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Therapeutic Role of Coenzyme Q10 in Male Infertility: A Semen Analysis-Based Study

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ABSTRACT

The health issue of male infertility affects about 15% of couples throughout the world and male factors drive approximately half of these cases. Sperm quality stands as a fundamental target in male infertility treatment since Ooxidative stress acts as a primary factor that impacts sperm quality. The natural compound Coenzyme Q10 (CoQ10) functions as a powerful antioxidant while serving important roles in mitochondrial bioenergetics because of its presence in semen. Measurable concentrations of CoQ10 exist in human semen with a direct relationship to enhanced sperm parameters regarded as motility as well as concentration alongside morphology. This study examines the potential of CoQ10 supplementation to enhance male fertility by improving semen quality and moderate Oxidative Stress. Clinical evidence demonstrates that CoQ10 improves sperm motility and reduces oxidative damage, thereby decreasing sperm DNA fragmentation. Research supports the use of CoQ10 supplements to enhance pregnancy achievements in assisted reproductive technology programs like in vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI). Despite these advancements, further research is necessary to establish standardized dosages and supplementation protocols for specific infertility cases. This study not only highlights the therapeutic potential of CoQ10, but also highlights the need for additional research to fully understand its role in treating male infertility.

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1. Introduction

Studies indicate that male infertility is available by way of numerous unidentified parameters. In addition, studies demonstrate that oxidative stress is leading reasons of idiopathic male infertility but there remains a need to carry out further research to identify the most effective therapeutic options of this complication [1]. Some of the researches have reported malfunction in spermatozoa like low numbers (azoospermia or oligospermia), decreased motility, and malformation as one of the key causes of male infertility in the world. Many reports have also recorded a steady and marked decrease

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in the sperm counts over the last decades as one of the factors that led to the increasing role of male factors in the world infertility outbreak [2]. ith this trend in mind, the World Health Organization (WHO) updated the reference standards of normal and abnormal sperm count that is now being used in andrology labs all over the world.

Approximately, a half of the total cases of infertility are attributed to male factor infertility, which explains the need to develop a more comprehensive knowledge of the factors that lead to this type of infertility. The infertility in men is often associated with impairments in the sperm quality, including the reduction in the amount of sperm, their motility, and morphology. Oxidative stress is one of the numerous etiological agents that have been recognized to play a significant part in the development of infertility in men, which has profound impacts on the functioning of the sperm and the overall reproductive success in men [3].

Measurable quantities of CoQ10 that are similar to vitamin-like substances are present in the human semen. It exhibits a major metabolic/antioxidant action and is vital in the bioenergetics of the mitochondria. As such, the biological redox balance can be maintained by using CoQ10 [4]. The level of seminal plasma CoQ10 is associated with the semen characteristics which are mainly the sperm motility and the amount. It is exposed that various male infertility disorders such as varicocele, asthenozoospermia and medical/surgical interventions to male infertility influence seminal CoQ10 levels [5]. These results are indicative of CoQ10 playing a physiologically important role in preserving and enhancing semen integrity. Coenzyme Q10 (CoQ10), a required cofactor during energy production and an effective antioxidant, is commonly used to promote spermatogenesis in idiopathic infertile males. This system review aims to shed light on the efficacy of CoQ10 supplementation in the treatment of male infertility based on its effects on the quality of the semen and pregnancy results. Generally, the articles reviewed all suggest a positive role of CoQ10 supplementation on semen parameters [6]. Thus, the purpose of this paper was to discuss how CoQ10 may control the reproductive functions of men and briefly discuss its efficiency as a therapeutic agent in improving semen parameters in infertile men, in addition to its effects on pregnancy, sperm DNA fragmentation in addition to Ooxidative Stress markers and the results of the assisted reproductive technologies [7].

1.1. Role of Coenzyme Q10 in Male Fertility

1.1.1. Potential mechanisms linking CoQ10 to male fertility

The human body naturally produces CoQ10, normally referred to as ubiquinone, from tyrosine. It is a soluble in fat, vitamin-like benzoquinone molecule [**7**]. The substance plays an important role in energy production and acts as a powerful antioxidant, protective cells from harm produced by free radicals. As persons age, the natural levels of CoQ10 in the body tend to decline, leading to several health implications. Studies have exposed that CoQ10 supplementation can provide numerous health benefits. Moreover, the use of this coenzyme may help progress fertility by enhancing sperm quality [8]. Approximately 25% of CoQ10 comes from dietary sources, absorbed in the small intestine and distributed to tissues via blood and lymph [9].The completely reduced form of CoQ10, ubiquinol, is an excellent lipophilic antioxidant that may regenerate the condensed form of vitamin E and neutralize free radicals It acts in cell membranes to protect against lipid peroxidation and can also protect mitochondrial proteins and DNA from oxidative damage [10,11]. Additionally, it can shield DNA and proteins found in mitochondria from oxidative harm and prevent lipid peroxidation in cellular membranes. It is essential to the synthesis of ATP. It is the sole lipophilic antioxidant with enzymatic capabilities to regenerate its reduced state and the ability to be generated by cells from scratch [12].

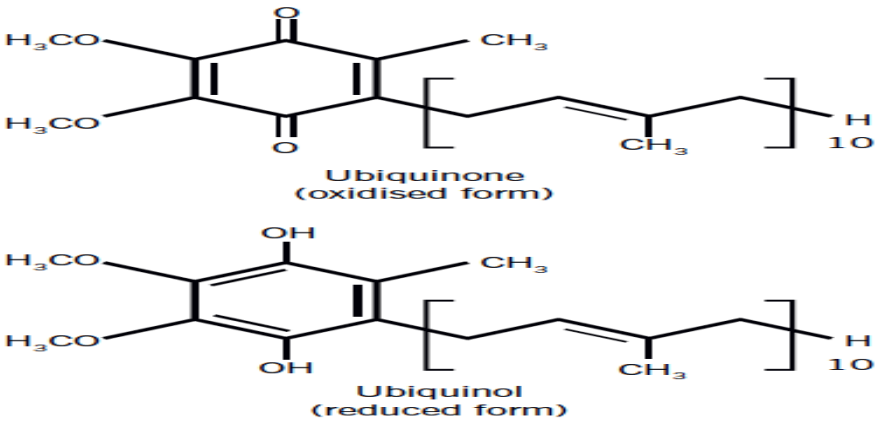

Fig.1. Oxidized and reduced form of coenzyme Q10.

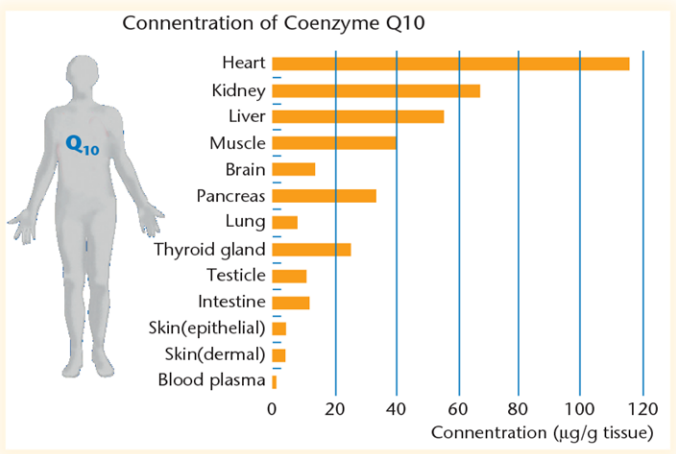

Fig.2. Concentration of Coenzyme Q10 in different human tissues

Fifty percent of instances include a malefactor. Although the exact cause of infertility in men is unknown, there is research linking oxidative stress to low seminal fluid qualities. Because of this, one of the main pillars of empirical therapies for infertility of men is antioxidant therapy. CoQ10 and vitamin E work together to shield lipoproteins against oxidative. Additionally, CoQ10 increases the movement of sperm, which may be due to both its bioenergetics and antioxidant qualities [13].

Fermentation of yeast is the primary process used to manufacture CoQ10 in industry. The end product of the method is CoQ10, which is the same as the molecule found in nature. People can find ubiquinol in commercial forms since this CoQ10 reduced version functions as a chain-breaking antioxidant while free radicals extract its hydrogen molecules. It is essential to note that CoQ10 functions together with vitamin E as critical lipophilic antioxidants because reduced Coenzyme Q has the capability to form the active component of vitamin E called a-tocopherol [14] .CoQ10 is mostly found in soft gels, capsules, and tablets that contain one or more ingredients as a dietary supplement. However, to increase its bioavailability several innovative administration methods have lately been developed. Previously, it was combined as a straightforward crystalline powder or dissolved in oil. The dosage forms for Coenzyme Q10 capsules/tablets are 25 mg, 30 mg, 50 mg, 75 mg, and 100 mg. When compared with other types of formulations, those that incorporate soybean oil had better bioavailability [15,16].

In contrast to multivitamins, there isn't a set starting dose for CoQ10 supplements. The supplement may be packaged in a variety of strengths and recommended dosages by every producer. The majority of manufacturers advise that persons with low blood levels of CoQ10 should begin taking 60–100 mg daily to get their levels back within the normal range. Usually, CoQ10 soft gels are available in dosages

of 60 or 100 mg. CoQ10 blood test findings are challenging to interpret and require particular management. A CoQ10 level before to therapy is still advised by certain doctors, and levels of blood may be monitored [16,17].

2. Oxidative Stress

2.1. Importance of oxidative stress as a major contributing aspect to sperm dysfunction

Seminal reactive oxygen species (ROS) levels are higher in 30–80% of infertile males with sperm production defects [18]. Male infertility refers to any condition that hinders the male reproductive system's capacity to contribute to a successful pregnancy. Its causes are diverse and may involve genetic, environmental, lifestyle, and physiological factors [19]. Spermatozoa are highly specialized cells vital for fertilization, yet they are particularly vulnerable to oxidative stress because of their unique biological characteristics. They are endowed with polyunsaturated fatty acids (PUFA) that keep the membranes fluid and functional yet very vulnerable to oxidative damages by the reactive oxygen species (ROS). This vulnerability is also supported by the low cytoplasmic concentration of sperm cells containing fewer antioxidant enzymes and molecules to counteract the ROS. As a result, spermatozoa depend heavily on both enzymatic and non-enzymatic antioxidant defense systems to protect against oxidative damage [20].

Antioxidant compounds, which are also abundant in the seminal fluid, are created in 2 ways: the enzymatic system, which includes superoxide dismutase, glutathione peroxidase, (SOD), and catalase (CAT); and the non-enzymatic system, which consists of a variety of chemicals that are taken as vitamins or through a healthy diet. OS develops and damages the DNA of sperm when ROS levels surpass the seminal fluid's antioxidant ability. In actuality, spermatozoa are vulnerable to OS due to the high proportion of polyunsaturated fatty acids in their cell membranes, which are subject to lipid peroxidation by ROS [21].

3. Seminal plasma of Male (SP)

3.1. Seminal Fluid: Definition and Composition

The testicular, epididymal, and additional sexual gland fluids combine to form the plasma of the seminal, Semen contains substances which function as the non-cellular elements. Given species-specific anatomic variations the composition of semen always consists of inorganic ions in conjunction with specific hormones together with proteins and peptides that contain cytokines and enzymes as well as cholesterol DNA and RNA., the latter of which is frequently shielded by vesicles outside the cell formed from the prostate or epididymis. Without a doubt, the SP takes involved in a variety of pre-fertilization activities related to sperm function. The SP ultimately modifies fertility by interacting with the different tubular genital tract divisions and causing changes in gene function that set the stage for pregnancy success [22]. Although Such ideas, it is essential to keep in mind that spermatozoa that are free of SP (epididymal or washed ejaculated) are still viable.

The scavenging effect in spermatozoa depends on two forms of antioxidants including both enzymatic and non-enzymatic compounds. Enzymatic chemical defenses of spermatozoa are catalase superoxide dismutase as well as glutathione peroxidase. The non-enzymatic antioxidants comprise coenzyme Q10 (CoQ10), the peroxidase enzyme glutathione, vitamins A, B complex, C and E, carnitines, as well as chromium, selenium, zinc and copper [23]. The management of male infertility with antioxidants includes CoQ10, vitamin A, carnitines, N-acetyl cysteine, vitamin C, vitamin E, and pentoxifylline together with zinc plus selenium as micronutrients [24,25]. Research shows that sperm quantity and movement and morphology and DNA fragmentation with ART results (for instance intracytoplasmic sperm injection and in vitro fertilization) and seminal plasma antioxidant levels directly convey to antioxidant benefits [26].

Table 1. Reference Values for Semen Parameters According to Different Editions of The WHO Manual for The Investigation and Processing of Human Semen

Semen characteristics	WHO 1999 [3]	WHO 2010[3]	WHO 2021[3]
Volume (ml)	≥2	1.5	1.4
Sperm concentration (10^6/ml)	≥20	15	16
Total motility (%)	≥50	40	42
Normal morphology (%)	14	4	4
Normozoospermia	31 (3.9%)	138 (17.5%)	126 (16.0%)
1 semen abnormality	217 (27.5%)	269 (34.1%)	257 (32.6%)
2 semen abnormalities	293 (37.2%)	235 (29.8%)	238 (30.2%)
3 semen abnormalities	247 (31.3%)	146 (18.5%)	167 (21.2%)

4. Infertility

4.1. Causes, Diagnosis, and Treatment Options

A failure to become pregnant is known as infertility. Both men and women may have infertility, which can be brought on by a number of situations. Age, ovulation disorders, endometriosis, uterine or cervix issues, and hormonal imbalance are some of the primary causes in women, whereas low levels of sperm or quality, varicocele, and environment or lifestyle factors are the primary causes in males. Factors After an individual or couple has engaged in unprotected intercourse for a full year without becoming pregnant, medical professionals diagnose it. Infertility can be treated with a variety of methods, like vitro fertilization (IVF), the operation, and drugs to address hormonal problems. Moreover, partner may be the cause of infertility. Infact, issues with the male reproduction system cause infertility exactly as often as problems with the female reproduction system [27]. Chromosome abnormalities and single gene mutations are the primary genetic reasons of male infertility, which can lead to a wide range of sperm abnormalities [28].

Nevertheless, in wealthy nations, only roughly half of infertile men seek medical help. A thorough medical and reproductive history, a physical check, and as a minimum two standard semen analyses performed in a professional andrology laboratory are all part of a well-conducted anthological evaluation, which is essential to reaching these objectives. According to the results of the clinical and semen analysis, second-line investigations (such as hormonal assessment, sperm functional testing, genetic analysis, and imaging studies) can be required. might be essential and are based on the clinical and semen analysis results [29].

4.2. Association between CoQ10 and Sperm Parameters

Several clinical studies confirmed that CoQ10 supplementation leads to better sperm parameters in infertile patients (11, 12, 13) A year-long CoQ10 treatment at 600 mg/day level enhanced sperm concentration by +113.7% while increasing sperm progressive motility by +104.8% and normal sperm shape by +78.9% for 287 patients diagnosed with OAT [30]. A food-based CoQ10 treatment study including 147 control test subjects and 149 treated patients underwent a systematic metanalysis for measuring CoQ10 seminal levels and sperm motility as well as semen count. A CoQ10 supplement enhanced all three-evaluation metrics including sperm concentration alongside sperm motility and

seminal CoQ10 content [31]. Current research has show that CoQ10 significantly improves both sperm mobility along with sperm progressive motility patterns [32]. Mobile sperm parameters with pregnancy outcomes showed improvement after male infertile patients received CoQ10 at 30 mg/day combined with L-carnitine fumarate at 440 mg/day alongside vitamin E at 75 IU/day and vitamin C at 12 mg/day**).**We conducted a randomized controlled trial providing 400 mg/day CoQ10 to 30 patients and 200 mg/day CoQ10 to 35 males who had idiopathic OAT for three months. Daily consumption of 400 mg CoQ10 generated superior test results for sperm parameters [33]. The research involved 70 male subjects with idiopathic OAT effects who received daily CoQ10 treatment at 200 mg to improve their sperm count and motility together with reduced OS indicators [34]. The spermatozoa cells along with seminal plasma demonstrated significant increases in both CoQ10 and D-Asp levels. Sperm motility improved during the research period but the effect did not alter sperm count or morphology values [35]. Scientific research has evaluated CoQ10 medicine for its effectiveness with infertile adults who have varicocel. The consumption of 100 mg CoQ10 daily for three months by male users led to improved sperm parameters and total antioxidant capacity measurements **.** A study lasting three months validated how CoQ10 increased sperm quantity and total motility and progressive movement among patients with idiopathic OAT who received two different vitamin doses [36]. The patients who received the highest CoQ10 dosage exhibited the most extensive recovery as the treatment increased their TAC and superoxide dismutase and their catalase activity**.** Several studies demonstrate that CoQ10 supplementation when taken at recommended doses improves sperm functions and Ooxidative Stress markers in male with idiopathic infertility even though the exact dosage remains contested [37].

4.3. Relationship between CoQ10 and Pregnancy Outcomes

Enhanced rates of pregnancy following CoQ10 supplementation have been shown in a number of trials [38,39]. ccording to certain research, CoQ10's positive effects on sperm motility and concentration cause the higher pregnancy rate. According to these results, [40] discovered that providing 40 infertile males with OA 90 mg of CoQ10 daily for three to nine months dramatically boosted their conception rate. With 45% of these patients' female companions becoming pregnant, Carni-Q-Nol (each soft gel containing 440 mg L-carnitine fumarate, 30 mg CoQ10, 75 IU vitamin E, and 12 mg vitamin C) proved helpful in boosting the pregnancy rate. Twelve women (30%) became pregnant between five and six months after their partners started therapy, and three men (7.5%) became fathers after receiving AR.

Statistical research by Safarinejad showed that 287 male with idiopathic OAT who took 300 mg CoQ10 doses two times per day for one year saw higher pregnancy rates after their CoQ10 therapy. The participants showed better sperm quality results after their therapeutic intervention. Couples achieved spontaneous clinical pregnancy with a rate of 34.1% following treatment periods of 9–12 months according to published data **.** This research used the joint administration of CoQ10 and L-carnitine to achieve improved pregnancy results in male infertility patients with idiopathic disorders through improved sperm measurements and lower SDF percentage along with better clinical pregnancy outcomes [41].

Table 2. The Effect of Coq10 on Assisted Reproductive Techniques, Pregnancy Outcomes, Besides Male Infertility.

Study	Participants	RCT	Intervention	Intervention period	Outcome
Alahmar et al. (2021) [12]	Infertile patients with idiopathic oligoasthenozoospermia; 65 patients	Yes	CoQ10 200 mg/day orally	3 mo	Enhanced levels of sperm, progressive and total motility, TAC, ROS and SDF percentag

					es, seminal fluid CoQ10 content, and glutathione peroxidase.
Alahmar and Sengupta (2021) [13]	Men with OAT; 70 patients	Yes	CoQ10 200 mg/day	3 mo	Increased sperm concentration, motility, and antioxidant activity.

4.4. CoQ10 and Assisted Reproductive Technologies Outcomes

The successful rate associated with ART is greatly impacted by oxidative stress spermatozoa and oocytes may be susceptible to high amounts of ROS after being removed from their microenvironments because of the absence of protecting systems (scavenger system) which exist in male reproductive system. Antioxidant prior to treatment may therefore be helpful in enhancing the quality of gametes. According to findings from numerous RCTs [42]. oral antioxidant medications significantly boost the conception rate in individuals following ART cycles by improving the fertility of men. However, because of differences in treatment plans, the findings of some of these trials need to be explained very carefully. CoQ10 has the potential to enhance the quality of sperm, which could lead to better ART results. Specific experimental investigation revealed that sperm motility, The mixture of zinc with D-Asp and Co-Q10 as an antioxidant treatment for three hours enhanced spermatozoa swim-up effectiveness however decreasing lipid damage. The data indicates these substances could serve as practical components in preART sperm processing methods [43].

In a different study by [24], seven patients with low ICSI success rates were given 60 mg/day of CoQ10 for a duration of 103 days prior to having additional ICSI cycles in order to examine the impact of oral CoQ10 supplementation on ICSI results. Following CoQ10 intake, the insemination rate increased dramatically from 10.3%±10.5% in ICSI cycles with no therapy to 26.3%±22.8% with therapy In another study by [24],38 individuals, both normozoospermic and asthenozoospermic, undergo for seminal fluid test. They discovered that patients with asthenozoospermia had higher sperm motility rates during a 24-hour incubation period with 50 µM CoQ10. The research did not analyze ICSI fertility rate growth during the course of this study. The supplement combination of 600 mg CoQ10 and dehydroepiandrosterone (DHEA) taken for completed a month helped women display advanced follicle development while reducing gonadotropin levels during stimulation in 797 intrauterine insemination (IUI) and 253 IVF treatment cycles [45].Research by analysts of 61 RCTs which involved 6,264 infertile persons showed antioxidant treatments resulted in enhanced clinical birth and infant delivery rates.

While the relationship between CoQ10 and female fertility has been well-documented, with evidence suggesting that CoQ10 plays a vital role in supporting healthy oocyte development in womenIt can avoid a premature ovarian failure and rise the sensitivity of the ovary to estrogen, which, in combination, facilitate better ovarian functioning. It is worth noting that according to research findings, CoQ10 supplementation has the potential to improve the quality of eggs used in the process of in vitro fertilization and embryo transfer (IVF-ET) causing in an increase in the success rate of embryo transfer [46].

4.5. Clinical Trials and Meta-Analysis of CoQ10 Supplementation Effect.

Research studies involving a combination of CoQ10 with one or supplementary other antioxidants on semen quality revealed alike trends. reported that the use of L-carnitine, zinc, astaxanthin, CoQ10, vitamin C, overall sperm motility, and vitamin B12, and vitamin E in a mixture had significant effects on total sperm motility but no significant effects on ejaculate volume, sperm count, and testosterone levels [47]. Similarly, with co-administration of CoQ10 and aspartic acid at a period of 3 months, there was an increase in the whole and progressive sperm motility in sperm, but then not in sperm concentration. Contrarily [48], proved that a mixture of antioxidants, which include, carnitine, arginine, zinc, vitamin E, glutathione, selenium, folic acid and CoQ10, led to favorable results in several semen parameters such as ejaculate volume, total motility, sperm count, and morphology [45]. Overall, these results suggest that, despite potential benefits of CoQ10 supplementation on semen quality, it is still shown to be inconsistent and even contradictory. Thus, it is possible to say that additional research should be conducted. To fill this knowledge gap, we performed a systematic assessment (SR) and meta-analysis (MA) to assess the impacts of CoQ10 supplementation on semen quality referring to the facts of randomized controlled trials (RCTs). Primary outcomes were the standard sperm parameters, whereas the secondary outcomes were the level of male reproductive hormones including the testosterone, follicle-stimulating hormone (FSH), luteinizing hormone (LH) as well as the inhibin B [47].

In vitro experiment showed that CoQ10 treatment (50 μg/mL and 1h) increased total sperm motility, whereas it did not produce significant effect on progressive motility. In addition [46] established the CoQ10 treatment (100mg two times daily, 6 months) enhanced sperm morphology and motility, but not sperm concentration in astheno- teratozoospermic sub fertile men. Conversely, [33] found that CoQ10 (200 mg/kg/day over 3 months) given orally enhanced sperm concentration and motility in infertile men with idiopathic oligoasthenozoospermia significantly. Also, [31] found out the CoQ10 supplementation (50 mg two times daily over 12 weeks) increased active sperm motility but then failed to improve sperm morphology among infertile men.

5. Conclusion

The results of the current review indicate that the antioxidant effect of CoQ10, along with the problem fundamental role in the bioenergetics of the male prontozoa, support the positive things of CoQ10 on the male fertility parameters by increasing the seminal CoQ10 levels. In addition, the present review proves that CoQ10 has positive effects on male fertility indicators because of the presence of antioxidant properties as well as the essential role in mitochondrial biological energy generation. Most of the studies are aimed at its effect on asthenozoospermia; however, it has been found that CoQ10 has been mostly effective in enhancing the motility and count of sperms in infertile men. Moreover, CoQ10 appears to prevent oxidative damages on sperms, and thus it improves OS and SDF indicators. Furthermore, CoQ10 partners showed better ART outcomes, like increased fertilization rates of IVF /ICSI. Further extensive actions need to be undertaken to help establish the precise mode of action of CoQ10, the right defined dosage and time of the CoQ10 use in the treatment of some cases of male infertility. Combined supplementation of CoQ10 and selenium, the latter being an essential cofactor of glutathione peroxidase, an important antioxidant enzyme, is the most widely investigated one. Most of the studies have however used different combinations of nutrients together which can support mitochondrial bioenergetics and antioxidant systems. Such combinations usually contain B vitamins, vitamin C, vitamin E, selenium, zinc, lipoic acid, L-carnitine and taurine.

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الدور العلاجي للإنزيم المساعد Q10 في العقم لدى الذكور: دراسة معتمدة على تحليل السائل المنوي

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Coenzyme Q10، الإجهاد التأكسدي، العقم عند الذكور، مؤشرات الحيوانات المنوية، العلاج بمضادات الأكسدة، تقنيات المساعدة على الإنجاب.

الملخص

تؤثر مشكلة العقم عند الذكور على نحو 15٪ من الأزواج في جميع أنحاء العالم، وتشكل العوامل الذكورية السبب في حوالي نصف هذه الحالات. تُعد جودة الحيوانات المنوية هدفًا أساسيًا في علاج العقم عند الرجال، حيث يُعتبر الإجهاد التأكسدي (OS)العامل الرئيسي الذي يؤثر على جودة الحيوانات المنوية. يعمل المركب الطبيعي Coenzyme Q10 (CoQ10)كمضاد أكسدة قوي، ويلعب أدوارًا حيوية في إنتاج الطاقة الميتوكوندرية نظرًا لتواجده في السائل المنوي. توجد تركيزات قابلة للقياس من CoQ10 في السائل المنوي البشري، مع وجود علاقة مباشرة بتحسين مؤشرات الحيوانات المنوية، بما في ذلك الحركة والتركيز بالإضافة إلى الشكل. تستكشف هذه الدراسة الإمكانيات المحتملة لتكملة CoQ10 في تعزيز خصوبة الذكور عن طريق تحسين جودة السائل المنوي وتقليل الإجهاد التأكسدي المعتدل. تشير الأدلة السريرية إلى أن CoQ10 يحسن حركة الحيوانات المنوية ويقلل الضرر التأكسدي، وبالتالي يقلل من تكسر الحمض النووي للحيوانات المنوية. تدعم الأبحاث استخدام مكملات CoQ10 لتحسين فرص الحمل في برامج تقنيات المساعدة على الإنجاب مثل التلقيح الاصطناعي (IVF) وحقن الحيوانات المنوية داخل البويضة.(ICSI) على الرغم من هذه التطورات، هناك حاجة إلى مزيد من الدراسات لتحديد الجرعات القياسية وبروتوكولات المكملات للحالات الخاصة بالعقم. بالإضافة إلى تسليط الضوء على الإمكانات العلاجية لـCoQ10 ، تؤكد هذه الدراسة على ضرورة المزيد من البحث لفهم دوره بالكامل في علاج العقم عند الرجال.

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