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The Role of Physical Activity in Male Reproductive Health – A Systematic Review

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Abstract:

Introduction and purpose: Nowadays infertility is an important problem, which affects even 17,5% couples during their lifetime. There are many factors playing a role in the development of infertility, among others the ones connected with lifestyle. There are many studies analysing lifestyle influence on the male reproductive health. The aim of this article is to review available literature concerning physical activity and to analyse its impact on male fertility, considering different exercise-related mechanisms, which may cause impairments.

Materials and Methods: The literature review was conducted via PubMed database and the search terms were as follows: "physical activity", "sport", "male fertility" and "male infertility". We included only the articles written in English and the search was limited to the following

types of articles: clinical trials, meta-analyses, systematic reviews and reviews. The studies cited in the mentioned reviews were also included.

State of knowledge: Physical activity affects male reproductive health on both ways – moderate exercise has a positive effect on male fertility, while an extent activity impairs it. The negative effect is caused by many mechanisms, such as impairing the functioning of hormonal axes, worsening semen parameters or injuries causing urogenital disorders.

Conclusions: People, particularly men with lifestyle-induced infertility issues, should be enhanced to sport. It is important to maintain an appropriate, moderate level of physical activity though. Further research in this field is still needed, because of the importance and prevalence of the infertility question.

Keywords: "physical activity", "sport", "male fertility", "male infertility"

Introduction

Infertility is an inability of a couple to establish a clinical pregnancy after 12 months of regular, frequent and unprotected sexual intercourse.[1] WHO created a report analysing all relevant studies from 1990 to 2021, which shows that infertility is a significant problem nowadays. Due to these data a lifetime prevalence of this condition (the proportion of a population who have ever experienced infertility in their life) is estimated at 17.5%. The period prevalence (the proportion of a population with infertility at a given point or interval in time, which may be current or in the past) is estimated at contrast at 12.6%.[2] Infertility caused only by a male factor is approximately 1/3 of all cases.[3] There are many couples though, who cannot conceive a child due to male, as well as female factors. Available data show that the male factor contributes overall to about 50% of all cases.[4] Speaking of the infertility, we can also differentiate it between two types – primary and secondary ones. The primary infertility is an inability of a couple to get pregnant after one year of unprotected sexual intercourse, while the secondary one refers to an infertility after a first pregnancy or after 12 months after stopping contraceptives.[5]

There are many risk factors for the male infertility[6,7] (Figure 1). Some of them are non-modifiable, while other ones may be behaviourally reduced. The hardly modifiable factors may

be for example pathophysiological conditions - different diseases (genetic, endocrinal, autoimmune or urogenital disorders), problems with ejaculation or sexual activity (e.g. erectile dysfunctions) or testicular injuries. Ageing has also an impact on male fertility, because it is connected to impaired cellular functions, andropause or late-onset hypogonadism. The factors, which can be more easily modified, are for example the environmental ones, as wearing tight-fitting underwear, recurrent hot baths or radiation exposure. An important role is also played by some modifiable, connected to lifestyle factors, such as smoking, alcoholism, poor nutrition and obesity.[6] Lifestyle factors of a great significance are also sedentary behaviour and lack of physical activity.[4] Physical activity can have different forms, though. It can be for example more or less intensive and predisposing to injuries. There are also many different sports, which affect human bodies in various ways. The aim of this article is to summarise the knowledge about the impact of physical activity on male infertility.

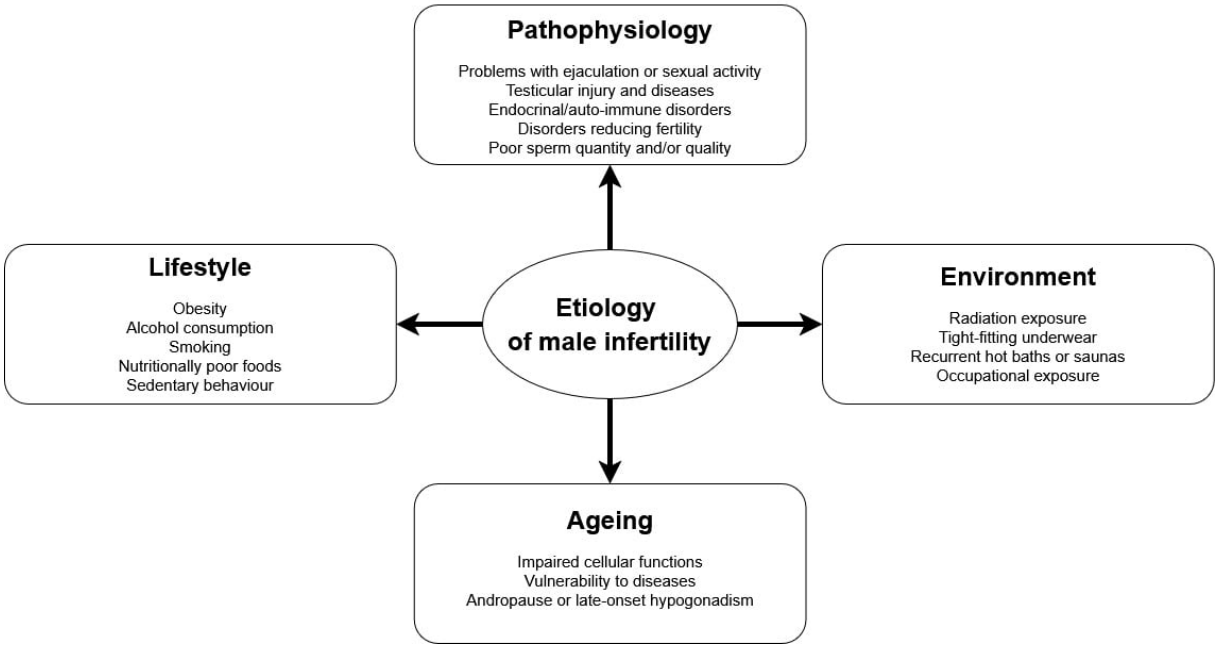

Figure 1. Etiology of male infertility.

Impact of physical activity on the hypothalamus-pituitary-gonadal (HPG) axis function

The hypothalamic-pituitary-gonadal (HPG) axis is a neuroendocrine system comprising a pulsatile GnRH release from the hypothalamus, which impacts on the anterior pituitary to induce expression and release of a luteinizing hormone (LH) and a follicle-stimulating hormone (FSH) into the circulation. The release of these hormones stimulates receptors on testicular

Leydig and Sertoli cells to promote steroidogenesis and spermatogenesis. The products of the Leydig cells (testosterone) and the Sertoli cells (inhibin B) exhibit negative feedback to the pituitary and/or hypothalamus, which allows to regulate the work of the HPG axis.[8]

In a review article by Aram Minas the authors analysed many studies concerning an impact of a physical exercise on the HPG axis. The conclusions were that exercise can affect the male fertility in both ways – a positive and a negative one. It depends on the intensity of the exercise. The excessive training can have a negative impact on a testosterone biogenesis, spermatogenesis and semen quality because of the reduced function of the HPG axis, among other factors.[9]

In another article - a systematic review about an effect of endurance exercise on semen quality in male athletes - the authors mention the exercise-induced hormonal changes. They claim that a moderate exercise has a preventive effect on pathogenesis of many diseases, but a prolonged exercise can cause a condition called "overtraining", which can harm many physiological mechanisms. They write for example about LEA (low energy availability), which is defined as a mismatch between energy intake and expenditure, thereby leaving insufficient energy for metabolic pathways and disrupting the normal function of the hypothalamic-pituitary–gonadal (HPG) axis.[10] They also cite an article about a relative energy deficiency in sports (RED-S) – a result of LEA - and the endocrinal changes caused by it. RED-S results from low-energy diets (intentional or unintentional) and/or excessive exercise. Energy deficiency causes reduction of hypothalamic pulsatile release of gonadotropin-releasing hormone (GnRH). It results in impairing anterior pituitary release of gonadotropins (FSH and LH). It reduces, in turn, the level of testosterone, which is necessary for normal spermatogenesis and the process of maturation of spermatozoa.[10,11]

To summarise, aforementioned articles claim that hypothalamus-pituitary-gonadal (HPG) axis function is negatively affected by an exercise with a high intensity.

Impact of physical activity on the oxidative stress and the free radicals

Oxidative stress is a state of an imbalance between reactive oxygen species (ROS) and antioxidants. The protein expression in cells being in such a state is often altered. The studies show that 30-80% of male factor infertility cases are caused by ROS-mediated sperm damage. There are two ways in which ROS can impair male fertility – through damage of the sperm membrane and damage of the sperm DNA.[12]

In a randomised controlled trial by Maleki and Tartibian, which included 1296 infertile men, the study group took part in a program consisting of 24 weeks of combined aerobic and resistance exercise training. The aim of the study was to examine the effect of it on seminal markers of inflammation and oxidative stress, as well as markers of reproductive function and reproductive performance in this group of infertile men. The results of the study showed a reduction in levels of seminal pro-inflammatory cytokines and markers of oxidative stress (including reactive oxygen species). The function of seminal antioxidant defence system was also better after the training program. All the changes were connected with better: semen parameters, integrity of sperm DNA and pregnancy rate.[13]

The same authors also conducted a randomised controlled trial considering an impact of high-intensity exercise training on a reproductive function in infertile patients. 433 infertile men were included and divided into exercise and non-exercise groups. The men from the study group were running on a treadmill, three times a week, through 24 weeks. The intensity of exercise was > 70 to 85% of maximal oxygen consumption. The semen samples were analysed during and after the program. The results showed significant reduction of inflammatory biomarkers, oxidative stress and antioxidants. The changes were also correlated with better semen parameters, sperm-DNA integrity and pregnancy rate.[14]

The third article by these authors described an impact of resistance exercise on male factor infertility, considering anti-inflammatory and anti-oxidative mechanisms. There were 1228 sedentary infertile patients considered and the participants were divided into two groups – exercise and non-exercise ones. The participants were doing resistance exercises three times a week through 24 weeks and the training sessions included exercises for all major muscle groups. The material for measurements were semen samples, which were collected before, during and after the end of the whole exercise period. Parameters measured in the semen samples were, among others, markers of oxidative stress (ROS, 8-isoprostane), which were significantly decreased after the time of the study. There were also enzymatic activities of antioxidants (superoxide dismutase (SOD) and catalase) measured – they were significantly increased. The levels of above mentioned parameters returned to baseline after some days of the recovery period, though. Pro-inflammatory cytokines were also decreased through one month after the end of the exercise period. All the described parameters changes were correlated with significant improvements of semen quality. It was connected with better pregnancy rate, because the intervention resulted in 36.2% partner pregnancies.[15]

The results of a literature review by Abedpoor et al. show that a moderate-intensity exercise done over a long time can reduce oxidative stress and then supress the production of

pro-inflammatory cytokines. A higher level of oxidative stress occurs e.g. in obesity and metabolic syndrome, that is why physical activity may help infertile men with such concomitant conditions, among others. High-intensity Interval Training (HIIT) can also improve sperm DNA integrity and make sperm characteristics in infertile males better. On the other hand, strenuous exercise can impair male fertility, due to inducing oxidative stress-inflammatory response.[16]

In another article describing influence of physical activity on male fertility the authors write that excessive exercise can cause male infertility, because it results in increased oxidative stress and chronic inflammations, as well as reduction of hypothalamus-pituitary-gonadal axis function. It can, in turn, negatively affect male fertility by lowering testosterone production and reduction of semen quality. On the other hand, low and moderate intensity exercise can protect testicular tissue in infertility cases connected to lifestyle problems, such as diabetes and obesity. In these conditions, such exercise increases testicular antioxidant defence and reduces chronic inflammation.[9]

To summarise, the studies show that moderate activity has a positive effect on male fertility, while the excessive exercise may impair it.

Physical activity and semen quality

Physical activity can affect semen quality through modulating oxidative stress, as mentioned above. There are some articles though, which describe the influence of exercise on semen quality, without concerning this aspect particularly and we would like to present them in this part of the article.

In a meta-analysis concerning the implication of physical activity on semen quality there were 32 studies included. 20 of them focused on the impact of the general physical activity (PA) on different semen parameters. The authors divided the activity described in considered studies into three different groups, based on the intensity. They separated: recreational moderate intensity physical activity (RMIPA), recreational high-intensity physical activity (RHIPA) and elite physical activity (EPA). Most studies showed a positive effect of RMIPA on some parameters, such as total sperm count, semen concentration or progressive motility. The data concerning RHIPA showed either positive or no significant associations with the semen quality. Both types of activity had rather no impacts on such parameters as total sperm volume and total motility. It is also important that RMIPA and RHIPA had no negative impact on the semen quality parameters. EPA, though, was correlated in described studies with worse semen

parameters, such as volume, concentration, total motility and morphology. This kind of activity seemed to have the greatest detrimental effect on the progressive motility.

To summarise, the authors do not recommend EPA to infertile men. They write that avoiding EPA should probably be recommended for men with poor sperm quality, but there are more studies needed to confirm it. The general conclusion is that recreational physical activity seems to have a positive impact on the sperm quality, while the intense activity, practised until exhaustion, can negatively affect it.[17]

Similar conclusions can be drawn from a review by Jóźków and Rossato, concerning an impact of intense exercise on semen quality. The authors claim that a recreational exercise seems to have positive or neutral effects on semen quality, as in the article cited above. Furthermore, they mention negative impact of intensive exercise on the same semen quality parameters as in the previous study – sperm concentration, percentage of motile spermatozoa and percentage of morphologically normal spermatozoa. The authors write that the exact impacts of these factors on fecundity are unknown, though.[18]

We also found an article concerning an impact of a lifestyle change intervention on semen quality in healthy young men living in highly polluted areas in Italy. The intervention in this study was wider, because it was concerning not only moderate physical activity program, but also Mediterranean diet. The duration of the intervention was 4 months. There were 263 participants in the study, and they were divided into study and control groups. The results showed an increase of sperm concentration, proportion of normal morphology cells and total and progressive motility in the intervention group and a decrease in aforementioned parameters in the control group. The data were statistically significant. There are no long-term results available, but the study shows that such lifestyle interventions among healthy young men can be successful in protecting and eventually ameliorating their semen quality.[19]

To summarise, presented studies show that moderate activity may have a positively influence on some semen parameters, while the excessive seems to have a negative impact.

Influence of different kinds of sports and sports-related injuries on male fertility

Another interesting question is the impact of particular kinds of sports on male fertility. In a systematic review by Aerts et al. the authors synthetized literature about the effect of endurance exercise on semen quality in male athletes. They described 13 studies, with a total number of participants of 280. Eight studies were focused on endurance runners, four on triathletes and three on cyclists. Some of them showed no statistically significant changes in

sperm parameters, some showed changes, but the results were still remaining within the WHO normal range. Only four articles showed changes, which could potentially have an impact on clinical fertility potential – they reported a reduced number of morphologically normal sperm cells among cyclists and triathletes and a greater amount of DNA fragmentation among triathletes. This review showed that endurance exercise can have a negative impact on semen quality, but it is rarely with clinical relevance on fertility potential. The authors pointed out that the data could be influenced by small sample sizes and they highlighted the need for future research of high methodological quality.[10]

When it comes to the topic of specific sports-related injuries, the authors of a review by Panara et al. write, among others, about an impact of bicycling on male fertility. This kind of sport causes injuries affecting genitourinary system often in comparison to other sports. The available studies show that bicycling can affect in an increase of perineal pressure, which can cause compression of the pudendal artery and nerve. This, in turn, can effect in transient ischaemic hypoxia.[20] They also cite a study by Marceau et al., which shows that erectile dysfunctions can be associated with cycling only among sports cyclists (cycling more than 3 hours per week). On the other hand, moderate cycling (less than 3 hours per week) seems to be protective and is connected to reduced probability of such dysfunctions.[21]

In an article by Brant et al. the authors analyse effects of male athletic activities on semen and hormonal parameters. They write, among others, about testicular injuries. The described studies show that overt testicular trauma in sports is rare, while subtler trauma can be more frequent among cyclists.[22] The cited article about cyclists shows that scrotal abnormalities – mainly scrotal tenderness or/and spermatoceles, are more common in mountain bikers than in non-biking healthy controls.[22,23] Some earlier studies (conducted in a different population though) demonstrated slightly higher prevalence of the abnormalities among infertile men than in asymptomatic men. The study did not assess the infertility though, that is why the findings are of an unknown significance.[24] Another cited follow-up study showed that scrotal abnormalities among cyclists were not corresponding to infertility or hormonal abnormalities. To summarise, the review results suggest that overt testicular injuries are not very common in sports and probably do not play a significant role in causing infertility.[22]

In an article by Leibovitch and Mor the authors reviewed the literature concerning bicycling related urogenital disorders. One of the most common urogenital disorders connected to cycling are pudendal nerve entrapment syndromes. They may present as genital numbness, which is quite frequent among cyclists (reported in 50-91% of them) and may be followed by erectile dysfunctions – ED (reported in 13-24% of cyclists). One of the vascular causes of

erectile dysfunctions may also be a subclinical chronic or direct strain type perineal injury, as one of the studies described in the cited article showed.[25,26] The next problem analysed in the study by Leibovitch and Mor is the impact of cycling on increasing temperature of the testicles. Among others, it can be caused by wearing tight Lycra race suits and compression of the scrotum against the saddle, which disturb the mechanisms of thermoregulation. Such an increase in the temperature of testicles may have a role in many disorders leading to infertility, like for example varicocele and cryptorchidism. To summarise, bicycling may cause some traumatic and overuse injuries, which may cause genitourinary disorders. They, in turn, can be connected with an impairment of male fertility.[25]

In an article by Sansone et al. the authors describe, among others, the influence of sports-related injuries on some morpho-functional alterations, which can lead to erectile dysfunctions or infertility. They write about traumatic brain injuries, popular among kickboxers and football players, which can cause long-term impairment of pituitary secretion.[27,28] It can present as isolated growth hormone (GH) deficiency, but can also affect many other axes. Another condition described in the article is a pudendal nerve compression, which can result in a higher risk of erectile dysfunction among people cycling more than 3 hours per week. The authors also mention other urogenital complications, which are more prevalent among cyclists, like for example chronic prostatitis.[27] The reproductive health can be also affected by a high-flow priapism. This condition can be an effect of exercise-induced vascular trauma and can lead to vasculogenic erectile dysfunctions.[25,27] Another condition, which can occur among athletes, is varicocele, caused by an aggravated abdominal pressure. The cited articles suggest, that there is no statistically significant difference in sperm parameters, but it seems to be connected to worse outcomes, when it comes to sperm morphology.[27,29] A newer study cited by the authors, with pubertal boys of 14-16 years old as participants, suggests that a danger of developing sports-related clinical varicocele is confirmed only in athletes with earlier occurring subclinical forms of this condition.[27,30] Another type of injury are sports-related spinal cord injuries (SCIs), which are more common among people training some particular kinds of sports, such as diving, rugby and horseback riding. An effect of such a harm is an impaired ability to obtain erection and to ejaculate. A person affected by such an injury often loses psychogenic erections but may still obtain reflexive erections. This is often not sufficient to have an intercourse though. There are some possibilities to collect semen samples from such patients, but it can be the only chance for parenthood for them. That is why such an injury has a negative effect on male fertility, because it impairs the chances for a conception in the natural way.[27,31] The last condition described by the authors is testicular torsion, which can rarely occur after an injury. They

mention cycling as one of the most predisposing activities, because the risk is aggravated by movements occurring in this sport (contraction of the cremasteric muscles and repeated up-and-down leg movements). Such a testicular torsion can effect in a primary hypogonadism, which may impair male fertility.[27]

To summarise, many kinds of sport may increase a risk of different specific injuries, which can significantly weaken male fertility.

Conclusions

Infertility caused by a male factor may have different etiology. It may be connected with lifestyle, among others. A level of physical activity plays an important role, too. The analysed literature shows that lack of activity may have a negative impact on male fertility, but the reproductive health may be also diminished by an excessive exercise. The article also shows, in what mechanisms a strenuous activity may impair male fertility – for example by exacerbating the functioning of hormonal axes (HPG axis). Analysed studies show that physical activity has an impact on the oxidative stress and a level of free radicals, too. Due to described articles, moderate activity reduces oxidative stress. It contributes to better semen parameters and pregnancy rates, while the excessive exercise has an opposite, negative influence on male fertility. There are similar results, when it comes to semen quality – a moderate activity improves some parameters, while an excessive exercise seems to have a detrimental impact on them. The last aspect analysed in this article was the influence of different kinds of sports and specific sports-related injuries on male fertility. The results showed that one of the most dangerous sport kinds is bicycling, because of a risk of urogenital trauma. Maybe overt and direct injuries are not very common among cyclists, but there are many subtle or overuse contusions possible. An important risk factor occurring among cyclists is also an increase in the temperature of testicles, because of wearing tight-fitting suits. It is important to mention that recreational cycling (< 3 hours per week) has a positive effect on male fertility though. Other conditions, risky in terms of development of infertility, are sports-related brain or spinal cord injuries, testicular torsion or progression of varicocele.

To summarise, some male infertile patients may profit from moderate activity and should be enhanced to it. Men should also be aware of the risks connected to specific sports. There is a need for further research in this field though.

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