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Review

The Impact of Curcumin on Sperm Parameters in Men: A Systematic Review

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Abstract

Male infertility accounts for 50% of infertility cases among couples. Medical treatments may have side effects; while curcumin has been explored as a therapeutic option due to its antioxidant properties and fewer side effects. This study assessed the effect of curcumin on sperm parameters. This systematic review focused on experimental human studies, searching databases such as PubMed, Web of Science, Scopus, Embase, as well as trial registration databases including trialsearch.who.int and clinicalTrials.gov. Additionally, Persian databases like SID and Magiran were searched up to August 2024, without any time or language restrictions, using keywords related to ″male infertility″, ″sperm analysis″, ″sperm freezing″, and ″curcumin″. The quality of the studies was assessed using the valid and reliable tool from the Joanna Briggs Institute (JBI) for semi-experimental studies. This systematic review was conducted using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Totally, out of 537 identified studies, 11 studies remained that aligned with the objectives of the current research. The results of the systematic review indicated that curcumin, at doses exceeding 200 micromoles, inhibited sperm motility; while lower doses enhanced it. Furthermore, under oxidative stress conditions resulting from freezing, curcumin improved both sperm motility and viability. Curcumin, as a potent antioxidant, can enhance sperm motility, viability, and DNA integrity; while at higher doses, it may act as a contraceptive agent. Its effects are dose- and time-dependent, and it may help reduce oxidative stress and damage associated with sperm freezing. Further clinical studies are recommended to explore the practical application of curcumin in the treatment of infertility.

Keywords: Curcumin; Sperm analysis; Male fertility; Infertility; Polyphenol

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Introduction

Today, one of the main issues related to reproductive health among couples is achieving a successful pregnancy, with 8-12% of couples of reproductive ages experiencing infertility problems. The World Health Organization (WHO) defines infertility as the inability of couples to conceive after one year of continuous efforts without the use of contraceptive methods. Male factors account for approximately 50% of infertility cases [1-3].

The main causes of male infertility include disorders of the hypothalamic-pituitary axis (pre-testicular), spermatogenesis disorders (testicular), and dysfunction or obstruction of the spermatic duct (post-testicular) [4]. Several risk factors contribute to male infertility, which can be classified into congenital, acquired, and idiopathic categories [3]. Congenital factors include known genetic causes and mutations, such as congenital absence of the vas deferens [5], acquired factors refer to obesity and unhealthy lifestyle choices (such as smoking, alcohol use, and drug abuse) [6], additionally, idiopathic causes account for 30-40% of male infertility cases [3,7]. Modernization of life, which increases occupational and environmental exposure to chemicals and heavy metals, also plays a role in the factors contributing to male reproductive disorders [8,9].

Treatment for male infertility is selected based on its underlying cause. Common treatment methods for infertility issues include medication, surgical interventions, and Assisted Reproductive Technologies (ART) [10-12]. Today, sperm freezing is one of the most widely used assisted reproductive methods for long-term sperm storage, it is extensively utilized to preserve fertility in men, particularly in cases before chemotherapy and radiotherapy [12,13]. However, despite these therapeutic approaches, they may be ineffective, invasive, expensive, and associated with numerous side effects [14]. This includes the processes of freezing and thawing sperm, which negatively impact sperm structure, motility, and longevity, ultimately reducing the fertilization potential of sperm [15].

On the other hand, the effectiveness of herbal medicines and traditional medicine in the treatment of infertility disorders is recognized worldwide [14]. The benefits of these treatments appear to lie in their cost-effectiveness and, importantly, their lower incidence of side effects compared to chemical therapies, evidence from a meta-analysis review study also indicates that the use of herbal medicines and antioxidants has a significant impact on increasing the chances of achieving pregnancy [16]. Curcumin, known as a polyphenol extracted from turmeric or scientifically "*Curcuma longa* L.", is one of the powerful antioxidants that may play a role in improving sperm parameters through its antioxidant effects [17]. Considering that the prevention of reproductive disorders is one of the goals of the field of reproductive and sexual health [18], some review studies have also been conducted to assess the impact of curcumin on male fertility [19,20]. However, given the limitations of existing studies and the inconclusive results regarding the impact of curcumin on sperm parameters, this research aims to assess the effect of curcumin on sperm parameters in men based on the current knowledge of researchers and the results of the current search.

Methods

The present study is a systematic review that conducted advanced searches for articles in international databases, including PubMed, Web of Science, Scopus, Embase, and trial registration databases such as trialsearch.who.int, clinicalTrials.gov and the PROSPERO database (https://www.crd.york.ac.uk/prospero/) was systematically searched to identify any ongoing or recently published projects on the same topic. No relevant registered or published studies were found. Consequently, this systematic review was registered in the PROSPERO database under the ID number CRD42025641860. Additionally, searches were performed in Persian databases, namely SID and Magiran. Relevant articles published up to August 2024 were extracted based on related keywords searched through MeSH in the PubMed database, along with appropriate synonyms. These keywords included "Infertility, Male," "Men Reproductive," "Male Genitalia," "Semen," "Spermatozoa," "Sperm Maturation," "Sperm Motility," "Sperm Transport," "Sperm Count," "Sperm Capacitation," "Semen Preservation," "Semen Analysis," and ″curcumin″ which were used for both main components of the search. The keywords were then combined using the operators OR and AND to formulate the search strategy. For each database, the logic of this search strategy was aligned with the guidelines specific to each database. An example of a PubMed search query is provided below:

("Infertility, Male"[tiab] OR "Male Infertility"[tiab] OR "Sterility, Male"[tiab] OR "Male Sterility"[tiab] OR "Subfertility, Male"[tiab] OR "Male Subfertility"[tiab] OR "Sub-Fertility, Male"[tiab] OR "Male Sub-Fertility"[tiab] OR "Sub Fertility, Male"[tiab] OR "men reproductive"[tiab] OR "male reproductive"[tiab] OR "men fertility"[tiab] OR "male fertility"[tiab] OR "Fertility Agents, Male"[tiab] OR "Agents, Male Fertility"[tiab] OR "Male Fertility Agents"[tiab] OR "Fertility Agents, Male, hormonal"[tiab] OR "Male Fertility Agents, Synthetic"[tiab] OR "Synthetic Male Fertility Agents"[tiab] OR "Fertility Agents, Male, Synthetic"[tiab] OR "male reproductive health"[tiab] OR "Male Genitalia"[tiab] OR "Genitals, Male"[tiab] OR "Genital, Male"[tiab] OR "Male Genital"[tiab] OR "Male Genitals"[tiab] OR "Genital organs, Male"[tiab] OR "Male Genital organs"[tiab] OR "Reproductive System, Male"[tiab] OR "Male Reproductive Systems"[tiab] OR "Reproductive Systems, Male"[tiab] OR Semen[tiab] OR "Seminal Plasma"[tiab] OR "Plasma, Seminal"[tiab] OR Spermatozoa[tiab] OR Sperm[tiab] OR Spermatozoon[tiab] OR "Sperm Maturation"[-

tiab] OR "Maturation, Sperm"[tiab] OR "Maturation of Spermatozoa"[tiab] OR "Spermatozoa Maturation"[tiab] OR "Sperm Motility"[tiab] OR "Motilities, Sperm"[tiab] OR "Motility, Sperm"[tiab] OR "Sperm Motilities"[tiab] OR "Sperm Transport"[tiab] OR "Transport, Sperm"[-tiab] OR "Sperm Count"[tiab] OR "Count, Sperm"[tiab] OR "Counts, Sperm"[tiab] OR "Sperm Counts"[tiab] OR "Sperm Number"[tiab] OR "Number, Sperm"[tiab] OR "Numbers, Sperm"[tiab] OR "Sperm Numbers"[-tiab] OR "Sperm Capacitation"[tiab] OR "Capacitation, Sperm"[tiab] OR "Capacitation of Spermatozoa"[tiab] OR "Spermatozoa Capacitation"[tiab] OR "Semen Preservation"[tiab] OR "Preservation, Semen"[tiab] OR "Frozen Semen"[tiab]OR "Semen, Frozen"[tiab] OR "Preservation, Sperm"[tiab]OR Semen Cryopreser*[tiab] OR Sperm Preservation[tiab] OR Semen Analysis [tiab] OR "Semen Analyses"[tiab] OR "Semen Quality Analysis"[-tiab] OR "Analyses, Semen Quality"[tiab] OR "Analysis, Semen Quality"[tiab] OR "Quality Analyses, Semen"[-tiab] OR "Semen Quality Analyses"[tiab] OR "Semen Quality"[tiab] OR "Qualities, Semen"[tiab] OR "Quality, Semen"[tiab] OR "Semen Qualities"[tiab]) AND (Curcumin[tiab] OR "Curcumin Phytosome"[tiab] OR "Phytosome, Curcumin"[tiab] OR "1,6-Heptadiene-3,5-dione, 1,7-bis(4-hydroxy-3-methoxyphenyl)-, (E,E)-"[tiab] OR Diferuloylmethane[tiab] OR "Turmeric Yellow"[tiab] OR "Yellow, Turmeric"[tiab] OR Mervia[tiab]).

Inclusion and exclusion criteria

Experimental studies that included randomized clinical trials, quasi-experimental studies, before-and-after studies, and laboratory studies examining the effect of curcumin on male sperm were utilized in this research. In the search strategy, no language or time restrictions were applied; however, in the inclusion criteria, only studies with full-text available in English or Persian were considered. Additionally, studies that examined both human and non-human sperm were also included. Review studies, non-human studies, and studies for which full-text access was not available were excluded. The population studied in the initial studies consisted of men whose sperm was collected for the research.

Outcome measures

The primary outcome measured in this study was the evaluation of the effect of curcumin on sperm parameters (viability and motility), which were assessed using standard laboratory methods. The secondary outcomes included the assessment of the effects of different doses of curcumin on sperm parameters, as well as the evaluation of curcumin's impact on frozen sperm.

Data extraction

In the initial search, articles were imported into EndNote software, and duplicate articles were removed. The abstracts of the remaining studies were assessed for eligibility for the next stage of evaluation by two independent reviewers. Subsequently, the full-texts of the eligible studies were re-evaluated by two individuals, and the necessary information was extracted according to a researcher-designed data extraction form. The extracted information included the names of the authors, year of publication, study location, type of study, number of participants, and the outcomes assessed.

Quality assessment

To assess the quality of the articles, the Joanna Briggs Institute (JBI) critical appraisal tool for quasi-experimental studies, version 2024, was utilized. This tool consists of nine questions that evaluate studies based on the clarity of the assessed outcomes, the presence of a control group, the similarity of study groups, measurement bias, attrition bias, data analysis, and response rate. For each question, a score of 1 was assigned for a "yes" answer; while a score of 0 was given for "no" or "unclear" responses. The total score for each study ranged from 0 to 9. A score of 7 or higher was considered indicative of high-quality studies [21]. In this study, the quality assessment was conducted independently by two reviewers, and in cases of disagreement, a third reviewer was consulted to reach a consensus. This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [22].

Data synthesis and presentation

Although a formal meta-analysis was not feasible due to methodological heterogeneity, we performed a descriptive statistical summary of the human and mix (Human and Animal) studies.

Results

In the search conducted, 537 studies were identified, of which 314 were recognized and removed as duplicates by EndNote software. In the next phase, the titles and abstracts of the remaining 223 studies were reviewed by two independent individuals. From this number, 202 studies were excluded based on the inclusion and exclusion criteria. Subsequently, the full-texts of the 21 remaining studies, which were deemed eligible in the initial title and abstract review, were evaluated by two independent reviewers. Ultimately, 11 studies aligned with the objectives of the present study, and data extraction was performed based on the information from these 11 studies (Figure 1). A total of sperm samples from 283 men were analyzed across the included studies, with the smallest and largest study sample sizes ranging from 5 to 75 participants. The descriptive statistical summary of the human studies indicated that the reported curcumin doses ranged from 100 nanomoles to 10 millimoles. Among these studies, six reported improvements in sperm motility, viability, or DNA integrity; while six studies described a decrease or inhibition of sperm motility, mainly at higher doses ($\geq$200 μM), highlighting the dose-dependent nature of curcum-

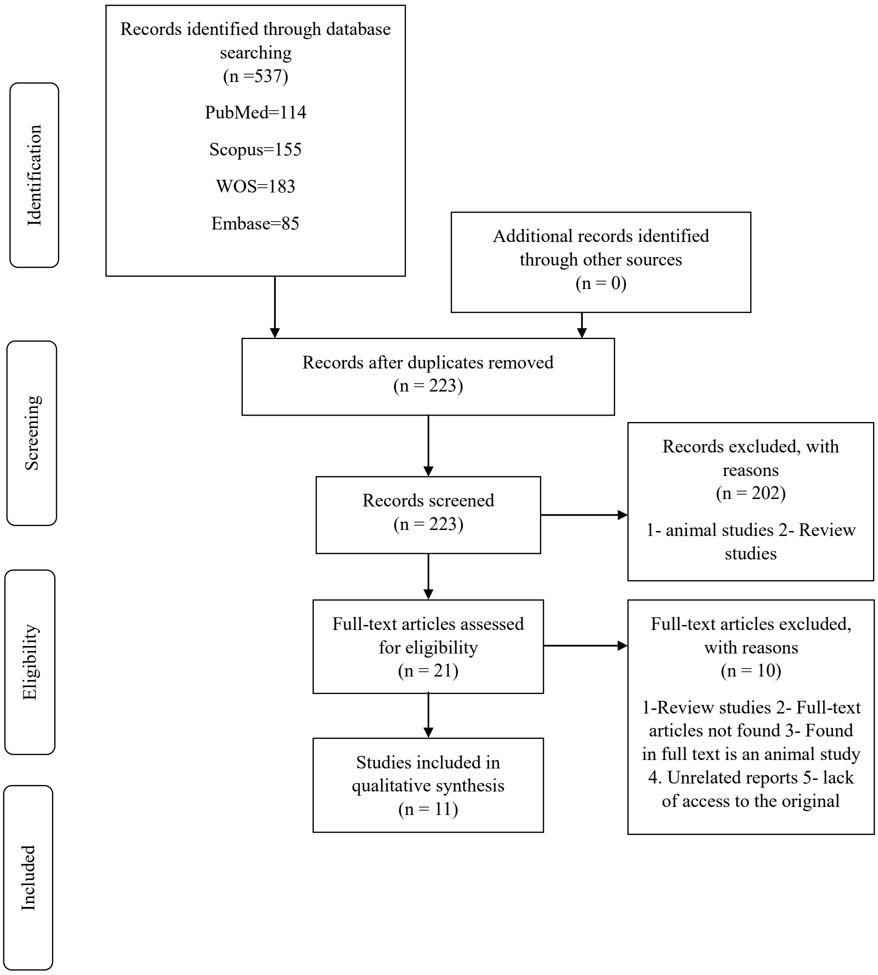

Figure 1. Flowchart of study

in's effects.

Specifically, curcumin demonstrated positive and protective effects on sperm motility, viability, and DNA integrity after freezing. For example, Karakus et al. (2021) [23] observed improved sperm quality following cryopreservation. Similarly, Santonastaso et al. (2021) [24] showed that treatment with 20 μM curcumin significantly improved overall sperm motility and reduced lipid peroxidation and DNA damage. Zamani et al. (2023) [25] also demonstrated that curcumin increased sperm motility and viability; while decreasing lipid peroxidation and DNA fragmentation after cryopreservation, although no effect was seen on morphology. Zhang et al. (2017) [26] reported that curcumin increased sperm motility and reduced oxidative stress levels in men with leukocytospermia. Likewise, Alizadeh et al. (2016) [27] found that curcumin supplementation significantly increased sperm count, concentration, motility, and viability in infertile men.

In contrast, some studies highlighted inhibitory effects at higher doses. Zhou et al. (2019) [28] reported that 100 nM of curcumin improved motility; whereas 1 mM significantly reduced it. Naz et al. (2011–2014) also showed that curcumin at concentrations ≥200 μM significantly inhibited motility [29-31]. Rithaporn et al. (2003) [32] and Patel et al. (2015) [33] confirmed that the effects of curcumin were dose- and time-dependent, with no significant impact on sperm viability. Furthermore, both Naz et al. (2013) (31) and Patel et al. (2015) [33] demonstrated that curcumin inhibited the growth of aerobic bacteria and fungi in a dose-dependent manner (Table 1 & 2).

To clarify the dose-dependent effects, the included studies were summarized in a comparative figure (Figure 2), showing that low-to-moderate concentrations of curcumin (100 nM–200 μM) generally improved sperm motility and viability; whereas higher concentrations (≥200 μM) consistently inhibited motility, confirming a two times dose-dependent effect.

Discussion

This systematic review was conducted to examine the effect of curcumin on sperm parameters. The results of this systematic review, based on the 11 included studies, indicate that curcumin, as a powerful antioxidant, can

Table 1. Effects of curcumin on sperm parameters in human studies

Number ID	Author/ Year	Country	Design	Sampel size /Participants	Main outcome	Results	Quality assess-ment
1	Karakus 2021 [34]	Turkey	Experi-mental	Semen of 23 normozoospermic men was collected and each sample was divided into three equal aliquots: Control, DMSO, Curcumin.	The effect of curcumin on sperm parameters after the cryopreservation process.	Sperm motility: The group in which 10 mmol of curcumin were added to the freezing environment exhibited significantly higher progressive sperm motility after thawing compared to the control and DMSO groups (*p*< 0.001). The chromatin density of sperm in the curcumin group improved significantly (*p*< 0.001). DNA Integrity: Curcumin significantly improved the DNA integrity of sperm after thawing compared to the control and DMSO groups (*p*< 0.001).	High
2	Santon-astaso 2021 [24]	Italy	Experi-mental (CT)	The semen samples (n = 60) were divided into five aliquots (10 × 106 sperm/mL) (n = 12 for each group) and frozen in the presence of freezing medium plus different concentrations of curcumin: 0 (vehicle control group), 2.5 µM, 5 µM, 10 µM and 20 µM. In the vehicle control group, ethanol was added at the same concentration used to dissolve curcumin in each group.	The effect of curcumin on parameters of frozen sperm	Sperm Motility: In the group treated with 20 µM of curcumin, overall sperm motility (including both progressive and non-progressive motility) increased significantly compared to the control group (*p*≤ 0.05). Intracellular ROS Levels: The production of reactive oxygen species (ROS) in the group treated with 20 µM of curcumin was significantly reduced compared to the control group. No significant differences in ROS levels were observed in groups with lower concentrations (2.5, 5, and 10 µM) (*p*≤ 0.05). The addition of curcumin to the freezing environment significantly reduced DNA fragmentation in sperm. This reduction was more pronounced in the group treated with 20 µM of curcumin compared to the control group (*p*≤ 0.05). Sperm treated with 20 µM of curcumin exhibited significantly higher expression of the GPX4 gene compared to the control group (*p*≤ 0.05).	High

3	Zhou 2019 [17]	Chin/	Experi-mental (CT)	Semen of normozoospermic and asthenozoospermia individuals were collected and then tested in 3 control groups, curcumin, brusatol and curcumin.	Effects of curcumin on asthenozo-ospermia	Sperm Motility: Cur-cumin at a concentration of 100 nmol signifi-cantly increased sperm motility in patients with asthenozoospermia. Concentrations above 1 mmol resulted in de-creased sperm motility, indicating the negative effects of curcumin at high concentrations. Curcumin significantly reduced the levels of reactive oxygen species (ROS) in sperm from patients with asthenozo-ospermia. Curcumin increased the percentage of sperm that underwent the acrosome reaction. Curcumin significantly reduced the levels of apoptosis in sperm from patients with asthenozo-ospermia.	Moder-ate
4	Alizadeh 2016 [27]	Iran	RCT	cases (n=60) were infertile men.	Evaluation of the curcumin nanomicelle supplemen-tation effects on sperm parameters, inflammatory factors, and sex hormones in men with idiopathic infertility	Curcumin supplemen-tation, compared to the placebo, statistically significant increased sperm count, sperm con-centration sperm, total motility, and live sperm ($p< .05$)	High
5	Zhang 2017 [26]	Chin	Experi-mental	35 semen samples were collected from the normal control group. Forty semen samples were obtained from forty patients with leuco-cytospermia (aged 21–40 years).	Investigate the effects and specific molecular mechanisms of curcumin on sperm quality in patients di-agnosed with leucocyto-spermia.	Curcumin can signifi-cantly improve sperm motility of leucocyto-spermic patients ($p< .001$). Curcumin can signifi-cantly decrease the H_2O_2 level in semen superna-tant of leukocytospermic patients ($p< .001$). Curcumin incubation in vitro can alleviate sperm mtDNA damage in leu-kocytospermic patients ($p< .001$). Decrease of sperm cyto-chrome B and NADH5 induced by oxidative stress can be antago-nized ($p< .001$).	High

6	Naz 2014 [31]	West Virginia, USA	Experimental	Semen was collected from healthy and fertile men.	Primary Outcome: Can curcumin halt sperm motility? Secondary Outcome: The effect of curcumin on the growth of bacteria and fungi associated with vaginal infections.	Sperm Motility: Curcumin, in a dose-dependent manner, reduced sperm motility. At concentrations above 250 μM, sperm motility was completely blocked. Effect on Aerobic Bacteria: Curcumin completely halted the growth of aerobic bacteria at concentrations between 100 and 250 μM. Effect on Fungi: Curcumin significantly inhibited fungal growth at concentrations of 250 μM and higher.	High
7		USA	Experimental	Sperm collected from male.	Evaluate the sperm-immobilizing effects of curcumin.	Sperm Motility: Curcumin caused a dose- and time-dependent reduction in the motility of healthy human sperm. At low doses (30 micrograms per milliliter), sperm motility decreased by 20% after 30 minutes. At higher concentrations (300 micrograms per milliliter), sperm motility was completely halted (100%) after 60 minutes. Sperm Viability: Curcumin did not have a significant effect on sperm viability. Mitochondrial Membrane Potential (MTP): Curcumin resulted in a significant decrease in the mitochondrial membrane potential of sperm. Protein Kinase C (PKC) Activity: Curcumin may disrupt sperm motility by inhibiting PKC activity, which plays a role in regulating sperm flagellar movement.	High

8	Zamani 2022 [25]	Iran	Experimental	The semen of 40 men with normal sperm. Sperm samples into different groups including: the control group was divided without adding melatonin and curcumin. The experimental groups were added different amounts of melatonin and curcumin separately and in combination.	Investigation of the combined effects of Melatonin and Curcumin on the functional parameters of frozen sperm (Including viability, motility, morphology, DNA fragmentation, and Lipid Peroxidation of the sperm membrane)	Sperm motility: The addition of curcumin (20 µM) and melatonin (0.01 mmol) to the freezing medium significantly increased the overall motility of sperm after cryopreservation. This increase was more pronounced in the combined curcumin and melatonin groups than in any other group ($p< 0.05$). Sperm viability: The viability of sperm in the groups receiving curcumin and melatonin was significantly higher compared to the control group ($p< 0.05$). Lipid Peroxidation: The levels of malondialdehyde (MDA), a marker of lipid peroxidation in sperm membranes, were significantly reduced in the groups treated with curcumin and melatonin. DNA fragmentation: The fragmentation of sperm DNA showed a significant decrease in the groups receiving curcumin and melatonin ($p< 0.05$). Sperm morphology: In this study, the use of curcumin and melatonin, both individually and in combination, did not have a significant effect on sperm morphology ($p> 0.05$).	High
9	Patel 2015 [33]	India	In vivo	5 ejaculate samples from male volunteers were fertile.	development intravaginal hydrogel loaded with curcumin to prevent pregnancy and prevent sexually transmitted diseases.	A dose- and time-dependent decrease in sperm motility was noted in normal human sperm exposed to curcumin ($p< 0.05$). Significantly halted the growth of bacteria and fungi.	High

Table 2. Effects of curcumin on sperm parameters in animal and mixed studies

	Author/ Year		Design	Sampel size / Participants	Main outcome	Results	Quality assessment
1	Naz 2014 [29]	West Virginia, USA	Experimental	Collection of sperm of human spermatozoa and mouse were collected from healthy, fertile men.	Investigate the effect of curcumin on sperm parameters.	Sperm Motility: Curcumin, in a dose-dependent manner, led to a reduction in progressive sperm motility: At a concentration of 50 µM, the effect was minor (p< 0.001) At concentrations above 100 µM, a significant decrease in sperm motility occurred within 5 to 10 minutes (p< 0.001). At concentrations of 200 µM and higher, sperm motility was completely halted within 5 to 10 minutes (p< 0.001). Intracellular pH (pHi): Curcumin, in a dose-dependent manner, caused a decrease in the intracellular pH of sperm (p< 0.001). At a concentration of 400 µM, curcumin significantly reduced the fluorescence intensity in sperm (p< 0.001), indicating greater hyperpolarization of the membrane.	High
2	Naz 2011 [30]	West Virginia, USA	Experimental	Sperm collected from male and adult mice.	Effect of curcumin on human and murine sperm function.	Sperm Motility: Curcumin at concentrations above 250 µM significantly halted progressive sperm motility completely within 5 to 15 minutes. At lower concentrations (125 µM), sperm motility gradually decreased and ultimately ceased. Acrosome Reaction and Sperm Capacitation: Curcumin, in a dose-dependent manner, reduced the ability of sperm to undergo the acrosome reaction.	Moderate

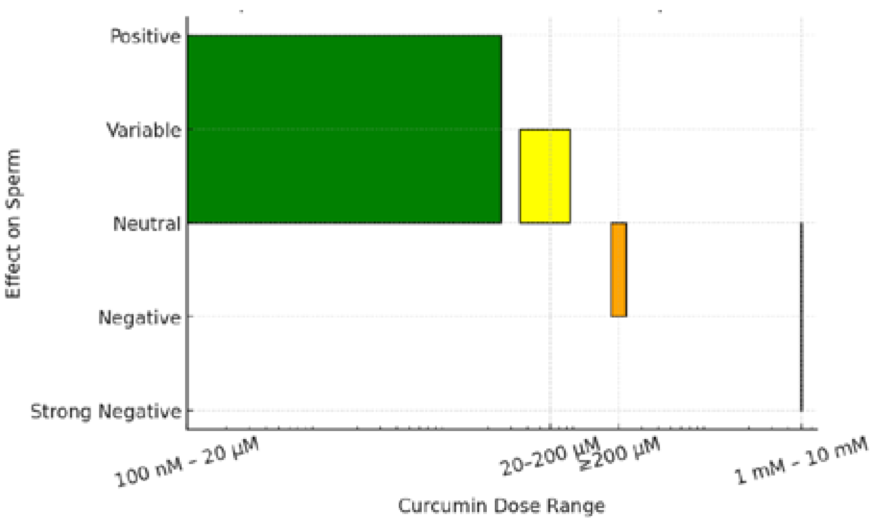

Figure 2. Dose dependent effects of curcumin on sperm parameters

have protective effects on various sperm parameters. In the studies by Karakus et al. (2021) [23] and Santonastaso et al. (2021) [24], the use of curcumin at various concentrations resulted in significant improvements in sperm motility, viability, and a reduction in DNA fragmentation after cryopreservation. This indicates the high potential of curcumin in preserving sperm quality under oxidative stress conditions associated with freezing. Additionally, the study by Zamani et al. (2023) found that curcumin significantly increased sperm motility and viability but had no effect on sperm morphology [25]. These findings suggest that sperm morphology may be less affected by oxidative processes, and changes in morphology may require other influencing factors.

The mechanisms underlying the observed effects of curcumin can be attributed to its potent antioxidant, anti-inflammatory, and antibacterial activities [35]. As an antioxidant, curcumin directly scavenges reactive oxygen species (ROS) such as superoxide and hydroxyl radicals, and upregulates endogenous antioxidant enzymes including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) [36]. This activity reduces lipid peroxidation in the sperm membrane and protects mitochondrial function, thereby improving motility and DNA integrity [37]. Its anti-inflammatory effects are mediated through inhibition of the nuclear factor kappa B (NF-κB) pathway and downregulation of pro-inflammatory cytokines like TNF-α, IL-1β, and IL-6, which collectively prevent oxidative and inflammatory damage to testicular and sperm cells [38]. Moreover, the antibacterial property of curcumin-by disrupting bacterial cell membranes and inhibiting enzymes such as DNA gyrase and β-ketoacyl carrier protein synthase-can help reduce microbial contamination and infections that negatively affect sperm motility and morphology [35, 39]. These synergistic mechanisms explain why curcumin, at optimal doses, exerts protective effects on male reproductive function; whereas excessive concentrations may induce oxidative imbalance and impair sperm motility [35,38].

However, some studies presented differing results. The study by Zhou et al. (2019) indicated that curcumin at low concentrations (100 nanomoles) increased sperm motility; while at higher concentrations (1 millimole), it significantly decreased sperm motility [28]. These findings are consistent with the results of studies by Naz et al. (2011-2014) [29-31] and Rithaporn et al. (2003) [32], which indicated that curcumin at concentrations above 200 micromoles dose-dependently inhibited sperm motility. These results emphasize that curcumin at high doses may act as a contraceptive agent by inhibiting sperm motility. In confirmation of our findings, the overview study by Saifi et al. (2021), titled "An Overview of the Therapeutic Effects of Curcumin in Reproductive Disorders with a Focus on the Anti-inflammatory and Immunomodulatory Activities," aimed to examine the molecular and clinical effects of curcumin on reproduction and related disorders. This review indicated that curcumin at concentrations below 100 mg provides protective effects against testicular damage. At concentrations above 250 mg, curcumin immobilizes sperm; while at 500 mg, it exhibits contraceptive properties [40]. Notably, this study reviewed both animal and human studies and confirmed the dose- and time-dependent effects of curcumin on sperm.

In addition to its effects on sperm parameters, studies by Naz et al. (2014) [31] and Patel et al. (2015) [33] also demonstrated that curcumin possesses antibacterial and antifungal properties, capable of inhibiting the growth of bacteria and fungi in a dose-dependent manner. These properties position curcumin as a protective agent against sexually transmitted diseases (STD). Curcumin is a bioactive compound extracted from the rhizome of the turmeric plant (Curcuma longa). Its pharmacological properties include antioxidant effects, anti-inflammatory, antibacterial, antiviral, and anticancer activities [41].

The strengths of the present study include a comprehensive search strategy, the review process of studies using a validated checklist JBI, data extraction performed by two independent individuals, and the use of precise inclusion and exclusion criteria. In the quality assessment review, most studies received high scores. However, due to the high heterogeneity among studies in terms of methodological diversity, the limited number of human studies, and the use of different doses of curcumin, a meta-analysis could not be performed. The limited number of human studies remains a significant barrier to drawing firm clinical conclusions, and future research should therefore prioritize well-designed randomized controlled trials to address this gap. Therefore, to facilitate the use of effective curcumin-containing compounds for improving sperm quality in men with fertility issues, it is recommended to conduct new clinical trials based on CONSORT guidelines.

Conclusion

According to the summary of the results from the included studies, curcumin not only protects against the stress effects that sperm freezing methods have on sperm parameters (motility and viability), but also exhibits dose- and time-dependent effects on sperm. Specifically, concentrations above 250 micromoles can completely stop sperm motility and act as a contraceptive agent. Additionally, it may be used as a treatment for sexually transmitted diseases. However, due to the lack of human studies in this area, comprehensive clinical conclusions cannot be drawn. Given this scarcity, future research should prioritize large-scale, well-designed randomized controlled trials to validate both the efficacy and safety of curcumin supplementation in male infertility.

Conflict of Interests

The authors declare that they have no conflict of interest.

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