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Published Online: 2025 January 31 **Systematic Review**

Effects of Team Sports on Female Testosterone and Cortisol Hormones: A Systematic Review

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Abstract

Context: Sex hormones play a vital role in reproductive health and influence muscle function and metabolism. Exercise affects these hormones by raising testosterone levels and improving metabolic markers. However, the impact of team sports on female sex hormone levels remains understudied.

Objectives: This review aims to systematically examine how sports like soccer, volleyball, basketball, and handball influence female sex hormone levels.

Evidence Acquisition: This systematic review was conducted without any restrictions on language, publication date, or study type, based on the guidelines for systematic reviews and meta-analyses [preferred reporting items for systematic reviews and meta-analyses (PRISMA)] on Google Scholar, PubMed (MEDLINE), Scopus, Embase, and Web of Science databases on June 22, 2024. The search strategy utilized a combination of keywords and their synonyms from MeSH and Emtree-controlled vocabulary, including "Sex Hormone", "testosterone", "cortisol", "team sport", and "women."

Results: Among the 690 articles identified, 11 were selected and used based on the inclusion criteria. Studies have shown that football, netball, volleyball, and handball have varying effects on testosterone and cortisol levels in athletes. Football generally increases both hormone levels, whereas netball often raises cortisol and lowers the testosterone-to-cortisol ratio. Volleyball tends to increase testosterone significantly, though with fluctuating trends, whereas handball mainly raises cortisol without a significant change in testosterone levels.

Conclusions: Despite the limitations of the included studies, such as sample size, study design, data collection standards, reporting practices, and potential biases, this systematic review indicated that playing team sports like football, basketball (netball), volleyball, and handball can alter testosterone and cortisol levels in females. However, further research is needed to fully understand these hormonal changes' effects.

Keywords: Team Sport, Sex Hormones, Testosterone, Cortisol, Female

1. Context

Sex steroids, or sex hormones, are among the most important differences between men and women, playing an essential role in the growth and maintenance of the reproductive system. These hormones fluctuate periodically during the normal menstrual cycle and exert various effects on strength, elasticity, and muscle mass (1, 2). Sex hormones have different physiological roles; thus, they can stimulate different tissues of the body, including skeletal muscles, affecting the function and metabolism of the body (3). Additionally, female sex hormones can influence cardiovascular function (4), sexual differentiation of the central nervous system, female reproductive cancers (5), and regulation of estrogen receptors in airway smooth muscle cells (6).

Sex hormones and exercise can have mutual effects on each other (7). Studies have shown that exercise can increase the levels of testosterone (8, 9) and estrogen (10), increase the ratio of testosterone to cortisol (11), decrease the ratio of estradiol to testosterone in circulation (8), decrease luteinizing hormone (LH) and follicle-stimulating hormone (FSH) (10, 12), improve blood progesterone levels (13, 14), blood estrogen levels (14), cortisol levels (15-17), and improve mean

dehydroepiandrosterone sulfate (DHEA-S) levels (16). Furthermore, various methods, such as estrogen therapy, can play an effective role by neutralizing the decrease in the number of satellite cells in muscle fiber after a 12-week training period in postmenopausal women (18). It has also been shown that transdermal estrogen therapy combined with 12 weeks of progressive resistance training can improve blood metabolic markers in postmenopausal women (19).

Due to the high importance of sex hormones in health and disease, studies have investigated the effects of different methods, intensity, and duration of exercise on sex hormone levels in women. However, the effects of team sports on female sex hormone levels have not been thoroughly investigated.

2. Objectives

We decided to conduct a systematic and comprehensive investigation of the impact of team sports, such as football, volleyball, basketball, and handball, on female sex hormone levels.

3. Method

3.1. Protocol and Registration

The systematic review adhered to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines (20, 21) and the ethical standards for sports and exercise science research (22). This study was registered in the International Prospective Systematic Review database under registration number CRD42024557904.

3.2. Data Sources and Search Strategies

On June 22, 2024, searches were conducted without any restrictions on language, publication date, or study type, in Google Scholar, PubMed (MEDLINE), Scopus, Embase, and Web of Science, resulting in 690 articles. The search employed the keywords ("Gonadal Steroid Hormone*" OR "Sex Hormone*" OR "Sex Steroid Hormone*" OR "gonadal hormone*" OR "sex steroid" OR "sex steroid hormone" OR "sexual hormone" OR "Estrogen*" OR "estrogenic hormone" OR "Oestrogen*" OR "oestrogenic hormone" OR "Progesterone" OR "Pregnenedione" OR "corpus luteum hormone*" OR "Hydrocortisone" OR "Cortisol" OR "cortisole") AND ("Team sport*" OR "Teamsport*" OR "Handball" OR "Volleyball*" OR "Basketball*" OR "Netball*" OR "Basket ball" OR "football" OR "soccer") AND ("Girl*" OR "Woman" OR "Women" OR "Women Group*" OR "Female*"), without any restrictions on language or publication year. The search strategy for the Web of Science is detailed in Table 1.

3.3. Study Selection

The initial and subsequent screenings, were conducted using a two-stage process. Duplicate records were manually deleted. Disagreements between reviewers were settled through consultation. The relevance of female sex hormone levels to team sports served as the second-stage screening criterion. The inclusion and exclusion criteria for studies in the present research were clearly defined. All studies were selected based on their relevance to the research topic and the use of specific keywords during the search process, which also served as a criterion for inclusion. Exclusion criteria encompassed review articles, case reports, conference papers, articles not written in English, and editorials. Furthermore, to ensure the recency and accuracy of the findings, only articles published from 2019 onwards were included, while older studies (1996 - 2019) were excluded.

3.4. Data Extraction and Quality Assessment

Data were extracted from eligible studies using a predefined template following the initial screening process. This template included author names, titles, publication years, demographic data, intervention details, study designs, and research results. The methodological quality of the articles was assessed using the Modified Jadad Scale (23) and the JBI critical appraisal tool for quasi-experimental studies (24). Discrepancies were resolved through consultation.

4. Results

4.1. Search Selection and Inclusion of Publications

A total of 690 articles were identified through searches conducted across five electronic databases. After removing 331 duplicates using bibliography management software (EndNote version 21), 359 unique articles remained. Following screening for relevance, 289 articles deemed non-relevant, along with 17 review articles, 12 case reports, 2 conference papers, 1 article in a language other than English, and 2 editorials were excluded. Among the remaining 36 articles, to comply with the principle of up-to-dateness of the articles and results and to avoid exaggeration, 25 articles related to the time period before 2019 (years 1996 - 2019) were excluded. Ultimately, 11 articles underwent comprehensive analysis and were included in the study (Figure 1). The selection process for articles from the

Table 1. Web of Science Search Strategy

Database	Search Strategy
Web of Science	[TS = ("Gonadal Steroid Hormone*" OR "Sex Hormone*" OR "Sex Steroid Hormone*" OR "gonadal hormone*" OR "sex steroid" OR "sex steroid hormone" OR "sexual hormone" OR "Estrogen*" OR "strogenic hormone" OR "Oestrogen*" OR "oestrogenic hormone" OR "Progesterone" OR "Pregnenedione" OR "corpus luteum hormone*" OR "Hydrocortisone" OR "Cortisol" OR "cortisole")] AND [TS = ("Team sport*" OR "Teamsport*" OR "Handball" OR "Volleyball*" OR "Basketball*" OR "Netball*" OR "Basket ball" OR "football" OR "soccer")] AND [TS = ("Girl*" OR "Woman" OR "Women" OR "Women Group*" OR "Female*")]

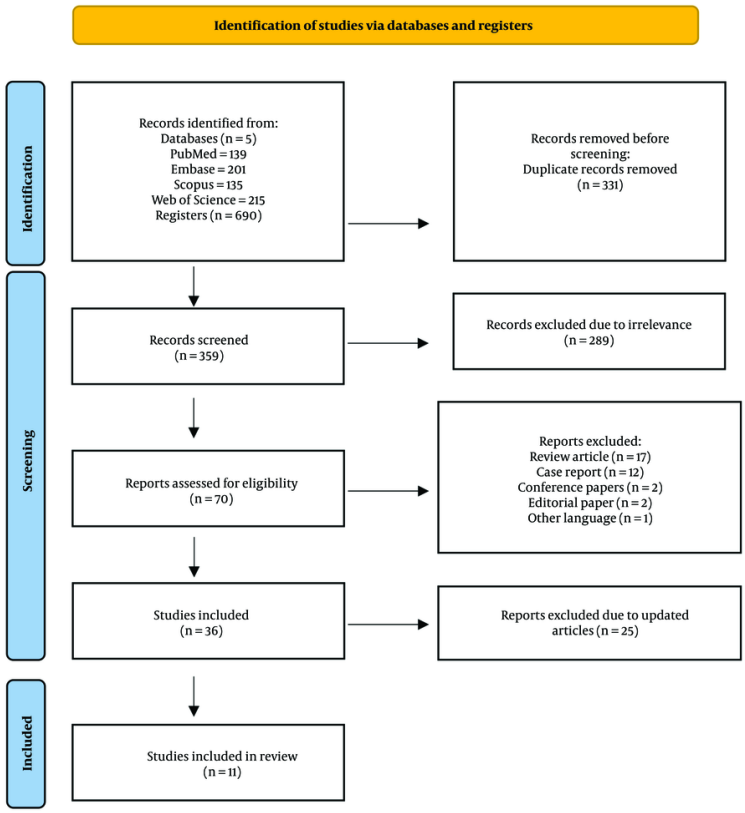

Figure 1. Study selection flowchart for inclusion in systematic review

databases is depicted in the PRISMA diagram, as presented in the accompanying flowchart.

4.2. Quality Assessment of Included Studies

Based on the two aforementioned methods for assessing the quality of articles (23, 24), all 11 included studies demonstrated an adequate quality level and met the criteria for inclusion in the present study.

4.3. Characterization of Studies

A total of 169 women players (volleyball, n = 23; soccer, n = 75; netball, n = 36; and handball, n = 35) were included in this study. Four articles utilized soccer training (25-28), three articles utilized netball training (29-31), two articles utilized volleyball training (32, 33), and two articles utilized handball training (34, 35) (Table 2). Seven studies were conducted across European countries: Spain (33, 34); the United Kingdom (29-31); Hungary (35); Portugal (28). One article was conducted in South America: Brazil (26); one article in Africa: South Africa (27); one article in the United States of America (25); and one article in Asia: China (32) (Table 2). The

Table 2. Summary of the Included Studies

Authors (Year)/Country	Purpose of the Research	Type of Studies	Participants (Age) (Mean ± SD; y)	Duration	Type of Exercise	Results
Botelho et al., 2022/Brazil (26)	Examine the variations and relationships between emotional states and different physiological indicators of stress following a 7-week preseason training period with elite female soccer athletes	Observational and descriptive study	24 elite female soccer players (26.4 ± 3.7)	7-week preseason (PRE) period (During the first week of PRE, and again 7 weeks after a systematic training period)	Soccer training	Significant increases in day and evening testosterone and cortisol
McFadden et al., 2022/United States of America (25)	Evaluate the effects of a season of women's collegiate soccer influences psychological indicators, biomarkers, sleep, and performance	Observational study	25 women's soccer players (19 ± 1)	Women's collegiate soccer season	Soccer match	Increase free testosterone (ES 1 - 2 = 1.27), total testosterone
Broodryk et al., 2021/South Africa (27)	Impact of a soccer tournament on the psychological and hormonal conditions of female college athletes.	Quantitative research	8 collegiate female soccer players	A week-long tournament	Soccer game	Cortisol increased significantly after most matches
Casanova et al., 2020/Portugal (28)	Evaluate the relationship between salivary concentrations of cortisol (C), testosterone (T), the ratio T:C and the individual performance of top-level female soccer athletes during official matches	Correlational Research	18 female athletes from a national soccer team (23.06 ± 4.33)	Four games in an international tournament for women's national soccer teams	Soccer games	Athletes in cluster 2 exhibited a significant increase in C ($p < 0.05$) and a significant decrease in T and the T:C before the games that were lost (M2 and M5).
Birdsey et al., 2022/United Kingdom (29)	Examined the 20 h responses of International female netball players to training days requiring two sessions (netball and strength, separated by two hours) ordered alternatively.	Repeated measures' cross-overstudy	11 international female netball players	Two sessions (netball and strength, separated by two hours)	The training protocol involved strength training followed by netball training two hours later (STR-NET), with the order reversed (NET-STR) on a separate day.	In the NET-STR group, PreS2 exhibited a 45% increase in cortisol concentration (ranging from 1% to 88%) and a 35% decrease in the testosterone-to-cortisol ratio (ranging from -72% to -2%) compared to PreS1.
Birdsey et al., 2022/United Kingdom (30)	Examined the 24 h responses to professional female netball-specific training.	Observational study	14 British Superleague Netball players	The training session, conducted exclusively on-court, lasted 90 minutes and commenced at 16:30.	A 90-min on-court netball training session featuring key movements, technical exercises, and scenario-specific match-play drills	At +0h: T and C increased. At +2h: T reduced. At +24h: Responses did not occur within 24h.
Birdsey et al., 2019/United Kingdom (31)	Neuromuscular, physiological and perceptual responses to an elite netball tournament	Observational study	11 female players (25 ± 4)	Played three matches over consecutive days in an international netball tournament	Netball match	Following match 1, T and C decreased. Following two matches, T decreased. Three days post-tournament, T and C decreased.
Wang et al., 2023/China (32)	Investigation of changes in catecholamine levels and other indicators across various training phases in female volleyball players	Experimental study	12 adult female volleyball players from Shanghai (26.23 ± 3.39); an average training period of (11.92 ± 3.73)	21 weeks (from the end of the 2020 - 2021 women's volleyball league and ending at the beginning of the final of the 2021 Shaanxi National Games)	Volleyball training	T levels showed a significant increase, peaking prior to the final match of the national games, with a notable difference observed between baseline and pre-match values ($P < 0.05$). Both T and T/C followed a similar trend throughout the entire period.
Miguel-Ortega et al., 2023/Spain (33)	Examined the coupling of hormonal responses and their association with stress levels in the athletic performance of an elite women's volleyball team	Retrospective, longitudinal and observational study	11 elite female (24.2 ± 2.7)	16 weeks of volleyball competition	Volleyball competition at the elite level	A reduction of 3.470% in C levels and an increase of 2.945% in T levels were observed, indicating a 10.574% improvement in the T:C ratio.
Cselko et al., 2021/Hungary (35)	Examines the alterations in anthropometric and physical parameters and fasting hormonal levels among pre-pubertal female handball players	Experimental study	14 pre-pubertal female handball players (11.53 ± 0.58)	Pre-season period following 8 weeks of handball training	During the 8-week handball training program, athletes engaged in concurrent resistance and aerobic exercises, which also incorporated game-based training sessions.	Not significant incearse plasma testosterone level significant elevations were found in cortisol levels (C, 34.30 %, $P < 0.05$)
Mariscal et al., 2019/Spain (34)	Assesses pre- and post-match concentrations of salivary cortisol, alpha-amylase (AA) and immunoglobulin A (IgA) in elite female handball players	Experimental study	21 elite female handball players (23.0 ± 5.4)	One handball match in Spanish national women's league	Handball match	Cortisol concentration increased significantly

Abbreviations: PRE, preseason; ES, effect size; C, cortisol; T, testosterone; M2, match 2; M5, match 5; h, hour; STR-NET, strength followed by netball training two hours later; NET-STR, strength followed by netball training two hours later with the order reversed; AA, alpha-amylase; IgA, immunoglobulin A.

articles were published in various academic journals, including Alternative Therapies in Health and Medicine (32), Journal of Applied Science: Advances in Sport Injury Prevention (33), The Journal of Strength & Conditioning Research (25-27), European Journal of Sport Science (29), PLoS One (30), International Journal of Environmental Research and Public Health (35), Kinesiology (28), Journal of Sports Sciences (31), and Scientific Reports (34).

4.4. Outcome Measurement

Overall, the studies showed that each of the sports — football, netball, volleyball, and handball — had different effects on the levels of testosterone and cortisol hormones. Among the included articles, four were categorized as observational studies (25, 26, 30, 31), one as quantitative research (27), one as correlational research (28), two as experimental studies (34, 35), one as a repeated measures crossover study (29), one as an experimental study (32), and one as a retrospective, longitudinal, and observational study (33) (Table 2).

4.4.1. Soccer

Four studies examined the effects of soccer on hormone levels, showing significant increases in testosterone and cortisol (25-27). However, one study reported a significant rise in cortisol ($P < 0.05$) and a decrease in testosterone and the testosterone-to-cortisol ratio before losing matches (M2 and M5) (28). The duration of evaluation varied across studies, ranging from a full season (25) to shorter periods such as seven weeks (26), a one-week tournament (27), and four matches during the Algarve Cup (28). Sample collection methods also differed. Some studies collected saliva samples at home in the morning and evening (26), while others gathered blood samples at different stages of the season (25). In tournament-based studies, saliva was

collected before and after matches to track hormonal fluctuations (27, 28) (Table 2).

4.4.2. Basketball (Netball)

The summary of three studies on basketball (netball) indicated that this sport increases cortisol levels (1 - 88%) and decreases the testosterone-to-cortisol ratio (-35%; -72 to 2-2%) (29). One study found that cortisol and testosterone levels rose post-exercise but declined after 2 hours, with no change after 24 hours (30). Another study reported a decrease in cortisol and testosterone after the first match, a further testosterone decline after the second match, and a reduction in both hormones after three days (31). The evaluation periods varied, including two training sessions (29), a 90-minute netball training session (30), and three consecutive match days during an international tournament (31). Sample collection times ranged from pre- and post-training (29, 30) to morning samples on match days and three days post-competition (31) (Table 2).

4.4.3. Volleyball

Two studies on volleyball indicated that this sport significantly increases testosterone levels during competition ($P < 0.05$), while testosterone-to-cortisol trends remained similar throughout the study (32). Another study found that post-match cortisol and testosterone levels decreased by 3.47% and 2.945%, respectively, while the testosterone-to-cortisol ratio increased by 10.574% (33). The evaluation periods varied, including a 21-week volleyball league season with seven training phases (32) and a 16-week competition period with an average of 22.5 hours of weekly training (33). Sample collection occurred at multiple points throughout the season in both studies, with morning tests taken before and after key training phases and competitions (32, 33) (Table 2).

4.4.4. Handball

Studies on handball suggest that this sport significantly increases cortisol levels (34.30%, $P < 0.05$), while plasma testosterone levels remain unchanged (35). Another study also reported a significant rise in cortisol post-match ($P < 0.05$) (34). Evaluation periods varied, including an 8-week preseason training program (35) and a single league match consisting of two 30-minute halves (34). Blood samples were taken before and after the training period in one study (35), while another collected saliva samples shortly before and after an official match (34) (Table 2).

5. Discussion

This review systematically examined the effects of team sports — soccer, basketball (netball), volleyball, and handball — on testosterone and cortisol levels in women. Despite methodological variations, all 11 included studies consistently reported hormonal changes following participation in these sports. Women's soccer is recognized as one of the fastest-growing sports in the world, especially in Spain (12). Current investigations have shown that participation in football can increase the concentration of testosterone and cortisol (25-27), and in some cases, besides increasing the concentration of cortisol, it has caused a decrease in the level of testosterone (28). In this regard, a systematic study indicated that testosterone responses differed based on match outcomes, with winners experiencing an increase and losers a decrease, while cortisol levels remained unchanged regardless of match results in female soccer players. A slight increase in testosterone levels was observed in men, although the difference was not statistically significant. Women did not exhibit a higher adaptive response to cortisol levels than men (36).

Netball, which is widely played across five continents and has 20 million participants, is one of the most popular women's sports worldwide (37). Research suggests that this sport can elevate cortisol levels and reduce the testosterone-to-cortisol ratio (29). However, hormone fluctuations have been observed at different time points post-exercise (30), and some studies have reported significant reductions in both hormones after training sessions (31). A systematic review concluded that netball did not significantly alter salivary testosterone, cortisol, or their ratio (38).

Studies on female volleyball players indicate that this sport can elevate testosterone levels (32). However, other research has reported a decrease in both cortisol and testosterone levels post-game, while the testosterone-to-cortisol ratio increased (33). Additionally, a study on elite Italian volleyball players found that their cortisol and testosterone reference values were higher than those of the general population (39).

In female handball players, cortisol levels have been shown to rise during gameplay (34, 35). Similarly, research on male handball athletes demonstrated significant post-game increases in both testosterone and cortisol levels (40).

Participation in team sports matches elevates cortisol levels due to both physiological and psychological stressors (41). Physiologically, the high-intensity demands of soccer, basketball, volleyball, and handball matches activate the hypothalamic-pituitary-adrenal (HPA) axis, leading to increased cortisol secretion (42-

44). This response is influenced by factors such as hemoconcentration, dehydration, and metabolite accumulation, as well as exercise intensity and training status (42-48). Additionally, cortisol mobilizes energy by raising blood glucose levels to sustain muscular activity, with variations occurring across different menstrual cycle phases (49, 50). Psychologically, the anticipation of competition, match-related stress, and environmental factors — such as temperature, match outcome, and sample timing — can further impact cortisol levels (42, 43, 46, 51). Moreover, cumulative fatigue from back-to-back matches in congested schedules may increase cortisol while reducing testosterone due to energy depletion and physiological stress (52).

Therefore, participating in team sports such as football, basketball, volleyball, and handball influences testosterone and cortisol (as sex hormones) levels in female athletes. However, further research is needed to determine the physiological implications of these hormonal changes.

This systematic review has several limitations. The heterogeneity in sample size, study design, and outcome measures may affect result generalizability. Variations in methodological quality and reliance on secondary data introduce potential biases. Additionally, some relevant studies, particularly unpublished or ongoing research, may have been missed. Future studies with standardized methodologies and diverse populations are essential to enhance the reliability of findings in this field.

5.1. Conclusions

This systematic review indicates that participation in team sports such as football, basketball (netball), volleyball, and handball can lead to fluctuations in testosterone, cortisol, and the testosterone-to-cortisol ratio in female athletes. These hormonal changes may reflect the physiological and psychological stress of training and competition, but their precise impact on performance, recovery, and overall well-being remains unclear.

From a practical standpoint, incorporating hormonal monitoring into training programs can help optimize performance and recovery. Proper nutrition also plays a key role in maintaining hormonal balance, making it essential to align training intensity, recovery, and dietary strategies accordingly. Understanding the interaction between hormonal fluctuations and factors such as training periodization, stress management, and nutrition can help athletes enhance performance while minimizing potential health risks.

Future research should explore hormonal responses across different menstrual cycle phases, as well as their effects on athletes with varying training levels, sports disciplines, and age groups. Longitudinal studies tracking hormonal changes over an entire season, alongside psychological, nutritional, and recovery strategies, would provide deeper insights into these hormonal shifts and their practical applications. Such research could lead to more individualized training and recovery plans that optimize performance while reducing the risk of hormonal imbalances in female athletes.

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Footnotes

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