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The Impact of Physical Activities on Male Fertility: A Systematic Review

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Abstract

Background

Semen quality appears to have declined over the past decades but reasons for this decline are unresolved. It may seem that an increase in the share of a sedentary lifestyle, at least due to the way of working or spending free time, and a decrease in the share of physical exercises during everyday activities may have an impact on this.

The objective of this study was to evaluate the relationship of physical activity, special types of physical activity and sedentary lifestyle with sperm parameters in a population of men. Another issue discussed is the negative impact of exercise on fertility, as well as injuries in the

perineal region—some of which directly affect organs, surrounding tissues (such as nerves), and regulatory mechanisms like hypothalamic-pituitary-gonadal axis.

Materials and Methods

This study was conducted as a comprehensive literature review based on scientific articles and research papers accessed through two primary databases: PubMed and Google Scholar. Relevant articles were selected using predefined keywords and phrases related to the study's topic. The search was limited to articles published in English between 1991 and 2023 to ensure the relevance and accuracy of the data. Duplicates, non-peer-reviewed sources, and studies lacking methodological transparency were excluded. The collected data were analyzed and synthesized to provide an up-to-date overview of the topic.

Conclusion

The authors argue that the generally positive impact of exercise on male fertility can be demonstrated on many levels. However, moderation in training load is necessary, as excessive training volume can lead to hormonal regulation issues or simply result in injury in the groin area.

Keywords: urology, male fertility, exercises, testosterone level, semen quality

1. Introduction

How is male fertility defined?

Fertility is the ability of an organism to reproduce, meaning to conceive and bring offspring into the world. In humans, fertility refers to a woman's ability to become pregnant and a man's ability to fertilize an egg by providing viable sperm. Fertility depends on various factors, such as the proper functioning of the reproductive system, hormonal health, lifestyle, diet, age, as well as environmental and genetic factors [1]. In this article we are focusing at male fertility.

Male fertility is closely linked to sperm production, which occurs in the testes through the process of spermatogenesis—a hormone-dependent mechanism. This process is primarily regulated by the hypothalamic-pituitary-gonadal axis. The hormones involved in the regulation of spermatogenesis are luteinizing hormone (LH), follicle-stimulating hormone (FSH), and testosterone. Luteinizing hormone (LH) controls spermatogenesis by acting on Leydig cells, which, under the influence of LH, produce testosterone within the testicular interstitium. Follicle-stimulating hormone (FSH) regulates spermatogenesis by influencing Sertoli cells during infancy. These cells play a crucial role in the structural development of seminiferous tubules and the formation of the blood-testis barrier. Testosterone is essential during fetal development, where it drives the differentiation of Wolffian ducts into male reproductive structures such as the seminal vesicles, epididymis, and ejaculatory ducts. Additionally, dihydrotestosterone (DHT), a derivative of testosterone, is pivotal during fetal development for the differentiation of the urogenital sinus and genital tubercle into the prostate, urethra, penis, and scrotum. Without these structures, semen would lack the proper characteristics and the ability to leave the male body for the purpose of fertilization [2].

Methods for proper semen sample collection

Semen analysis serves as a fundamental component of laboratory assessment in cases of male infertility. To obtain accurate results, at least two separate samples should be collected, ideally spaced at least a week apart, with a preferred interval of up to one month. Each sample collection should be preceded by a period of abstinence lasting at least three days. This protocol is advised due to the significant variability observed in semen analysis results. The World Health Organization (WHO) has established detailed guidelines for proper semen collection. While at-home sperm testing kits are now widely available, their reliability is questionable, as they fail to evaluate all the essential semen parameters recommended for a comprehensive analysis [3,4].

The semen is evaluated for volume, pH, leukocytes, immature germ cells, and liquefaction, while the sperm is assessed for count, concentration, vitality, motility, progression, debris, and morphology [5].

2. Exercise and testosterone

Testosterone plays a key role in the body by supporting erection quality, secondary sexual characteristics, and the cardiovascular, neuromuscular, and central nervous systems. Its production is controlled by the hypothalamic-pituitary-testicular axis, where gonadotropin-releasing hormone (GnRH) from the hypothalamus triggers the pituitary gland to release LH and FSH, with LH stimulating Leydig cells in the testes to produce testosterone [2].

Physical activity functions as a stressor that impacts hormone production, including gonadotropins such as LH and FSH, which tend to rise during vigorous exercise. Studies indicate that moderate physical activity leads to an increase in testosterone levels, whereas highly intensive activities, such as long-distance running, are linked to reduced levels of both total and free testosterone when compared to those engaging in moderate exercise or no exercise at all. This implies that intense or professional-level training might have a detrimental effect on testosterone levels [6].

The impact of resistance exercises on testosterone levels in previously inactive individuals was analyzed. Particular attention was given to the effect of leg exercises, including leg press performed in 4 or 5 sets of 10 repetitions. A significant increase in salivary testosterone levels was observed in the participants. This was not the only exercise during which a notable rise in hormone levels was recorded. Other muscle groups, such as the chest, back, and shoulders, were also examined. Examples of other exercises included bench press, pec-deck, and decline bench press [7, 8].

Another study observed that different types of exercises result in varying increases in testosterone levels. The analysis included strength exercises (8 sets of 6 repetitions at 45% of 1 repetition maximum [1RM], 3-minute rest periods, ballistic movements), hypertrophic exercises (10 sets of 10 repetitions at 75% 1RM, 2-minute rest periods, controlled movements), and maximal strength exercises (6 sets of 4 repetitions at 88% 1RM, 4-minute rest periods, explosive movements). Testosterone level increases were noted across all exercise types. However, the study highlights that the increase was noticeably highest in the hypertrophic exercise protocol [9].

There are studies that demonstrate a chronic increase in testosterone secretion as a result of resistance training. Scientists suggest that this increase may be attributed to a reduction in body fat percentage, an increase in muscle mass, the volume of the training program, the younger average age of the research group, and the use of free weights [10].

Hackney and colleagues claim that chronic exposure to excessive endurance training can disrupt the function of the hypothalamic-pituitary-gonadal (HPG) axis, resulting in persistently low basal levels of free and total testosterone, which may still fall within the normal physiological range, without a corresponding increase in LH levels [11].

Retrospective studies often show a decrease in both total and free testosterone levels in men engaged in endurance training, while prospective studies frequently fail to provide conclusive results due to the varying characteristics of the training period, the intensity of the training stimulus, and the volume of the training load [12].

The literature review demonstrates that testosterone levels generally increase in individuals who exercise, but may decrease in those who train excessively or in overtrained athletes. Whether testosterone suppression is a result of physiological adaptation to stress or an undesirable side effect of excessive training remains a subject of ongoing research. Continuous monitoring of androgen hormones remains useful for individuals undergoing

intensive training. This is of great importance for fertility, as the literature shows that testosterone levels have an inherent impact on semen quality.

3. Exercise and semen quality

Semen parameters can vary not only due to testosterone levels. Researchers indicate that fertility may also be regulated by other factors, such as the body's response to stress, increased testicular temperature, perineal pressure, and injuries [13]. The mentioned factors can be caused by excessively intense physical activity or, conversely, by very low levels of physical activity.

Evidence indicates that 10% of marathon runners experience severe oligospermia. Additionally, a study found that triathletes engaging in very high training volumes had poorer semen parameters compared to physically active individuals and water polo players. Research also highlights changes in the semen quality of long-distance runners, showing reduced sperm concentration and total motile sperm. Furthermore, the proportion of normal sperm was lower in these high-mileage runners, suggesting that intense professional exercise negatively impacts semen quality [6].

Several authors have proposed that the harmful effects of exercise on spermatogenesis are primarily due to increased scrotal temperature rather than hormonal changes. This effect is thought to be more pronounced in cyclists because tight-fitting shorts and the compression of the scrotum against the saddle limit effective thermoregulation [14]. In a study by Jung and colleagues, 25 healthy men engaged in noncompetitive biking at moderate intensity for an hour. While their core body temperatures rose during exercise, scrotal temperatures—closely linked to testicular temperatures—did not increase [15]. This aligns with findings from other forms of exercise, where scrotal temperatures tend to decrease. Interestingly, scrotal temperature rises are more commonly linked to sedentary behaviors, such as prolonged sitting [16]. However, researches found that cyclists who reported cycling for at least 1.5 hours had 34% lower sperm concentrations compared to non-cyclists [17].

It can be observed that individuals who exercise moderately, such as runners covering 40-56 km per week for a year, have unchanged semen profiles. However, the situation is different for those training very intensively. Runners who covered distances of 108 km per week or more over the course of a year showed decreased parameters in sperm count, motility, and round cells [18].

In another study from Iran, 286 participants engaged in either moderate or high-intensity treadmill running for 60 weeks. High-intensity running caused notable declines in sperm density, motility, and morphology after 24 weeks, worsening with continued training, though still within the fertile range. Moderate-intensity running caused milder, statistically insignificant changes.

Importantly, semen parameters returned to normal levels during a 36-week recovery period of low-intensity exercise [19].

Gaskins and colleagues analyzed the effect of watching TV as a form of sedentary behavior and sperm count compared to people who exercised. Watching television had a significant impact on the relationship between moderate to vigorous physical activity and sperm concentration. Those who spent more time watching TV (>14hrs per week) showed a strong positive correlation between physical activity and sperm concentration, while those who watched less TV (<14hrs per week) did not exhibit this association. In general, individuals with the highest amount of TV viewing and the lowest levels of physical activity had the lowest sperm concentration [20].

Other researchers examined the impact of exercise on sperm DNA fragmentation - one of the semen parameter - in recreationally active individuals. It turned out that the level of sperm DNA fragmentation in those who engaged in sports only occasionally was lower than in professional athletes. This somewhat suggests that excessive physical activity can damage fertility [21].

The precise evaluation of individual exercises and their specific impact on semen quality remains a significant technical challenge. Research protocols should aim for maximum standardization to ensure that the exercises performed by participants are consistent across the study. The primary difficulty lies in isolating specific muscle groups during exercise, as individuals may engage different muscles to perform the same movement. Consequently, it is expected that the results will represent averaged outcomes rather than precise, individualized effects.

4. The negative impact of exercise: Fertility issues due to anatomical factors

When considering fertility, in addition to biochemical factors, anatomical factors such as innervation also play a significant role. The most important nerve in the perineal region is the pudendal nerve, as it is most often subject to injury. Its role is crucial because it innervates numerous muscles, the pelvic visceral vessels, and is responsible for bowel control and sexual functions. The pudendal nerve contains sensory and motor branches, as well as sympathetic and parasympathetic fibers originating from the ventral branches of the spinal nerves S2, S3, S4, and the intermediomedial nucleus [22].

The complex system of innervation of pelvic region can be harmed due to mechanical stress – this damage can lead to erectile dysfunction. This is a clinical condition defined as inability to achieve and maintain an erection sufficient to permit sexual function and impairs satisfaction with sexual life [23]. One study found that over 60% of cyclists experience genital numbness and erectile dysfunction. ED may result from reduced blood flow and nerve compression due to extended time on the sadle [24].

Research has demonstrated that neuropraxia of the pudendal nerve, which innervates the posterior part of the scrotum and the base of the penis, can result in numbness and changes in sensation during ejaculation [25].

Fatigue and tiredness can diminish libido and make it difficult to achieve or maintain an erection. Endurance athletes, particularly those experiencing overtraining or overreaching, may suffer from exhaustion that contributes to ED. Cycling, in particular, is strongly associated with ED, with 13-24% of cyclists reporting the condition [26]. It should be emphasized that the risk of developing erectile issues primarily concerns professional athletes. Moderate physical activity in recreational cyclists generally supports the maintenance of normal erectile function [27].

Important anatomical structures involved in maintaining fertility are the testes and the structures that provide blood supply to them, namely the pampiniform plexus, a part of spermatic cord [28]. Studies using ultrasound have found that mountain bikers experience a higher rate of scrotal and testicular issues compared to non-cyclists. Notable abnormalities include testicular calcifications, hydrocele, varicocele, and testicular microlithiasis, all of which could potentially contribute to infertility [29]. A different study demonstrates that varicocele was identified in 25.4% of men with abnormal semen, in contrast to 11.7% of men with normal semen. This condition was associated with reduced testicular volume, diminished sperm quality, and a decrease in Leydig cell secretion [30].

As observed, physical exercise, particularly when performed at high intensity and professionally, can contribute to fertility impairments through varying degrees of damage to anatomical structures.

5. Conclusions

Physical exercise is generally associated with positive outcomes [31]. Media constantly inform us about the health benefits of physical activity. The purpose of this paper is to examine, based on available scientific sources, the impact of physical activity on male fertility in a broad sense. The effects of exercise, different types, and various training intensities on both semen quality and surrounding anatomical structures, hormonal mechanisms, and injury risks were analyzed.

Moderate-intensity exercises, such as hypertrophic strength training, improve male fertility by enhancing semen parameters, increasing testosterone levels, and improving overall cardiovascular fitness. However, excessively intense training in professional athletes may reduce semen parameters, induce hormonal and oxidative stress, and lead to mechanical injuries of the perineum, erectile dysfunction, which indirectly affects fertility and sexual life satisfaction. The negative impact of exercise on fertility is more often related to damage to anatomical structures than a decrease in testosterone levels in individuals engaging in high-

intensity exercise. A sedentary lifestyle, especially when combined with overweight and unhealthy habits, also leads to a decrease in fertility parameters.

Disclosure

Author's contribution

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Competing interests

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