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THE EFFECT OF SPORTS ACTIVITIES IN WOMEN ON TESTOSTERON HORMONE LEVELS

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Abstract
Testosterone is an important hormone that plays a role not only in men, but also in women in maintaining muscle mass, energy, metabolic function, and reproductive health. This article aims to comprehensively examine the effect of physical exercise on testosterone levels in women. The method used was a literature review by analyzing various relevant studies related to hormonal responses to exercise. The results of the study show that exercise, especially strength training and high-intensity exercises such as *High Intensity Interval Training* (HIIT), are able to increase testosterone levels acutely in women so that it can support increased muscle strength, better body composition, and hormonal balance. This improvement also contributes to sports performance and bone health. However, excessive exercise without adequate recovery can lower hormone levels, cause physiological stress, and potentially disrupt the menstrual cycle. Thus, regular, measurable, and tailored exercise to individual conditions plays a positive role in modulating testosterone levels in women. This article emphasizes the importance of a balance between exercise intensity and recovery to maintain hormonal stability and promote optimal health benefits for women.
Keywords: Testosterone Hormone, Sports, Women

INTRODUCTION

Sports activities are an important aspect in maintaining health and improving quality of life, especially for women who have different physiological and hormonal characteristics compared to men (Selviani, I et al., 2024). In this context, testosterone, better known as the male sex hormone, also plays a vital role in the female body. In women, testosterone functions not only in regulating muscle function and fat metabolism but also contributes to increased physical strength, endurance,

and hormonal balance, which influences mood and energy (Prasana & Negara, 2025; Hirschberg et al., 2017). However, the effect of exercise on testosterone levels in women remains a complex and incompletely understood topic.

Different types of exercise, such as resistance training and endurance training, show different effects on the levels of this hormone, where resistance training tends to increase testosterone levels, while endurance training can decrease them. (Khaleghi & Ahmadi, 2025). This phenomenon poses its own challenges, particularly due to the practice of testosterone abuse by some female athletes to enhance performance, which has the potential to cause serious health risks such as hormonal disorders, reproductive problems, and psychological side effects (Oktario, 2023).

Testosterone plays a crucial role in sports, contributing significantly to increased muscle strength, mass, and endurance in athletes. Testosterone is an androgen that stimulates muscle growth through muscle fiber hypertrophy and increases satellite cell production and myonuclear activity, all of which contribute to the development of larger, stronger muscles (Ilham, I et al., 2024). This hormone also influences protein and carbohydrate metabolism, providing athletes with sufficient energy for high-intensity, long-duration physical activity (Siregar, N. A., & Sitompul, S. F. 2019). Furthermore, testosterone increases bone density and aids muscle recovery after intense training, thereby reducing the risk of injury and improving the body's ability to adapt to training loads. Through these effects, testosterone supports athlete performance in various sports, particularly those that rely on strength, speed, and muscle power (Ilham, I et al., 2024).

However, unbalanced testosterone levels can also have negative impacts, such as menstrual cycle disruption in female athletes. Therefore, managing this hormone is crucial in training programs and the overall health of athletes. Therefore, testosterone is a key hormone that contributes to the success and optimal performance of athletes in sports. (Sandi, IN, Ashadi, K., & Womsiwor, D., 2021). Therefore, this study aims to comprehensively explore how exercise affects testosterone levels in women by reviewing various relevant empirical studies. The research framework is based on the concept that exercise is a physiological stimulus that can trigger adaptive hormonal responses in the body. Therefore, a thorough understanding of the causal relationship between exercise type, changes in testosterone levels, and their impact on physical performance and health is crucial.

Thus, the results of this study are expected to provide useful insights for female athletes, coaches, and medical personnel in designing effective and safe training programs, while also raising awareness of the importance of proper hormone management in the context of sports and women's health in general. Furthermore, this research also has the potential to open up opportunities for the development of interventions that can maximize the benefits of exercise without incurring adverse

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hormonal risks, thereby supporting the creation of healthy and sustainable lifestyles for women across all age groups.

METHODOLOGY

This study used a literature review method to examine the effects of testosterone on women during high-intensity exercise. A literature review was chosen as an approach to collect, analyze, and synthesize findings from various relevant scientific studies to gain a comprehensive understanding of the topic. Data were collected through a search of scientific journal articles published between 2010 and 2025. Data were collected through searches in academic databases such as "Google Scholar, PubMed". The keywords used included "testosterone", "exercise", "Female", and in this study, 7 journals were used, namely 5 international journals and 2 national journals according to the review.

The data obtained were analyzed qualitatively to identify patterns and key findings related to changes in testosterone levels in women due to high-intensity exercise, their impact on muscle mass, strength, and performance, and long-term health implications. Data from various studies were then synthesized to provide a comprehensive overview of the effects of testosterone in the context of high-intensity exercise in women.

RESULTS

Five primary articles and journals were used as literature, covering various research types. The content of the articles and journals, including authors, titles, samples, and research results, is presented in Table 1 as follows :

Table 1. Article used as literature

No	Author	Title	Sample	Intervention	Result
1	Mohammad Mehdi Khaleghi, Fatemeh Ahmadi (2025)	The Impact of Team Sports on Testosterone and Cortisol Hormones in Women	The study involved a total of 169 female athletes participating in various team sports.	Focus on team sports like soccer, volleyball, basketball (netball), and handball, which have been shown to influence testosterone and cortisol levels in women. Use moderate-to-high-intensity training, as this intensity increases testosterone and cortisol, indicating physiological adaptation to the stress of training.	The findings showed that soccer increased both hormones, while netball tended to increase cortisol and decrease the testosterone-to-cortisol ratio. Volleyball also showed a significant increase in testosterone, albeit with fluctuations, while handball focused more on increasing cortisol without significant changes in testosterone.

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2	Rizki Oktario (2023)	Hormone Injection Increase an 20lbs Masa Muscle? Natural vs. Steroids	The study involved 43 men who divided into four groups based on Testosterone use.	Athletes or adult male individuals who want to increase mass significant muscle and strength gains. Monitoring and evaluation of testosterone therapy with a dose of approximately 600 mg testosterone enanthate per week for 10 weeks.	This study examined whether a dose of 600 mg/week of Testosterone can increase muscle mass by about 6.1 kg, although the final result is also influenced by nutrition, genetics, training patterns, and sleep quality.
3	Angelica Linden Hirschberg, Jona Elings Knutsson, Torbjörn Helge, Manne Godhe, Maria Ekblom, Stephane Bermon, Jörn Ekblom (2018).	The impact of increasing testosterone concentrations moderate to physical performance in young women.	The study involved 30 young women aged 18-25 who were healthy and physically active.	Young women aged 18-35, physically active and healthy. A daily dose of 10 mg testosterone cream is recommended to moderately increase serum testosterone levels.	Moderate increases in testosterone concentrations can improve physical performance in young women, including strength and endurance. However, moderate increases in testosterone concentrations do not significantly impact speed and flexibility.
4.	I Gej Prasana, Child of Agap Negara (2025).	Effect of type of exercise on testosterone levels in female athletes.	This study involved 40 healthy women (67 years old) and Arazi et al. (2017) with 30 female volleyball athletes (18.5 years old).	Resistance training such as weight lifting, squats, or bench presses 2–3 times per week at moderate to high intensity progressively.	The type of training affects testosterone levels in female athletes. Endurance training tends to lower testosterone, possibly due to *overtraining*. Conversely, resistance training, especially high-intensity training, increases testosterone, which is beneficial for muscle strength and lean body mass. Resistance training can raise testosterone levels by 20-25% over baseline after a few weeks of training, significantly increasing muscle strength and muscle mass.
5.	Nengah Sandi, Visit Ashadi, Daniel	Division of sports environment.	This journal refers to studies involving 64 elderly people	Improve athlete performance by paying attention to internal and external	Testosterone significantly contributes to differences in muscle proportion and size between men and

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	Womsiwor (2021).		(nutrition), 544 respondents (exercise humidity), and 40 students (night exercise perspiration).	environmental factors in a balanced manner.	women. In men, testosterone levels increase to approximately 15 to 20 times higher than in women of the same age after puberty, resulting in larger muscles in men. After menstruation, women's fat tissue increases significantly, resulting in relatively less active muscle tissue. Specifically, women's upper body muscle strength is only about 50% of that of men, women's pelvic floor muscle strength is about 80% lower than men's, and women's lower body muscle strength is about 30% lower than men's. These differences are primarily due to significantly lower testosterone levels in women after puberty.
6.	Anthony C Hackney, Hannah N Willet (2020).	Testosterone response to intensive, Prolonged endurance training in women	This study involved ten healthy eumenorrhoeic women who experienced fatigue at ~100% of their ventilatory threshold in the follicular phase of the menstrual cycle.	Design a resistance training program for women that considers the 24-hour recovery phase after strenuous exercise, as testosterone increases post-exercise but declines after 24 hours. Include adequate carbohydrate intake and optimal hydration before and during exercise to support hormones and performance.	Total testosterone levels increased by 56%, free testosterone increased by 36%, and bioavailability increased by 50% immediately after exercise, all of which were statistically significant ($p < 0.05$). However, 24 hours after exercise, these levels decreased by -21%, -31%, and -18%, respectively, also with statistical significance ($p < 0.05$).
7	Kraemer, WJ, Ratamess, NA, Hymer, WC, Nindl, BC, & Fragala, MS (2020).	Growth hormone, testosterone, insulin-like growth factor, and cortisol: roles and integrases for cell developme nt and	Three key hormones—testosterone, growth hormone, and insulin-like growth factor (IGF)—are considered the "anabolic giants." Furthermore, glucocorticoids, particularly	Perform high-intensity resistance training that involves large muscle groups, such as squats and deadlifts. Ensure your body has 24-48 hours of recovery time to allow hormones to function optimally for muscle growth. Consume a diet rich in protein and carbohydrates to	The role of growth hormone, testosterone, insulin-like growth factor (IGF), and cortisol in regulating activity-related cell growth and repair. These hormones interact in complex signaling pathways, with testosterone and IGF-I serving as primary anabolic hormones, while cortisol has catabolic

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		growth with exercise.	cortisol, are also recognized as having a significant adverse effect on muscle anabolism.	support protein and hormone synthesis. Avoid stress and overtraining, which can increase catabolic hormones like cortisol.	effects. Research shows that resistance training can increase levels of these hormones, with effects varying depending on the type and intensity of exercise. This article emphasizes the importance of understanding hormone interactions in the context of exercise to improve athletic performance and overall health.

DISCUSSION

The discussion section will outline the analysis of previously presented articles used as research sources. This discussion will explain the effect of sports activities on testosterone levels in women. In volleyball, Khaleghi (2025) stated that testosterone levels tend to increase during competition, but there are also reports showing a decrease in hormone levels after the match accompanied by an increase in the testosterone-to-cortisol ratio, which may indicate a hormonal recovery process. Sports activities can cause complex hormonal changes that affect athlete performance and recovery. This discussion examines the results of various related studies to provide a comprehensive understanding of hormonal change patterns in the context of women's team sports.

Based on the opinion of Oktario (2023), he explained the impact of testosterone injections on muscle growth by comparing four groups of men: no testosterone/training, testosterone without training, training without testosterone, and testosterone with training. The results showed that testosterone alone increased muscle mass (3.2 kg), and exercise alone was also effective (1.9 kg). However, the combination of testosterone and exercise was superior, resulting in an average increase in muscle mass of 6.1 kg, as well as significant increases in muscle size and strength. This confirms that testosterone, especially when combined with weightlifting, is very effective for building muscle, although the dose used in this study (600 mg/week) is considered high and bodybuilders can use higher doses with increased risk of side effects.

Although testosterone is known as the male sex hormone, it is also produced in smaller amounts by women and contributes to increased lean muscle mass, strength, and aerobic performance. Physical exercise, especially intense exercise involving muscular strength, can stimulate increased testosterone levels in women. This increase in testosterone aids in muscle protein synthesis, thus supporting the growth and maintenance of lean muscle mass. Furthermore,

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physical activity is also associated with increased aerobic capacity, which is beneficial for cardiovascular fitness (Padli, P et al., 2024) . Changes in testosterone levels due to physical activity in women vary depending on the type of exercise, intensity, duration, and individual factors such as age and health conditions. (Prasetyo, T et al., 2024) . Regular, structured exercise can maintain healthy testosterone levels, supporting optimal fitness and physical function. Conversely, excessive exercise without adequate recovery can lower testosterone levels due to high physiological stress. Through biological interactions, testosterone works by binding to androgen receptors in muscle tissue, triggering anabolic processes that accelerate muscle repair and growth. Therefore, for physically active women, proper exercise management can help optimize testosterone levels, thus supporting hormonal health and improving overall physical performance.

Based on Hirschberg's (2018) opinion, serum testosterone levels increased significantly in the group receiving testosterone supplements, which had a positive impact on the run-to-exhaustion time, which increased by 21.17 seconds. Although the average power in the Wingate test also increased in the testosterone group, the difference was not significant. Changes in lean muscle mass were also detected, with a significant increase in the group of participants receiving testosterone. The results of the study concluded that increased testosterone levels can improve aerobic capacity and muscle mass in young, physically active women, suggesting possible therapeutic benefits in the context of physical exercise.

Based on Prasana's (2025) opinion, it is explained that resistance training such as weight lifting significantly increases testosterone production through stimulation of Leydig cells and luteinizing hormone, while endurance training tends to reduce testosterone levels due to overtraining. However, the combination of aerobic and resistance training did not significantly change testosterone levels. Hormonal responses also vary in sports such as ballet and volleyball, where resistance training provides greater hormonal benefits. These findings are important to help coaches and athletes design optimal training programs, maximizing the anabolic effects of resistance training while minimizing the negative impacts of excessive endurance training. Exercise plays a significant role in influencing testosterone levels, which significantly impact fitness and health, particularly in increasing muscle mass, strength, and physical recovery. Exercise involving high-intensity strength training can stimulate testosterone production in both men and women.

Sandi (2021) states that weight training, such as weightlifting and intensive training involving large muscle groups, is known to temporarily increase testosterone levels. This increase contributes to muscle protein synthesis, which increases lean muscle mass and muscle strength. Furthermore, aerobic exercise also has positive effects, although these are more related to improvements in cardiovascular fitness and metabolism. The response of testosterone levels to exercise is influenced

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by the type, intensity, and duration of exercise, as well as individual conditions such as age and health. Regular, planned exercise can help maintain optimal testosterone levels, while excessive exercise without adequate recovery time can lower testosterone levels due to high physical stress. In women, increasing testosterone levels through physical activity also provides benefits such as improved aerobic performance and lean muscle mass, which enhances physical function and overall fitness. Biologically, testosterone interacts with androgen receptors in muscle tissue, triggering anabolic processes that accelerate muscle repair and growth. Therefore, appropriate and regular exercise is an effective way to optimize testosterone levels and physical function, while supporting overall hormonal health (Harahap, NS, & Siregar, NS 2021).

This study examined the impact of exercise on testosterone levels in women, particularly in the context of intense and prolonged endurance training. Results showed that total, free, and bioavailable testosterone levels increased significantly after exercise to exhaustion, with increases of 56%, 36%, and 50%, respectively, compared to pre-exercise levels (Hackney & Willett, 2020). However, these hormone levels decreased 24 hours after exercise, with decreases of 21%, 31%, and 18% for total, free, and bioavailable testosterone, respectively (Hackney & Willett, 2020).

It's important to note that this hormonal response exhibits a biphasic pattern, with testosterone increasing immediately after exercise but then decreasing during the recovery period. This finding aligns with previous research showing that men also experience a temporary increase in testosterone after exercise, followed by a decrease during the recovery process (Anderson et al., 2016; Kraemer et al., 2017).

This research highlights that although women are often overlooked in sports studies, their hormonal responses to endurance exercise are similar to those of men, albeit with noteworthy differences in concentration (Hackney & Willett, 2020) . With the increasing participation of women in endurance sports, a deeper understanding of these hormonal responses is crucial. This will not only help design more effective and safe training programs for women but also provide new insights into the mechanisms of physiological adaptation that occur during exercise (Mujika & Taipale, 2019). Therefore, further research is needed to explore the factors influencing these hormonal responses and how appropriate interventions can support women's performance and health in sports (Hackney & Willett, 2020) . The results indicate that testosterone acts as a primary anabolic hormone influencing muscle tissue growth and repair. Although numerous studies have examined testosterone responses in men, information on women is limited. This study found that total and free testosterone levels increased significantly after exercise to exhaustion, but then decreased during the recovery period (Kraemer et al., 2020).

Testosterone functions through genetic and non-genetic signaling pathways, influencing the

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activity of muscle satellite cells, which contribute to muscle regeneration and growth (Kraemer et al., 2020). In the context of resistance training, testosterone can increase protein synthesis and reduce catabolism, thereby contributing to increases in strength and muscle mass. However, this hormonal response is influenced by various factors, including the type of exercise, nutritional status, and training experience. Previous research has suggested that women may not experience the same increase in testosterone levels as men after intense exercise, possibly due to differences in plasma volume and hormone clearance (Kraemer et al., 2020).

Furthemore, it is important to note that while testosterone levels may increase immediately after exercise, the long-term effects of this increase on muscle adaptation and performance require further investigation. With women increasingly participating in competitive sports, a deeper understanding of their hormonal responses will aid in designing more effective and safe training programs (Kraemer et al., 2020). This study provides important insights into how exercise affects testosterone levels in women and emphasizes the need for further study to elucidate the underlying mechanisms. Previous research has shown that sex hormones, such as testosterone, play a crucial role in reproductive health, muscle function, and metabolism in women.

Hirschberg's et al. (2020) opinion, stated that physical activity can affect these hormone levels; high-intensity resistance training typically increases testosterone levels and decreases estrogen, while endurance training tends to decrease testosterone levels. A double-blind, randomized, placebo-controlled study in active young women showed that daily use of 10 mg testosterone cream for 10 weeks increased muscle size by 4.4% and strength by 12% to 26%, although excessive testosterone levels may risk disrupting the menstrual cycle. Furthermore, environmental factors, both internal (such as age, gender, and genetics) and external (such as temperature, humidity, and altitude), also play an important role in an athlete's success (Siregar, N. S., 2016).

The primary strength of this study lies in its specific and comprehensive focus. It fills a gap in knowledge by systematically examining the effects of team sports on sex hormone levels in women, a topic that remains under-researched. Using a systematic review method, the study integrates and analyzes data from multiple related studies, resulting in stronger and more reliable conclusions than a single study. Furthermore, the study evaluates the impact of different types of training (both endurance and resistance) on testosterone levels in female athletes, providing crucial insights for determining the most effective training strategies. Finally, a literature review within the study provides a deeper understanding of how various environmental factors influence athlete performance, further enhancing the value of the information presented.

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CONCLUSION

This literature review shows that testosterone plays an important role in improving strength, muscle mass, and exercise performance in women. High-intensity exercises such as weight training and HIIT can increase testosterone levels acutely, providing benefits to metabolism and recovery. However, excessive exercise and lack of energy can disrupt hormonal balance as well as reproductive health, including the menstrual cycle.

Therefore, a high-intensity training program in female athletes must be designed in a measured manner with nutritional needs, recovery, and monitoring of hormonal conditions in mind. Further research is needed to determine the optimal exercise dose so that the benefits of testosterone can be maximized without long-term health risks.

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