



THE IMPACT OF LIFESTYLE ON FERTILITY AND BIRTH RATE

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This evidence-based review evaluates the impact of lifestyle risk factors on fertility. The aim of this paper is to review already known data on the effect on fertility of the following lifestyle risk factors: body mass index (BMI), diet, physical activity, smoking, alcohol consumption, psychological stress. A comprehensive search of literature was performed. As a search strategy, the information databases of PubMed and Medline were searched for relevant papers.

There is strong evidence that smoking and being overweight or obese have both a major impact on fertility and reproductive health. Another lifestyle risk factors such as physical exercise, diet, alcohol consumption and psychological stress have also a certain impact on fertility, but the results of the studies are inconclusive and sometimes even controversial.

It is concluded that government factors should facilitate access to reproductive health education and to lifestyle change programs that improve reproductive health not only in infertile couples, but also in general population of reproductive age. More than that, extensive and prospective studies on the combined effects of lifestyle risk factors are required in the future.

Keywords: fertility, lifestyle, weight, smoking, physical activity.

INTRODUCTION

From the second half of the 19th century to present, great scientific discoveries in the field of medicine (antibiotic therapy, vaccines, therapies for non-communicable diseases and their prevention) as well as other factors (urbanization, increasing standard of living) have led to a decrease in overall mortality, especially in developed countries. After the Second World War, the crude birth rate (the ratio between the number of live births and the average number of inhabitants of the period considered, per thousand inhabitants) gradually decreases, reaching 9.3‰ in Europe in 2019. Unfortunately, this downward trend is maintained both in Europe and in our country until today. Our country has practically followed the European downward trend, but with some delay, due to later industrialization and economic development.

The study of the numerous indices of birth rate and fertility is particularly important for predicting the demographic evolution trend of a population.

Factors influencing fertility and implicitly the birth rate are of several categories: demographic factors (distribution by sex, by structure of the female population, by age groups), biological factors (female and male sterility, genital pathology, sexual hygiene), social factors (extension of education, the degree of employment of women in socio-economic activities, belonging to a certain social category and mobility between social categories, population migration), legislative factors (programs to encourage births, family protection), traditional factors (cultural level, religion, local habits), subjective factors (related to lifestyle, attitude towards children).

Among the many factors that influence fertility and birth rate we should also consider lifestyle. Modern European society takes care of its citizens and emphasizes the role and the need of a healthy lifestyle. Nutritional status, smoking status, exercise, diet, psychological stress, caffeine and

alcohol consumption, exposure to environmental pollutants are most often incriminated in modulating fertility. A great number of studies have evaluated these parameters, sometimes with controversial results. For some of them the impact on fertility is proven, others still need studies in this regard.

The aim of this paper is to review already known data on lifestyle risk factors. We have studied the literature in the field related to body mass index (BMI), diet, physical activity, smoking, alcohol consumption, psychological stress.

METHODOLOGY

The data from the literature on the lifestyle risk factors described above will be reviewed. A comprehensive search of literature was performed. As a search strategy, the information databases of PubMed and Medline were searched, to identify appropriate and relevant papers written in English between 1990 and 2021. We used the following key words for searching: body mass index, alcohol, diet, physical activity, smoking, psychological stress, fertility, birth rate, diet, nutrition, conception.

The selected relevant and robust studies were fully read and the data on each lifestyle risk factor was studied and sorted in order to provide information on their effect on fertility and birth rate.

BODY MASS INDEX

Obesity increases cardiovascular risk and the risk of type II diabetes. Both obesity and underweight can impact fertility through hormonal disorders and ovarian dysfunction¹.

In general population, after adjustment of age, menstrual pattern and other lifestyle characteristics, there was a 12-month delay in the time required for conception for women with BMI $\geq 25\text{kg/m}^2$ or $< 19\text{kg/m}^2$ ². On the other hand, in women who have undergone an assisted reproduction procedure, the chance of becoming pregnant has halved for obese women compared to normal-weight ones³. It appeared also that the body fat distribution, namely an increased waist-hip ratio, has also a negative impact on fertility, with a 30% decrease of pregnancy rate per cycle⁴. Another study in the Netherlands, performed in all in vitro fertilization (IVF) clinics in the country showed a 1/3 third reduction in birth rate for women with

BMI $> 27\text{kg/m}^2$ on their first IVF cycle as compared to women with normal BMI⁵.

A Norwegian study demonstrated an increased risk of early pregnancy loss in obese women as compared to women with normal BMI⁶.

An interventional study was performed in Australia. A number of 87 women were undergone a program consisting of losing weight, improving physical exercise and decreasing psychological distress. Despite the small number of patients, the results were remarkable, a weight loss of 6,5 kg was associated with spontaneously ovulation recovery⁷.

Another study demonstrated that every 5 kg gain over 18 years of age increases the conceiving time, and for gaining more than 20 kg the median time to conceive was 1,4 years longer. On the other hand, being underweight at 18 years and overweight at the time of willing to conceive, leads to doubling the time to conception^{8,9}.

In infertile obese women, lifestyle intervention has led to an increase in the natural rate of conception, but has not changed the rate of healthy life birth¹⁰. Underweight in women is associated with ovarian dysfunction and infertility¹¹ and the risk of infertility increases significantly in women with a BMI below 17kg/m^2 ¹².

The LIFE study was the first prospective study to enrol 500 couples before conception and to use standardized protocols for measuring body size and shape. A collection of one or two sperm samples for each man was performed, for the assessment of sperm quality. This study showed a linear association between higher BMI and low sperm volume, low sperm concentration and low total sperm count. Adiposity is related to sperm production when it is assessed by both BMI and waist circumference (WC). Visceral obesity, measured by WC, is associated with poor sperm quality¹³.

The relationship between obesity and male infertility has long been studied. Over 14,000 articles on the impact of obesity and metabolic syndrome on male fertility were written¹⁴. Obesity lowers sperm concentration, volume and total sperm count via hypogonadism¹⁵. Metabolic syndrome reduces male fertility¹⁶, probably due to the insulin resistance that is well associated with WC.

Underweight men have lower sperm concentrations than those with normal BMI¹⁷, but most of trials referred to obesity, consequently more studies are needed for evaluating infertility in underweight men. On the other hand, several

studies have not found a significant link between BMI and sperm characteristics.

DIET

Nutritional factors are determinants of normal reproductive function in both sexes¹⁸. The ideal diet for optimal fertility has not been established. The effect of nutritional factors on fertility is not yet well known. Certain dietary changes have been shown to improve ovulatory disorder infertility¹⁹. An appropriate food intake may have effects on the relationship between hormones released by the gastrointestinal system and neuropeptides with influence on follicular development²⁰.

Reproduction involves higher energy costs in women than in men, so in women there is a protective mechanism against malnutrition, by suppressing ovarian activity in the case of eating disorders and in excessive physical activity²¹.

Vegetable protein consumption was correlated with a low risk of infertility, but did not reach the threshold of statistical significance²². In women, replacing carbohydrates with animal protein has negatively affected fertility. The addition of a single meat meal (especially chicken and turkey) increased the risk of developing ovulatory infertility by 32%. In contrast, carbohydrate replacement with vegetable protein has been shown to be protective²².

The Nurses' Health Study II, a prospective study, followed the diet of over 17,000 women and established that a diet that increases fertility contains: low intake of trans-fat, greater intake of mono-unsaturated fat, low intake of animal protein, greater vegetable protein intake, high fiber intake, low glycaemic carbohydrates, high fat dairy products and high non-heme iron intake. Women on this diet had a 66% lower risk of infertility due to ovulatory disorder. In men semen parameters could be improved by limiting the processed meat and increasing the consumption of low-fat dairy and fish²³.

In men, several studies have shown that reproductive health can be improved by eating fruits, vegetables and fish. Regular consumption of such foods is associated with better sperm quality²⁴.

High intakes of fruit and vegetables^{25,26}, legumes²⁵ and fish^{27,28}, improve sperm parameters probably due to antioxidants and polyunsaturated fatty acids (among which omega3). Processed meat and full fat dairy products are negative associated with male

fertility²⁹. Mediterranean diet is associated with better sperm parameters. Mediterranean diet or similar diets, with fruits, vegetables, fiber, fish, vegetable oils, improve sperm quality²⁴.

A diet rich in carbohydrates, fiber, lycopene and folate³⁰ and the consumption of fruits and vegetables³¹ are correlated with the improvement of sperm parameters, as well as low protein and fat intakes³⁰.

We believe that observational studies on nutritional factors may show associations with infertility but not causation, so further prospective randomized controlled studies are needed to confirm certain correlations.

PHYSICAL ACTIVITY

Exercise has proven to be useful in overweight and obese infertile women. An interventional study¹⁰ showed that exercise combined with weight loss in obese women improved fertility. In contrast, a study of more than 5,000 women with a normal BMI found that vigorous exercise was inversely associated with fertility, but positively associated with fecundability among overweight or obese women³².

Women who practice physical activity excessively are at risk for infertility due to anovulation and implantation defect³³. The majority of studies on physical activity and fertility have been done in athletes rather than in people with moderate physical activity. After BMI adjusting, each hour of rigorous physical exercise per week was correlated with a 5% reduction in protecting ovarian function³³. On the contrary, increased physical activity along with psychological wellbeing resulted in significant improvement in ovulation and conception in obese infertile women³⁴.

A Norwegian study found that women who were active daily (vigorous exercise) had three times more infertility problems than inactive women. In the case of moderate exercise, the risk of infertility was lower than in sedentary women³⁵.

In men performing physical activity for one hour, at least three times a week, the quality of sperm was 15.2% better than in men who perform exercise rarely or excessively³⁶. There is currently controversy over the effect of physical activity on male fertility.

Some studies have shown that vigorous and regular exercise can decrease sperm quality and testicular function while moderate exercise can

reduce the oxidative stress of semen cells compared to vigorous exercise³⁴. Other studies showed that men who exercise regularly have better sperm quality than sedentary men³⁷.

The Nurses' Health Study showed that exercise for at least 30 minutes per day was associated with a decrease in ovulatory disorder infertility³⁸. It appears that physical activity causes ovarian protection independent of BMI, but, interestingly, there was no correlation with moderate exercise¹.

An interventional study (six months lifestyle modification program) found that losing weight, improving physical activity and psychological wellbeing resulted in significant improvement in ovulation and pregnancy rate⁷.

Frequent physical activity of high intensity and duration were inversely correlated with female fertility³⁵. Excessive physical exercise is associated with decreased fertility³⁹.

More studies are needed to clarify the effect of physical activity on reproductive performance in women, related mainly to moderate and light physical exertion.

Parameters of sperm were found better in physically active subjects as compared to sedentary men^{40,41}. In men, one-hour exercise at least three times a week proved better in improving sperm parameters than vigorous and more frequent exercise⁵³.

Regular moderate exercise improves male fertility *via* reducing oxidative stress and DNA fragmentation, but intense and vigorous physical exertion should be avoided⁴².

Interventional studies conducted in men, including diet and physical exercise, improved sperm parameters even in the absence of weight loss^{43,44}. Intensive cycling is negatively correlated with sperm parameters due to increased scrotal temperature⁴⁵. Cycling over 5 hours a week negatively affects sperm parameters⁴⁶.

In conclusion, moderate exercise is recommended for increasing fertility in infertile men, while rigorous exercise can lead to decreased male fertility. However, as well as in women, further prospective randomized trials are needed to identify the best management options and lifestyle changes in order to improve fertility in men.

SMOKING

Cigarette smoking has been associated with serious adverse effects on fertility in both sexes,

although this is not widely recognized⁴⁷. Smoking has a deep effect on fertility of a couple, in women as well as in men⁴⁸.

Smoking in women increases the thickness of the zona pellucida of the ovule, making sperm penetration more difficult⁴⁹. Another study reported smoking delays conception by more than a year⁵⁰. Smoking is also associated with complications at a young age of pregnancy such as risk of miscarriage, prematurity and ectopic pregnancy^{50,51}. With the cessation of smoking, fertility returns at rates similar to non-smoking women even if smoking cessation occurs one year before the conception attempt⁵².

Menopause is reported to install 1 to 4 years earlier in smoking women as compared to non-smoking women⁵³. Another study found that reduction in ovarian reserve was significantly higher in smokers (12.31%) than in non-smokers women (4.83%), during the study period⁵⁴. Smoking women have an increased incidence of ectopic pregnancies, prolonged conception time and infertility compared to non-smokers⁵⁵. Cigarette smoking has endometrial negative effects and increases the risk of aneuploidy, both leading to increased risk of miscarriage^{56,57}.

Data from the literature on smoking and male infertility are inconclusive⁵⁸. One of the largest studies comparing smokers with non-smokers found that smoking was associated with a significant decrease in sperm concentration, sperm count and motility⁵⁸. Another study showed that, in males, smoking reduces sperm concentration and motility and increases DNA damage⁵⁹. As well as in women, smoking cessation increases male fertility⁶⁰.

Smoking decreases the quality of sperm, affecting all its parameters. When smoking exceeds 15 cigarettes per day, it reduces male fertility². The effect is proportional to the number of cigarettes smoked per day and to the duration of smoking⁶¹. Male fertility was lower for smokers, both before and during the conception as compared to non-smokers⁵⁰. Only 6% of smokers in Guar's study had normozoospermia and both moderate and heavy smokers had simultaneously asthenospermia, oligospermia and teratozoospermia⁶².

ALCOHOL CONSUMPTION

Inadequate alcohol consumption leads to an estrogen excess and a testosterone deficiency⁴⁸. It

is well known that alcohol is a teratogenic factor and decreases both female and male fertility⁶³. Even mild alcohol consumption can lead to female infertility due to hormonal disorders³³.

Several studies show that increased alcohol consumption is related to decreased conception in women^{2,64,65}. In a Swedish study that included more than 7,000 women, consuming large amounts of alcohol (over 140 g of alcohol / week) was associated with infertility. The risk of infertility decreases in women who consume less than 50 g per week, compared to moderate alcohol consumption (50–140 g alcohol/week)⁶⁶. A prospective Danish study has confirmed that there is a correlation between decreased fertility and increased alcohol consumption in a dose-related manner⁶⁵.

The level of consumption that leads to decreased fertility is not well known. Moderate alcohol consumption (7–8 drinks per week) has been associated with reduced fertility and increased risk of miscarriage⁶⁷. One drink per week has also been associated with reduced conception⁶⁵.

Women who experienced hangovers (due to the probability of ingesting a large amount of alcohol) have a higher risk of infertility than women who have not had this experience, suggesting that there is a correlation between the amount of alcohol consumed and infertility⁶⁸.

Alcohol consumption from one drink per week to 5 drinks per day may have various effects on fertility, including prolonging the time for conception⁶⁹, decreasing the probability of conceiving by more than 50%⁶⁵ and increasing the risk of miscarriage⁷⁰ and fetal death⁷¹.

Some studies in men show a negative effect of alcohol on sperm parameters while others suggest a beneficial effect or lack of any effect^{72,73,74}. In Jensen's study, a moderate alcohol consumption (less than 5 drinks per week) does not seem to affect the parameters of the sperm, except for the reduction in volume^{75,76}. Excessive alcohol consumption (over 20–25 drinks per week) decreases spermatogenesis and promotes damages on all the sperm parameters (sperm concentration, motility and morphology)^{75,77,78}.

A meta-analysis of 57 studies that included more than 29,000 men showed a significant correlation between alcohol and decreased semen volume, with high statistical significance ($p = 0.0007$)⁷⁷. In another study, only 12% of heavy drinkers had normozoospermia while 73% of heavy drinkers and 63% of moderate drinkers were found with teratozoospermia⁶².

The data regarding alcohol consumption in men and women are still controversial. Randomized controlled studies are required for establishing the amounts of alcohol that are safe in maintaining fertility.

PSYCHOLOGICAL STRESS

Unfortunately, psychological stress is part of everyday life in our society, affecting our health in general, including reproductive health. In a Nigerian study, Makanjola et al showed that anxiety, depression and domestic violence decrease fertility in women, leading to secondary amenorrhea. In men, anxiety and depression also significantly affect spermatogenesis by decreasing testosterone secretion⁷⁹. Still, the effect of moderate mental stress on fertility is controversial⁸⁰.

Severe daily stress reported in a group of healthy women has been associated with a reduction in serum estradiol, luteinizing hormone and progesterone and has been associated with a predisposition to anovulation⁸¹.

A study of about 2,700 infertile women found no relationship between infertility and self-reported stress levels⁸². Likewise, a meta-analysis that included 14 studies on mental stress failed to demonstrate a worse outcome in women with higher levels of psychological stress⁸³.

An observational study of 430 couples trying to conceive showed a link between the intensity of psychological stress and conception. Stress was assessed using a standardized questionnaire and an inverse association was found between stress and conception; couples were followed for 6 menstrual cycles⁸⁴.

Actively coping with stress, whether assertive or confrontational, increases adrenergic activation and consequently vasoconstriction in the testes, damaging spermatogenesis⁸⁵. Similarly, another study found linear negative association between stress and sperm concentration, motility and percentage of normal spermatozoa⁸⁶. In contrast, another study did not find any association between stress and sperm parameters. Still, the same study found that fecundability decreased with increasing psychological stress in men having already low sperm quality⁸⁷.

Although associations have been found between psychological problems and infertility, it is currently difficult to establish a cause-effect relationship because there is no general consensus for an objective assessment of stress, depression and anxiety.

COMBINED EFFECTS OF LIFESTYLE RISK FACTORS

Risk factors for unhealthy lifestyle such as smoking, alcohol and caffeine, may have an additive effect on fertility⁴⁹. A recent study evaluated couples who tried natural conceiving over 12 months and found that 38% of couples with 4 risk factors for unhealthy lifestyle managed to conceive a child as compared to 52% with 3, 62% with 2, 71% of couples with one risk factor and respectively to 83% of couples who did not have any risk factor³³.

The combined effect of several lifestyle risk factors is associated with progressive reduction in fertility⁸⁸. A number of 2112 pregnant women were studied in regard with their lifestyle and the time needed to conceive. A progressive increase of the time taken to conceive was associated with increasing numbers of negative lifestyle factors³⁴.

CONCLUSIONS

Most lifestyle factors are modifiable, on one condition, if there is present a strong determination in affected subjects. The motivation is in most cases very strong in couples who want to conceive a child. They will easily adhere to programs of lifestyle change that increase their chance of having a child, but for some of them it may be too late. Reproductive health should be taken into account in late adolescence, especially in women, as the results of the studies suggest.

Government factors and healthcare providers need to campaign to promote a healthy lifestyle, to raise public awareness of the need for a healthy lifestyle in order to improve fertility and birth rate. The majority of the population is unaware of the impact of lifestyle on fertility. Governments of European countries together with the European Commission should facilitate access to reproductive health education and to lifestyle change programs that improve reproductive health not only in infertile couples, but also in general population of reproductive age. There is a great need of awareness campaigns related to the effects of drugs, smoking and alcohol consumption on fertility.

There are many lifestyle risk factors and there is a difference in their distribution from one population to another or even within the same population. The negative lifestyle risk factors have an additive effect on fertility, but we do not know

how they combine and how they interfere with each other. This multifactorial aspect requires rigorous, extensive and prospective studies on the combined effects of lifestyle risk factors in the future.

ABBREVIATIONS

BMI body-mass index
IVF *in vitro* fertilization
WC waist circumference

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