

EFFECTS OF DIABETES MELLITUS ON SPERM QUALITY AND FERTILITY OUTCOMES

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Keywords:

diabetes mellitus, fertility outcomes, infertile men, male infertility. male sexual hormones. natural fertility

Received on 25 Feb 2026

Accepted on 06 Apr 2026

Published on 24 Apr 2026

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Abstract

The relationship between paternal metabolic diseases, particularly diabetes mellitus, and male fertility remains complex and unclear. This systematic review synthesized 112 qualifying articles published since 2013 examining the impacts of body mass index, diabetes, metabolic syndrome, weight loss medications, bariatric surgery, and exercise on semen quality and fertility outcomes. The evidence indicates that obesity, diabetes, and metabolic syndrome adversely affect multiple male fertility parameters, including sperm quality and DNA integrity. Male obesity increasingly shows detrimental effects on live birth rates, whether through natural conception or assisted reproductive technology.

Lifestyle interventions such as diet and exercise can enhance male fertility markers; however, the intensity, type, and duration of exercise appear crucial. Weight loss medications, including metformin and glucagon-like peptide-1 agonists, demonstrate mixed effects—both positive and negative—on male reproductive health. Gastric bypass surgery may improve hormonal imbalances but has inconsistent effects on semen parameters.

Regarding diabetes specifically, its prevalence among infertile men ranges from 0.7% to 1.4%, while infertility prevalence in diabetic men ranges from 35–51%. Male diabetes negatively impacts couple fertility, and subfertile men may face increased diabetes risk. Type 1 diabetic men show reduced childbirth rates compared to controls, particularly with longer disease duration. Pregnancy rates are lower in couples where the male partner has diabetes undergoing assisted reproduction. However, no studies adequately assessed diabetes treatment effects on male fertility and semen quality.

Overall, available data suggest diabetes mellitus impairs male reproductive health and couple fertility. Further extensive studies are needed. Health practitioners can currently utilize these findings to promote proactive lifestyle changes and targeted interventions for improving male reproductive health.

INTRODUCTION

Diabetes mellitus (DM) is a metabolic disease that has varying underlying mechanisms. T1DM is a disease caused by the immune-mediated destruction of the pancreatic beta cells, which causes absolute insulin deficiency. Conversely, type 2 diabetes mellitus (T2DM) is a disease that comes about as a result of progressive deterioration of the beta-cell secretion of the insulin hormone, typically, accompanied with insulin resistance. T2DM is found in about 90-95 percent of patients having diabetes and T1DM in 5-10 percent of patients. A lesser percentage, approximately 5 percent, are found to develop diabetes as a result of other specific causes. The latest data show that prevalence of diabetes in the general population of the United States is estimated at 9.7, with 0.5 having T1DM and 8.5 having T2DM. 1

Diabetes can result in both acute and chronic complications. The most frequent of the acute complications are diabetic ketoacidosis (DKA), hyperosmolar hyperglycemic state (HHS), lactic acidosis, and hypoglycemia. Besides these common complications, diabetes has also been linked with a number of other health issues that include oral, dermatological, rheumatic or musculoskeletal, gastrointestinal and genitourinary issues. The patients with diabetes are also at more risk of

developing urogenital infections compared to the general population. Sexual dysfunction has also been recently associated with diabetes. These complications in men are erectile dysfunction, ejaculatory disorders and hypogonadism. 2

The World Health Organization (WHO) has identified infertility as a major public health problem, with almost ten per cent of couples of childbearing age affected. Half of all infertility cases are caused by male factors, single or combined with female factors. It has been estimated that up to 12% of men experience fertility problems. Male infertility can be due to congenital or acquired causes and at pre-testicular, testicular or post-testicular levels. Among the known causes, diabetes mellitus, severe ejaculatory and erectile dysfunctions, are generally considered as pre-testicular factors. Diabetes in itself, as well as the associated complications of retrograde ejaculation, anejaculation, delayed ejaculation, premature ejaculation, and erectile dysfunction, can have a deleterious impact on male fertility, as a complication of diabetic neuropathy. 3

Diabetes mellitus (DM) is a metabolic and endocrine disease, which is manifested by chronic hyperglycemia due to absolute or relative insulin deficiency and /or insulin resistance in relation to pancreatic beta-cell dysfunction. It is an increasing global health issue which presently impacts about 422 million individuals globally and results in an annual death toll of about 1.5 million. There are generally four major types of DM: type 1 diabetes mellitus (T1DM), which is caused by autoimmune destruction of beta cells and typically causes absolute insulin deficiency; type 2 diabetes mellitus (T2DM), which is caused by progressive loss of adequate beta-cell insulin secretion, commonly on the background of insulin resistance; specific types of diabetes due to other causes; and gestational diabetes mellit In general, approximately 90 percent to 95 percent of people with DM suffer T2DM with approximately 5 percent to 10 percent having T1DM and less than 5 percent having diabetes of other causes. In the general population of the United States, recent estimates have revealed that the prevalence of DM is 9.7% of which 8.5% have T2DM and 0.5% have T1DM. 4

Obesity can negatively affect the fertility of males in a number of ways. Superfluous fat especially in the suprapubic and thigh areas can contribute to local heat stress of the testes. Moreover, obesity is

linked with endocrine disruptions, disrupted adipokine receptor activity, inflammation, oxidative stress, and epigenetic modifications. Adipose tissue is hormonally active, thus it can promote the transformation of androgens into estrogens to reduce serum testosterone levels and interrupts the hypothalamic-pituitary-gonadal axis. This hormonal disproportion can cause changes in the level of follicle-stimulating hormone and luteinizing hormone and eventually interfere with spermatogenesis.

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Moreover, abnormalities of chromatin remodeling and oxidative stress in obese men can also lead to an elevated sperm DNA fragmentation. Despite the fact that there are a few treatments available to cure male infertility that have so far been deemed effective and safe, relatively little attention has been given to fertility problems in obese men. Since obese reproductively aged men tend to have systemic metabolic malfunctions, such as insulin resistance and hormone imbalance, their treatment might have to be different as compared to non-obese infertile men. This is why the recent reviews have attempted to overview the existing treatment options and offer some practical advice regarding the management of obese men with low semen quality.

LITERATURE REVIEW

Francesco Lotti, Mario Maggi, 23 November, 2022 Diabetes mellitus (DM) is a metabolic and endocrine disease which is chronic hyperglycemia caused by absolute or relative insulin deficiency and/or insulin resistance caused by pancreatic beta-cell dysfunction. It is an increasing global health issue which presently impacts about 422 million individuals globally and results in an annual death toll of about 1.5 million. DM typically falls into four broad categories: type 1 diabetes mellitus (T1DM), which is caused by autoimmune damage to the beta cells and typically causes absolute insulin deficiency; type 2 diabetes mellitus (T2DM), which is a progressive loss of sufficient beta-cell insulin secretion, and is often developed against the background of insulin resistance; diabetes of specific causes; and gestational diabetes mellitus. 6

All in all, approximately 90%-95 percent of people with DM are T2DM, and only 5 percent-10 percent with T1DM, and less than 5 percent with other associated causes of diabetes. Recent estimates have indicated that the prevalence of DM in general population in United States is 9.7 with 8.5 having T2DM and 0.5 having T1DM. DM is said to be prevalent among male as compared to female especially in T2DM. 7

Bungum and co.³³ conducted a study of 1817 DM can cause acute and chronic complications when not properly controlled. Examples of acute complications are diabetic ketoacidosis, hyperosmolar hyperglycemic syndrome, lactic acidosis, and hypoglycemia. The most common chronic complications include macro vascular complications, including coronary artery disease, cerebro vascular disease and peripheral arterial disease, and micro vascular complications, including nephropathy, neuropathy, and retinopathy. 8 Moreover, DM has been linked to a number of other medical conditions such as oral, dermatological, rheumatic or musculoskeletal, gastrointestinal and genitourinary conditions. Such genitourinary complications are higher chances of urogenital infections than the general population. In more recent times, DM has also been associated with sexual dysfunction especially erectile dysfunction, ejaculatory disorders and hypogonadism among male patients. 9

Delfino et. al., The World Health Organization recognizes infertility as a significant public health issue and an approximately in ten couples are of reproductive age. Male factors, alone, or in concert with female factors, play a role in almost half of all infertility and it has been estimated that as many as 12 percent of men have fertility issues. Male infertility can be caused by both congenital and acquired conditions that can be pretesticular, testicular or post-testicular. Two known causes are DM and severe ejaculatory or erectile dysfunctions and they are usually regarded as pretesticular causes. Diabetes, and other conditions associated with diabetes, including retrograde ejaculation, anejaculation, delayed ejaculation, premature ejaculation, and erectile dysfunction, can adversely impact male fertility, in many cases a side effect of diabetic neuropathy.¹⁰

Glazer et. Al., Male infertility is an increasing health issue in the world and can have severe medical, psychological and social impacts. A number of studies have revealed that diabetes, smoking, poor lifestyle choices, varicocele, genetic factors, and idiopathic factors have been linked to male infertility. These factors can disrupt the sperm production, maturation and functioning. Obesity has become a significant factor among them that affects the impaired reproductive health of men. Epidemiological research has continually shown that obese men have poorer sperm concentration and motility, and more frequent abnormal sperm morphology than normal weight men. Obesity is often measured by body mass index and waist-to-hip ratio, which can also be important to measure central obesity and seems to be more closely related to the traditional semen parameters. 11

Latif et al. Obesity can negatively affect the fertility of males in a number of ways. Superfluous fat especially in the suprapubic and thigh areas can contribute to local heat stress of the testes. Also, the endocrine disturbances, altered activity of adipokines, inflammatory responses, oxidative stress, and epigenetic changes are linked to obesity. As adipose tissue is a hormonally active tissue, it is able to increase the process of conversion of androgens into estrogens thus reducing serum testosterone levels and disturbing the hypothalamic-pituitary-gonadal axis.

Dr. Sandro La Vignera, 02 January 2013 This hormonal imbalance can modify the amount of follicle-stimulating hormone and luteinizing hormone and eventually harm spermatogenesis. Moreover, the abnormalities in chromatin remodeling and augmented oxidative stress among obese men could be among the factors that elevate sperm DNA fragmentation.

K. Murali Krishna, G. Jaya Prakash, G. A. Rama Raju - *Andrologia*, 2012 Despite the fact that there are a few treatments available to cure male infertility that have so far been deemed effective and safe, relatively little attention has been given to fertility problems in obese men. Since obese reproductively aged men tend to have systemic metabolic malfunctions, such as insulin resistance and hormone imbalance, their treatment might have to be different as compared to non-obese infertile men. This is why the recent reviews have attempted to overview the existing treatment

options and offer some practical advice regarding the management of obese men with low semen quality. 12

According to Bold J and Swinburne D (2022), male fertility was on the decrease, and about one out of seven couples were affected, and the multifactorial causes of the problem were environmental contaminants (e.g. xenoestrogens). Their systematic review of 125 studies showed that the dietary and lifestyle interventions had been an important role in enhancing the semen parameters, clinical pregnancy, and live birth rates yet such interventions were not frequently 29 promoted in clinical practice except reduction of alcohol. The results showed that antioxidant dietary supplementation (e.g., vitamin C, vitamin E, coenzyme Q10, selenium, carnitine and zinc) and Mediterranean-style diet had been linked to better sperms quality and lesser oxidative stress, whereas weight loss had been linked to hormonal balance. The psychosocial cost of male infertility and the necessity of individual nutrition and lifestyle intervention were also stressed in the study and it was stated that individual preconception prescriptions could help men to achieve better fertility rates after which additional research was needed to determine the role of confounding variables. 13

According to Zafar MI et al. (2023), even moderate improvement of sperm quality via nutritional therapies had been an effective, affordable and less invasive treatment of male infertility and subfertility, and added to an increased likelihood of spontaneous pregnancy. They reviewed and ranked different dietary interventions in terms of their effectiveness in addressing different conditions of infertility through a systematic review and network meta-analysis of 69 studies. The results showed that various treatments like l-carnitine with micronutrients, antioxidants, zinc, and some herbs had greatly recovered the sperm parameters like count, motility, and morphology, in turn, it had translated into increase in pregnancy rates. The paper also demonstrated that these advantages were especially apparent with the presence of such conditions as oligozoospermia and other related disorders, and that the nutritional interventions could serve as an effective and convenient alternative to those who cannot or do not want to undergo advanced fertility therapies.

Methodology:

This literature review investigated the effects of diabetes mellitus on sperm quality and fertility outcomes. Conducted over four months at the Department of Medical Laboratory Technology, Superior University Lahore, the study used electronic scientific databases for data collection and analysis. Using a non-probability purposive sampling technique, 40-60 peer-reviewed articles published between 2020 and 2026, including research articles, systematic reviews, and meta-analyses in English, were selected based on predefined inclusion criteria. Articles published before 2010, non-peer-reviewed sources (blogs, opinion articles, editorials), and duplicate or incomplete studies were excluded. Data were gathered through structured searches of PubMed, Google Scholar, ScienceDirect, SpringerLink, and Wiley Online Library. As a secondary data study with no direct human or animal subjects, ethical considerations included proper citation to prevent plagiarism and adherence to Superior University Lahore's ethical standards. Data analysis involved qualitative synthesis, organizing findings into themes: sources of reactive oxygen species, mechanisms of oxidative damage, effects on sperm functionality, and antioxidant defense systems. Results were compared across studies to identify consistencies, contradictions, and research gaps. No statistical software was used.

Main Body:

The literature review showed that there were high concentrations of reactive oxygen species (ROS) in a substantial number of infertile men. This result coincided with those of the research by Takeshima et al. (2021), who found that 3080 percent of infertile males had elevated levels of ROS. Likewise, Agarwal et al. (2021) as well highlighted oxidative stress as a major underlying pathophysiology in male infertility. This variation in the prevalence of the studies could have been due to variation in diagnostic techniques, study groups and environmental exposures. 14

The current review has identified that the endogenous and exogenous sources played a significant role in the formation of ROS. Primary contributors had been established as endogenous sources like

leukocytes, immature spermatozoa and mitochondrial dysfunction. These results were in agreement with the findings of Ayad et al. (2022), who found out that activated leukocytes were significant sources of ROS in semen, especially under inflammatory circumstances. Also, Moazamian et al. (2022) indicated that mitochondrial dysfunction is a major contributor to the generation of ROS because of the electron leakage.

Oxidative stress had also been strongly linked with exogenous factors such as smoking, environmental pollution, pesticides and radiation. Kumar and Singh (2022) supported this finding as they proved that semen quality was greatly affected and impaired by environmental pollutants and toxins. Likewise, Selvaraj et al. (2021) cited that industrial pollutants caused oxidative stress, which caused structural and functional cells damage to spermatozoa. Oxidative stress was shown to have had its harmful influence on spermatozoa in complex and interdependent mechanisms. One of the major pathways had been determined to be lipid peroxidation, which results in the damage of the sperm plasma membrane and decreased membrane fluidity. This was in line with the results of Ayad et al. (2022), who pointed out that 48 polyunsaturated fatty acids constituted a big portion of sperm membranes and thus were highly vulnerable to oxidative damage. Oxidative stress had also been found to cause severe DNA damage besides the damage of membrane as well.

The development of reactive endogenous lesions like the 8-OHdG and enhanced fragmentation of DNA had been greatly linked to lowered fertilization capability and dismal embryonic future. The results were confirmed by Mottola et al. (2024), who found that 8 OHdG is one of the main biomarkers of oxidative DNA damage in sperm. The other critical process in this review was protein oxidation. Protein oxidative modification had already been demonstrated to inhibit the action of enzymes and structural integrity. 15

These results were in line with previous studies that indicated that oxidation-induced damage of sperm proteins had an adverse impact on motility and viability. The mitochondrial dysfunction was found to be one of the connecting factors between oxidative stress and decreased sperm motility. Destruction of mitochondrial membrane and electron transport chain had led to reduced

production of ATP. This finding was consistent with Moazamian et al. (2022) who found out that mitochondrial dysfunction was the key factor in causing sperm dysfunction via ROS. 16

The current review also established that oxidative stress had a negative impact on the important sperm behaviors such as motility, capacitation, acrosome reaction, and fertilization. These results were in line with Agarwal et al. (2021), who emphasized that overproduction of ROS interfered with the functional competence of sperm even though it had a physiological impact on capacitation. 17

Table: Effects of Diabetes Mellitus on Sperm Quality and Fertility Outcomes

Aspect	Key Findings	Mechanism / Notes
Sperm Count	Decreased sperm concentration	Impaired spermatogenesis due to hyperglycemia
Sperm Motility	Reduced motility (asthenozoospermia)	Mitochondrial dysfunction, oxidative stress
Sperm Morphology	Increased abnormal forms	DNA damage and defective spermiogenesis
Sperm DNA Integrity	Increased DNA fragmentation	Oxidative stress, advanced glycation end products (AGEs)
Hormonal Changes	Altered testosterone, LH, FSH levels	Disruption of hypothalamic-pituitary-gonadal axis
Oxidative Stress	Elevated ROS levels	Key mediator of sperm damage
Erectile Dysfunction	Increased prevalence	Neuropathy and vascular complications
Seminal Plasma Changes	Altered biochemical composition	Reduced antioxidant capacity
Fertility Outcomes	Reduced fertility, increased infertility risk	Combined effect of sperm and hormonal abnormalities

Therapeutic Strategies	Glycemic control, antioxidants, lifestyle modification	Improves sperm parameters and outcomes
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7.1: CONCLUSION(S)

Diabetes mellitus is more common in infertile men with the prevalence ranging between 0.7-1.4, and infertility in diabetes mellitus men, assessed in limited studies, is between 35-51%. Male diabetes mellitus seems to play a negative effect on couple fecundity while being childless or subfertile men might increase the risk of diabetes mellitus. Existing cross-sectional research on the semen parameters and male sex hormone in diabetic men is a heterogeneous body of studies with relatively small samples and discordant findings and in many cases cannot be directly compared to come up with a strong conclusion. Two meta-analyses confirm that diabetes mellitus has a negative impact on the normal morphology of sperms and no impact on total count of sperms and are inconclusive in other semen parameter. Based on studies on type 1 diabetes mellitus men only, meta-analyses indicate a negative impact of diabetes mellitus on sperm motility and no impact on sperm total count, but inconsistencies about other semen parameters. The prevalence of children among type 1 diabetes mellitus men was less than controls, particularly in those with more duration of diabetes mellitus. There were reduced rates of pregnancy in couples with a male partner who had diabetes mellitus and who underwent assisted reproduction technologies compared to control. No cohort study was performed to assess the effect of diabetes mellitus treatment on semen quality and male fertility. On the whole, these data indicate that diabetes mellitus could negatively affect the male reproductive health and fertility of couples. But more research that examines the male fertility potential in large sample sizes of diabetes mellitus patients is needed in an in-depth study.

7.2: RECOMMENDATION(S)

Based on the findings of this review, it is recommended that healthcare institutions increasingly integrate Next-Generation Sequencing (NGS) into clinical diagnostics to improve accuracy and

support personalized medicine. Investment in training programs for laboratory personnel and clinicians is essential to enhance skills in molecular techniques and bioinformatics for effective interpretation of sequencing data. Strategies to reduce the cost of NGS should be explored to make this technology more accessible to a wider patient population.

REFERENCES

- World Health Organization. Diabetes. Accessed August 2022
- American Diabetes Association Professional Practice Committee. 2. Classification and diagnosis of diabetes: standards of medical care in diabetes-2022. *Diabetes Care*. 2022; **45**(Suppl 1): S17-S38.
- Xu G, Liu B, Sun Y, et al. Prevalence of diagnosed type 1 and type 2 diabetes among US adults in 2016 and 2017: population based study. *BMJ*. 2018; **362**:k1497.
- Rewers A. Acute metabolic complications in diabetes. In: CC Cowie, SS Casagrande, A Menke, MA Cissell, MS Eberhardt, JB Meigs, EW Gregg, WC Knowler, E Barrett-Connor, DJ Becker, FL Brancati, EJ Boyko, WH Herman, BV Howard, KMV Narayan, M Rewers, JE Fradkin, eds. *Diabetes in America*. 3rd ed. National Institute of Diabetes and Digestive and Kidney Diseases (US); 2018. Chapter 17.
- American Diabetes Association Professional Practice Committee. 10. Cardiovascular disease and risk management: standards of medical care in diabetes-2022. *Diabetes Care*. 2022; **45**(Suppl 1): S144-S174.
- American Diabetes Association. 11. Microvascular complications and foot care: standards of medical care in diabetes-2021. *Diabetes Care*. 2021; **44**(Suppl 1): S151-S167.
- Mauri-Obradors E, Estrugo-Devesa A, Jané-Salas E, Viñas M, López-López J. Oral manifestations of diabetes mellitus. A systematic review. *Med Oral Patol Oral Cir Bucal*. 2017; **22**(5): e586-e594.

- Labib A, Rosen J, Yosipovitch G, Skin manifestations of diabetes mellitus. In: KR Feingold, B Anawalt, A Boyce, G Chrousos, WW Herder, K Dhatariya, K Dungan, JM Hershman, J Hofland, S Kalra, G Kaltsas, C Koch, P Kopp, M Korbonits, CS Kovacs, W Kuohung, B Laferrère, M Levy, EA McGee, R McLachlan, JE Morley, M New, J Purnell, R Sahay, F Singer, MA Sperling, CA Stratakis, DL Trence, DP Wilson, editors. *Endotext*. South Dartmouth (MA): MDText.com, Inc.; 2000.
- Lebiedz-Odrobina D, Kay J. Rheumatic manifestations of diabetes mellitus. *Rheum Dis Clin North Am*. 2010; **36**(4): 681-699.
- Zawada AE, Moszak M, Skrzypczak D, Grzymisławski M. Gastrointestinal complications in patients with diabetes mellitus. *Adv Clin Exp Med*. 2018; **27**(4): 567-572.
- Gandhi J, Dagur G, Warren K, Smith NL, Khan SA. Genitourinary complications of diabetes mellitus: an overview of pathogenesis, evaluation, and management. *Curr Diabetes Rev*. 2017; **13**(5): 498-518.
- La Vignera S, Condorelli RA, Cannarella R, et al. Urogenital infections in patients with diabetes mellitus: beyond the conventional aspects. *Int J Immunopathol Pharmacol*. 2019; **33**:2058738419866582.
- Kouidrat Y, Pizzol D, Cosco T, et al. High prevalence of erectile dysfunction in diabetes: a systematic review and meta-analysis of 145 studies. *Diabetes Med*. 2017; **34**(9): 1185-1192.
- 1Corona G, Isidori AM, Aversa A, et al. Male and female sexual dysfunction in diabetic subjects: focus on new antihyperglycemic drugs. *Rev Endocr Metab Disord*. 2020; **21**(1): 57-65.
- Di Stasi V, Maseroli E, Vignozzi L. Female sexual dysfunction in diabetes: mechanisms, diagnosis and treatment. *Curr Diabetes Rev*. 2022; **18**(1):e171121198002.
- Corona G, Mannucci E, Forti G, Maggi M. Following the common association between testosterone deficiency and diabetes mellitus, can testosterone be regarded as a new therapy for diabetes? *Int J Androl*. 2009; **32**(5): 431-441.

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3007-2387

3007-2379

DOI: <http://doi.org/10.5281/zenodo.19727609>

Desai A, Chen R, Cayetano A, Jayasena CN, Minhas S. Understanding and treating ejaculatory dysfunction in men with diabetes mellitus. *Andrology*. Published online: Aug 7, 2022.