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Effect of physical activity on seminal quality: a systematic review and meta-analysis

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Leonardo Monteiro Nesello
ORCID: https://orcid.org/0000-0001-7839-2460
Universidade de Caxias do Sul, Brasil
E-mail: lmnesello@ucs.br
Fábio Firmbach Pasqualotto
ORCID: https://orcid.org/0000-0002-8829-1652
Universidade de Caxias do Sul, Brasil
E-mail: ffpasqua@ucs.br
Dieneffer Silva Barbosa
ORCID: https://orcid.org/0009-0009-6644-9875
Universidade de Caxias do Sul, Brasil
E-mail: dsbarbosa1@ucs.br

ABSTRACT

The practice of regular physical exercise appears to benefit sperm parameters, though intense exercise can significantly alter them. With increasing global physical activity and conjugal infertility rates between 8%-10%, half of which stem from male factors, this relationship is crucial. This study reviewed current literature on the impact of physical activity on male reproductive health. Using PubMed and PRISMA guidelines, 261 articles were identified, with 13 selected. Evidence suggests intense exercise may impair sperm quality, while regular activity offers neutral or beneficial effects. However, findings remain inconclusive due to contradictions and difficulties in quantifying activity.

Keywords: Semen; Infertility; Physical exercise;

INTRODUCTION

The increased adoption of an active lifestyle has been promoted as a way to improve health, reduce stress, and enhance quality of life for people of different ages and genders (WHO, 2020). However, physical activity can have adverse effects, such as physical stress, body imbalances, and muscle injuries. Therefore, understanding the impact of physical activity on semen quality is crucial.

Male reproductive health, including semen quality and fertility, can be influenced by various risk factors such as age, lifestyle, environment, alcohol consumption, smoking, stress, obesity, and sedentary behavior. Additionally, physical activity (PA) can also impact semen quality (AL-DAGHESTANI et al., 2023; HAMZAH et al., 2022).

With conjugal infertility affecting up to 15% of the global population and male factors accounting for up to half of the cases, questions arise about how physical activity relates to male reproductive health (AL-DAGHESTANI et al., 2023). Studies on female professional athletes, particularly runners, indicate that intense physical exercise can affect the menstrual cycle and cause disorders such as delayed puberty, luteal phase defects, anovulation, and amenorrhea (PRATHER; HUNT, 2015).

Research on the relationship between physical activity (PA) and semen quality is sometimes contradictory. While some studies have found positive associations between PA and semen quality (GASKINS et al., 2022; JONES et al., 2023), others report negative associations (SMITH et al., 2021) or find a neutral effect (MINGUEZ-ALARCON et al., 2024). Despite advances in andrology, the precise influence of PA on male fertility is still not fully understood, with discrepancies across studies. The challenge in accurately quantifying the effects of PA stems from variations in the intensity, volume, and types of physical activities practiced.

In this context, regular physical activity seems to be more favorable for male reproductive health, while very intense exercise loads may have negative impacts. Different sports modalities can also influence male fertility (DENHAM et al., 2020; KIPANDULA; LAMPIAO, 2021), but more studies are needed to reach more definitive conclusions (LALINDE-ACEVEDO et al., 2022).

METHODOLOGY

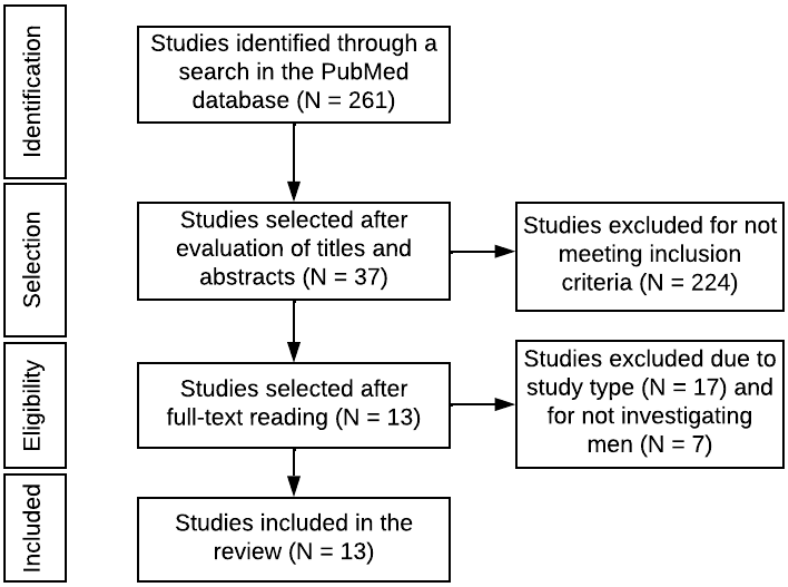
A systematic review of PubMed databases was conducted to search for relevant articles on the impact of physical activity on male reproductive health. The search terms used were "(Semen Quality or Fertility or Seminal Parameters) and (Physical Activity or Physical Exercise)," in accordance with the Health Sciences descriptors from the Virtual Health Library (DeCS). There was no restriction on the year of publication, and only full-text articles in English were considered, with the latest search updated until June 2024.

For the selection and writing of this systematic review, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist was adopted (MOHER et al., 2009). The inclusion criteria for the studies were: a) publication as an original article in scientific journals; b) full availability in English; c) indexing in the selected database; d) addressing the effect of physical activity on semen quality or male fertility. Exclusion criteria included: a) case reports, reviews, commentaries, or articles not in English; b) studies involving non-human or female populations.

The selection of eligible studies involved analyzing titles, abstracts, and full texts by two independent reviewers. Out of the 261 articles initially found, 13 were deemed eligible for the review, as shown in Figure 1, following PRISMA guidelines (MOHER et al., 2009). The information extracted from each study included author, publication date, study type, objective, WHO criteria, type and intensity of physical activity, number of participants, and results obtained.

Tables and illustrations (such as maps, diagrams, organizational charts, charts, photographs, graphs, flowcharts, among others) must be presented within the body of the document, centered, with identification at the top in 11 pt font and at the bottom in 10 pt font, always with the best possible graphic quality. See the example below.

Figure 1 – Flowchart of article identification and selection for the systematic review on the effect of physical activities on male reproductive health



Source: Nesello (2024)

RESULTS

The 13 studies considered are presented in Table 1. An analysis of these studies reveals a significant increase in the number of publications over the past decade (n = 12; 92.3%), with seven of these studies adopting the most recent guidelines for seminal parameters according to WHO (2010). It is also noteworthy that most research was conducted in developed countries (n = 10; 76.9%). There was a wide variation in sample sizes, with six studies (46.2%) including between 107 and 2261 participants, and the other seven studies (53.8%) varying from seven to 31 subjects. All studies included participants aged between 18 and 40 years, considered the most fertile age range.

The most frequent sports modality among these studies was running (KARKOULIAS et al., 2008; SAFARINEJA et al., 2009; CASTO et al., 2014) (n = 3; 23.1%), followed by cycling (WISE et al., 2011; GASKINS et al., 2014; TARTIBIAN; MALEKI, 2015) (n = 3; 23.1%). Other physical activities were also addressed, though in fewer studies. These included treadmill walking (MALEKI; TARTIBIAN, 2017), outdoor activities (GASKINS et al., 2014), basketball (MARTÍNEZ et al., 2010), martial arts (TARTIBIAN; MALEKI, 2012), weightlifting (GASKINS et al., 2014), mountaineering (VERRATTI et al., 2016), water polo (VAAMONDE et al., 2009), tennis

(IBAÑEZ-PEREZ et al., 2019), and triathlon (VAAMONDE et al., 2009; VAAMONDE et al., 2019). Regarding exercise intensity, five studies (38.5%) investigated moderate intensity, while eight studies (61.5%) addressed high intensity.

The diversity in sports modalities and the intensity at which they are practiced makes it challenging to reach definitive conclusions. However, to date, most preliminary studies indicate that regular physical exercise does not have a significant effect on male reproductive health.

Cycling is recognized as a sport that may negatively impact the male reproductive system (GASKINS et al., 2014; TARTIBIAN; MALEKI, 2015) due to mechanical stress in the scrotal area during pedaling, as well as factors such as tight clothing and excessive heating of the genital organs. Among the included studies, only three specifically addressed cycling, all associating the practice with adverse effects on sperm concentration. However, conclusions about differences in hormonal profiles between cyclists and athletes from other sports seem to diverge among studies.

Regarding other physical activities, it is notable that as exercise intensity increases, indicators associated with male reproductive health tend to decrease. This raises the possibility that high-intensity sports may negatively impact male fertility. On the other hand, when exercise is performed at a moderate load, the effects appear to be beneficial or neutral for male reproductive health.

Chart 1 – Studies on the effect of physical activity on semen quality

Physical Exercise	**Author (year)**	**N**	**Analysis**	**Results**
Treadmill Exercises	Maleki and Tartibian (2017)	433	Effect of intense exercise in sedentary and infertile patients. Pregnancy and live birth rates.	High-intensity training significantly improved sperm quality.
Outdoor activities	Gaskins et al. (2014)	231	Outdoor activity (≥1.5 h/week) vs. Sedentary control group.	Men in the outdoor activity category had a 42% higher sperm concentration compared to sedentary men.
Basketball	Martínez et al. (2010)	26	Basketball competition season (2 times/week; 2-3 hours of basketball) vs. Control group of healthy, physically active individuals.	Basketball practice showed a transient initial increase in testosterone and cortisol during the competition season.

Cycling	Wise et al. (2011)	2.261	Cyclists (≤ 2 h/week: 3–4 h/week and ≥ 5 h/week) vs. Sedentary control group.	Cycling ≥ 5 h/week was associated with lower sperm concentration and total motile sperm count.
	Gaskins et al. (2014)	231	Cyclists (≥1.5 h/week) vs. Sedentary control group.	Men who cycled had 34% lower sperm concentrations compared to men who did not cycle.
	Tartibian ; Maleki (2015)	24	16 weeks of high-intensity cycling (eight weeks: 371 km/week; 12 hours/week) plus (eight weeks: 659 km/week; 16 hours/week) vs. WHO (2010) reference control group.	Seminal cytokine levels increased and remained high after 30 days of recovery. The volume, motility, morphology, concentration, and total sperm count decreased. All the aforementioned variables (except for volume, motility, and concentration) decreased after 30 days of recovery.
Running	Karkoulias et al. (2008)	11	Blood samples collected 1 week before the marathon, immediately after the race, and 1 week later.	The run resulted in an acute decline in testosterone levels. The mentioned changes returned to baseline one week later.
	Safarinej a et al. (2009)	286	60 weeks of high-intensity running training (80% of VO2 max[11]) vs. Moderate-intensity running (60% of VO2 max).	Subjects who engaged in high-intensity running showed significantly reduced semen parameters compared to those who exercised at moderate intensity.
	Casto et al. (2014)	25	Three saliva samples: before warm-up, after warm-up, and immediately after completing an 8 km run.	The run was associated with a significant increase in salivary cortisol and testosterone.
Combat sports	Tartibian ; Maleki (2012)	108	Fighters (62.3% of VO2 max) vs. Physically active group (50.1% of VO2 max).	Physically active men showed significantly higher levels of seminal plasma oxidative stress and antioxidants, and lower sperm DNA fragmentation rates compared to elite fighters.
Weight lifting	Gaskins et al. (2014)	231	Weight lifting (≥2 h/week) vs. Sedentary control group.	Men in the weight lifting category had 25% higher sperm concentrations compared to sedentary men.

[1] VO2max = maximal oxygen consumption.

Mountaineering	Verratti et al. (2016)	7	Short-term exposure to hypoxia (5 days) combined with physical activity (mountaineering).	There was a significant reduction in motility after the expedition. Other seminal parameters were not significantly altered.
Water polo	Vaamonde et al. (2009)	30	Water polo players (54.2% of VO2 max; 5 times/week; 90 min/session) vs. Physically active group (45.2% of VO2 max; 3.3 times/week; 60 min/session).	Sperm concentration was higher in the physically active group. However, the total sperm count, due to concentration and volume, was higher in the water polo group. Sperm morphology was significantly lower in the water polo players.
Tennis	Ibañez-Perez et al. (2019)	107	Tennis players (≤ 2 h/week; > 2 h/week) vs. WHO (2010) reference control group.	Tennis sports activity did not show a significant correlation with semen quality for any seminal parameter in men from infertile couples.
Triathlon	Vaamonde et al. (2009)	31	Triathletes (64.0% of VO2 max; 9.9 times/week; 122.6 min/session) vs. Physically active group (45.2% of VO2 max; 3.3 times/week; 60 min/session).	Values for all parameters showed a trend of being higher in the physically active group and lower in the triathlete group. Sperm morphology was significantly lower in the triathletes.
	Vaamonde et al. (2018)	12	Two weeks of intense triathlon training.	High levels of endurance training performed by triathletes resulted in a negative correlation for sperm DNA.

Source: Nesello (2024)

DISCUSSION

Metabolic repercussions and hormonal changes resulting from physical exercise

Research in animal models, such as male albino rats, has revealed significant reductions in plasma testosterone and luteinizing hormone levels due to intense physical activity, such as prolonged swimming (Silva et al., 2023). This study highlights the role of oxidative stress, suggesting that increased exercise intensity can negatively impact semen quality. Physical activity acts as a powerful stimulant of the endocrine system, potentially leading to notable physiological changes, such as interference with hormonal secretion. This stimulation can affect both hypothalamic and testicular levels, playing a

crucial role in the endogenous stimulation of gonadotropin-releasing hormone (GnRH) and the testicular secretion of testosterone (Rocha et al., 2022).

Moreover, the relationship between exercise volume and intensity and hormonal changes is evident in comparative studies. A recent study (Santos et al., 2021) showed that high-intensity exercise can lead to a significant decrease in semen parameters, in contrast to moderate-intensity exercise. These findings reinforce the idea that strenuous, long-duration exercise can have adverse effects on reproduction. Therefore, the evidence discussed highlights that the effects on semen quality in response to physical activity are directly related to the intensity and volume of exercise. However, it is important to note that low to moderate-intensity physical activity may not be sufficient to cause significant changes in hormonal levels, as demonstrated by recent studies (Gomes et al., 2020), which showed that only high-intensity exercise can impair sperm parameters related to oxidative stress, such as morphology and DNA fragmentation.

Contextualizing the effect of physical activity on semen quality

Physical activity is defined as any voluntary and repetitive bodily movement involving large muscle groups and significantly increasing energy expenditure above resting levels (Blair et al., 2023). To enhance performance, physical activity requires an optimal balance between intensity, volume, and recovery. These factors may be directly related to semen quality, as physical activity seems to influence male reproductive health. Recent studies indicate that high-intensity running training on a treadmill may lead to an increase in semen volume and sperm concentration (Denham et al., 2022; Fernández-García, 2020). On the other hand, high-intensity physical exercise may also be related to a decrease in the proportion of morphologically normal sperm (Fernández-García, 2020). Thus, the association between physical activity and semen quality is not so straightforward. The lack of a clear association may be explained by various potential factors, such as the level of physical activity. Recent studies, such as those by Denham et al. (2022) and Fernández-García (2020), have addressed these issues in subfertile or infertile populations.

Although physical activity has been associated with many health benefits, engaging in strenuous exercise may be an important risk factor for male infertility (Jozkow & Rossato, 2021). In human reproductive research, there has been considerable debate about the decline in semen quality over recent decades. One possible explanation

for this phenomenon could be the increase in sedentary behavior and obesity, resulting from a simultaneous decrease in physical activity.

Intensity and volume of physical activity associated with semen

Studies indicate that a controlled increase in exercise overload can lead to a more positive response in hormonal parameters and male reproductive health (Silva et al., 2022). However, when exercise intensity exceeds certain limits, it can have a direct negative impact on semen quality (Rodrigues et al., 2020). Intense physical activity can affect various aspects of semen, including sperm motility, concentration, and morphology (Pereira et al., 2021). While it is recognized that physical activity needs to reach a minimum intensity, such as moderate intensity, to bring health benefits (Mendes et al., 2019), the ideal intensity has not yet been definitively determined to prevent or treat male infertility (Oliveira et al., 2023). Studies suggest that men who maintain moderate levels of physical activity for sustained periods, such as ten minutes or more, may exhibit better semen quality compared to those with very low or very high levels of physical activity (Silva et al., 2022). However, it is important to consider the uncertainty and variation in actual training intensities compared to the targets set in exercise programs (Rodrigues et al., 2020).

Male infertility

Infertility is defined as the inability of a sexually active couple, not using contraceptive methods, to achieve pregnancy within one to two years. During this period, approximately 90% of couples will conceive in the first year and 95% in the second year. It is estimated that infertility affects 8% to 15% of reproductive-age couples worldwide, regardless of their ethnic, economic, or social backgrounds (Nunes et al., 2021). The distribution between genders is roughly equal, with about 50% of cases attributed to male factors and 50% to female factors. Infertility is a global issue associated with a range of negative psychosocial conditions (Silva et al., 2020). The high incidence of sexually transmitted diseases and the delay in childbearing seem to contribute to this prevalent infertility issue. The quality of life for couples can be significantly affected by infertility factors, leading to decreased sexual satisfaction, psychological well-being, emotional health, and psychiatric symptoms (Silva et al., 2020; Oliveira et al., 2019).

Evaluating the male partner plays a crucial role in addressing this condition. After a detailed medical history and thorough physical examination, semen analysis should be

the primary source of information for the physician (Fonseca et al., 2022). Traditionally, the diagnosis of male infertility is based on a descriptive evaluation of ejaculate parameters, focusing on sperm concentration, motility, and morphology. However, it is important to note that semen analysis is not a fertility test. Fertility assessment is a complex and multifactorial phenomenon involving the evaluation of the couple (Fonseca et al., 2022). Most infertile men present with oligozoospermia (sperm count less than 15x10^6 sperm/ml), asthenozoospermia (inadequate motility - less than 40% motility A and B), or teratozoospermia (less than 4% normal morphology), indicating quantitative and qualitative alterations in spermatogenesis (Silva et al., 2020).

For standardization and to ensure comparability and reliability of results between different semen collection sites, semen tests can be performed following guidelines such as those established by the World Health Organization (WHO, 2010). The values are detailed in Chart 2.

Chart 2 – Normal values of seminal parameters

Semen parameter	Normal values
Volume	≥ 1,5 ml
pH	7,2 - 8,0
Color	opaque white
Liquefaction	≤ 30 min, complete
Viscosity	normal
Concentration	≥ 15 x 10^6 sperm per ml of semen
Total concentration	≥ 39 x 10^6 sperm per ejaculate
Progressive motility	≥ 32% with linear progression
Total motility	≥ 40%
Morphology	≥ 4% with normal forms
Vitality	≥ 58% of live forms

Source: Nesello (2024)

Relationship between sedentary lifestyle and obesity on semen quality

A sedentary lifestyle can negatively impact semen quality, as indicated by studies establishing a link between sedentary work and poor sperm quality (GONÇALVES et al., 2023). Additionally, prolonged periods of inactivity in front of the television may reduce total sperm concentration in seminal samples (OLIVEIRA et al., 2020).

Along with sedentary behavior, a high Body Mass Index (BMI) is also associated with reduced semen quality. Obese individuals tend to have lower testosterone levels and higher estradiol levels in their blood, contributing to changes in semen quality (SILVA et al., 2021; RIBEIRO et al., 2022; SANTOS et al., 2023). A recent study conducted in

Brazil, involving 1,285 men, found that obesity is correlated with lower semen volume, low concentration, reduced motility, and a higher number of sperm defects (SANTOS et al., 2023).

In this context, there is a clear trend showing that physically active individuals have better semen health compared to those who are obese or lead sedentary lifestyles. A study conducted in Spain showed a higher number of motile sperm and normal morphology among active people compared to the sedentary group (GONÇALVES et al., 2021).

Another study revealed that men who adopted moderate physical exercise after seeking infertility treatment had 43% higher sperm concentration (OLIVEIRA et al., 2019). This conclusion was corroborated by a study that evaluated semen quality in sedentary men with a history of infertility, suggesting that moderate aerobic training can be effective as a treatment for male infertility (SILVA et al., 2020).

CONCLUSION

Despite variations in study results, most preliminary research suggests that regular physical exercise does not significantly negatively impact male reproductive health. However, high-intensity activities, such as prolonged cycling and triathlon, may have more pronounced adverse effects on sperm concentration and morphology. These findings emphasize the need to consider exercise intensity and type when assessing its effects on fertility. Future research should expand sample diversity, explore a wider range of exercise modalities and intensities, and include additional factors like diet and lifestyle to improve our understanding and treatment of male infertility.

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