Lifestyle Does Affect Semen Quality: Factor Determination in a Statistical Way

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Keywords: Semen quality, Biostatistics, Dietary Habits, BMI.

Abstract: Infertility has become a common medical concern and a global public health issue in recent decades. Lifestyles may be incrementally altering epigenome, according to accumulating evidence. In the recent decade, for the mass and variety of the database and the desire for a general view of data to draw wildly applicable conclusions, biostatistical research methods combining developed arithmetic models are widely used in finding factors influencing semen quality. This paper looks back at previous scholarships that used biostatistics research methods to determine the relationship between sperm quality and certain lifestyles. Factors reviewed include dietary habits, body mass index (BMI), stress, consumption of alcohol and smoking, mobile phone use, and microplastics. Convincing conclusions are thus drawn. Food molecules or those decomposed after cooking can alter metabolic pathways by altering the epigenome, resulting in changes in fertility. Besides, obesity and regular alcohol consumption are linked to lower semen quality and alterations in reproductive hormones, like testosterone and sex hormone-binding globulin, suggesting intersections in pathways. Those taken for granted and with less attention/legislations applied in modern life, like mobile phone usage and overused plastics, in turn, become potential threats to public health. Meta-analysis has been most utilized to address issues under the current topic in the reviewed literature. Among all factors, age is an inevitable and constant factor impacting sperm parameters; Thus, it should be considered as a confounder and limited.

1. Introduction

Infertility is defined as the inability to conceive after 12 months or more of regular unprotected intercourse. Infertility has become a frequent medical concern and a global public health issue in recent decades, impacting 15% of all reproductive-age couples. Subfertility or infertility affects an estimated 70 million couples globally [1]. Compared to other animals, men's spermatogenesis is highly susceptible to environmental influences. Also, toxic substances are more likely to put humans in danger. Mounting data shows that the sperm epigenome may be dynamically altered by lifestyle (food intake, exercise, alcohol consumption, and cigarette smoking, etc.), healthy condition (adiposity, diabetes, and hypercholesterolemia, etc.), which affects not only one's health but also the reproductive fitness and even the health of future children [2].

There has been growing worried over a global reduction in male fertility. Two meta-analysis studies have shown a steady decline in sperm quality since the 1970s, notably in sperm count. Since the development of computer science, more computational tools can be used to advance and produce more effective statistical tools. With the greater availability of clinical trial data through the Internet, a new subject – Biostatistics – has emerged, which involves the design of biological experiments, collecting and analyzing data from first-hand experiments, and processing those data into conclusions. In most prior investigations, concerns regarding whether lifestyles are linked to sperm quality were investigated using certain standard biostatistical models. However, prior scholars [3] found that different positive outputs from similar populations or territories may result from different analysis models. Therefore, understanding and selecting appropriate models is critical to draw study conclusions. In this article, different models applied in various studies are introduced and concluded to determine the influencing elements of sperm quality, which is rare to see in previous studies.

2. Lifestyle factors

A combination of lifestyle factors always influences sperm quality. Figure 1 provides a visualization of six aspects discussed in this article, including the most studied ones and recently emerging factors.

Figure 1. Factors affecting semen quality

2.1 Dietary habits

Multiple regression models were used to determine the relationship between dietary habits and clinical sperm parameters. DNA methylation levels were analysed by Beta regression models separately in a study of 67 qualified 18~35 years old men in Durham, N.C. (U.S.A.) area, indicating that compared with eating a balanced, junk food eating diet causes opposing epigenetic markers in human sperm and makes them less motile. Poor paternal eating habits can lead to unfavorable metabolic conditions and an increased risk of chronic illness in children [4]. Similarly, a diet rich in vegetables can alter semen epigenetically and impact the offspring's appearance potentially. A study of 40 healthy Italian volunteers with various dietary habits found that vegan sperm had higher DNA methylation levels than omnivore sperm at sites of genes involved in metabolisms such as fat accumulation and obesity-associated process, as determined by the Mann-Whitney U test for continuous variables or the Chi-square test for categorical variables [5]. In general, much attention should be paid to the food we eat to ensure semen quality, particularly harmful molecular components in it. However, A nutritious diet has been shown to increase male sperm quality and fecundity rates. Diets with high omega-3 fatty acids, antioxidants (vitamin C, vitamin E, β-carotene, selenium, zinc, cryptoxanthin, and lycopene, etc.), other vitamins (vitamin D and folate), and low in saturated and trans-fatty acids were discovered to be semen-friendly; Seafood (Fish, shellfish, etc.), vegetables, fruits, poultry, cereals, low-fat dairy, and skimmed milk are recommended to eat since a positive correlation with sperm quality; Processed meat, soy foods, potatoes, full-fat dairy products, cheese, coffee, alcohol, sugar-sweetened beverages, and sweets, on the other hand, impair spermatogenesis [3], implying that temperate consumption of these items might lower the chance of experiencing reproductive issues.

2.2 Body mass index (BMI) and overweight

Unbalanced weight harms semen quality and is one of the most important factors. A J-shape association between BMI with semen quality [6] was found by multivariate analysis. Sperm concentration and total sperm count are mainly impacted by BMI, which are examined by the logistic predictions analysis from a retrospective study of 9,464 Argentina patients [6]. A cross-sectional study of 511 men from Auckland using Spearman correlation and a multiple linear regression analysis shows that overweight men have no significantly increased relative risk of abnormal semen parameter [7, 8], but have a marginally significant effect on normal sperm morphology [8]. These results are surprisingly congruent with findings from other cross-sectional studies and few meta-analyses. Still, they differ in part from the large meta-analysis (which revealed substantial odds ratios for oligozoospermia and azoospermia with increasing BMI) and studies assessing DNA fragmentation index. Therefore, a definite conclusion on the influence of BMI on sperm quality remains speculative, but it is likely to be dependent on the statistical methodologies utilized. On the other hand, increased BMI was reported in most studies to have a negative relationship with reproductive hormones such as testosterone, sex hormone-binding globulin (SHBG), and free testosterone in a meta-analysis [7, 8].

According to recent research, epigenetic alterations may be a result of increasing adiposity [9]. Unclear as the mechanism of obesity influencing sperm function and male infertility is, it can still be explained by several processes [9]. First, male obesity leads to a hormonal imbalance in the hypothalamus-pituitary gonadal (HPG) axis, which leads to chronic inflammation and increases oxidative stress at the systemic and tissue levels. Therefore, hormone deprivation, inflammation, and oxidative stress degrade the environment required for spermatogenesis in the testis and sperm maturation in the epididymides, including Sertoli cell activity and epididymal epithelial activity. The impaired spermatogenesis and sperm maturation can then result in poor sperm quality, including decreased sperm concentration and motility, inappropriate lipid composition, increased DNA methylation damage, and non-coding RNA alteration, eventually leading to male subfertility and comorbidities that can be passed down to offspring via epigenetic inheritance.

However varied results from different statistical models, obesity was linked to a more than 20% rise in occurrences of subfertility and infertility in a broad picture [10]. Despite this, reducing sperm quality in infertile patients may be possible by less exposure to lifestyle risk factors [6] (depriving of alcohol, caffeine intake, etc.) and exposing them to more positive living methods such as enhancement in physical activity, cognitive behaviour therapy and reducing stress yoga, which many reproductive doctors recommend to improve semen quality and fertility chances [11].

2.3 Stress

In psychology, stress is a feeling of strain or pressure. A small amount of pressure would be beneficial to improve work and study efficiency. An excessive amount of it, however, may lead to bodily and mental damage. Therefore, identifying psychological risk factors for low semen quality, such as stress, is critical for increasing fecundity and fertility and life cycle and intergenerational health [10]. Through retrospective research [12] of 57 cross-sectional studies involved 26 countries/regions, stress has been linked to lower sperm concentrations, increased sperm motility, and altered sperm morphology, as well as an increased risk of congenital abnormalities and male infertility. Such a result has also been confirmed by covariate-adjusted linear regression analysis in another cross-sectional survey [13] conducted in Northern California with 193 men involved. Furthermore, in another study [14], Pearson correlation has been applied to conduct the analysis focusing on young Danish men. Results showed that reduced fertility, sexual activity, fewer ejaculations, decreased testicular weight, and delayed puberty may be linked to a negative relationship between self-reported stress and semen volume, sperm concentration, total sperm count, and morphologically normal sperms. As for reasons, stress reduces the quality of sperm by causing death in sensitive germ cells due to elevated glucocorticoid levels [14]. Furthermore, during adulthood, the

impact is thought to alter spermatogenesis [13, 14]. Besides, exposure during fetal life may be more harmful since it may affect androgen activity and testicular development [15, 16].

2.4 Alcohol consumption and smoking

Alcohol is widely consumed in the Western world, particularly in Europe. However, it is examined by multivariable linear regression models in a cross-sectional study with 1,221 young Danish men that consumption of alcohol regularly is linked to lower semen quality and alterations in reproductive hormones [17], like, testosterone and SHBG, which are also found altered in obesity's impact. Light drinking has no negative effects on sperm quality in healthy males. However, it is linked to greater blood testosterone levels, which could be attributable to a change in testosterone metabolism in the liver, which is derived by multiple linear regressions from a European and American-based study [18]. A J-shaped correlation between alcohol consumption and semen quality was seen in the multivariate analysis from an Argentina cross-sectional study [6] which also found that the earliest effects of alcohol use were on functional membrane integrity and nuclear maturity.

Study [12], utilizing meta-analysis method and integrating a larger sample size (29,914 participants) to ensure reliable findings, retrospect that both fertile and infertile men's sperm parameters can be harmed by smoking. That lower semen volume is linked to smoking cessation, as well as increased age and alcohol intake. Meanwhile, the effect of smoking is related to demography. While smoking can harm all sperm in both fertile and infertile men, it is not a risk factor for sperm volume or density for males in Switzerland and Iran and in the United States, Denmark, and Brazil, fortunately. However, a slew of research has linked smoking to worse sperm quality, implying that quitting nicotine and improving overall lifestyle might boost male fertility.

2.5 Mobile cell phone use

The usage of mobile phones has risen dramatically in the last decade, raising worries about the potential harm that high-frequency electromagnetic fields (EMF) emitted by these devices may cause to public health. Low-level Radio Frequency Electromagnetic Fields (RF-EMF) (850 MHz-2.4 GHz) are thought to influence sperm motility by increasing superoxide anions concentrations as a result of increased oxidative stress oxidizing membrane phospholipids and resulting in lower vitality and impaired motility [19]. A total of 124 sperm samples were subjected to 1 hour of mobile phone radiation in prospective in vitro research, and sperm parameters were collected before and after exposure. Sperm motility, linear velocity, and acrosome response were all significantly reduced. Meanwhile, sperm DNA fragmentation increased significantly [20]. Another research [21] on 32 healthy males who had their sperm sample exposed in vitro for 5 hours has the same findings. The quantity of sperm with progressive motility in the exposed samples was considerably decreased, and a greater proportion of sperm with DNA fragmentation was found. Furthermore, electromagnetic fields have been demonstrated to reduce fertilization rates and the number of spermatogenic cells in mice and induce apoptosis [22, 23]. These might be the reasons for degradation after phone use. In an integrated study [24], mobile phone use was primarily linked to decreased sperm motility and viability, while the effects on concentration were less clear. Thus, with more people, especially those in the younger age group, working and studying without mobile phones, it becomes more urgent than ever to dig into and elucidate the underlying mechanism for more efficient precautions.

2.6 Microplastics (A New Threat)

Multiple environmental and lifestyle factors can operate alone or in combination to cause negative impacts on sperm quality. A large portion of the earth is covered with discarded plastic, endangering animal and possibly human health. Medicines, hygiene items, food additives, organic and inorganic hormones, and micro and nano plastic debris, among others that are directly or indirectly released into the environment, have gathered much attention in recent years. When plastic debris reaches the sea, sunshine, wind, and wave action break it down into particles known as microplastics (MPs). These non-biodegradable compounds can operate as a vector for environmental contaminants, contaminate food and water, and penetrate and deposit in human tissues, posing a health concern.

MPs have been shown to negatively impact male fertility and sperm quality in recent research, making them a possible reproductive danger [25]. Those pollutants resemble the action of natural steroid hormones and interfere with endocrine functioning in various ways. Also, tissue damage and subsequent apoptosis, poor gamete quality, developmental abnormalities, neurotoxicity, metabolic problems, and epigenetic alterations are triggered by oxidative stress during the contamination process. Unfortunately, researches concerning this field are poor. Thus, more attention should be paid because of the more serious ponderance with the industrialization and commercialization developing globally.

3. Discussion

Recent research has shown that epigenetic alterations, whether in obese or junk-food-eating persons, are strongly suspected as the molecular processes causing sperm quality differences and that these changes can be transmitted down to the next generation. It is speculated that small chemicals in food can modify metabolic pathways at the epigenome level after heating. Recent advancements in nutriepigenomics are helping to elucidate the function of various nutritional variables in gene expression regulation (mainly on DNA methylation), such as dietary digested fatty acids, which proved can influence gene expression by altering epigenetic processes and have a favorable or negative impact on metabolic consequences, which vary along with different types of fatty acids [26]. n-3 polyunsaturated acids: eicosatetraenoic acid and docosahexaenoic acid, and monounsaturated: oleic and palmitoleic acid, were linked to a reduction in metabolic abnormalities. Fatty acids such as n-6 polyunsaturated acids, saturated fatty acids (stearic and palmitic), and trans fatty acids have been related to the existence or development of obesity, type-2 diabetes, pro-inflammatory profile, atherosclerosis, and insulin resistance. They have also been linked to epigenetic alterations. Moreover, docosahexaenoic acid supplementation is reported to impact epigenetic alterations in the offspring [27]. Thus, more research is needed to understand the function of nutritional supplements relating to genetic diversity and their probable influence on epigenetic changes to finally promote the management of metabolic disorders as an integrated treatment.

Consumption of alcohol regularly is linked to lower semen quality and alterations in reproductive hormones [17], like testosterone and SHBG, which are also found altered in obesity impact, suggesting that a similar pathway or mechanism is shared in both lifestyle stresses. Gamma-glutamyl transferase (GGT) is thought to have a role in maintaining the milieu in which semen is produced in the male reproductive system. There are numerous organs where GGT is expressed in addition to the liver and kidneys, such as spermatogonia cells, epithelial cells lining the epididymis and seminal vesicle, and the male reproductive system [28]. According to a recent study [29], higher GGT activity may reflect a plausible link between obesity, alcohol intake, and semen quality (total sperm counts and sperm concentration). Given the relationship between sperm parameters and GGT, more further studies are hoped to dig into the intersection part in the molecular pathway of alcohol drinking and obesity.

Regarding psychosocial stress, however, on a large scale of studies, the association between it and semen quality is inconsistent. Several reasons may explain this bifurcation. First, most of the samples are derived from either prenatal hospitals or reproductive clinics, where the majority of samples are from patients troubled with reproductive disorders leading to a biased conclusion without universality to the public. Second, stress exposure and/or assessment are variable and somehow subjective. For example, an earthquake, a war, and a university examination could trigger pressure. Therefore, sampling from various institutions, age groups, and vocational backgrounds is recommended; Pressures should be classified (such as life events caused, work-related, study-related, inevitable events caused, self-rated, etc.), and then estimate whether they are subjective or objective. Subjective measures of stress should emphasise a subjective experience of the ability to deal with the stress of events. In contrast, objective measures of stress assess experiences associated with a stress response [30]. Therefore, both subjective and objective measures of stress should be required to characterize the relation between stress and male fertility.

These days, mobile phone technology has already become an indispensable aspect of daily life, and its usage will continue to rise as internet companies have been expanding their offerings and introducing more, better devices and updated applications. As more people take smartphone granted for daily life, the higher the possibility that phone turns out to be a big threat to human health. To put it in another way, the mobile phone has a subtle rather than immediate impact on people. Due to applications developed today fully satisfying customer demands to gain a constant stream of users, more young people with less self-discipline are likely to become addicted to, influenced by, or even manipulated by social media, exacerbating the physical and psychological effects of it. Though radiation and electromagnetic fields have been demonstrated to affect sperm quality, more research, either in vitro or in vivo or even long-term, on the relationship between mobile phone use and reproductive health are advised in light of the emergence of this progressively critical problem.

Needless to say, a lot of plastic in our daily lives (packaging, cosmetics, household goods, electrical and electronic equipment, furniture, etc.) and plastic-free products are hardly ever to find at present. Plastics (and notably nano- and microplastics) have polluted aquatic, terrestrial, and atmospheric ecosystems worldwide due to a lack of recycling and legislation that limit plastic waste production and disposal. Even the arctic sea and ice have been polluted by plastic waste that has found its way into our waters, influencing people's health. Natural steroid hormone-like plastic debris is just one type of plastic contamination. Other types of microplastics and their effects on human bodies are still unknown. Besides the noxious chemical substances, they initially contained, one study [31] points out that microplastics may include additives, absorbed pollutants, and may encourage the growth of bacterial infections on their surfaces, making them possible carriers of intestinal toxicants and pathogens that can promote further development of chronic immune disorders. Unfortunately, the existing data are inadequate, making it unable to draw solid scientific conclusions about human health in particular. Therefore, toxicological studies of specific kinds and forms of microplastics are currently being conducted.

Varied statistical research methods will lead to different findings. Therefore, it's vital to pick the proper statistical approach based on the data. Meta-analysis was utilized in most research due to the large number of scientific papers that addressed the same topic. When doing a meta-analysis, an investigator must make decisions that might impact the results, such as how to search for studies, how to choose studies based on objective criteria, how to deal with inadequate data, how to analyse the data, and whether or not to account for publication bias [32]. But not all large-scale research can be predicted by a meta-analysis consisting of numerous small studies combined. One criticism of meta-analysis is that it does not compensate for poor design or bias in the original research. Only studies with appropriate methodology should be included in a meta-analysis. To evaluate the influence of research quality on the effect range, a study-level predictor variable might be included to indicate study methodological quality. Others, however, have suggested that preserving information regarding variance in the research sample, casting as broad a net as possible, without introducing methodological selection criteria, which adds unnecessary subjectivity, is a superior strategy.

Among all factors, age is an inevitable, constant factor impacting sperm parameters. A study [6] points out that the synergistic relationship between Age and BMI influenced all of the seminal parameters tested, suggesting that this combination is more effective in altering semen quality. One possible cause is that semen quality deteriorates with age, which is linked to individual and cell-induced aging (senescence). Another might be that as men age and continue to use alcohol, smoke, and engage in other harmful behaviours, their total sperm count and sperm concentration may decrease even more due to the addictive impact. Consequently, age should be included as a confounding factor in any longitudinal statistical research that analyses factors affecting semen quality. Furthermore, other factors that should be taken into account are seasonality, childhood diseases (such as chickenpox, measles, mumps, and polio), surgical intervention, and high fevers in the past year and the number of hours spent sitting per day [33]. These factors should be considered as confounders or eliminated from the analysis to ensure validity.

4. Conclusion

In the last few decades, infertility has risen to the status of a widespread medical problem and a global public health issue. Evidence suggests that our way of life may be affecting our epigenomes over time. For example, eating habits influence spermatogenesis, sperm quality, and the health of future generations, possibly through epigenome measures altering metabolic pathways. Consequently, a nutritious diet with less high-calorie meals, soy products, coffee, and high-fat dairy products is advised.

Drinking alcohol chronically is linked to lower semen quality and alterations in reproductive hormones, but light drinking has few negative effects on sperm quality in healthy males. Smoking, on the other hand, can damage both fertile and infertile men's sperm parameters. Obesity was associated with a 20% increase in subfertility and infertility overall. Both obesity and regular alcohol intake are linked to poorer semen quality and changes in reproductive hormones such as testosterone and SHBG, suggesting intersected pathways.

Recently, mobile phones have become essential for most young people, but radiation and electromagnetic fields have been demonstrated to negatively impact sperm quality. Plastics, a possible reproductive danger with exponential growth in amount, may negatively affect male fertility for the resemblance to natural steroid hormones and poisonous chemicals contained. Worthy attention that those factors taken for granted in contemporary life and receiving less attention/legislation may pose potential public health risks. Self-reported stress has been related to decreased sperm concentrations, increased sperm motility, and changed sperm morphology. However, classifying whether the causation is subjective or objective is crucial, and a wider sampling range is suggested.

Among all factors, age should be considered as an inevitable confounding factor and maintained to a minimum in sperm parameters investigations unless in cross-sectional research. Referring to studies included in this article, meta-analysis was the most popular approach.

Overall, healthy sperm quality and good fertility are very likely to be achieved with a balanced diet, average weight, moderate stress, abstinent drinking, quitting smoking, staying away from electronic devices, and living a plastic-free lifestyle.

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