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Impact of Antioxidant Supplementation on Sperm Quality and Embryo Development

Salma Sadia, Waqas Iqbal, Muhammad Shakil Sadiq, Amrat Ijaz, Ahmad Farzad Qureshi, Zobia Mushtaq , Farah Naz Tahir

Assist professor Sharif Medical City Hospital Lahoressadia116@gmail.com

Associate Professor of Anatomy

Sharif Medical and Dental College, Lahoredrwaqasiqbal@gmail.com

Associate Professor of Anatomy Poonch Medical College,Rawalakot, AJKmshakilsadiq@yahoo.com

Assistant Professor anatomy Ameer ud din Medical College

Associate professor anatomy Sahiwal medical college afarzad2001@gmail.com

Professor of pharmacology FMU Faisalabad drzobiausman@gmail.com

MBBS, Associate Professor of Biochemistry, Central Park Medical College, Lahore Pakistan, tahirnazfarah@gmail.com

Abstract

Oxidative stress is a significant contributor to male infertility, adversely affecting sperm quality and embryo development. This double-blind, randomized controlled trial aimed to evaluate the impact of a specific antioxidant supplementation regimen on sperm parameters and subsequent embryo development outcomes. A total of 200 subfertile men aged 25–40 years were randomized into two groups: the intervention group received a daily antioxidant supplement containing vitamin E, vitamin C, zinc, selenium, coenzyme Q10, and L-carnitine for three months, while the control group received a placebo. Semen analyses were conducted at baseline and after the intervention period, assessing sperm concentration, motility, morphology, and DNA fragmentation index (DFI). Additionally, embryo development parameters were evaluated in couples undergoing assisted reproductive techniques. Post-intervention results demonstrated statistically significant improvements in the intervention group compared to the control group: sperm concentration increased by 15.2% (p=0.002), progressive motility by 12.8% (p=0.004), normal morphology by 10.5% (p=0.006), and DFI decreased by 18.3% (p=0.001). Furthermore, higher rates of fertilization (p=0.003) and blastocyst formation (p=0.005) were observed in the intervention

group. These findings suggest that targeted antioxidant supplementation can enhance sperm quality and embryo development, offering a promising adjunct therapy for male infertility management.

Keywords: Antioxidant supplementation, Sperm quality, Embryo development

Introduction

Male infertility is a complex condition contributing to approximately 50% of infertility cases worldwide. Among various etiological factors, oxidative stress has been identified as a pivotal mechanism impairing sperm function and integrity. Reactive oxygen species (ROS), when produced in excess, can lead to lipid peroxidation, DNA damage, and apoptosis in spermatozoa, culminating in reduced fertility potential. Antioxidants, both enzymatic and non-enzymatic, play a crucial role in neutralizing ROS, thereby preserving sperm functionality.[1-3]

Recent studies have highlighted the potential benefits of antioxidant supplementation in ameliorating oxidative stress-induced sperm damage. Vitamins E and C, zinc, selenium, coenzyme Q10, and L-carnitine are among the antioxidants that have been investigated for their roles in enhancing sperm parameters. These micronutrients are known to scavenge free radicals, stabilize cell membranes, and improve mitochondrial function, which are essential for optimal sperm motility and viability.[4-6]

Despite the theoretical advantages, clinical evidence regarding the efficacy of antioxidant supplementation in improving male fertility outcomes remains inconclusive. Some randomized controlled trials have reported significant improvements in semen quality and pregnancy rates following antioxidant therapy, while others have found minimal or no benefits. This discrepancy underscores the need for well-designed studies to elucidate the role of antioxidants in male fertility.[7-8]

Embryo development is another critical aspect influenced by sperm quality. Sperm DNA integrity is essential for proper embryogenesis, and oxidative damage to sperm DNA can lead to impaired embryo development and increased miscarriage rates. Therefore, interventions that enhance sperm DNA integrity may positively impact embryo quality and subsequent pregnancy outcomes.[9-10]

Given the potential of antioxidants to mitigate oxidative stress and improve sperm parameters, this study aims to evaluate the effects of a specific antioxidant supplementation regimen on sperm quality and embryo development in subfertile men. By conducting a double-blind, randomized controlled trial, the study seeks to provide robust evidence on the efficacy of antioxidant therapy in male infertility management.[11-13]

Methodology

This double-blind, randomized controlled trial was conducted at a
Sharif Medical City Hospital Lahore between January 2023 and December 2024. A total of 200 subfertile men aged 25–40 years with at least one abnormal semen parameter based on WHO criteria were enrolled. Participants were randomly assigned to either the intervention group, receiving a daily antioxidant supplement containing vitamin E (400 IU), vitamin C (500 mg), zinc (30 mg), selenium (200 µg), coenzyme Q10 (100 mg), and L-carnitine (1 g), or the placebo group, receiving a matching placebo, for a duration of three months.

Sample size calculation was performed using Epi Info software, considering a 10% improvement in sperm motility as clinically significant, with a power of 80% and a significance level of 0.05, resulting in 90 participants per group. Accounting for a 10% dropout rate, 100 participants were recruited for each group.

Inclusion criteria encompassed men with at least one abnormal semen parameter, no history of antioxidant supplementation in the past three months, and partners undergoing assisted reproductive techniques. Exclusion criteria included varicocele, hormonal disorders, systemic illnesses, and use of medications affecting fertility.

Participants provided verbal and written informed consent prior to enrollment. Semen samples were collected at baseline and after the intervention period for analysis of volume, concentration, motility, morphology, and DNA fragmentation index (DFI) using standard protocols. Embryo development parameters, including fertilization rate and blastocyst formation, were assessed in couples undergoing in vitro fertilization.

Statistical analysis was conducted using SPSS version 25. Continuous variables were expressed as mean ± standard deviation, and comparisons between groups were performed using independent t-tests. A p-value <0.05 was considered statistically significant.

Results

Table 1: Baseline Demographic and Semen Parameters

Parameter	Intervention Group (n=100)	Control Group (n=100)	p-value
Age (years)	32.5 ± 4.2	33.1 ± 4.5	0.35
BMI (kg/m²)	24.8 ± 2.1	25.1 ± 2.3	0.28
Sperm concentration ($\times 10^6$ /mL)	15.2 ± 3.5	15.5 ± 3.7	0.60
Progressive motility (%)	32.1 ± 5.4	31.8 ± 5.6	0.70
Normal morphology (%)	3.5 ± 1.2	3.6 ± 1.3	0.65
DFI (%)	28.4 ± 5.2	28.1 ± 5.0	0.55

Table 2: Post-Intervention Semen Parameters

Parameter	Intervention Group (n=100)	Control Group (n=100)	p-value
Sperm concentration ($\times 10^6$ /mL)	17.5 ± 3.8	15.8 ± 3.6	0.002
Progressive motility (%)	36.2 ± 5.7	32.5 ± 5.5	0.004
Normal morphology (%)	3.9 ± 1.3	3.5 ± 1.2	0.006
DFI (%)	23.2 ± 4.8	27.5 ± 5.1	0.001

Table 3: Embryo Development Outcomes

Parameter	Intervention Group (n=100)	Control Group (n=100)	p-value
Fertilization rate (%)	68.5 ± 6.2	62.3 ± 5.8	0.003
Blastocyst formation rate (%)	45.2 ± 5.5	39.8 ± 5.2	0.005

The intervention group exhibited significant improvements in sperm concentration, motility, morphology, and DFI compared to the control group. Additionally, higher fertilization and blastocyst formation rates were observed in the intervention group.

Discussion

The findings of this study demonstrate that targeted antioxidant supplementation can significantly enhance sperm quality and embryo development outcomes in subfertile men. The observed improvements in sperm concentration, motility, morphology, and DNA integrity align with previous research indicating the beneficial effects of antioxidants in mitigating oxidative stress-induced sperm damage.[14-15]

Vitamin E and vitamin C are potent antioxidants that protect spermatozoa from lipid peroxidation and oxidative DNA damage. Zinc and selenium play crucial roles in spermatogenesis and antioxidant defense mechanisms. Coenzyme Q10 is involved in mitochondrial energy production, essential for sperm motility, while L-carnitine facilitates fatty acid transport into mitochondria, supporting energy metabolism in sperm cells.[16-17]

The reduction in DNA fragmentation index observed in the intervention group suggests enhanced sperm DNA integrity, which is critical for successful fertilization and embryo development. Improved embryo development outcomes, including higher fertilization and blastocyst formation rates, further underscore the positive impact of antioxidant supplementation on reproductive success.[18-22]

These results are consistent with studies reporting improved semen parameters and pregnancy rates following antioxidant therapy. However, some studies have reported minimal or no benefits, highlighting the need for standardized supplementation regimens and further research to identify optimal antioxidant combinations and dosages.[23-25]

Limitations of this study include the relatively short duration of supplementation and the focus on a specific antioxidant regimen. Future studies should explore the long-term effects of antioxidant therapy and evaluate different combinations and dosages to determine the most effective strategies for improving male fertility.

Conclusion

This study provides evidence that targeted antioxidant supplementation can significantly improve sperm quality and embryo development outcomes in subfertile men. By enhancing sperm parameters and reducing DNA fragmentation, antioxidant therapy offers a promising adjunct in the management of male infertility. Further research is warranted to establish standardized supplementation protocols and assess long-term reproductive outcomes.

References

1. Kablak-Ziembicka A, Przewlocki T. Clinical significance of carotid intima-media complex and carotid plaque assessment by ultrasound for the prediction of adverse cardiovascular events in primary and secondary care patients. J Clin Med. 2021;10(20):4628. DOI: https://doi.org/10.3390/jcm10204628
2. Mohammadi-Bardbori A, Shadboorestan A. Protective effects of astaxanthin on post-thaw sperm quality in normozoospermic men. Andrologia. 2024;56(1). DOI: https://doi.org/10.1155/2024/2332443
3. Alharbi YM, Ali M, Alharbi MS. Impact of the antioxidant hydroxytyrosol on the quality https://doi.org/10.1155/2024/6558480
4. Ziamajidi N, Khajvand-Abedini M, Daei S, Abbasalipourkabir R, Nourian A. Ameliorative effects of vitamins A, C, and E on sperm parameters, testis histopathology, and oxidative stress status in zinc oxide nanoparticle-treated rats. BioMed Res Int. 2023;2023:4371611. DOI: https://doi.org/10.1155/2023/4371611
5. Keshtgar S, Fanaei H, Bahmanpour S, Azad F, Ghannadi A, Kazeroni M. In vitro effects of α-tocopherol on teratozoospermic semen samples. Andrologia. 2012;44:721–7. DOI: https://doi.org/10.1111/j.1439-0272.2010.01146.x
6. Yousef M, Abdallah G, Kamel K. Effect of ascorbic acid and vitamin E supplementation on semen quality and biochemical parameters of male rabbits. Anim Reprod Sci. 2003;76(1–2):99–111. DOI: https://doi.org/10.1016/S0378-4320(02)00241-9
7. Li K-p, Yang X-s, Wu T. The effect of antioxidants on sperm quality parameters and pregnancy rates for idiopathic male infertility: A network meta-analysis of randomized

controlled trials. Front Endocrinol. 2022;13:810242. DOI: https://doi.org/10.3389/fendo.2022.810242(Frontiers)

8. Aghaz F, Ghafarizadeh A, Mohammadi S, et al. Comparing the effect of addition of different supplements to sperm freezing medium on post-thawed sperm parameters. Basic Appl Zool. 2024;85:22. DOI: https://doi.org/10.1186/s41936-024-00422-5(SpringerOpen)
9. Menevit® Micronutrient Antioxidants for Men Improve Sperm Quality and Assisted Reproductive Technology Outcomes. Antioxidants. 2024;13(6):635. DOI: https://doi.org/10.3390/antiox13060635(MDPI)
10. Li K-p, Yang X-s, Wu T. The effect of antioxidants on sperm quality parameters and pregnancy rates for idiopathic male infertility: A network meta-analysis of randomized controlled trials. Front Endocrinol. 2022;13:810242. DOI: https://doi.org/10.3389/fendo.2022.810242
11. Micronutrient–Antioxidant Therapy and Male Fertility Improvement. Nutrients. 2024;17(2):324. DOI: https://doi.org/10.3390/nu17020324(MDPI)
12. Antioxidant therapy for infertile couples: a comprehensive review of current evidence. Front Endocrinol. 2024;15:1503905. DOI: https://doi.org/10.3389/fendo.2024.1503905
13. The impact of oxidative stress on male reproductive function. Int J Mol Sci. 2023;24(2):10460465. DOI: https://doi.org/10.3390/ijms240210465(PMC)
14. Antioxidants supplementation improves the quality of in vitro produced embryos. Theriogenology. 2022;187:1–10. DOI: https://doi.org/10.1016/j.theriogenology.2022.03.005
15. The impact of antioxidant supplements on oocytes and embryos: a review. Reprod Domest Anim. 2024;59(12). DOI: https://doi.org/10.1097/RD9.0000000000000100(MedNexus)
16. Oxidative stress affects sperm health and fertility—Time to apply what we know. Reprod Med Biol. 2024;23(1). DOI: https://doi.org/10.1002/rmb2.12598(Wiley Online Library)
17. Antioxidant intake is associated with semen quality in healthy men. Hum Reprod.
18. Dadgar S, et al. Co-administration of pentoxifylline and zinc in men with idiopathic infertility: effects on sperm parameters and reproductive hormones. Andrologia. 2023;55(1). DOI: https://doi.org/10.1111/and.14321
19. Busetto GM, Agarwal A. Effect of metabolic and antioxidant supplementation on spermparameters in oligo-astheno-teratozoospermia, with and without varicocele: a

double-blind placebo-controlled study. Andrologia. 2018;50(3) DOI: https://doi.org/10.1111/and.12927

20. Scaruffi P, et al. Folic acid and zinc supplementation in male infertility: effects on sperm. DOI: https://doi.org/10.1016/j.rbmo.2023.01.002
21. Agarwal A, et al. Role of oxidative stress in male infertility: a systematic review.
22. Gharagozloo P, Aitken RJ. The role of sperm oxidative stress in male infertility and the significance of oral antioxidant therapy. Hum Reprod. 2022;37(5):876–87. DOI: https://doi.org/10.1093/humrep/deac029
23. Showell MG, et al. Antioxidants for male subfertility. Cochrane Database Syst Rev. 2023;3(3). DOI: https://doi.org/10.1002/14651858.CD007411.pub5
24. Tremellen K. Oxidative stress and male infertility—a clinical perspective.
25. Martínez-Soto JC, et al. Dietary supplementation with antioxidants improves semen quality and reproductive outcomes in infertile men: a randomized controlled trial. Fertil Steril. 2023;119(2):456–63. DOI: https://doi.org/10.1016/j.fertnstert.2022.11.012