Research Article

Effect of lifestyle modifications on oxidative stress in elderly essential hypertensive patients

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Abstract

Background: Cardiovascular disease (CVD) is one of the leading causes of morbidity and mortality in elderly people, while essential hypertension is a major risk factor for CVD. However, extensive experimental data support a role for increased reactive oxygen species levels and altered redox signaling in the pathogenesis of hypertension.

Objective: This study evaluates the effects of lifestyle modifications on oxidative stress and blood pressure in elderly hypertensive patients.

Materials and Methods: 83 hypertensive patients (49 males and 34 females) were recruited from Santosh Medical College, Ghaziabad, India for 3 months lifestyle modifications program which included morning walk, nadi shodan pranayama, dietary restrictions, and increase uptake of water.

Result: Post lifestyle modifications technique values revealed significant reduction of systolic blood pressure ($p < 0.0001$) and diastolic blood pressure ($p < 0.0001$) besides all fasting lipids decreased except LDL. Moreover, there was significant increase in the GSH ($p < 0.0001$) and SOD ($p < 0.0001$), whereas significant decrease in the MDA ($p < 0.0001$) was recorded.

Conclusion: In this study, lifestyle modification program improved cardiovascular risk factors such as hypertension and dyslipidaemia along with oxidative stress. Modest modification in lifestyle can have substantial effects on human health status which can be achievable and unavoidable in developing countries as it is economical. We emphasize more researches should be done on lifestyle modifications program to make future policies and guidelines.

KEY WORDS: Elderly, hypertension, lifestyle modifications, oxidative stress

Introduction

Cardiovascular disease (CVD) is one of the leading causes of mortality and morbidity in modern societies, with prevention as well as treatment of the condition is a focus of recent attention.[1] Essential hypertension is major risk factor for CVD in spite of our advance understanding to its pathophysiology and availability of effective treatment strategies.[2] Endothelial dysfunction is the most significant pathological factor in producing hypertension; as endothelium is widely considered to be the largest endocrine gland in the human body. While mechanical damage, or loss of functional integrity, disturbs the homoeostasis of microenvironment, leading to the development of pathological states, such as hypertension or atherogenesis.[3] However, essential hypertension is a heterogeneous disorder with different patients having different causal factors including insulin resistance, obesity, high alcohol intake, sedentary life, high salt intake, aging, stress, low potassium intake, and low calcium intake. High blood pressure is one of the primary factors for the CVD.[2,4–6]

Reactive oxygen species participate in a variety of chemical reactions with biomolecules leading to a pathological condition

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known as oxidative stress.[7] Oxidative stress contributes to the process of aging as well as a variety of chronic degenerative diseases.[8] Moreover, extensive experimental data support a role for increased reactive oxygen species levels and altered redox signaling in the pathogenesis of hypertension.[9] Nevertheless, oxidative stress contributes to mechanisms of atherosclerosis and plaque instability. Biomarkers of oxidative stress, such as malondialdehyde (MDA), may represent independent indicators of risk for patients with stable coronary artery disease.[10]

A combination of diet and exercise ameliorates oxidative stress, inflammation, and monocyte–endothelial interaction whereas intensive lifestyle modification may improve novel coronary artery disease risk factors[11] as psychological stress increases oxidative stress whereas relaxation decreases it.[8] Lifestyle modifications are recommended as a non-pharmacological approach to treatment of hypertension because modifications of lifestyle not only have antihypertensive effects by themselves but also help in reducing the dose of drugs. In addition to dietary modification, exercise, moderation of alcohol consumption, and stopping smoking are important for hypertensive patients.[12,13] It has been suggested that yoga effectively reduces blood pressure, heart rate, body mass index, body weight, cholesterol level, blood glucose level along with it increases super oxide dismutase (SOD) and glutathione peroxidase level.[14–18] Similarly, sudarshankriya yoga significantly decreases diastolic blood pressure (DBP) and MDA.[19] Moreover, nadishodhan pranayama considerably reduces basal heart rate and systolic blood pressure.[20,21] Pharmacological treatment for hypertension is effective in reducing blood pressure, morbidity, and mortality from CVD. However, long-term pharmacological therapy can have adverse effects and requires continuous medical supervision. On the other hand, lifestyle modifications can have a real and significant reduction in blood pressure.[22] Therefore, this study was designed to analyze the effects of life style modifications on blood pressure changes, oxidative stress in elderly patients suffering from essential hypertension.

Materials and Methods

Study Population

Study group consisted of 89 elderly patients (51 males and 38 females), between 60 and 80 years of age, suffering from essential hypertension diagnosed on the basis of long-term increase in blood pressure. All the patients were recruited from Santosh Medical College and Hospital, Ghaziabad, India and the research work was done from 20 June 2014 to 20 June 2015. However 6 patients (2 males and 4 females) left the study in between and 83 patients (49 males and 34 females) completed the lifestyle modifications. Inclusion criteria in the study were hypertension >140/90 mm Hg,[23] body mass index 18.5–25 kg/m^2, non alcoholics and non-smokers. None of the subjects was suffering with any type of chronic disease, for example, diabetes mellitus, tuberculosis, renal failure, thyroid disorder, etc. Subjects were not on antihypertensive medicines, any other medication or hormone replacement therapy.

All of the patients received detailed information regarding the purpose and nature of the study and gave their inform consent before enrolment for the lifestyle modifications program. This study was approved by ethical committee of Santosh University NCR, Ghaziabad, India.

Lifestyle Modifications

Patients suffering from essential hypertension were asked to modify their day to day life style for 3 months by performing yogic exercise **"Nadi Shodhan Pranayama"** (forced one side nostril breathing) on an empty stomach for 20 min, early morning 6 days in a week, restricting salt intake up to 100 m Eq/day, lowering fat intake up to 44–77g, increasing intake of water 2–3 litres per day, daily sleep of minimum 5–6 h, and morning walk of 2 miles (3.2 km) for 6 days in a week.

Measurements

Blood Pressure

All the measurements and blood samples were collected in the morning empty stomach before and after intervention of life style modifications. Subjects were asked to sit quietly in comfortable position for 10 min and then blood pressure was measured three times by auscultatory method at every 10 min interval by Sphygmomanometer (manufactured by Diamond Regular India).

Biochemical Parameters

Serum concentration of total cholesterol (TC) was estimated by the enzymatic CHOD-POD method.[24] Serum concentration of triglycerides (TG) was measured by the GPO-PAP method.[24] Serum concentration of high density lipoprotein (HDL) was measured by CHOD-POD/phosphotungstate method.[24] Serum concentration of low density lipoprotein (LDL) was calculated by using Friedewald's formula: LDL cholesterol = total cholesterol – HDL cholesterol – [triglycerides/5].[24]

Markers of oxidative stress glutathione (GSH) and SOD were estimated in serum sample using enzyme linked immunosorbent assay (ELISA),[25,26] whereas MDA in serum was estimated by thiobarbituric acid method (TBA).[27] ELISA kits for GSH and SOD manufactured by Qayee-Biotechnology Co. Ltd Shanghai, China were used. TBARS assay kit manufactured by Cayman chemical company, Ann Arbor, USA was used. Elisa Reader of Robonik (India) Pvt. Ltd. and Biochemistry Analyser E-C5VZ(10k) manufactured by Transasia (India) were used for the biochemistry analysis.

Statistical Analysis

The results were expressed as mean ± SD (Standard deviation of Mean). To compare the values obtained before and after lifestyle modifications, paired student's *t*-test was used. Pearson correlation on the entire data was used to test whether GSH, SOD, and MDA were correlated with blood pressure.

A *p*-value < 0.05 was considered statistically significant. IBM SPSS Statistics 21 manufactured by IBM USA was used for entire calculations.

Result

Total 83 patients, aged 66.81 ± 5.22 years completed lifestyle modifications of 3 months. Table 1 shows that lifestyle modifications have significantly decreased SBP (165.08 ± 11.04 vs. 156.77 ± 10.56, $p < 0.0001$) and DBP (106.75 ± 8.82 vs. 100.67 ± 7.98, $p < 0.0001$). Beside this, other parameters of cardiovascular disease, heart rate, pulse pressure, and mean arterial pressure showed significant decrease in baseline values after lifestyle modifications [Table 1].

Further, we observed significant changes in lipid profile shown in Table 2. TC, TG, and LDL showed significant decrease of 9.68 ± 2.95, 4.9 ± 1.1, 7.12 ± 0.23, respectively, from base line values whereas HDL significantly increased from base line value (1.19 ± 0.51, $p < 0.0008$).

Oxidative stress markers are presented in Figure 1. It shows that baseline values of GSH and SOD significantly increased to (87.77 ± 8.63 ng/mL vs. 95.04 ± 9.31 ng/mL), (68.88 ± 15.02 ng/mL vs. 77.5 ± 15.51 ng/mL), respectively. However, baseline value of MDA significantly decreased (5.99 ± 0.68m mol/mL vs. 4.85 ± 0.86 m mol/mL). The results further revealed that GSH and SOD had negative correlation with both SBP and DBP. On the other hand, MDA had a positive correlation with SBP and DBP [Table 3].

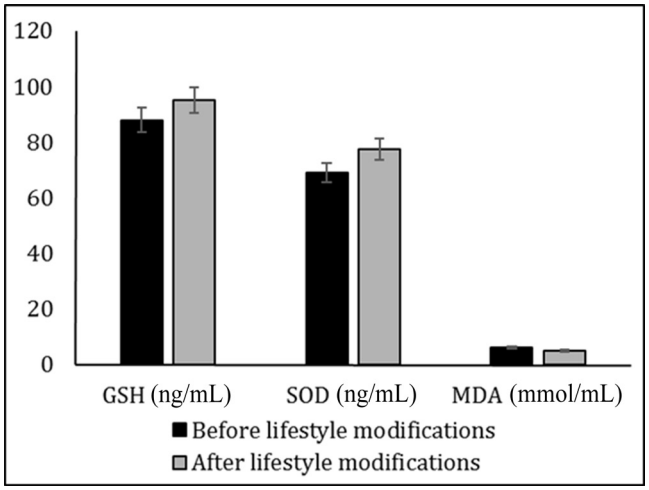

Figure 1: Changes in oxidative stress (GSH, Glutathione total; SOD, superoxide dismutase; MDA, malondialdehyde).

Discussion

Hypertension can result in various diseases and there are several lines of treatment for hypertension in early stage;

Table 1: Comparison of pre and post lifestyle modifications values of blood pressure and heart rate

Parameters	Before lifestyle modifications	After lifestyle modifications	*P*-value	*t*-value
Systolic blood pressure mmHg	165.08 ± 11.04	156.77 ± 10.56	<0.0001	15.29
Diastolic blood pressure mmHg	106.75 ± 8.82	100.67 ± 7.98	<0.0001	13.33
Heart rate	77.83 ± 5.58	75.76 ± 4.29	<0.0001	6.03
Pulse pressure	58.07 ± 7.43	56.19 ± 7.17	<0.0001	16.78
MAP	126.3 ± 8.72	119.42 ± 8.35	<0.0001	16.78

Values expressed as mean±SD; MAP, mean arterial pressure; SD, Standard deviation of mean.

Table 2: Changes in lipid profile after following lifestyle modifications

Parameters	Before lifestyle modifications	After lifestyle modifications	*P*-value	*t*-value
Total cholesterol (mg/dL)	223.22 ± 28.35	213.54 ± 25.4	<0.0001	11.12
Triglycerides (mg/dL)	137.61 ± 25.58	133.52 ± 24.68	<0.0001	7.43
HDL (mg/dL)	41.17 ± 5.74	42.36 ± 5.23	<0.0008	3.49
LDL (mg/dL)	154.46 ± 22.79	147.35 ± 22.56	<0.0001	9.47

Values expressed as mean±SD; HDL, high density lipids; LDL, low density lipids; SD, standard deviation of mean.

Table 3: Pearson correlation between oxidative stress and blood pressure

Oxidative stress	Systolic blood pressure		Diastolic blood pressure	
GSH	$r^2 = -0.194$	*P*<.0001	$r^2 = -0.055$	*P*<0.0001
SOD	$r^2 = -0.12$	*P*<.0001	$r^2 = -0.058$	*P*<0.0001
MDA	$r^2 = +0.046$	*P*<.0001	$r^2 = +0.024$	*P*<0.0001

GSH, Glutathione total; SOD, superoxide dismutase; MDA, malondialdehyde.

although, the results vary from person to person. Nevertheless, in last few years, studies have shown that lifestyle modifications can reduce blood pressure in hypertensive patients.[28,19] Investigators have suggested though there is a lot of advancement in our understanding of its pathophysiology and effective modus operandi of treatment; most of the hypertensive patients require two or more medicines. Nonetheless, the hypertension and its concomitant remain uncontrolled, especially in elderly, having systolic blood pressure >160 mmHg.[29]

Our study recorded significant reduction in systolic and diastolic blood pressure in comparison of baseline values after 3 months of lifestyle modifications. The results of this study are similar to that of Svetkey et al.[30] where lifestyle changes significantly reduced systolic and diastolic blood pressure. Likewise Jiro et al.[31] recorded that regular exercise significantly reduces systolic and diastolic blood pressure in mild hypertensive patients. Various researches have suggested diverse mechanism of decrease in blood pressure; as Pal et al. suggested that increased sympathetic activity and vagal inhibition is reflection of autonomic imbalance in prehypertensive patients although yoga and exercise reestablish the sympathovagal imbalance and blood pressure hemostasis in prehypertensive patients.[32,33] We observed a significant decrease of heart rate, pulse pressure, and mean arterial pressure in our study as yoga has been found effective in reducing heart rate and blood pressure by affecting baroreflex sensitivity.[34]

Increased level of lipid profile is more common in untreated hypertensive than normotensive, and lipid levels are directly related to increase of blood pressure.[35,36] In this study, lifestyle modifications have significantly reduced TC, TG, and LDL concentrations though increased the HDL level. Similarly, Agrawal et al. showed significant reduction in serum TC, LDL, and triglyceride concentrations beside considerable increase in HDL concentrations after 3 months of yoga.[37] Agte et al. recorded moderate decrease of serum TC and TG in type 2 diabetic patients after 4 month's Sudarshan kriya yoga.[15] Alike effects of yoga was observed by Lorenzo et al.[38] Decline in lipid profile along with blood pressure may decrease the risk for CVD in elderly hypertensive patients as previous studies revealed that increase in TC level, particularly in the presence of hypertension has been associated with coronary artery disease.[39–41] Moreover, studies have suggested that management of arterial hypertension should focus both on lowering high blood pressure and correcting associated dyslipidaemia.[42,43]

Previous studies have shown that uncontrolled reactive oxygen species are pivot of many pathological conditions; various cardiovascular diseases have been affected by reactive oxygen species to different degrees.[44,45] However, alteration in oxidant and antioxidant status in early stage of hypertension is reported. It is found that more than one factor are included in development of hypertension; therefore, hypothetical role of oxidative stress in development of hypertension cannot be ruled out.[46–48] We have observed in our study that there is a significant enhancement in SOD activity by 12.57% which is near to the results of Gorden et al. as they observed 24.08% and 20.18% inflation in hath yoga group and conventional PT exercise group, respectively.[49] On the other hand, we recorded increase of GSH level by 8.28% after lifestyle modifications which are nearly to the findings of Cheong et al. and Sinha et al.[50,17] Enhancement of GSH and SOD may be helpful in diminishing the consequences of chronic disease like hypertension as GSH and SOD have been found effective against harmful oxidative stressors.[50] Furthermore, both SOD and GSH have shown negative correlation with hypertension in our study which is similar to negative correlation reported in previous studies.[51,52] MDA is found elevated in hypertensive subjects as it is produced due to damage of the membrane polyunsaturated fatty acids by reactive oxygen species.[45] In this study, we observed a significant reduction in serum MDA level by 19.03% after lifestyle modifications, which is very similar to the findings of Gordon et al. 18.1% decrease in hath yoga group and 19.9% in conventional PT exercise group. Similarly, Patil et al. observed decline of 20.54% whereas Singh et al. recorded significant decrease after yoga. Moreover, MDA has shown positive correlation with blood pressure in our study which is similar to previous studies.[49,53,54] This decline in MDA level suggests the reduction of cardiovascular risk for elderly hypertensive patients as MDA is the independent risk factor for CVD.[10] Finding of this study has demonstrated that lifestyle modifications decrease the adverse effects of lipid peroxidation as MDA had been significantly induced by Yoga may be due to its up regulation.[49,55]

In this study, we observed decrease of lipid profile along with oxidative stress; moreover, decrease level of oxidative stress has shown positive correlation with blood pressure. These evidences are strongly advocating the fact that oxidative stress might be an important factor in developing and maintaining the hypertension as reduction of the oxidative stress is correlated with regression of target organ disease and normalization of metabolic activities; furthermore, hypotensive effects of medicines are not related with decrease of oxidative stress. That is why antihypertensive treatment should be focused both: on hypotensive effect and oxidative stress.[56] However, dyslipidaemia, hypertension, and lipid peroxidation are directly related to the severity of atherosclerosis. If elimination of free radicals in the plasma takes place before the peripheral tissues take them up, it might reduce atherosclerosis. Therefore, a management strategy aimed at simultaneously reducing lipid peroxidation and increasing total antioxidant status in dyslipidaemic patients may be beneficial.[57]

Conclusion

In this study, lifestyle modifications program improved cardiovascular risk factors such as hypertension and dyslipidaemia along with oxidative stress. Modest modification in lifestyle can have substantial effects on human health status which can be achievable and unavoidable in developing countries as it is economical. We emphasize further research should be done on lifestyle modifications program to make future policies and guidelines for elderly hypertensive patients.

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References

1. Mozaffarian D, Wilson PW, Kannel WB. Beyond established and novel risk factors for cardiovascular disease. Circulation 2008;117(23):3031–38.
2. Carretero OA, Oparil S. Essential hypertension: Part I: definition and etiology. Circulation 2000;101:329–35.
3. Kuklinska AM, Mroczho B, Musical WJ, Usowicz-Szarynska M, Sawicki R, Borowska H, et al. Diagnostic biomarkers of essential arterial hypertension: the value of prostacyclin, nitric oxide, oxidized – LDL, and peroxide measurements. Int Heart J 2009;5: 341–51.
4. Intersalt Co-operative Research Group. Sodium, potassium, body mass, alcohol and blood pressure: the intersalt study. J Hypertens 1988;6(suppl.4):S584–6.
5. Sever PS, Poulter NR. A hypothesis for the pathogenesis of essential hypertension: the initiating factors. J Hypertens. 1989;7(suppl.1):S9–S12.
6. Whelton PK. Epidemiology of hypertension. Lancet 1994:344: 101–6.
7. Kunwar A, Priyadarsini KI. Free radicals, oxidative stress and importance of antioxidants in human health. J Med Allied Sci 2011;1(2):53–60.
8. Yadav RK, Ray RB, Vempati R, Bijlani RL. Effect of a comprehensive yoga-based lifestyle modification program on lipid peroxidation. Indian J PhysiolPharmacol 2005;49(3):358–62.
9. Montezano A, Touyz RM. Reactive oxygen species, vascular Noxs and hypertension: focus on translational and clinical research. Antioxident Redox Singling 2013;22.
10. Walter MF, Jacob RF, Jeffers B, Ghadanfar MM, Preston GM, Buch J, et al. Serum levels of thiobarbituric acid reactive substances predict cardiovascular events in patients with stable coronary artery disease: a longitudinal analysis of the prevent study. J Am Coll Cardiol 2004;44(10):1996–2002.
11. Roberts CK, Won D, Pruthi S, Lin SS, Barnard RJ. Effect of a diet and exercise intervention on oxidative stress, inflammation and monocyte adhesion in diabetic men. Diabetes Res Clin Pract 2006;73(3):249–59.
12. Ando K. Modification of daily life in patients with mild hypertension. Nihon Rinsho 2008;66(8):1542–6.
13. Ohta M, Nanri H, Matsushima Y, Sato Y, Ikeda M. Blood pressure-lowering effects of lifestyle modification: possible involvement of nitric oxide bioavailability. Hypertens Res 2005;28(10): 779–86.
14. Okonta NR. Does yoga therapy reduce blood pressure in patients with hypertension? An integrative review. Holist Nurs Pract 2012;26(3):137–41.
15. Agte VV, Jahagirdar, Tarwadi KV. The effects of SudarshanKriya Yoga on some physiological and biochemical parameters in mild hypertensive patients. Indian J Physiol Pharmacol 2011;55(2): 183–7.
16. Mahapure HH, Shete SU, Bera TK. Effect of yogic exercise on supra oxide dismutase levels in diabitics. Int J Yoga 2008; 1(1):21–6.
17. Sinha S, Singh SN, Monga YP, Ray US. Improvement of glutathione and total antioxidant status with yoga. J Altern Complement Med 2007;13(10):1085–90.
18. Bhattacharya S, Pandey US, Verma NS. Improvement in oxidative status with yogic breathing in young healthy males. Indian J Physiol Pharmacol 2002;46(3):349–54.
19. McCaffery R, Ruknui P, Hatthakit U, Kasetsmboon P. The effects of yoga on hypertensive persons in Thailand. Holist Nurs Pract 2005;19(4):173–80.
20. Subbalakshmi NK, Saxena SK, Urmimala, D'Souza UJA. Immediate effect of 'Nadi–Shodhana Pranayama' on some selected parameters of cardiovascular, pulmonary, and higher functions of brain. Thai J Physiol Sci 2005;18(2):10–16.
21. Sukhdev S, Vishaw G, Ved P. Effects of a 6-week nadi-shodhana pranayama training on cardio-pulmonary parameters. J Physical Educ Sports Manage 2011;2(4):44–7.
22. Frisoli1 TM, Schmieder RE, Grodzicki T, Messerli FH. Beyond salt: lifestyle modifications and blood pressure. European Heart J 2011;32:3081–7.
23. Head GA, Mihailidous AS, Duggan KA, Beilin LJ, Berry N, Brown MA, et al. Definition of ambulatory blood pressure targets for diagnosis and treatment of hypertension in relation to clinic blood pressure: prospective cohort study. BMJ 2010;340:1104.
24. Burtis CA, Ashwood ER, Bruns DE. *Teitz Fundamentals of Clinical Chemistry*, 6th ed. pp. 422–24.
25. Emokpae MA, Uadia PO, Gadzama AA. Correlation of oxidative stress and inflammatory markers with the severity of sickle cell nephropathy. Ann African Med. 2010;99(3):141–6.
26. Onorato JM, Thorpe SR, Baynes JW. Immunohistochemical and ELISA assays for biomarkers of oxidative stress in aging and disease. Ann N Y Acad Sci 1998; 854277–90.
27. Mossa MM, Bushra MM, Salih MR, May NY. Estimation of malondialdehyde as oxidative factor & glutathione as early detectors of hypertensive pregnant women. Tikrit Med J 2009; 15(2):63–9.
28. Apple LJ, Champagne CM, Harsha DW, Cooper LS, Obarzanek E, Elmer PJ, et al. Effects of comprehensive lifestyle modification on blood pressure control. JAMA 2003;289 (16):2083.
29. Anand SI, Mustafa IA, Gerasimos SF, James E, Inmaculada BA, Thomas EL, et al. Uncontrolled hypertension and increased risk for incident heart failure in older adults with hypertension: findings from a propensity-matched prospective population study. J Am Soc Hypertension 2010;4(1):22–31.
30. Svetkey LP, Erlinger TP, Vollmer WM, Feldstein A, Cooper LS, Appel LJ et al. Effect of lifestyle modifications on blood pressure by race, sex, hypertension status, and age. J Human Hypertension 2005;19:21–31.
31. Jiro M, Hiroshi I, Sanae H, Kazuo T, Tsuguru H, Tetsuo N, et al. Low frequency regular exercise improves flow-mediated dilatation of subjects with mild hypertension. Hypertens Res 2005; 28:315—21.
32. Santella DF, Araujo EA, Ortega KC, Tinucci T, Mion D Jr., Negrao CE, et al. After effects of exercise and relaxation on blood pressure. Clin J Sport Med 2006;16(4):341–7.
33. Pal GK, Chandrasekaran A, Hariharan AP, Dutta TK, Pal P, Nanda N et al. Body mass index contribute to sympathovagal imbalance in prehypertensives. BMC Cardiovascular Disord 2012;12:54.

34. Tyagi A, Cohen M. Yoga and hypertension: a systematic review. Altern Ther Health Med 2014;20(2):32–59.
35. Borghi C. Interactions between hypercholesterolemia and hypertension: implications for therapy. Curr Opin Nephrol Hypertens 2002;11(5): 489–96.
36. Neaton JD, Wentworth D. Serum cholesterol, blood pressure, cigarette smoking, and death from coronary heart disease: overall findings and differences by age for 316 099 white men. Arch Intern Med 1992;152(1):56–64.
37. 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 Diab Dev Ctries 2003;23(4):130–4.
38. Lorenzo AG, Errol YM, Donovan AM, Ronald Y, Yeiny TPF, Eslaen MZ, et al. Effect of exercise therapy on lipid profile and oxidative stress indicators in patients with type 2 diabetes. BMC Complem Altern Med 2008;8:21.
39. Reaven GM. Are triglycerides important as risk factor for coronary heart disease? Heart Dis Stroke 1993;2:44–8.
40. McKeigue PM, Shah B, Marmot MG. Relationship of central obesity and sinsulin resistance with high diabetes prevalence and cardiovascular risks in South Asians. Lancet 1991;338:842–7.
41. Reaven GM. Are triglycerides important as risk factor for coronary heart disease? Heart Dis Stroke 1993;2:44–8.
42. Okazaki T, Himeno E, Nanri H, Ikeda M. Effects of a community-based life style modification program on cardiovascular risk factors in middle aged women. Hypertence Res 2001;24:647–53.
43. Lepira FB, M'Buyamb KJR, Kayembe KP, Nseka MN. Correlates of serum lipids and lipoproteins in Congolese patients with arterial hypertension. Cardiovasc J S Afer 2005;16(5):249–55.
44. Alfaddal AA, Sallam RM. Reactive oxygen species in health and disease. J Biomed Biotechnol 2012;2012:936486.
45. Aggarwal NT, Makielski JC. Redox control of cardiac excitability. Antioxid Redox Singal 2013;18(4):432–68.
46. Sohal RS, Mockett RJ, Orr WC. Mechanisms of aging: an appraisal of the oxidative stress hypothesis. Free Radic Biol Med 2002;33(5):575–86.
47. Nandeesha H, Sathiyapriya V, Bobby Z, Pavithran P, Agarwal A, Selvraj N. Altered oxidant-antioxidant status in non-obese men with moderate essential hypertension. Indian J Med Sci 2007; 61(6):326–31.
48. Subash P, Premagurumurthy K, Sarasabharathi A, Cherian KM. Total antioxidant status and oxidative DNA damage in a South Indian population of essential hypertensives. J Hum Hypertens 2010;24(7):475–82.
49. 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.
50. Cheong KJ, Lim SA. Antioxidant effects of regular yoga training on the healthy university students controlled clinical trial. J Yoga Phys Ther 2012;2(6):2157–7595.
51. Rodrigo R, Prat H, Passalacqua W, Araya J, Guichard C, Bachler JP. Relationship between oxidative stress and essential hypertension. Hypertens Res 2007;30:1159–67.
52. Kojda G, Hambrecht R. Molecular mechanism of vascular adaptations to exercise. Physical activity as an effective antioxidant therapy? Cardiovasc Res 2005;67:187–97.
53. Singh S, Malhotra V, Singh KP, Sharma SB, Madhu SV, Tandon OP. A preliminary report on the role of yoga asanas on oxidative stress in non-insulin dependent diabetes mellitus. Indian J Clin Biochem 2001;16(2):216–20.
54. Patil SG, Dhanakshirur GB, Aithala MR, Naegal G, Das KK. Effect of yoga on oxidative stress in elderly with grade-I hypertension: a randomized controlled study. J Clin Diabn Res 2014; 8(7):BC04–7.
55. Kim JD, Yu BP, McCarter RJ, Lee SY, Herlihy JT. Exercise and diet modulate cardiac lipid peroxidation and antioxidant defenses. Free Radic Biol Med 1996;20:83–8.
56. Ogunro PS, Balogun WO, Fadero FF, Idogun ES, Ononla SO, Elemile PO, et al.. Plasma lipid peroxidation and totalantioxidant status among dyslipidaemic and hypertensive Nigerians with high risk of coronary heart disease. West Afr J Med 2009; 28(2):87–91.
57. Kozłowska JS, Litwin M, Niemirska A, Płudowski P, Wierzbicka A, Skorupa E, et al. Oxidative stress in hypertensive children before and after 1 year of antihypertensive therapy. PediatrNephrol 2012; 27:1943–51.

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