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Original Research Article

Influence of Vitamin C and E Supplementation on Oxidative Stress Parameters in Aging

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Abstract

Background: Oxidative stress, caused by an imbalance between reactive oxygen species (ROS) and antioxidant defenses, plays a central role in aging. Vitamins C and E are potent dietary antioxidants that may counteract age-related oxidative damage. This study aimed to evaluate the effect of vitamin C and E supplementation on oxidative stress parameters in elderly individuals.

Material and Methods: A randomized, placebo-controlled study was conducted in 120 participants divided into two groups: elderly (≥60 years, n=60) and young adults (20–30 years, n=60). Each age group was further subdivided into control and supplementation subgroups. Participants in supplementation groups received oral vitamin C (500 mg/day) and vitamin E (400 IU/day) for 12 weeks. Blood samples were analyzed for malondialdehyde (MDA, a marker of lipid peroxidation), superoxide dismutase (SOD), and glutathione peroxidase (GPx) using spectrophotometric methods.

Results: At baseline, elderly participants showed significantly higher MDA levels and lower antioxidant enzyme activity compared to young adults ($p < 0.05$). Following supplementation, elderly subjects exhibited a significant reduction in MDA ($p < 0.01$) and an increase in SOD and GPx activities ($p < 0.05$). Improvements were modest in young adults. Placebo groups showed no significant changes.

Conclusion: Vitamin C and E supplementation effectively reduced oxidative stress and improved antioxidant enzyme activities in the elderly. These findings suggest that targeted antioxidant supplementation may mitigate age-related oxidative damage and promote healthy aging.

Keywords: Aging, Oxidative stress, Vitamin C, Vitamin E, Antioxidant enzymes.

Introduction

Aging is a complex biological process associated with gradual functional decline and increased vulnerability to chronic diseases such as neurodegeneration, cardiovascular disease, and cancer. One of the most widely accepted mechanisms underlying aging is the oxidative stress theory, which attributes functional decline to cumulative damage caused by reactive oxygen species (ROS) [1]. ROS, generated during normal cellular metabolism, can damage lipids, proteins, and DNA if not adequately neutralized by antioxidant defenses [2].

The human body possesses enzymatic (superoxide dismutase, catalase, glutathione peroxidase) and non-enzymatic (vitamins C and E, glutathione, carotenoids) antioxidant systems that maintain redox balance [3]. With advancing age, these defenses weaken, resulting in oxidative stress, which contributes to accelerated aging and the pathogenesis of chronic diseases [4,5]. Vitamins C and E are among the most studied dietary antioxidants. Vitamin C (ascorbic acid), a water-soluble antioxidant, directly scavenges ROS and regenerates oxidized vitamin E (6]. Vitamin E (α-tocopherol), a lipid-soluble antioxidant, protects cell membranes from lipid peroxidation by terminating free radical chain reactions [7]. Their synergistic action is critical in maintaining oxidative stability within cells.

Previous studies have suggested that supplementation with these vitamins may improve oxidative stress parameters, especially in elderly populations [8,9]. However, results remain inconsistent, with some trials reporting significant benefits and others showing minimal impact [10,11]. Variability in population demographics, supplementation dosage, and study duration may explain these discrepancies. The elderly are particularly vulnerable to oxidative stress due to reduced endogenous antioxidant enzyme activity

and increased ROS generation from mitochondrial dysfunction [12,13]. Nutritional interventions targeting this imbalance could represent a cost-effective strategy to slow aging-related decline and improve quality of life.

Therefore, this study was designed to assess the influence of combined vitamin C and E supplementation on oxidative stress parameters—malondialdehyde (MDA), superoxide dismutase (SOD), and glutathione peroxidase (GPx)—in elderly and young adults. By comparing baseline and post-supplementation values, we sought to provide insights into the efficacy of antioxidant supplementation as a potential anti-aging strategy.

Aim and Objectives

Aim:

To evaluate the influence of vitamin C and E supplementation on oxidative stress parameters in aging.

Objectives:

1. To measure MDA, SOD, and GPx levels before and after vitamin C and E supplementation in elderly and young adults.
2. To compare the changes in oxidative stress parameters between supplemented and control groups.

Materials and Methods

This was a randomized, placebo-controlled interventional study conducted in the Department of Biochemistry of a tertiary care hospital. A total of 120 healthy participants were recruited and stratified into two age groups: elderly (≥60 years, n=60) and young adults (20–30 years, n=60). Each age group was randomly subdivided into supplementation and placebo groups (30 participants each).

Inclusion criteria: Healthy individuals within defined age groups, non-smokers, non-alcoholic, and not on antioxidant or multivitamin therapy.

Exclusion criteria: Individuals with diabetes, cardiovascular disease, cancer, chronic renal/hepatic disease, or on medications affecting oxidative metabolism.

The supplementation group received oral vitamin C (500 mg/day) and vitamin E (400 IU/day) for 12 weeks, while placebo groups received identical capsules containing starch. Fasting venous blood samples were collected at baseline and after 12 weeks.

- **MDA** was estimated using the thiobarbituric acid reactive substances (TBARS) method.
- **SOD activity** was measured by inhibition of pyrogallol autoxidation.
- **GPx activity** was determined using NADPH oxidation assay.

Data were analyzed using SPSS v25.0. Paired t-tests compared pre- and post-supplementation values, while ANOVA compared between groups. A p-value <0.05 was considered statistically significant.

Results

Table 1. Baseline Oxidative Stress Parameters in Young vs Elderly Participants

Parameter	Young Adults (n=60)	Elderly (n=60)	p-value
MDA (nmol/mL)	2.1 ± 0.4	3.6 ± 0.7	<0.001
SOD (U/mg Hb)	12.8 ± 1.9	9.2 ± 1.5	<0.001
GPx (U/g Hb)	46.2 ± 5.8	37.4 ± 5.6	<0.001

Interpretation: Elderly subjects showed significantly higher oxidative stress and lower antioxidant enzyme activities compared to young adults.

Table 2. Effect of Supplementation on Oxidative Stress in Elderly Participants

Parameter	Baseline	Post-Supplementation	p-value
MDA (nmol/mL)	3.6 ± 0.7	2.8 ± 0.5	<0.01
SOD (U/mg Hb)	9.2 ± 1.5	11.1 ± 1.7	<0.05
GPx (U/g Hb)	37.4 ± 5.6	42.8 ± 5.2	<0.05

Interpretation: Elderly supplementation group showed significant improvement in oxidative stress parameters.

Table 3. Comparison of Supplementation Effect between Young and Elderly Groups

Parameter	% Change in Young Adults	% Change in Elderly	p-value
MDA	-8%	-22%	<0.05
SOD	+5%	+21%	<0.05
GPx	+6%	+15%	<0.05

Interpretation: Antioxidant supplementation was more effective in elderly individuals than in young adults.

Discussion

This study evaluated the effect of vitamin C and E supplementation on oxidative stress parameters in young and elderly individuals. The findings clearly indicate that elderly participants exhibited higher oxidative stress at baseline, as evidenced by elevated MDA levels and reduced SOD and GPx activities, compared to young adults. Supplementation with vitamins C and E significantly improved these parameters, particularly in the elderly group.

The observed baseline differences align with the oxidative stress theory of aging proposed by Harman [1], which suggests that aging is accompanied by increased ROS production and diminished antioxidant defenses. Mitochondrial dysfunction and cumulative oxidative damage are key contributors to this imbalance [12]. The elevated MDA levels in elderly participants reflect enhanced lipid peroxidation, consistent with previous studies [14,15].

Vitamin C and E supplementation reduced MDA and enhanced enzymatic antioxidant activity, indicating improved oxidative balance. Vitamin E, being lipid-soluble, primarily protects membrane lipids, while vitamin C, a hydrophilic antioxidant, scavenges ROS in aqueous environments and regenerates oxidized vitamin E [6,7]. Their combined supplementation likely contributed to the synergistic protective effect observed.

Our results corroborate findings by Meydani et al. [16], who reported decreased lipid peroxidation in elderly subjects following vitamin E supplementation. Similarly, Jacob et al. [17] observed improvements in antioxidant enzyme activities with vitamin C intake. The greater benefit observed in elderly compared to young adults in our study suggests that supplementation is particularly effective when endogenous defenses are compromised.

Interestingly, young adults exhibited only modest improvements in oxidative stress markers. This may be due to their relatively intact antioxidant defenses at baseline, resulting in a ceiling effect where supplementation provides limited additional benefit. These findings emphasize the relevance of targeted supplementation in populations at higher risk of oxidative stress, such as the elderly. Mechanistically, vitamins C and E reduce oxidative damage by directly neutralizing ROS and upregulating antioxidant enzyme activities [18]. The increase in SOD and GPx observed in our study may also result from improved redox signaling, as antioxidants modulate transcription factors involved in antioxidant gene expression [19]. The clinical implications are noteworthy. Oxidative stress contributes to the pathogenesis of neurodegenerative disorders, atherosclerosis, and metabolic syndromes in elderly individuals [5,13]. By lowering oxidative burden, supplementation with vitamins C and E may reduce the risk of these conditions and promote healthy aging. However, large-scale longitudinal studies are needed to confirm whether biochemical improvements translate into clinical benefits.

Our study has certain limitations. The sample size was relatively small, and supplementation was limited to 12 weeks. Longer duration and varying dosages might yield more robust outcomes. Additionally, dietary intake of antioxidants was not strictly controlled, which could influence baseline variability.

Despite these limitations, the study provides strong evidence supporting the beneficial role of vitamin C and E supplementation in reducing oxidative stress in elderly individuals.

Future directions include longitudinal trials with larger populations, exploration of combined supplementation with other antioxidants such as polyphenols, and clinical outcome-based studies to evaluate reductions in age-related disease risk.

Conclusion

The present study demonstrated that aging is associated with increased oxidative stress, characterized by elevated lipid peroxidation and reduced antioxidant enzyme activity. Supplementation with vitamin C and E significantly reduced MDA levels and improved SOD and GPx activities, particularly in elderly individuals. These results suggest that targeted antioxidant supplementation can enhance redox balance and potentially mitigate age-related oxidative damage.

While young adults showed only modest benefits, the elderly exhibited significant improvements, highlighting the importance of supplementation in populations with compromised endogenous defenses. The synergistic action of vitamins C and E in different cellular compartments underscores their relevance as complementary antioxidants.

From a public health perspective, dietary supplementation with vitamins C and E represents a simple, safe, and cost-effective strategy to support healthy aging. However, long-term studies are necessary to establish clinical efficacy in preventing age-related diseases.

In conclusion, vitamin C and E supplementation may serve as a valuable adjunct in maintaining oxidative balance and promoting healthy aging, particularly among elderly individuals.

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