REVIEW ARTICLE

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Impact of Faulty Lifestyle Behaviors on Male Fertility: A Narrative Review

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ABSTRACT: There is global rise in male infertility cases in the past few decades. With declining semen quality due to a variety of reasons, more and more researches have been directed to find the cause of such rise in male infertility. Several modifiable factors including environmental pollution, occupational exposures and faulty lifestyle habits have been observed to be associated with poor semen quality and male infertility. The present review focuses on some of the lifestyle factors including rise in sedentary life, obesity, smoking, alcohol and drug abuse, excessive use of electronic gadgets, altered sleeping habits, stress and faulty dietary habits that have affected the male reproductive health adversely leading to decreased male fertility. *Methodology:* The literature from 2000 till 2021 was searched from World Health Organization site and various English peer-reviewed journals using the USA National Library of Medicine (PubMed) database, regional portal of Virtual Health Library, and Scientific Electronic Library Online. The search terms used were: "Lifestyle and male fertility", "Obesity and male infertility", "Stress and infertility", "Electronic gadgets and male fertility". *Conclusion:* Poor lifestyle habits have significant impact on the process of spermatogenesis leading to impaired semen quality including decreased sperm concentration, count, motility, viability and increased abnormal sperm morphology, sperm DNA fragmentation, thereby affecting overall male reproductive health and fertility. However, all these factors are treatable and reversible and by just bringing a positive change in daily lifestyle many of these risk factors can be circumvented.

Keywords: Lifestyle, Infertility, Semen, Sperm, Stress

INTRODUCTION

Infertility affects millions of people annually all around the world. According to a recent World Health Organization (WHO) report, it was found that an estimated 48 million couples and 186 million individuals live with infertility worldwide (WHO, 2020). Furthermore, the past few decades have witnessed a steep rise in male infertility cases and a decline in semen quality all over the world. Male infertility accounts for 50% of all infertility cases and is mainly due to defective spermatogenesis (Ilacqua, et al., 2018). Numerous factors affect male fertility, but major changes in lifestyle in recent few years due to advances in technology and newer developments have adversely affected the semen quality of humans resulting in decreased male fertility worldwide. The present review briefs some of the modifiable lifestyle factors and their mechanisms by which they adversely affect the overall male reproductive health and cause infertility.

Sedentary lifestyle

An important reason of concern nowadays that can affect male fertility is a sedentary lifestyle. Professions today are forcing people to sit for long durations and spend sedentary lives. A sedentary lifestyle is defined as any rousing activity with energy loss less than 1.5 metabolic equivalents of task (MET) of sitting or lying down (Sedentary Behaviour Research Network, 2012). It was observed that a sedentary lifestyle causes a rise in testicular temperature, failing sperm chromatin remodeling during spermiogenesis, and hence, sperm DNA integrity leading to a rise in sperm DNA damage and male infertility (Gill et al., 2019). A recent study observed an inverse relationship between increased television watching and semen quality. They found that healthy men with higher moderate-to-vigorous physical activity and decreased duration of television watching had higher total sperm count and sperm concentration as compared to those with less physical activity and prolonged television watching hours (Gaskins et al., 2015). Many other studies have also reported that physically active men have higher semen volume, sperm viability, progressive motility, total motility, normal morphology as compared to their sedentary counterparts (Vaamonde et al., 2012; Priskorn et al., 2016; Lalinde-Acevedo et al., 2017; Ilacqua et al., 2018). A recent study reported that men with lower physical activity and higher fat mass for their age have infertility. They suggested that both sedentary lifestyle and physical inactivity represent two independent risk factors for male infertility (Foucaut et al., 2019). A similar study reported that regular exercise in healthy, non-infertile men can result in improved semen quality parameters, especially sperm motility (Sun et al., 2019). Another contradictory study in athletes reported that prolonged intensive exercise or training can result in changes in male reproductive hormone levels (Fitzgerald et al., 2012; Vaamonde et al., 2009), atrophy of testicular germinal epithelium with poor spermatogenesis, abnormal seminal parameters including abnormal sperm morphology, and decreased motility (Vaamonde et

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al., 2017). A similar study on professional athletes also reported that intense physical activity including training at higher intensities and with heavy loads can adversely affect the semen concentration, the number of motile, and morphologically normal spermatozoa (Jóźków et al., 2017). Hence, both sedentary lifestyles with physical inactivity and excessively strenuous exercise can lead to male infertility by affecting semen parameters.

Obesity

Both sedentary lifestyle and physical inactivity result in obesity. Obesity is a strong risk factor for both male and female infertility. Obesity is defined as a body mass index (BMI) of more than 30 kg/m^2 (World Health Organization, 2016). Several mechanisms explain the role of obesity in causing male infertility, including impaired spermatogenesis due to thermal effects produced from increased scrotal adiposity, decreased production of sex hormone-binding globulins, testosterone, rise in estrogen levels causing hyper-estrogenism, obesity-related diabetes mellitus, sexual dysfunction, hypogonadotropic hypogonadism due to decreased pulsatile Luteinizing hormone (LH) release from pituitary and decreased response of testes to LH, etc. (Craig et al., 2017) Obesity results in the enhanced peripheral conversion of testosterone to estradiol and estrone by adipocyte- related aromatization process. This excess estrogen, in turn, results in inhibition of the hypothalamic-pituitary-gonadal axis further decreasing the levels of testosterone leading to male infertility (Craig et al., 2017). Obesity also affects the male reproductive system by causing hyperinsulinemia, hyperleptinemia, chronic inflammation, and oxidative stress, leading to poor semen quality with decreased sperm concentration, motility, viability, and normal morphology (Leisegang et al., 2020).

Several studies have shown that obesity in males is found to be significantly associated with decreased semen quality, sperm concentration (Sermondade et al., 2013; Belloc et al., 2014), mobility, and sperm DNA damage (Chavarro et al., 2010; Dupont et al., 2013; Foucaut et al., 2019) leading to reduced overall fertility. A recent study has also reported a strong correlation between high body mass index (BMI) and increased sperm DNA fragmentation index which is due to obesity-induced increased testicular oxidative stress leading to enhanced production of ROS and DNA damage (Agarwal et al., 2020). Another study reported an inverse relationship between BMI and semen parameters like sperm concentration, motility, and morphology (Keszthelyi et al., 2020). Furthermore, obesity also results in erectile dysfunctions in males leading to coital infertility (El Salam, 2018). Hence, the rise in obesity amongst men all over the world has also led to a rise in the incidence of male infertility worldwide either directly or due to associated co-morbidities.

Smoking, Alcohol, and Drug Abuse

Cigarette smoking, tobacco, and/or alcohol consumption are two important avoidable lifestyle factors associated with the risk of male infertility. Both alcohol consumption and smoking cause increased oxidative stress and production of large amounts of reactive oxygen species (ROS) leading to sperm DNA damage and infertility (Aboulmaouahib et al., 2018; Sansone et al., 2018). Furthermore, several studies have proposed different mechanisms by which smoking causes infertility including structural abnormalities of axonemal microtubules and tail (Yeung et al., 2009), impaired acrosomal reaction and capacitation (Shrivastava et al., 2014), smoking-induced tissue hypoxia leading to impaired spermatogenesis (Taha et al., 2014; Gabrielsen and Tanrikut, 2016), abnormal mitochondrial function, and sperm chromatin structure due to the presence of numerous toxins in cigarette smoke (Sharma et al., 2013; Sharma et al., 2016). Alcohol consumption on the other hand affects the hypothalamus–pituitary-gonadal axis, causing decreased production of LH and follicle-stimulating hormone (FSH), resulting in Sertoli and Leydig cells dysfunction. This in turn results in reduced production of testosterone. As a result of decreased levels of testosterone, LH, and FSH there is abnormal morphological development and maturation of spermatozoa, a decline in production of sperms, testicular atrophy, and hence, male infertility (Gude, 2012). It was found that asthenozoospermia, teratozoospermia, oligozoospermia, and their combination were around 2-3 times more prevalent in alcoholic men as compared to non-alcoholics (Gaur et al., 2010). Another study reported that alcohol consumption of more than 60 g per day was significantly associated with azoospermia in males (Guthauser et al., 2014). A similar study reported that significantly lower levels of FSH and testosterone, and abnormal semen parameters like sperm concentration and progressive motility were observed in smokers and alcoholics. They also reported that alcohol consumers had oligozoospermia and asthenozoospermia on semen analysis (Mathur et al., 2019). It was observed that excessive alcohol consumption, specifically affects sperm morphology and overall sperm production, whereas cigarette smoking-related toxins mainly affect sperm motility and seminal fluid quality. Several studies have reported that smoking results in decreased semen volume, total sperm count, sperm concentration, motility, and viability (Mostafa, 2010; Hassa et al., 2006; Lingappa et al., 2015). Besides, it also results in an increased number of abnormal sperm forms including oval sperms, head-piece defects, spermatozoa with cytoplasmic droplets, and immature sperms (Harlev et al., 2015; Bundhun et al., 2019).

Another reason of concern, especially in young boys and girls is an alarming rise in illicit use of drugs. These drugs are known to produce adverse effects on male reproductive organs and fertility (Sansone et al., 2018). Drugs especially cannabis, cocaine, MDMA (ecstasy), marijuana, and opioids harm the male hypothalamus-pituitary-gonadal axis, thereby affecting spermatogenesis, sperm function, testicular cell apoptosis, DNA damage, etc. all leading to male infertility (du Plessis et al., 2015; Sanson et al., 2018). Studies have reported that illicit drug abuse can also result in decreased sperm count, motility, poor

sperm morphology (Pacey et al., 2014; Samplaski et al., 2015; Sansone et al., 2018). Hence, alcohol consumption, cigarette smoking, and drug abuse all can result in a progressive decline in semen quality leading to male infertility.

Mobile Phones, Laptop Screens

Mobile phones have become an essential part of our day-to-day lives and people are now too much dependent on this technology. Though mobile phones have a huge list of benefits at the same time they are not free from health risks, especially related to radio-frequency radiation exposure. Mobile phones have emerged as one of the major factors associated with the increased risk of infertility among male partners in recent years. They produce a detrimental effect on the testicular tissues by increasing oxidative stress through radiation released from them and by raising the local temperature (Agarwal et al., 2011). They are known to produce a significant negative effect on semen quality by reducing semen volume, sperm concentration, sperm count, motility, and viability, thus affecting the overall male fertility (Agarwal et al., 2011). Mobile phones produce low-power radiofrequency radiations, having frequencies between 450 and 2700 MHz (World Health Organization, 2014). Mobile phones produce electromagnetic waves which are carried from the handset to the nearest base station for making calls, texting messages, E-mails, downloading data, etc. These electromagnetic waves are similar to ionizing radiation like X-rays or gamma rays, which can be absorbed by tissues that are in close contact with the mobile phone and can result in the local rise of temperature (Dhami, 2012). Hence, the main mechanism by which cell phones cause infertility is the thermal effect on testicular tissue. A study reported that increased use of cell phones in males' results in decreased sperm motility and increased sperm DNA fragmentation index as compared to the males who don't use mobile phones (Gorpinchenko et al., 2014). Another recent study also reported that mobile phone users had significantly lower sperm concentration and semen volume, increased seminal viscosity, liquefaction time, number of immotile sperms, and abnormal morphology. Furthermore, they also found that men spending more time on wireless phones had significantly lower percentages of normal morphology sperms (Al-Bayyari, 2017). A recent meta-analysis also reported that mobile phone exposure results in reduced sperm motility and viability (Adams, et al., 2014). Several other studies have also reported the deleterious effect of cell phone use on semen quality including decreased sperm motility, concentration, morphology, and viability (Agarwal et al., 2008; Kesari and Behari, 2012; Meena et al., 2014; Kesari et al., 2018). A similar study on Wistar rats reported that exposure to mobile phone frequencies resulted in a significant reduction in protein kinase C and total sperm count and an increased rate of apoptosis leading to male infertility (Kesari et al., 2010).

Another commonly used electronic gadget by students, teachers, businessmen, researchers, office workers, etc. is laptop computers. As the name suggests, people usually keep the laptops on their laps while working on it, which in men results in increased heat around the scrotum, and the electromagnetic fields created by the laptop's internal electronic circuits and Wi-Fi Radiofrequency radiation may adversely affect the spermatogenesis process leading to poor semen quality and male infertility (Mortazavi et al., 2016). It was observed that placing laptops on laps causes a significant rise in scrotal temperature due to heat produced from it and because of postural effects, which in turn can harm the spermatogenesis process in young men and adolescent boys (Sheynkin et al., 2005). A recent study reported that putting a laptop connected to wireless internet on the thigh near the testes can result in reduced sperm motility and enhanced DNA fragmentation by nonthermal effect leading to diminished male fertility (Avendaño et al., 2012).

Sleep Disturbances

In recent years it was observed that due to poor lifestyle habits and increasing stress a great number of people are now suffering from sleep disorders. Sleep is known to play a crucial role in overall human health, including the functioning of the nervous, immune, cardiovascular, and endocrine systems (Choi et al., 2016). A recent study has reported that the increasing prevalence of sleep disturbance has been observed as an important factor associated with deterioration in sperm quality (Palnitkar et al., 2018). A study in male albino rats has shown that sleep deprivation adversely affects sperm motility, viability, morphology, and count (Rizk et al., 2020). The exact mechanism by which sleep disturbance causes male infertility is still under research, but it was observed that sleep deprivation induces a stressful environment, leading to activation of the hypothalamic-pituitary-adrenal axis which in turn results in increased corticosterone production. The raised corticosteroid levels then inhibit testosterone production, leading to decreased testosterone levels and male infertility (Lateef and Akintubosun 2020). A recent study reported that short-duration sleepers have significantly lower sperm counts and motility as compared to long-duration sleepers. They also observed that short-duration sleep and late bedtime sleeping significantly impair sperm health by increasing the production of anti-sperm antibodies (Liu et al., 2017). A similar study reported an inverse relationship between sleep deprivation and sperm concentration, total sperm count, motility, and morphologically normal sperms, further indicating that sleep disturbances adversely affect semen quality (Jensen et al., 2013). Another recent large case-control study reported that obstructive sleep apnea was linked with a 1.24-fold higher risk of developing male infertility (Jhuang et al., 2021). Furthermore, it was found that lying awake for most of the night results in decreased sperm motility, and difficulty in starting sleep results in lower semen volume and increased sperm concentration (Viganò et al., 2017). Several other studies have also reported an inverse relationship between

sleep disturbances and semen quality (Alvarenga et al., 2015; Chen et al., 2016; Choi et al., 2016). Hence, sleep quality is one major factor associated with male fertility.

Stress

Stress is an important risk factor associated with reduced semen quality, especially in today's era where everyone is stressed at the workplace, at home, and in daily life. Chronic stress results in increased production of corticosterone, which negatively inhibits the release of gonadotrophin-releasing hormones, FSH, LH, and testosterone hormones, thereby affecting the process of spermatogenesis (Arun et al., 2016; Arun et al., 2018). It was observed that stress suppresses testosterone and inhibin release due to excessive production of corticosterone, which results in alteration in the testicular microenvironment leading to decreased sperm motility and male infertility (Nargund, 2015; Durairajanayagam, 2018). Furthermore, chronic stress enhances lipid peroxidation and apoptotic protein expressions due to reduced total tissue antioxidants, leading to sperm DNA damage (García-Díaz, 2015). Several studies have reported a significant correlation between chronic stress and reduced semen qualities including low sperm count, motility, viability, and morphology (Arun et al., 2018; Ribeiro et al., 2018; Zou et al., 2019). A recent study has reported the impact of chronic stress on seminal vesicle fluid which plays a vital role in fertilizing the egg by spermatozoa. It was observed that chronic stress resulted in increased malondialdehyde levels and expressions of certain proteins like heat-shock protein 70, caspases-3 and 9, and tyrosine-phosphorylated proteins in seminal fluid, which in turn has a detrimental effect on overall semen quality and male fertility (Iamsaard et al., 2020). Another study reported that psychological stress results in excessive production of Nitric oxide (NO) which in turn causes increased generation of peroxynitrite radicals ($ONOO^-$) that leads to oxidative damage and dysfunction of mitochondria, thereby causing decreased sperm motility (Eskiocak et al., 2006).

Dietary Factors

Diet plays a major role in maintaining male fertility. A healthy diet is associated with good sperm quality and a lower possibility of abnormalities in sperm count, sperm concentration, motility, and decreases the risk of sperm DNA fragmentation (Skoracka et al., 2020). An unhealthy hypercaloric diet, excessive intake of saturated fats and trans-fatty acids, high glycemic index, and low nutritional density may be directly associated with increased oxidative stress leading to infertility (Walczak-Jedrzejowska et al., 2013; Salas-Huetos et al., 2017). It was observed that a diet rich in items like red meat, caffeine, fatty dairy, sweet drinks and sweets, potatoes, etc. is associated with adverse semen parameters and decreased male fertility (Salas-Huetos et al., 2017; Nassan et al., 2018; Skoracka et al., 2020). Furthermore, it was proposed that some dietary factors like dairy products, soy foods serve as sources of exogenous antiandrogenic or proestrogenic substances which may affect spermatogenesis leading to infertility (Nassan et al., 2018). A study reported that higher consumption of seafood was associated with a rise in total sperm count (Cutillas-Tolín et al., 2015). Another similar study reported that a higher intake of seafood, legumes, chicken, whole grains, was positively associated with sperm motility, but has no impact on sperm concentration and morphology (Gaskins et al., 2012). Many studies have reported the adverse impact of dairy products on semen parameters. It was observed that consumption of full-fat dairy was inversely associated with sperm motility and morphology (Afeiche et al., 2013; Afeiche et al., 2014). Recent studies have proposed that adherence to western pattern diet consisting of red and processed meats, organ meats, sweets, sweet beverages, rice, potatoes, junk food like pasta, French fries, snacks and high-fat dairy products, mayonnaise, and fatty sauces increase the risk of decreased sperm concentration, total sperm motility, normal sperm morphology. It also leads to an increased risk of asthenozoospermia (Liu et al., 2015; Eslamian et al., 2016). Several other studies have also reported a positive impact of a diet rich in fruits, vegetables, whole cereals, nuts, seafood, poultry, low dairy products, fiber, omega-3 PUFA, and antioxidants on sperm quality including sperm concentration and sperm motility (Esmaeili et al., 2015; Ricci et al., 2018; Salas-Huetos et al., 2017; Salas-Huetos et al., 2019). Hence, consumption of the right diet pattern is very essential for maintaining semen quality and overall fertility in males.

Table 1. *Depicts impact of lifestyle factors on semen quality and male fertility*

No	Lifestyle Factor	Cause	Impact on Male fertility	Reference
1	Sedentary life	Profession, long television watching hours, change in lifestyle.	• Increased sperm DNA damage. • Decreased total sperm count and sperm concentration.	(Gaskins et al., 2015; Gill et al., 2019)
2	Obesity	Sedentary life, poor dietary habits, hereditary.	• Poor semen quality with decreased sperm concentration, motility, viability, and normal morphology. • Increased sperm DNA fragmentation index.	(Agarwal et al., 2020; Leisegang et al., 2020)
3	Smoking/Alcohol /Drug abuse	Lifestyle changes, stress, easy availability, peer pressure.	• Increased sperm DNA damage. • Structural abnormalities of axonemal microtubules and tail. • Impaired acrosomal reaction and capacitation. • Impaired spermatogenesis & abnormal mitochondrial function. • Abnormal sperm count.	(Gaur et al., 2010; Shrivastava et al., 2014; Gabrielsen and Tanrikut 2016; Sharma et al., 2016; Sansone et al., 2018)
4	Mobile Phones/Laptops	Increased use due to advancement in technology, easy communication by mobile phones. laptops are used by students, teachers, businessmen, researchers, office workers.	• Decreased sperm motility and increased sperm DNA fragmentation index. • Lower sperm concentration, semen volume. • Increased seminal viscosity, liquefaction time, number of immotile sperms, and abnormal morphology.	(Gorpinchenko et al., 2014; Al-Bayyari 2017;)
5	Sleep disturbances	Change in lifestyle, day-to-day or work-related stress.	• Decreased sperm concentration, total sperm count, motility, and morphologically normal sperms	(Jensen et al., 2013)
6	Chronic Stress	Work related, at home, familial and other factors leading to stress.	• Increased oxidative stress and sperm DNA damage. • Reduced semen qualities	(Arun et al., 2018; García-Díaz et al., 2015; Zou et al., 2019)
7	Faulty Dietary habits	Excessive intake of saturated fats and trans-fatty acids, high glycemic index, and low nutritional density.	• Decreased sperm concentration, sperm motility, morphology. • Increased risk of asthenozoospermia.	(Liu et al., 2015; Eslamian et al., 2016)

CONCLUSION

Lifestyle factors play a crucial role in male reproductive health. Faulty lifestyle habits can adversely affect the semen quality including sperm concentration, count, viability, motility, morphology and sperm DNA fragmentation by a complex mechanism, all leading to impaired male fertility. Though many more studies are needed to completely understand the role and mechanism of various lifestyle factors in causing male infertility, but still, most of these factors are treatable or modifiable and hence, by counseling of infertile couples or by creating awareness among people about these faulty habits, many of these adverse impacts of lifestyle factors on the semen quality can be prevented leading to a healthy reproductive outcome. Therefore, by mere changing of daily lifestyle the reproductive health can be significantly improved.

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CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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