Original Article

Effects of Yoga Training on Body Composition and Oxidant-Antioxidant Status among Healthy Male

Abstract

Background: The stressful condition may cause oxidative stress, which is responsible for various diseases. **Aims:** The present study was designed to find out whether yoga has impact on the reduction of oxidative stress. **Methods:** For the present study, 95 (n = 95) healthy male volunteers within the age group of 18–24 years were included, 35 (n = 35) volunteers were excluded. The remaining 60 (n = 60) volunteers were randomly divided into two groups: (a) Yoga Group (n = 30) and (b) Control Group (n = 30). Yoga training was given for 60 min per day, 6 days per week for 12 weeks in the yoga group, with no yoga training in control group. Assessment of body composition and oxidant-antioxidant status were performed in both the groups at baseline, before yoga training (0 week) and after (12 weeks) of the training. **Results:** Significant reduction ($P < 0.001$) in the percentage of body fat and malondialdehyde; significant elevation ($P < 0.001$) in superoxide dismutase, catalase, reduced glutathione and ascorbic acid levels were noted in the yoga group after 12 weeks when compared to baseline data (0 week). However, there was no significant difference in height, weight, body mass index, body surface area and lean body mass among the yoga group after 12 weeks when compared to baseline data. These changes might be due to yoga training. **Conclusions:** Regular yoga practice reduces body fat and oxidative stress. Yoga training may be helpful to reduce the chance of occurrence of various diseases and helps to maintain normal healthy lifestyle.

Keywords: *Body composition, oxidative stress, yoga*

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Introduction

Stress has been defined as a "nonspecific response of the body to any noxious stimuli." Sustained stress can have numerous pathophysiological effects on the body system.[1,2] Persistent stressful conditions can lead to the excessive production of free radicals and oxidative burden.[3] Disturbances in the normal redox state of tissues can cause toxic effects through the production of peroxides and free radicals that damage all components of the cell, including proteins, lipids, and DNA.[4] In humans, oxidative stress is involved in many diseases, including sickle cell disease, atherosclerosis, Parkinson's disease, Alzheimer's disease, heart failure, myocardial infarction, schizophrenia, Bipolar disorder, fragile X syndrome, and chronic fatigue syndrome.[5] A variety of natural antioxidants exist to scavenge free radicals and prevent oxidative damage to biological membranes. One group of these antioxidants is enzymatic (intracellular), which includes superoxide dismutase (SOD), glutathione (GSH) peroxidase, and catalase (CAT).[6] In addition to enzymatic antioxidants, are the major natural antioxidants, most of them derived from natural sources by dietary intake and include Vitamin A, Vitamin C, Vitamin E, and carotenoids.[7] Abnormally high levels of peroxidation and the simultaneous decline of antioxidant defense mechanisms can lead to damage of cellular organelles and resulting in the development of oxidative stress.[8] Stress has been shown to be responsible for the depletion of several free radical detoxifying enzymes such as GSH peroxidase, CAT, and SOD.[9,10]

Environmental factors and workload impose stress which may lead to oxidative stress among the young working people. The stressful conditions, alteration in physiological factors, may lead to various diseases. Thus, reducing the number of working days, productivity and enhance the expenditure toward medication. These

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impose a huge burden on the employers and the country at large. Yoga, with origins in ancient India, has several subtypes and incorporates physical postures (asanas), controlled breathing (pranayama), deep relaxation, and meditation. Regular practice of yoga enhances fitness and coordination to the brain and muscular activities.[11] There are several studies in Indian context on the effect of yoga on cardiorespiratory fitness[12] and oxidant-antioxidant defence mechanism.[13-15] However, limited information is available on Indian context on the effect of yoga on oxidant-antioxidant defence mechanism of Bengali population of West Bengal, India. On the basis of the above, the present study was designed to find out the effects of yoga on body composition and oxidant-antioxidant status among healthy adult male.

Methods

Subject and experimental design

For the present study, 95 (n = 95) healthy male volunteers within the age group of 18–24 years were screened randomly from the Midnapore District, West Bengal, India. All the volunteers went through a medical examination performed by Physicians. Thirty-five (n = 35 [Not meeting the inclusion criteria (n = 09), decline to participate (n = 08), inability to perform yoga (n = 11), and unable to follow the schedule (n = 07)]) volunteers were excluded from the study. The remaining sixty (n = 60) volunteers were randomly divided into two groups: (a) Yoga Group (n = 30) and (b) Control Group (n = 30).

Yoga training was provided in the yoga group volunteers, whereas no yoga training was given to the control group volunteers. Yoga training was given by qualified yoga instructor for 60 min per day, 6 days per week for 12-week duration following a standard protocol.[16] The detail of yoga protocol is presented in Table 1. Assessment of body composition and oxidant-antioxidant status was estimated among the groups. All the parameters were recorded at baseline, before yoga training (0 week) and after (12 weeks) of the training. The detail of the yoga training schedule was given in Table 1. The volunteers were informed about the purpose and the possible complications of the study, and written consents were taken from them. The volunteers were asked to refrain from smoking and alcohol throughout the experiment. The yoga group participants were informed not to involve in any other physical activity during the entire period of the study. The participants were asked to maintain their normal diet. The experimental protocol was approved by the Institutional Ethical Committee (Human Studies) (Ref No. MC/IEC (HS)/PHY/FP-02/2016; date: 07.06.2016). The participant flow during the study is shown in Figure 1.

Table 1: Contents of yogic package practiced by the volunteers during the training schedule

Yogic training schedule	Duration of each session (min)
Prayer	2
Om chanting	2
Gayatri Mantra	2
Yogic Sukshma vyayam	10
Surya Namaskar	12
Yogasana	
Shavasana	10
Supt Pawanmuktasana	
Kandhrasana	
Makarasana	
Shalabhasana	
Bhujangasana	
Mandukasana	
Ushtrasana	
Gomukhasana	
Pranayama	
Kapal bhati	15
Mahabandh	
Laybadh Shvas Prashwas	
Nadi Shodhan	
Ujjayi and Bhramari Pranaya	
Meditation	
Ajapa Jap	5
Shanti Mantra	2
Total	60

Measurements

Measurement of height (stature) and body mass

The height was measured by the stadiometer (Seca 220, UK) with an accuracy recorded to the nearest 0.5 cm. The participant stood barefoot, and erect with heels together and arms hanging naturally by the sides. The heels, buttocks, upper part of the back, and usually but not necessarily, the back of the head were in contact with the vertical wall. The participant looked straight ahead and took a deep breath during measurement. The distance from the standing platform, to the highest position of the head (vertex), was measured with the help of stadiometer, which indicates the participants' height.[17] The stature was recorded in centimeters. The body mass was taken on a standard electronic weighing machine (Seca Alpha 770, UK), having an accuracy recorded to the nearest 50 g. The participant was examined in clothing of known weight to record nude weight 12 h after the last meal. The participant stood at the center of the weighing machine looking straight. The body mass was recorded in kilograms.[17]

Determination of body mass index and body surface area

Body mass index (BMI) and body surface area (BSA) were derived from the following equation using body mass and stature.[17]

$$\text{BMI} = \text{Weight (kg)}/\text{Height (m}^2\text{)}$$

$$\text{BSA (m}^2\text{)} = \text{Weight (kg)}^{0.425} \times \text{Height (cm)}^{0.725} \times 71.84/10000$$

Assessment of percent body fat and lean body mass

A skinfold caliper (Holtain Limited, UK) was used to assess the body fat percentage following standard methodology.[18]

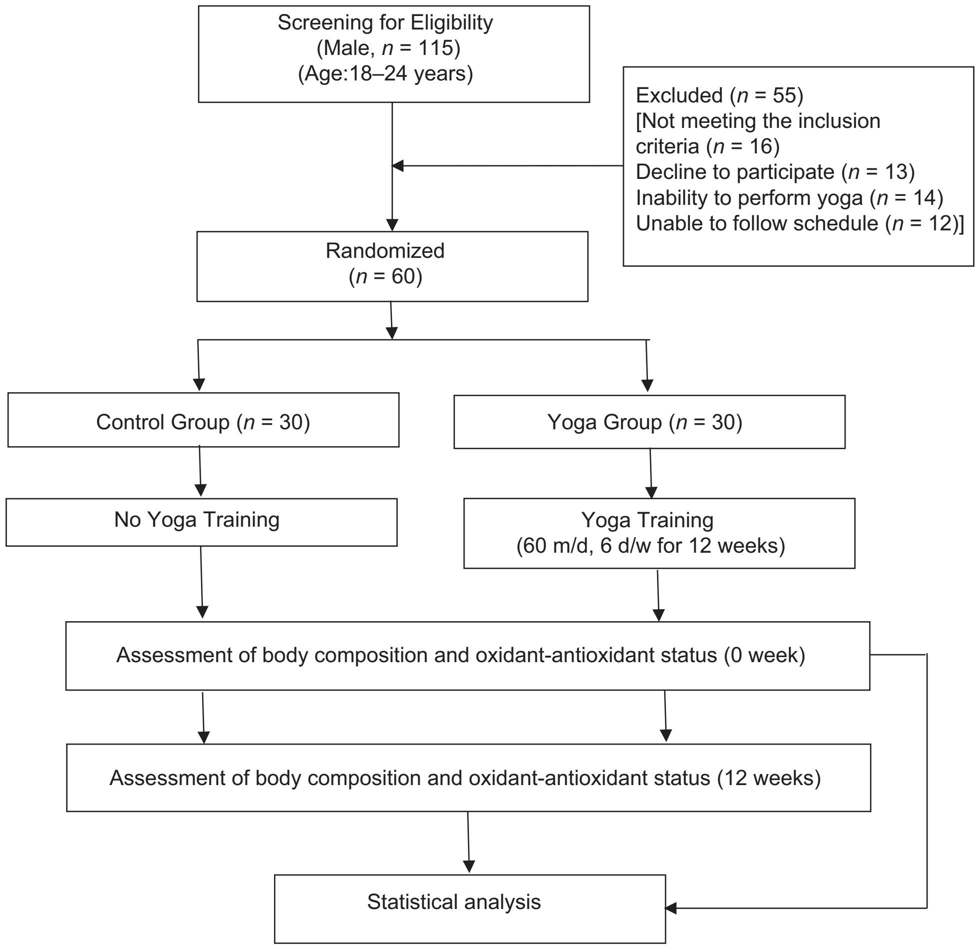

Figure 1: Consort flowchart

The instrument consists of accurately calibrated dial which indicates the thickness of the skin fold in millimeters (mm) when the skinfold is held by the open jaws. The skinfold was taken from four different sites of the body (biceps, triceps, subscapular, and suprailiac) using the skinfold caliper on the right side of the body. The thickness of the skin and subcutaneous fat was grasped between the thumb and index finger. To estimate the errors, reading was made between 3 and 4 s when essentially all compressions have taken place, and the measurements were established.

Computation of body density

Body density (BD) was calculated by the standard formulae.[19] The skinfold thickness at the site of biceps, triceps, subscapular, and suprailiac was used to calculate the BD.

Calculation for body density

- BD = 1.1620 − 0.0630 log (Biceps + Triceps + Subscapular + Suprailliac) (for 14–19 years)
- BD = 1.1631 − 0.0630 log (Biceps + Triceps + Subscapular + Suprailliac) (for 20–29 years).

Computation of percent body fat was derived using the standard equation.[15]

Body fat (%) = (495/BD) − 450

Computation of lean body mass (LBM) was derived by subtracting fat mass from total body mass[18] using the following equation.

Fat mass (kg) = (Body mass [kg] × body fat [%])/100

LBM (kg) = Body mass − Fat mass

Assessment of oxidant-antioxidant defence mechanism

A 5 ml of venous blood was drawn from an antecubital vein after a 12-h fast and 24 h after the last yoga exercise for the determination of selected biochemical parameters. For the determination of oxidant-antioxidant defence mechanism, lipid peroxide as malondialdehyde (MDA) (ELISA; MAK085, Sigma, USA),[20] SOD (ELISA; 19160, Sigma, USA),[21] CAT (ELISA; CAT100, Sigma, USA),[22] reduced GSH (ELISA; CS0260, Sigma, USA)[23] and ascorbic acid (ELISA; MAK074, Sigma, USA)[24] were estimated following standard methods.

Statistical analysis

To find out whether data were normally distributed, Shapiro–Wilk normality test was performed. All the data were expressed as the mean and standard deviation (SD). Analysis of variance with repeated measures followed by multiple comparison (*post hoc*) tests was performed to find out the significant difference in intragroup and intergroup variables. In each case, the significant level was chosen at 0.05 levels. All the statistical analysis was performed using SSPSS 20 software for Windows [IBM, USA].

Results

Effect of yoga on body composition variables

The body composition variables showed that there was significant reduction ($P < 0.001$) in the percentage of body fat as well as total fat mass among the yoga group after 12 weeks when compared to baseline data. However, there was no significant difference in height, body mass, BMI, BSA, and LBM among the yoga group after 12 weeks when compared to baseline data (0 week). Further, the yoga group had significantly ($P < 0.001$) lower body mass, BMI and body fat when compared to control group at the end of 12 weeks [Tables 2 and 3].

Effect of yoga on oxidant-antioxidant defence mechanism

The oxidative stress parameters showed that there was significant reduction ($P < 0.001$) in MDA level among the yoga group after 12 weeks when compared to baseline data (0 week). On the other hand, there was significant increase ($P < 0.001$) in SOD, CAT, reduced GSH, and ascorbic acid levels among the yoga group after 12 weeks in comparison to baseline data (0 week). Further, the yoga group had significantly ($P < 0.001$) lower MDA; and significantly higher ($P < 0.001$) SOD, CAT, GSH, and ascorbic level when compared to control group at the end of 12 weeks [Table 4].

Table 2: Height and weight parameters of yoga and control group participants

Parameters	Groups			
	Yoga group		Control group	
	0 week	12 weeks	0 week	12 weeks
Height (cm)	171.1±6.8	171.1 (NS)±6.8	169.3±4.1	169.3 (NS)±4.1
Body mass (kg)	60.1$^{###}$±5.4	58.7$^{###}$±6.2	64.4±4.0	64.8 (NS)±5.1
BMI (kg/m^2)	20.5$^{###}$±1.7	20.1$^{###}$±1.2	22.5±1.2	22.8 (NS)±1.6
BSA (m^2)	1.7 (NS)±0.1	1.7 (NS)±0.1	1.7±0.1	1.7 (NS)±0.1

(when compared to control group: $^{###}P$<0.001) All the data were expressed as mean ± SD. ANOVA with repeated measures followed by multiple comparison (*post hoc*) tests were performed. NS=Not significant, BMI=Body mass index, BSA=Body surface area, ANOVA=Analysis of variance, SD=Standard deviation

Table 3: Body composition characteristics of yoga and control group participants

Parameters	Groups			
	Yoga group		Control group	
	0 week	12 weeks	0 week	12 weeks
Fat (%)	14.1$^{##}$±1.7	10.4$^{***,###}$±1.5	15.8±2.6	14.7 (NS)±2.3
Fat mass (kg)	7.9$^{###}$±1.2	6.4$^{***,###}$±1.2	9.6±1.6	9.2 (NS)±1.4
LBM (kg)	53.4 (NS)±5.0	51.7 (NS)±4.6	54.8±3.9	55.9±4.3

(when compared to baseline data: ***P<0.001) (when compared to control group: $^{###}P$<0.001, $^{##}P$<0.01), All the data were expressed as mean ± SD. ANOVA with repeated measures followed by multiple comparison (*post hoc*) tests were performed. NS=Not significant, LBM=Lean body mass, ANOVA=Analysis of variance, SD=Standard deviation

Table 4: Oxidative stress parameters of yoga and control group participants

Parameters	Groups			
	Yoga group		Control group	
	0 week	12 weeks	0 week	12 weeks
MDA (nmol/mL)	1.71$^{###}$±0.05	1.62$^{***,###}$±0.06	1.82±0.07	1.80 (NS)±0.05
SOD (U/mL)	2.11$^{###}$±0.08	2.73$^{***,###}$±0.06	1.98±0.06	2.00 (NS)±0.05
CAT (U/mL)	72.8 (NS)±4.02	79.53$^{***,###}$±3.77	70.44±5.12	69.46 (NS)±4.07
GSH (mg/dl)	17.5 (NS)±2.05	19.3$^{***,###}$±1.51	16.9±1.72	17.1 (NS)±1.67
Ascorbic acid (mg/dl)	0.81$^{###}$±0.05	0.89$^{***,###}$±0.07	0.72±0.06	0.74 (NS)±0.07

(when compared to baseline data: ***P<0.001) (when compared to control group: $^{###}P$<0.001), All the data were expressed as mean ± SD. ANOVA with repeated measures followed by multiple comparison tests were performed. NS=Not significant, MDA=Malondialdehyde, SOD=Superoxide dismutase, CAT=Catalase, GSH=Reduced glutathione, ANOVA=Analysis of variance, SD=Standard deviation

Discussion

Yoga has a role in maintaining good health and physical fitness. In the present study, significant reduction in body fat was noted after 12 weeks of yoga training. The reduction in body fat might be due to the fact that the volunteers underwent a high level of yogic exercise over a period, which resulted in lowering of body fat percentage. Yoga involves verity of physical activity, change of postures, repeated contractions, and relaxations of the abdominal muscles might be the cause of reduction of body fat. Similar observations were noted by many authors where reduction in body fat was noted after yoga training.[25,26] Another study conducted by Zorofi *et al*.[27] has reported significant reduction of body fat after yoga training. On the other hand, no significant difference was observed in body mass and LBM among the participants after the training program. This might be due to improper optimization of the training load and/or short duration of the yoga training. Increase in body fat can elevate the risk factors for obesity, cardiovascular disease, diabetes, and many other complications.[25,26,28] Regular yoga practice may reduce body fat, which is essential to maintain disease-free lifestyle.

Reactive oxygen species (ROS) have been implicated in the etiology of a most of degenerative diseases including cardiovascular disease, diabetes, cancer, Alzheimer's disease, and other neurodegenerative disorders and aging.[4,5] ROS induced oxidative stress, damages the membrane polyunsaturated fatty acids resulting in elevation in MDA level.[3,13-15] A decrease in the activity of antioxidants such as SOD, CAT, GSH, and vitamins C may also contribute to oxidative stress.[29] Antioxidants such as SOD, CAT, and GSH act as a primary line of defense against the toxic effects of ROS. Superoxide radicals are detoxified by SOD to produce hydrogen peroxide (H_2O_2) which is further converted to water by CAT and glutathione peroxidase. GSH peroxidase requires GSH as a coenzyme to convert H_2O_2 to water.[30] In the present investigation, significant reduction in serum MDA level was noted among the participants after 12 weeks of yoga training. In addition, significant increase in SOD, CAT, GSH, and ascorbic acid (Vitamin C) concentrations among the participants after 12 weeks of yoga training. Similar findings were reported by many researchers. Findings of Hegde *et al*.[31] and Gordon *et al*.[32] reported significant reduction in MDA level in type 2 diabetic patients. They reported reduction in MDA level and increase in GSH and ascorbic acid levels after yoga training. A recent study showed that Yoga practice for 3 months has significantly reduced serum MDA level, and enhanced antioxidants level such as SOD activity, serum GSH, and Vitamin C in elderly hypertensive individuals.[33] Yoga has been found to be beneficial in reducing oxidative stress. It may be noted in the yoga training incorporated to the volunteers by slow-breathing practices, relaxation techniques, meditation, and asanas (maintaining postures). It is widely accepted that increased oxygen consumption during exercise results in the excess generation of ROS.[34] Whereas, yoga-based relaxation technique and meditation were found to be associated with decreased oxygen consumption and breath holding.[34] Hence, it is presumed that low consumption of oxygen during yoga practice alter the metabolic state of the participants, and this probably reduced serum MDA level in the yoga practitioners of the present study.[34]

Yoga-induced enhancement in endogenous antioxidants such as SOD, CAT, and GSH might be due to increase in their upregulation[35] and decreased rate of utilization due to lowering of oxidative stress. Similarly, an increased level of serum Vitamin C, an exogenous antioxidant, in yoga practitioners might also be due to lowering rate of utilization. This yoga-induced achievement in antioxidant capacity may help to cope with deleterious effects of oxidative stress and prevents further damage to body tissues. Superoxide radicals combine with nitric oxide to form peroxynitrite leading to nitrosative stress. Yoga-induced elevated SOD level may also prevent formation of peroxynitrite, and thus reduces the possibility of nitrosative stress. Yoga-based relaxation technique and meditation were found to be associated with decreased oxygen consumption.[35] Hence, it can be presumed that low consumption of oxygen during yoga practice probably reduced serum MDA level in the yoga practitioners of the present study. This study indicates that even a brief practice of yogic lifestyle can significantly reduce oxidative stress and help in promoting healthy life.

Conclusion

Regular yoga practice helps to maintain normal healthy lifestyle and physical fitness which is indicated by decreasing body fat. The findings of the study demonstrate the efficacy of yoga exercise on body composition, oxidative stress markers, and antioxidant status in healthy participants. The findings of the present study suggest that yoga can be used as an effective lifestyle modality to reduce oxidative stress and to enhance antioxidant defense. Thus, regular practice of yoga may be helpful to reduce stress and maintain disease-free lifestyle.

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Conflicts of interest

There are no conflicts of interest.

References

1. Sarubin N, Nothdurfter C, Schüle C, Lieb M, Uhr M, Born C, *et al.* The influence of hatha yoga as an add-on treatment in major depression on hypothalamic-pituitary-adrenal-axis activity: A randomized trial. J Psychiatr Res 2014;53:76-83.
2. Corey SM, Epel E, Schembri M, Pawlowsky SB, Cole RJ, Araneta MR, *et al.* Effect of restorative yoga vs. Stretching on diurnal cortisol dynamics and psychosocial outcomes in individuals with the metabolic syndrome: The PRYSMS randomized controlled trial. Psychoneuroendocrinology 2014;49:260-71.
3. Lim SA, Cheong KJ. Regular yoga practice improves antioxidant status, immune function, and stress hormone releases in young healthy people: A Randomized, double-blind, controlled pilot study. J Altern Complement Med 2015;21:530-8.
4. Amer J, Ghoti H, Rachmilewitz E, Koren A, Levin C, Fibach E, *et al.* Red blood cells, platelets and polymorphonuclear neutrophils of patients with sickle cell disease exhibit oxidative stress that can be ameliorated by antioxidants. Br J Haematol 2006;132:108-13.
5. Valko M, Leibfritz D, Moncol J, Cronin MT, Mazur M, Telser J, *et al.* Free radicals and antioxidants in normal physiological functions and human disease. Int J Biochem Cell Biol 2007;39:44-84.
6. Halliwell B, Gutteridge JM. Free Radicals in Biology and Medicine. New York: Oxford University Press; 1999.
7. Liu SX, Hou FF, Guo ZJ, Nagai R, Zhang WR, Liu ZQ, *et al.* Advanced oxidation protein products accelerate atherosclerosis through promoting oxidative stress and inflammation. Arterioscler Thromb Vasc Biol 2006;26:1156-62.
8. Mahboob M, Rahman MF, Grover P. Serum lipid peroxidation and antioxidant enzyme levels in male and female diabetic patients. Singapore Med J 2005;46:322-4.
9. Zaidi SM, Banu N. Antioxidant potential of Vitamins A, E and C in modulating oxidative stress in rat brain. Clin Chim Acta 2004;340:229-33.
10. Gordon L, McGrowder DA, Pena YT, Cabrera E, Lawrence-Wright MB. Effect of yoga exercise therapy on oxidative stress indicators with end-stage renal disease on Hemodialysis. Int J Yoga 2013;6:31-8.
11. Manna I, Ghosh N, Banerjee S, Ghosh S, Kar SK, Dhara P. Effect of yoga on flexibility and reaction time in adolescent boys and girls. Ind J Sports Stud 2004;3:29-35.
12. Agrawal RP, Aradhana R, Hussain S, Sabir M, Kochar DK, Kothari RP. Influence of yogic treatment on quality of life outcomes, glycaemic control and risk factors in diabetes mellitus. Int J Diabetes Dev Ctries 2003;23:130-4.
13. Bute SS, Dhule SS, Surdi AD, Handergulle SM. A Comparative study of antioxidant status in yoga and normal adult males. Int J Basic Appl Physiol 2012;1:120-2.
14. Sinha S, Singh SN, Monga YP, Ray US. Improvement of glutathione and total antioxidant status with yoga. J Altern Complement Med 2007;13:1085-90.
15. Sharma KK, Nandini M, Sriharisukesh N, Ajithesha NH. Impact of yoga therapy on respiratory function and oxidative stress in middle aged subjects (A pilot study). Int J Multidiscip Educ Res 2016;1:1-4.
16. Chatterjee S, Mondal S. Effect of regular yogic training on growth hormone and dehydroepiandrosterone sulfate as an endocrine marker of aging. Evid Based Complement Alternat Med 2014;2014:240581.
17. Jonson BL, Nelson JK. Practical Measurements for Evaluation in Physical Education. London: Macmillan Publishing Co.; 1996.
18. Siri WE. The gross composition of the body. In: Tobias CA, Lawrence JH, editors. Advances in Biological and Medical Physics. New York: Academic Press; 1956. p. 239-80.
19. Durnin JV, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 years. Br J Nutr 1974;32:77-97.
20. Satoh K. Serum lipid peroxide in cerebrovascular disorders determined by a new colorimetric method. Clin Chim Acta 1978;90:37-43.
21. Marklund S, Marklund G. Assay of SOD activity in tissue. J Biochem 1998;13:305-15.
22. Beers RF Jr., Sizer IW. A spectrophotometric method for measuring the breakdown of hydrogen peroxide by catalase. J Biol Chem 1952;195:133-40.
23. Beutler E, Duron O, Kelly BM. Improved method for the determination of blood glutathione. J Lab Clin Med 1963;61:882-8.
24. Brewster MA. Vitamins. In: Kaplan LA, Pesce AJ, Kazmierczak SC, editors. Clinical Chemistry Theory, Analysis and Correlation. New York: Mosby Publisher; 1996. p. 786-7.
25. Himashree G, Mohan L, Singh Y. Yoga practice improves physiological and biochemical status at high altitudes: A Prospective case-control study. Altern Ther Health Med 2016;22:53-9.
26. Bhutkar MV, Bhutkar PM, Taware GB, Surdi AD. How effective is sun salutation in improving muscle strength, general body endurance and body composition? Asian J Sports Med 2011;2:259-66.
27. Zorofi F, Hojjati Z, Elmiyeh A. Effect of yoga exercises on the body composition of fasting females. J Fasting Health 2013;1:70-8.
28. Bera TK, Rajapurkar MV. Body composition, cardiovascular endurance and anaerobic power of yogic practitioner. Indian J Physiol Pharmacol 1993;37:225-8.
29. Ceriello A. Possible role of oxidative stress in the pathogenesis of hypertension. Diabetes Care 2008;31 Suppl 2:S181-4.
30. Li H, Horke S, Förstermann U. Oxidative stress in vascular disease and its pharmacological prevention. Trends Pharmacol Sci 2013;34:313-9.
31. Hegde SV, Adhikari P, Kotian S, Pinto VJ, D'Souza S, D'Souza V, *et al.* Effect of 3-month yoga on oxidative stress in type 2 diabetes with or without complications: A controlled clinical trial. Diabetes Care 2011;34:2208-10.
32. Gordon LA, Morrison EY, McGrowder DA, Young R, Fraser YT, Zamora EM, *et al.* Effect of exercise therapy on lipid profile and oxidative stress indicators in patients with type 2 diabetes. BMC Complement Altern Med 2008;8:21.
33. Patil SG, Dhanakshirur GB, Aithala MR, Naregal G, Das KK. Effect of yoga on oxidative stress in elderly with grade-I hypertension: A randomized controlled study. J Clin Diagn Res 2014;8:BC04-7.
34. Kojda G, Hambrecht R. Molecular mechanisms of vascular adaptations to exercise. Physical activity as an effective antioxidant therapy? Cardiovasc Res 2005;67:187-97.
35. Telles S, Reddy SK, Nagendra HR. Oxygen consumption and respiration following two yoga relaxation techniques. Appl Psychophysiol Biofeedback 2000;25:221-7.