International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Researcher Article *DOI: 10.61336/im/26-2-12*

Effect of Vitamin C Supplementation on Oxidative Stress in Subjects with Metabolic Risk Factors

Alok Pal[1] Amar Deep Patel[2] Indushri[3] and Vani Gupta[4]
[1]*Associate Professor, Dept. Of Physiology, MSDASMC, Bahraich*
[2]*Associate Professor, Dept. Of Psychiatry, MSDASMC, Bahraich*
[3]*Associate Professor, Dept. Of Anatomy, GMC Kannauj*
[4]*Professor, Dept. Of Physiology, KGMU Lucknow*

Correspondence:
Alok Pal
Associate Professor, Dept. Of Physiology, MSDASMC, Bahraich

Received: **December 10, 2025**
Revised: **January 15, 2026**
Accepted: **February 09, 2026**
Published: **February 21, 2026**

Abstract ***Background***- Hypertension, diabetes and obesity and dyslipidemia are emerging life style disorders. These disorders are multifactorial but oxidative stress has been postulated to be a common underlying pathology. This might be due to increased ROS production or insufficient antioxidant systems. Vitamin C and glutathione are important antioxidants that plays multiple beneficial an protective roles against oxidative damage in the body. This study had been planned to study the effect of treatment and antioxidant supplementation on oxidative stress in metabolic risk factors. ***Material and methods-*** Apparently healthy adults were enrolled for this study on the basis of exclusion and inclusion criteria. Detailed personal, family and medical history was noted. BMI, lipid profile, fasting blood sugar, serum GSH and hsCRP was measured. Subjects with any one or more metabolic risk factors were kept in case group (n=77) and subjects with no risk factors were put in control group (n=43). The case group was again divided into two groups- Group A (n=37) and Group B (n=40). Group A was supplemented with vitamin C tabs 500 mg twice a day for 2 months along with the treatment required for their clinical conditions. Group B was provided with only treatment required for their disease for 2 months and serum GSH and hsCRP was measured in both groups after 2 months. After 2 months, Group A received only relevant treatment and Group B was supplemented with vitamin C along with treatment and again hsCRP and serum GSH was measured after next 2 months and statistical analysis was done. ***Observations***- We observed that in group A, baseline GSH & hsCRP was 3.11±0.82ug/ml &4313.3±1883.58 ng/ml respectively. At two & four months it was 3.23±0.81 ug/ml, 3369.5±986.44 ng/ml & 3.23±0.80 ug/ml, 2943.6±731.08 ng/ml respectively. hs-CRP was significantly different (p=0.006) after first 2 months and 4 months (p<0.001) compared with those at the baseline. Serum levels of GSH didn`t change significantly after 2 months and four months with those at baseline. In group B, baseline GSH & hsCRP was 3.22±0.80 ug/ml & 5217.8±2143.17 ng/ml respectively. At two & four months it was 3.24±0.76 ug/ml, 4445.6±1383.25 ng/ml & 3.35±0.73 ug/ml, 3537.5±1012.83 ng/ml respectively. ***Results:*** Our observations suggest that metabolic risk factors are state of increased oxidative stress. Treatment of metabolic risk factors reduces oxidative stress and this reduction is augmented by vitamin C supplementation. This will not only prevent cellular damage but it will also replenish the antioxidant store in the body and may be responsible for the Beneficial effect observed due to early control of metabolic risk factors ***Conclusions***- Drug treatment of metabolic risk factors reduces oxidative stress. When vitamin C was given along with treatment there was more reduction in oxidative stress

Keywords-Metabolic risk factors, oxidative stress, antioxidants, vitamin C, hsCRP, GSH, glutathione

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (http://creativecommons.org/licenses/by/4.0/).

INTRODUCTION

Prevalence of chronic life style disorders are gradually increasing in India. Obesity, diabetes and hypertension and dyslipidemia are emerging life style disorders in todays` era which are collectively called as part of the metabolic syndrome. NCEP ATP III [1] has defined metabolic syndrome as a condition consisting of any three of the following i.e., increased blood pressure (>130/85mm of Hg), increased fasting blood sugar (>100mg/dl), increased TG >150 mg/dl, decreased HDL <40 mg/dl in male & < 50 mg/dl in female and waist circumference > 90cms in male and >80 cms in females (for Indian population) [2].

These disorders are multifactorial but oxidative stress has found to be a common underlying pathology in all disorders as shown in various researches [3,4]. According to Roberts CK et al [3] oxidative stress can be defined as an imbalance between

the ROS and antioxidants in the body. This imbalance may be due to increased ROS production or depressed antioxidant systems in the body. In normal conditions, these ROS are neutralized by antioxidants present in the body. When oxidative stress increases for longer duration, continuous increased production of ROS occurs resulting in depletion of antioxidants and ROS remain free and damage the cells and in turn increases the inflammation. Vona R [4] found a significant decrease in the activity or expression of antioxidant systems in subjects with metabolic syndrome.

The cause of oxidative stress in conditions of metabolic risk factors are multifactorial and increased oxidative stress play important role in pathogenesis of metabolic syndrome. Hopps E [5] reviewed the evidences showing that Metabolic risk factors are characterized by increased oxidative stress and the later contribute to the development of metabolic and cardiovascular complications. Thus, it can be postulated that reduction in oxidative stress will slow down the end organ damage in metabolic syndrome. Decreased ROS production can be obtained by controlling various factors that increases oxidative stress but as discussed earlier these conditions are multifactorial and some factors are not known or modifiable, therefore, it might be difficult to control the ROS induced end organ damage by just controlling the risk factors. Another approach to control ROS induced tissue damage is to strengthen the antioxidant system of the body. These antioxidants will neutralize the ROS and prevent the damage at cellular level. Important antioxidants for the body are vitamin C, vitamin E, vitamin A, reduced Glutathione & some enzymes (e.g. superoxide dismutase & catalase). From a quantitative point of view, glutathione and vitamin C are the most abundant reducing agents in cells [4]

Vitamin C, a water-soluble vitamin, is an important antioxidant. Vona R [4] mentioned vitamin C as biologically ubiquitous and the first antioxidant defense in body tissues. Vitamin C traps the free radicals produced in body. Vitamin E and glutathione depends on vitamin C for regeneration back to their active isoforms. Vitamin C improves endothelium-dependent vasodilation by restoring Nitric Oxide (NO) activity in essential hypertension [6]. Ascorbic acid cannot be synthesized in body due to lack of enzyme gluconolactone oxidase [7] therefore, human body is dependent on external sources for the supply of vitamin C.

Glutathione is another important intracellular antioxidant which is synthesized intracellularly by cytosolic enzymes. Glutathione plays vital roles in protection against cellular oxidative damage. Glutathione deficiency leads to increased oxidative stress and the later plays an important role in the pathogenesis of many diseases like diabetes.[8]

As cardio-metabolic risk factors are associated with increased inflammation and oxidative damage leading to depletion antioxidants including glutathione. Therefore, we conducted this study to see the effect of vitamin C supplementation on oxidative stress and glutathione in such individuals.

MATERIAL AND METHOD-

This study was conducted after taking the ethical approval from Institutional Ethics Committee.

Apparently healthy adults between 21 to 45 years of age of both the gender, were enrolled (n=120) for the study after taking their written consent for the participation. All individuals were enquired for their personal, family and detailed medical history.

Subjects with any known endocrinal, inflammatory, metabolic disorders, cardiac or oncological problems were excluded from the study. Persons with any acute or chronic infections were also not included in the study.

Pregnant and lactating females, post-menopausal females & females with any known gynecological or obstetrical disorders were also not included in this study.

In all recruited subjects, waist circumference and blood pressure were measured. Serum levels of HDL, LDL, Triglycerides & fasting blood sugar was measured in all the subjects. Serum GSH and hsCRP was also measured in all subjects.

Every subject was screened for metabolic risk factors as per NCEP ATP III criteria [1,2]. Subjects with any one or more metabolic risk factors were kept in case group (n=77) and subjects with no risk factors were put in control group (n=43). The case group was divided into two groups- Group A (n=37) and Group B (n=40). Group A was supplemented with vitamin C tabs 500 mg twice a day for 2 months along with the treatment required for their clinical conditions. Group B was provided with treatment required for their disease for 2 months and serum GSH and hsCRP was measured in both groups after 2 months. After 2 months, Group A received only relevant treatment and Group B was supplemented with vitamin C (500 mg twice a day) along with treatment and again hsCRP and serum GSH was measured after next 2 months and statistical analysis was done.

OBSERVATIONS AND RESULTS-

The demographic profile of the subjects are shown in Table-1. Both the cases and control groups were matched to their age, sex and height. Waist circumference, Systolic BP, Diastolic BP, LDL, TG, FBS, GSH and hsCRP were statistically significantly raised and HDL was statistically significantly lower in case group.

Tables 1- Demographic Profile of the Study Group

S. no	Parameters	Control(n=43)	Cases (n=77)	p-Value
1	Age (years)	34.05±5.49	35.67±5.76	0.134
2	Sex Male Female	 32 (74.42%) 11 (25.58%)	 67 (87.01%) 10 (12.99%)	 0.136
3	Waist (cm)	79.02±7.10	89.29±18.05	0.001**
4	SBP (mmHg)	118.05±7.55	134.78±13.33	<0.001**
5	DBP (mmHg)	78.23±4.96	86.13±13.49	<0.001**
6	TG (mg/dl)	102.35±21.95	152.77±38.85	<0.001**
7	HDL (mg/dl)	44.30±4.34	38.47±5.85	<0.001**
8	LDL (mg/dl)	111.40±15.49	151.19±30.36	<0.001**
9	FBS (mg/dl)	89.44±5.91	104.13±23.35	<0.001**
10	GSH (ug/ml)	4.79±0.77	3.17±0.81	<0.001**
11	hs-CRP (ng/ml)	1640.5±547.47	4783.1±2060.21	<0.001**

For group A, effect of vitamin C supplementation on level of GSH and hs-CRP during 4 months is shown in **Table 2.** In group A, baseline GSH & hsCRP was 3.11±0.82ug/ml &4313.3±1883.58 ng/ml respectively. At two & four months it was 3.23±0.81 ug/ml, 3369.5±986.44 ng/ml & 3.23±0.80 ug/ml, 2943.6±731.08 ng/ml respectively as shown in table 2.

Table 2: Effect of vitamin C supplementation on serum GSH and hs-CRP during 4 months in group A (n =37)

	Group A Mean±SD n=(37)			p-Value
	Baseline	2 months	4 months	
GSH (ug/ml)	3.11±0.82	3.23±0.81	3.23±0.80	0.768
hs-CRP (ng/ml)	4313.3±1883.58	3369.5±986.44	2943.6±731.08	<0.001**

**= significant (p≤0.001)

As shown in **Table 3**, the level of hs-CRP was significantly different (p=0.006) after first 2 months and 4 months (p<0.001) compared with those at the baseline. Serum levels of GSH didn`t change significantly after 2 months and four months with those at baseline.

Table 3: Tukey Post-Hoc test for Effect of vitamin C supplementation on GSH and hs-CRP parameters during 4 months in group A (n =37)

	Baseline vs 2 months			Baseline vs 4 months			2 months vs. 4 months		
	95% Confidence Interval		p-value	95% Confidence Interval		p-value	95% Confidence Interval		p-value
	Lower	Upper		Lower	Upper		Lower	Upper	
GSH (ug/ml)	-0.57	0.33	0.81	-0.57	0.33	0.804	-0.45	0.45	1.000
hs-CRP (ng/ml)	226.55	1661.02	0.006*	652.49	2086.97	<0.001**	-291.29	1143.18	0.339

**=significant (p≤0.001), *= significant (p≤0.05)

Effect of vitamin C supplementation on level of GSH and hs-CRP for group B, during 4 months is shown in **Table 4.** In group B, baseline GSH & hsCRP was 3.22±0.80 ug/ml & 5217.8±2143.17 ng/ml respectively. At two & four months it was 3.24±0.76 ug/ml, 4445.6±1383.25 ng/ml & 3.35±0.73 ug/ml, 3537.5±1012.83 ng/ml respectively as shown in table 4.

Table 4: Effect of vitamin C supplementation on GSH and hs-CRP parameters during 4 months in group B (n =40)

	Group B Mean±SD n=40			p-Value
	Baseline	2 months	4 months	

GSH (ug/ml)	3.22±0.80	3.24±0.76	3.35±0.73	0.720
hs-CRP (ng/ml)	5217.8±2143.17	4445.6±1383.25	3537.5±1012.83	<0.001**

As shown in **Table 5**, the level of hs-CRP & GSH was not significantly different after first 2 months. The level of hs-CRP was significantly different after second 2 months (p=0.031) and 4 months (p<0.001) compared with those at the baseline. Serum levels of GSH didn`t change significantly after 2 months and four months with those at baseline.

Table 5: Tukey Post-Hoc test for Effect of vitamin C supplementation on GSH and hs-CRP parameters during 4 months in group B (n =40)

	Baseline vs 2 months			**Baseline vs 4 months**			**2 months vs. 4 months**		
	95% Confidence Interval		**p-value**	**95% Confidence Interval**		**p-value**	**95% Confidence Interval**		**p-value**
	Lower	Upper		Lower	Upper		Lower	Upper	
GSH (ug/ml)	-0.42	0.39	0.995	-0.53	0.28	0.737	-0.52	0.30	0.793
hs-CRP (ng/ml)	-90.37	1634.77	0.089	839.14	2521.36	<0.001**	66.94	1749.16	0.031*

**=significant (p≤0.001), *= significant (p≤0.05)

RESULTS and DISCUSSION-

All selected subjects in case and control group were matched for their age, sex, and height. Waist circumference values were statistically significantly higher in case group. Systolic and diastolic blood pressure, TG, LDL and FBS was significantly higher and HDL was significantly lower in case group as this group was consisting of subjects at metabolic risks.

Case group was found to have statistically significant higher hsCRP levels in comparison to control group. Raised blood sugar causes non enzymatic glycation of various proteins in body which is linked with glucose auto oxidation process. These glaycated proteins are source of free radicals that results in increased inflammation and in turn increased hsCRP levels [9]. Hypertension is considered to be the result of endothelial dysfunction that may be due to the presence of chronic inflammation indicated by raised hsCRP.[10] It is also noted that the fat cells release various proinflammatory cytokines [11] which induces inflammation which is responsible for raised hsCRP levels in obese individuals. Thus diabetes, hypertension, dyslipidemia and obesity all are chronic conditions associated with increased inflammation. Our study demonstrated the similar results.

We observed lower levels of serum GSH, an antioxidant in case group. Increased inflammation as indicated by higher hsCRP causes enhanced production of ROS which in turn consumes more antioxidants resulting in depletion of antioxidants.

In group A, on supplementing ascorbic acid (for initial two months) along with life style modification and medication (prescribed by physician), we observed rise in serum GSH level and lowering of hsCRP levels and change in later was statistically significant. Mohammed S Ellulu et al [12] observed in their randomized control trials that Vitamin C supplementation decreases inflammation by reducing hs-CRP, IL-6, and FBG in hypertensive and/or diabetic obese patients. Similarly, C S Johnston et al [13] found in their study that Vit C supplementation increases mean RBC glutathione by 50% and improves overall antioxidant property of the blood. Thus, treatment along with Vitamin C supplementation decreases inflammation and increases antioxidant (glutathione) in subjects at metabolic risks.

On further two months follow up without ascorbic acid supplementation, we observed almost no change in GSH level but further decline in serum hsCRP levels. This change in hsCRP from baseline to two months and baseline to four months was statistically significant. But change in hsCRP levels between later two-month duration was not statistically significant. These observations suggest that ascorbic acid supplementation was helpful in decreasing hsCRP levels. Although change in GSH level was not statistically significant but we observed rise in its levels from baseline to two months during which ascorbic acid supplementation was given.

In Group B, a rise in serum GSH levels and lowering of hsCRP was observed. Decrease in hsCRP between baseline and 2 months was not statistically significant but between baseline and 4 months this decline was statistically significant. We also observed statistically significant decrease in hsCRP between later 2 months when ascorbic supplementation was given. These observations suggest that vitamin C supplementation definitely augments decrease in hsCRP levels. Maryam

Safabakhsh et al [14] found similar results in their systematic review and meta-analysis of clinical trials in which they observed that vitamin C supplementation have a significant effect on CRP reduction.

We also observed a rise in serum GSH levels between initial 2 months, later 2 months and between baseline to 4 months but these changes were statistically not significant. We also observed that increase in GSH level was more when ascorbic acid was supplemented. Kevin J Lenton et al [15] observed in their study that ascorbic acid supplementation in vitamin C deficient healthy adults for 13 weeks increases glutathione in human lymphocytes. Thus, it can be concluded that vitamin C decreases inflammation and helps in restoration of antioxidant glutathione in body. Carole L. Linster et al [16] mentioned that Vitamin C and glutathione are the most abundant reducing agents in cells from the quantitative point of view. Thus, reduced oxidative stress and inflammation due to treatment with antioxidant supplementation will not only prevent cellular damage but it will also replenish the antioxidant store in the body. Decreased oxidative stress and replenishing of antioxidants might be the reason of Beneficial Effect (especially in diabetes and hypertension) observed due to early control of clinical condition by drug treatment.

CONCLUSIONS

Above observations suggest that metabolic risk factors are state of increased inflammation and oxidative stress. When treatment and life style modifications are done, inflammation and oxidative stress both decreases. But if treatment and life style changes are supplemented with antioxidants then there is more reduction in oxidative stress

REFERENCE

1. Lipsy RJ. The National Cholesterol Education Program Adult Treatment Panel III guidelines. Journal of managed care pharmacy: JMCP. 2003;9(1 Suppl):2-5.
2. Misra A, Vikram N, Gupta R, Pandey R, Wasir J, Gupta V. Waist circumference cutoff points and action levels for Asian Indians for identification of abdominal obesity. International journal of obesity. 2006;30(1):106-11.
3. Roberts CK, Sindhu KK. Oxidative stress and metabolic syndrome. Life sciences. 2009;84(21-22):705-12.
4. Vona R, Gambardella L, Cittadini C, Straface E, Pietraforte D. Biomarkers of Oxidative Stress in Metabolic Syndrome and Associated Diseases. Oxidative Medicine and Cellular Longevity. 2019;2019:8267234.
5. Hopps E, Noto D, Caimi G, Averna M. A novel component of the metabolic syndrome: the oxidative stress. Nutrition, Metabolism and Cardiovascular Diseases. 2010;20(1):72-7
6. Taddei S, Virdis A, Ghiadoni L, Magagna A, Salvetti A. Vitamin C improves endothelium-dependent vasodilation by restoring nitric oxide activity in essential hypertension. Circulation. 1998;97(22):2222-9.
7. Valdés F. [Vitamin C]. Actas dermo-sifiliograficas. 2006;97(9):557-68.
8. Wu G, Fang YZ, Yang S, Lupton JR, Turner ND. Glutathione metabolism and its implications for health. The Journal of nutrition. 2004;134(3):489-92.
9. Ceriello A. Hyperglycaemia: the bridge between non-enzymatic glycation and oxidative stress in the pathogenesis of diabetic complications. Diabetes Nutr Metab. 1999;12(1):42-6.
10. Dinh QN, Drummond GR, Sobey CG, Chrissobolis S. Roles of inflammation, oxidative stress, and vascular dysfunction in hypertension. 2014;2014:406960.
11. Rodríguez-Hernández H, Simental-Mendía LE, Rodríguez-Ramírez G, Reyes-Romero MA. Obesity and Inflammation: Epidemiology, Risk Factors, and Markers of Inflammation. International Journal of Endocrinology. 2013;2013:678159.
12. Ellulu MS, Rahmat A, Patimah I, Khaza'ai H, Abed Y. Effect of vitamin C on inflammation and metabolic markers in hypertensive and/or diabetic obese adults: a randomized controlled trial. Drug design, development and therapy. 2015;9:3405.
13. Johnston CS, Meyer CG, Srilakshmi JC. Vitamin C elevates red blood cell glutathione in healthy adults. The American Journal of Clinical Nutrition. 1993;58(1):103-5.
14. Safabakhsh M, Emami MR, Zeinali Khosroshahi M, Asbaghi O, Khodayari S, Khorshidi M, et al. Vitamin C supplementation and C-reactive protein levels: Findings from a systematic review and meta-analysis of clinical trials. Journal of complementary & integrative medicine. 2020.
15. Lenton KJ, Sané AT, Therriault H, Cantin AM, Payette H, Wagner JR. Vitamin C augments lymphocyte glutathione in subjects with ascorbate deficiency. The American Journal of Clinical Nutrition. 2003;77(1):189-95.
16. Linster CL, Van Schaftingen E. Vitamin C. Biosynthesis, recycling and degradation in mammals. The FEBS journal. 2007;274(1):1-22.