and 30% from fat. A dietitian prepared all of the energy-restricted diets.

Yoga practice program

Participants in the other group of the study were asked to attend 5 days a week in the gymnasium of paramedicine school for yoga practicing. Yoga exercises were done by a yoga instructor at 7:30 AM (the start time of a working day in the university) and lasted for 1 h, and participants were practiced with her movements. This exercise was equivalent to 200 kcal of energy consumed per day. For determining the energy burning by yoga, before the study, a participant practiced the yoga asana when she was breathing in a potable indirect calorimeter and following energy burning by yoga exercise, during 1 h, was determined. In order to continue the workouts during weekends, a video CD was given to the participants and they were asked to practice yoga using that video CD. A balanced and varied energy-restricted diet that was reduced 300 kcal of daily energy intake also prescribed (the macronutrient distribution was the same as the energy-restricted diet group). Therefore, the yoga group also received a total of 500 kcal less energy than their daily requirement (200 kcal during yoga practicing and 300 kcal through diet), which was equal to the energy-restricted diet group. Yoga practice lasted 8 weeks.

For the proper follow-up of participants, two WhatsApp (a social media mobile application) channels were created

for each yoga and diet group, to follow up and sending notifications for each mentioned group.

Measurements

Resting metabolic rate

The RMR was measured using an indirect calorimeter (Desktop metabolic monitor, Fitmate PRO, COSMED, Rome, Italy), according to the manufacturer's protocol. This procedure was done after 6-8h sleeping. In addition, subjects were fasting for at least 12h, with no heavy physical activity, no smoking, also no drinking of alcohol and caffeine, the day before the test. This indirect calorimeter calculated RMR by the oxygen consumption at rest when participants breathed in a silicone facemask. Participants were relaxed in a room with temperature-controlled, low-light, and noiseless environment for measuring their RMR.

Anthropometry

Height was measured with the participant barefoot and standing situation (Seca 216, Hamburg, Germany) with the 0.1 cm accuracy. Body weight was measured with the 50 g accuracy (Seca 700, Hamburg, Germany) and light clothes. BMI was obtained by dividing the participant's weight (kg) by the square of their height (m^2). Waist circumference (WC) was measured using a measuring tape on the horizontal plane immediately above the iliac crest. Waist-to-hip ratio was calculated as the ratio of WC to hip circumference. The body composition was measured using a dual-frequency bioelectrical impedance analysis (Tanita DC-430 MAP, Japan).

Blood parameters

Before and after the intervention period, five milliliters of venous blood was taken after 12 h fasting. Sera were isolated to determine the blood parameters including serum lipid profiles, fasting blood sugar (FBS), and also leptin and adiponectin serum levels. Serum lipid profiles, including triglyceride (TG), high-density lipoprotein-cholesterol (HDL-C), and total cholesterol (TC) were determined using the enzymatic colorimetric method (Pars Azmoon, Iran). Low-density lipoprotein-cholesterol (LDL-C) levels were calculated with the Friedewald equation: LDL= ([TC] – [HDL-C] – [TGs/5]). The plasma level of leptin was determined by the enzyme-linked immunosorbent assay (ELISA) method (LDN, Germany). The adiponectin levels were measured using ELISA method too (Mediagnost, Germany). Intra-assay coefficient variation (CV) and inter-assay CV were <8% and <9%, respectively.

Ethical statement

This study was approved by the Ethics Committee of the Ahvaz Jundishapur University of Medical Sciences (IR.AJUMS.REC.1396.730) based on the Declaration of Helsinki. All participants completed a formal consent form; they were free to leave the trial in each level of the study and their information was kept secret. The study was submitted in Iran clinical trial website (ID: IRCT20140107016123N12).

Data analysis

All data presented were analyzed by the SPSS version 17.0 (SPSS Inc. SPSS Statistics for Windows, Chicago, 2008). General categorical variables were compared between two yoga and diet groups using the Chi-square test. The Kolmogorov–Smirnov test was used to find the normality of the data. An independent sample *t*-test was used to compare the mean of variables and their changes between the two study groups. A paired sample *t*-test was used to compare the mean of variables before and after the intervention, within each group. ANCOVA test was used to remove the effect covariates. Statistical significance was set as $P < 0.05$.

RESULTS

Forty-four overweight and obese females participated in the study, but 38 participants completed it. Figure 1 shows the flowchart of the study. Kolmogorov–Smirnov test showed the distribution of the adiponectin and RMR was not normal. These variables were analyzed using nonparametric tests (Mann–Whitney instead of independent *t*-test and Wilcoxon test instead of paired *t*-test).

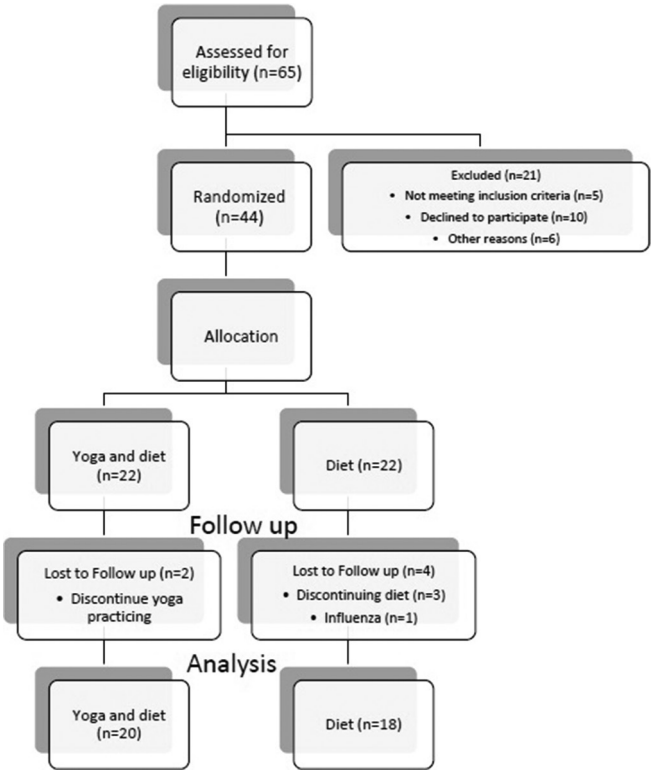

Figure 1: CONSORT flowchart of participants' enrollment, allocation, follow up and analysis

The baseline characteristics of participants are shown in Table 1. There was no significant difference between the two study groups for these characteristics.

After 8 weeks, all the anthropometric measurements were decreased significantly in both the groups, so there were no significant differences between the two study groups for these variables. RMR (kcal/day) was not increased after the intervention period in the diet group; however, this factor was increased in the yoga group ($P = 0.001$), and there was a significant difference between the two study groups ($P = 0.01$) [Table 2].

The results showed a significant decrease in concentrations of leptin at the end of the study compared with baseline values

Table 1: Basic characteristics, dietary intake, and physical activity of participants

Variables	Yoga + diet	Diet	P*
Age (years), mean±SD	40±5.9	40±5.9	0.77
Ethnicity (%)			
Persian	44.5	55.5	0.315
Lor/Bakhtiari	58.4	41.6	
Arab	66.6	33.4	
Others	60	40	
Education (%)			
Diploma and collage	58.4	41.6	0.629
Bachelor	50	50	
Master and above	40	60	
Married status (%)			
Married	58.6	41.4	0.173
Single	33.3	66.7	
History of the disease (%)			
Digestive disorders	66.7	33.3	0.758
Asthma and allergy	33.3	66.7	
Other diseases	33.3	66.7	
No diseases	55.2	44.8	
Physical activity (metabolic equivalent/week)			
Pretest	1344±39.0	1393±51.1	0.345
Posttest	1561±37.8	1329±10.3	0.031
Energy (Kcal/day), mean±SD			
Pretest	1820.1±362.8	1813.7±162.2	0.934
Posttest	1610.8±270.3	1458.7±108.1	0.290
Carbohydrate (percentage of energy), mean±SD			
Pretest	61.3±9.9	62.9±6.7	0.56
Posttest	54.3±15.8	49.8±16.2	0.037
Protein (percentage of energy), mean±SD			
Pretest	15.4±3.9	12.9±3.1	0.041
Posttest	18.2±3.5	17.1±4.3	0.378
Fat (percentage of energy), mean±SD			
Pretest	26.5±10.5	28.5±8.3	0.599
Posttest	27.1±6.9	27.2±6.6	0.945

*Chi-squared test for categorical values and independent *t*-test for quantitative values. SD=Standard deviation

Table 2: Comparison of anthropometric measurements, blood parameters, and their changes between the two study groups

Variables	Mean±SD		P
	Yoga + diet	Diet	
RMR (kcal)			
Pretest	1418.10±179.16	1440.11±166.85	0.698
Posttest	1512.70±160.28	1440.11±136.09	0.143
Difference	94.6±104.68	0.00±110.21	0.010*
P	0.001*	1.00	
Weight (kg)			
Pretest	74.64±9.05	77.62±11.96	0.390
Posttest	72.41±8.62	74.83±11.78	0.470
Difference	−2.23±1.59	−2.78±1.80	0.327
P	<0.001*	<0.001*	
BMI (kg/m^2)			
Pretest	30.15±3.15	31.67±4.64	0.241
Posttest	29.21±2.95	30.53±4.71	0.303
Difference	−0.93±0.72	−1.13±0.73	0.401
P	<0.001*	<0.001*	
WHR (cm)			
Pretest	0.82±0.05	0.84±0.05	0.175
Posttest	0.80±0.05	0.81±0.05	0.531
Difference	−0.01±0.03	−0.02±0.02	0.193
P	0.031*	<0.001*	
WC (cm)			
Pretest	100.40±7.19	104.02±8.54	0.168
Posttest	96.37±7.47	98.72±7.44	0.339
Difference	−4.05±4.40	−5.30±3.31	0.334
P	0.001*	<0.001*	
Fat mass (%)			
Pretest	25.42±5.93	28.30±8.02	0.212
Posttest	23.33±5.25	26.34±7.79	0.168
Difference	−2.08±1.88	−1.96±1.52	0.826
P	<0.001*	<0.001*	
Fat free mass (%)			
Pretest	48.20±4.75	48.80±3.88	0.677
Posttest	48.08±4.81	48.22±4.13	0.926
Difference	−0.12±1.25	−0.57±1.68	0.344
P	0.673	0.163	
Total fat (%)			
Pretest	34.20±4.40	36.11±6.98	0.244
Posttest	32.40±4.04	34.73±5.01	0.121
Difference	−1.80±1.98	−1.38±1.73	0.483
P	0.001*	0.004*	
Adiponectin (μg/ml)			
Pretest	8.35±2.85	9.16±2.61	0.372
Posttest	9.35±3.30	8.91±2.19	0.635
Difference	0.99±1.96	−0.24±1.40	0.031*
P	0.035*	0.470	
Leptin (ng/ml)			
Pretest	57.49±18.89	56.95±21.31	0.935
Posttest	48.08±16.68	42.88±17.46	0.355
difference	−9.41±11.31	−14.07±14.49	0.281
P	0.001*	0.001*	
TG (mg/dl)			

Contd...

Table 2: Contd...

Variables	Mean±SD		*P*
	Yoga + diet	Diet	
Pretest	109.90±47.10	125.33±60.68	0.391
Posttest	103.20±48.97	118.94±55.65	0.360
Difference	−6.70±35.09	−6.39±41.47	0.128
P	0.404	0.753	
TC (mg/dl)			
Pretest	177.90±36.01	190.83±20.82	0.180
Posttest	176.70±36.72	180.77±17.53	0.661
Difference	−1.20±22.82	−10.05±11.44	0.136
P	0.817	0.002*	
LDL-C (mg/dl)			
Pretest	103.20±31.93	111.72±19.91	0.326
Posttest	103.05±26.70	108.72±12.04	0.399
Difference	−0.15±19.79	−3.00±16.04	0.627
P	0.973	0.438	
HDL-C (mg/dl)			
Pretest	53.00±5.92	53.11±4.96	0.950
Posttest	52.50±7.31	48.27±4.22	0.035*
Difference	−0.050±5.17	−4.83±4.14	0.006*
P	0.671	<0.001*	
FBS (mg/dl)			
Pretest	88.05±9.33	88.50±7.29	0.869
Posttest	71.20±16.22	70.83±11.21	0.935
Difference	−16.85±14.43	−17.66±9.14	0.835
P	<0.001*	<0.001*	

*Statistical significance was set at *P*<0.05. Data are presented as mean and SD. ANCOVA analysis was used to eliminate the effect of energy percentage from protein and total intake of energy. RMR=Resting metabolic rate; BMI=Body mass index; WHR=Waist-to-hip ratio; WC=Waist circumference; TG=Triglyceride; TC=Total cholesterol; LDL-C=Low-density lipoprotein-cholesterol; HDL-C=High-density lipoprotein-cholesterol; FBS=Fasting blood sugar; SD=Standard deviation

in both the groups (*P* = 0.001). There was a significant increase in serum levels of adiponectin in week 8 versus baseline in the yoga group (*P* = 0.035). This difference was significant between the two study groups (*P* = 0.031) [Table 2]. No significant differences in lipid profiles were found between the two groups after 8 weeks; however, TC was decreased significantly in the diet group, although the level of HDL-C was also decreased in this group, and this change was significant between the two study groups (*P* = 0.006). FBS decreased in both the groups, but there were no significant differences between the two groups [Table 2].

DISCUSSION

There have been different recommended plans in order to manage obesity. For example, an energy-restricted diet doing exercise at least half an hour daily, and also modifying eating behaviors.[2] Yoga is not merely a type of physical activity but also considered as a semi-cognitive behavioral therapy (CBT) which includes some features of CBT.[20]

The effects of Hatha yoga – in combination with a balanced and varied diet – on anthropometric measurements, RMR, and adipokine hormones have not received much of a direct attention on obese participants in the previous studies. According to the results of our study, yoga can help obese and overweight participants, as well as patients with type 2 diabetes or cardiovascular risk factors by an increase in energy consumption of the body.[21] In this study, the anthropometric indices were decreased, but there were no significant differences compared with the diet group. However, yoga had some other benefits for yoga practitioners, because their RMR and adiponectin levels were increased. Several groups of researchers have offered no change in body weight by yoga practicing.[22,23] Constant with our current findings, Kristal *et al*.,[7] and Bera and Rajapurkar[24] showed that some of the fat-fold, waist, umbilical, and hip circumferences were decreased significantly after yoga practicing.

The most favorable finding of our study was the positive effect of yoga exercise on RMR, which helped the participants lose weight more easily than those who followed a common energy-restricted diet. RMR can be highly correlated with one's nutritional status and physical activity.[25] One of the reasons for the rise in RMR is the effect of yoga on muscles (since yoga is a stretching exercise) and high metabolic rate organs such as heart and lung.

In the present study, no significant differences in FBS, TG, TC, and LDL-C levels were found between the yoga exercise and the diet groups; however, the amount of HDL-C significantly dropped in the diet group. Some researchers have observed that yoga programs have a positive effect on lipid profiles.[12,26-28] We did not observe a significant difference in FBS, LDL-C, and TG between the two study groups, probably for that these items decreased in both the groups. However, it is important to notice that HDL-C was significantly decreased in the diet group and this negative effect on HDL-C was not observed in the yoga group.

We particularly found that the yoga group had higher levels of adiponectin than the diet group. Adiponectin which is known as an anti-inflammatory adipokine is secreted by adipocytes. Obesity can be associated with low levels of adiponectin and plasma anti-inflammatory proteins. The reduction in visceral fat content (a 10% reduction in unnecessary fat) would be required to increase plasma adiponectin concentration.[29] In addition, the yoga and diet groups displayed a significant drop in leptin levels after 8 weeks. As the body loses weight, leptin levels drop owing to the reduction in fat mass. Kiecolt-Glaser *et al*. showed a yoga effect on leptin reduction in novice compared to expert yoga practitioners.[30] Participants in our study were novice yoga practitioners, and our finding was the same as the mentioned study.

This study had its own strength and limitation. The limitations were short intervention period (8 weeks) and difficulties for participants monitoring during the weekends. The strong point of the study was that a yoga instructor trained participants in yoga and practiced with them though the intervention days. Furthermore, to the best of our knowledge, this study is the first in which yoga practicing along with less energy-restricted diet was compared with a common energy-restricted diet.

CONCLUSION

The findings of the study demonstrated the positive effect of yoga exercise in weight reduction with an increase in RMR and also an improvement in serum adiponectin in overweight and obese women. It could be concluded that overweight or obese participants with a balanced and varied diet along with yoga practicing will reach a healthier body weight. The following recommendations are made for further studies: studies about the effects of yoga on the anthropometric and metabolic variables in both sexes, by considering the age, and the intensity of the exercise.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Bray GA, Kim KK, Wilding JP; World Obesity Federation. Obesity: A chronic relapsing progressive disease process. A position statement of the World Obesity Federation. Obes Rev 2017;18:715-23.
2. Shojasaadat F, Ayremlou P, Hashemi A, Mehdizadeh A, Zarrin R. A randomized controlled trial comparing effects of a low-energy diet with n-3 polyunsaturated fatty acid supplementation in patients with non-alcoholic fatty liver disease. J Res Med Sci 2019;24:21.
3. Gil-Rojas Y, Garzón A, Hernández F, Pacheco B, González D, Campos J, *et al*. Burden of disease attributable to obesity and overweight in Colombia. Value Health Reg Issues 2019;20:66-72.
4. Salimi Y, Taghdir M, Sepandi M, Karimi Zarchi AA. The prevalence of overweight and obesity among Iranian military personnel: A systematic review and meta-analysis. BMC Public Health 2019;19:162.
5. Sirithienthad P. Comparison of the Effects of Post Exercise Basal Metabolic Rate among Continuous Aerobic, Intermittent Aerobic, and Resistance Exercise: Implications for Weight Control; 2006. Available from: http://purl.flvc.org/fsu/fd/FSU_migr_etd-1697. [Last accessed on 2019 May 21].
6. Feuerstein G. The Yoga Tradition: Its History, Literature, Philosophy, and Practice. 3rd ed. Prescot, United States: Hohm Press; 2001.
7. Kristal AR, Littman AJ, Benitez D, White E. Yoga practice is associated with attenuated weight gain in healthy, middle-aged men and women. Altern Ther Health Med 2005;11:28-33.
8. Abbenhardt C, McTiernan A, Alfano CM, Wener MH, Campbell KL, Duggan C, *et al*. Effects of individual and combined dietary weight loss and exercise interventions in postmenopausal women on adiponectin and leptin levels. J Intern Med 2013;274:163-75.
9. Meier U, Gressner AM. Endocrine regulation of energy metabolism: Review of pathobiochemical and clinical chemical aspects of leptin, ghrelin, adiponectin, and resistin. Clin Chem 2004;50:1511-25.
10. Ramezankhany A, Nazar Ali P, Hedayati M. Comparing effects of aerobics pilates exercises and low calorie diet on leptin levels and lipid profiles in sedentary women. Iran J Basic Med Sci 2011;14:256-63.
11. Vaiopoulos AG, Marinou K, Christodoulides C, Koutsilieris M. The role of adiponectin in human vascular physiology. Int J Cardiol 2012;155:188-93.
12. Lee JA, Kim JW, Kim DY. Effects of yoga exercise on serum adiponectin and metabolic syndrome factors in obese postmenopausal women. Menopause 2012;19:296-301.
13. Zamani M, Peeri M. Comparing the effect of 8-weeks resistance training with different patterns of movement on the levels of adiponectin, leptin, testosterone and cortisol in sedentary men. Indian J Endocrinol Metab 2016;17:448-56.
14. Yadav R, Yadav RK, Khadgawat R, Mehta N. OS 28-06 beneficial effects of a 12-week yoga-based lifestyle intervention on cardio-metabolic risk factors and adipokines in subjects with pre-hypertension or hypertension. J Hypertens 2016;34:e252.
15. Supriya R, Yu AP, Lee PH, Lai CW, Cheng KK, Yau SY, *et al*. Yoga training modulates adipokines in adults with high-normal blood pressure and metabolic syndrome. Scand J Med Sci Sports 2018;28:1130-8.
16. Abbott MJ, Killian TJ, Walsh CS, Yim VT. The effects of Ashtanga yoga on circulating adipokines and inflammatory associated miRNAs. FASEB J 2018;32 Suppl 1:lb267.
17. Balaji PA, Varne SR, Ali SS. Effects of yoga – Pranayama practices on metabolic parameters and anthropometry in type 2 diabetes. I. Int J Multidiscip Res 2011;1:1-4.
18. Hegde SV, Rao SK, Menezes RG, Kotian SM, Shetty S. Knowledge, attitude, and practice of yoga in medical students: Assessment of anthropometry and lifestyle factors. Int J Yoga Therap 2018;28:9-14.
19. Ross A, Brooks A, Touchton-Leonard K, Wallen G. A different weight loss experience: A qualitative study exploring the behavioral, physical, and psychosocial changes associated with yoga that promote weight loss. Evid Based Complement Alternat Med 2016;2016:1-11.

20. Khalsa MK, Greiner-Ferris JM, Hofmann SG, Khalsa SB. Yoga-enhanced cognitive behavioural therapy (Y-CBT) for anxiety management: A pilot study. Clin Psychol Psychother 2015;22:364-71.
21. Cramer H, Thoms MS, Anheyer D, Lauche R, Dobos G. Yoga in women with abdominal obesity□a randomized controlled trial. Dtsch Arztebl Int 2016;113:645-52.
22. Rioux JG, Ritenbaugh C. Narrative review of yoga intervention clinical trials including weight-related outcomes. Altern Ther Health Med 2013;19:32-46.
23. Jain SC, Talukdar B. Role of yoga in control of hyperglycemia in middle aged patients of non-insulin dependent diabetes mellitus. Indian J Clin Biochem 1995;10:62.
24. Bera TK, Rajapurkar MV. Body composition, cardiovascular endurance and anaerobic power of yogic practitioner. Indian J Physiol Pharmacol 1993;37:225-8.
25. Chaya MS, Kurpad AV, Nagendra HR, Nagarathna R. The effect of long term combined yoga practice on the basal metabolic rate of healthy adults. BMC Complement Altern Med 2006;6:28.
26. Singh S, Kyizom T, Singh KP, Tandon OP, Madhu SV. Influence of pranayamas and yoga-Asanas on serum insulin, blood glucose and lipid profile in type 2 diabetes. Indian J Clin Biochem 2008;23:365-8.
27. Doddoli S, Shete S, Kulkarni D, Bhogal R. Effect of yoga training on lipid metabolism in industrial workers with reference to body constitution (Prakriti). J Tradit Complement Med 2017;7:322-6.
28. Azami M, Hafezi Ahmadi MR, YektaKooshali MH, Qavam S. Effect of yoga on lipid profile and C-reactive protein in women. Int J Prev Med 2019;10:81.
29. Lin H, Hu M, Yan Y, Zhang H. The effect of exercise on adiponectin and leptin levels in overweight or obese subjects: A meta-analysis of randomized controlled trials. Sport Sci Health 2017;13:303-14.
30. Kiecolt-Glaser JK, Christian LM, Andridge R, Hwang BS, Malarkey WB, Belury MA, *et al*. Adiponectin, leptin, and yoga practice. Physiol Behav 2012;107:809-13.