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PROLACTIN AS A HORMONE RESPONSIVE TO PHYSICAL EXERCISE

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ABSTRACT

Background. Physical exercise is a major physiological stressor that affects the human endocrine system. Among the hormones responsive to physical exertion is prolactin (PRL), known primarily for its role in lactation but also involved in stress regulation, immune function, metabolism, and reproduction.
Aim. This article aims to review current knowledge on the effects of intense physical activity on prolactin levels and the potential consequences for hormonal balance in athletes.
Material and methods. A systematic literature review was conducted using PubMed and Scopus databases. Inclusion criteria were English-language articles with full-text access, including original and review papers analyzing prolactin changes in response to exercise in humans. A total of 183 publications were screened, and those not meeting the methodological or thematic criteria were excluded.
Results. Intense physical exercise, particularly above the anaerobic threshold (e.g., HIIT), causes a sharp and transient increase in prolactin levels, with the response magnitude influenced by exercise intensity, duration, and environmental factors. Regular training may modulate both baseline prolactin levels and acute hormonal responses. Differences based on sex, training status, and menstrual cycle phase were also observed. Prolactin's rise post-exercise may contribute to metabolic adaptation, immune modulation, and recovery processes. However, chronically elevated PRL levels—common in overtrained individuals—can negatively affect reproductive and metabolic health.
Conclusions. Prolactin plays a broader physiological role than previously appreciated. Its exercise-induced elevation reflects the integration of neuroendocrine and immune responses to physical stress. Understanding this hormonal response is essential in optimizing training protocols, supporting recovery, and preventing endocrine dysfunction in athletes.

KEYWORDS

Prolactin, Exercise, Endocrinology, Exercise Endocrinology

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1. Introduction

Physical exercise is one of the primary stimuli influencing the functioning of the human endocrine system. One of the hormones that responds to physiological stress is prolactin—best known for its role in lactation, but also playing a significant part in the regulation of immunity, metabolism, stress, and reproduction. In sports, where the body is frequently exposed to extreme stimuli, changes in prolactin levels may affect overall condition, recovery, and contribute to hormonal disturbances, particularly within the hypothalamic–pituitary–gonadal axis. It has been observed that exercise exceeding the anaerobic threshold—such as high-intensity interval training (HIIT)—induces a marked increase in prolactin levels, surpassing that caused by moderate-intensity aerobic activity [1]. This increase depends on the duration and intensity of the effort, as well as environmental conditions such as elevated body temperature. Moreover, some studies suggest that regular training may influence endocrine adaptation, modifying both baseline prolactin levels and the hormonal response to acute exercise. However, these conclusions are not unequivocal and depend on the training protocol, participants' fitness level, and sex [2].

The aim of this article is to present current knowledge on the effects of intense physical exertion on prolactin concentration and its possible implications for hormonal balance in athletes.

2. Research materials and methods

To develop this literature review, a systematic search of scientific publications was conducted using the PubMed and Scopus databases. The inclusion criteria were: English-language articles, availability of full-text, and article types limited to original research and review papers addressing changes in prolactin levels in response to physical exercise in humans. The search process was based on carefully selected keywords, including: *prolactin*, *prolactin secretion*, *exercise*, *physical activity*, *intense training*, *high-intensity exercise*, *endurance*, and *resistance training*. The initial search yielded a total of 183 publications. The authors independently screened titles, abstracts, and full texts, excluding studies outside the scope of this review, duplicates, and articles not meeting methodological criteria. To broaden the physiological and endocrinological context of the impact of exercise on prolactin levels, older publications considered relevant for a more comprehensive understanding of the topic were also included.

Prolactin and its functions

Prolactin (PRL) is a polypeptide hormone primarily produced by lactotroph cells in the anterior pituitary gland. Its fundamental, classical role is the initiation and maintenance of lactation; however, contemporary research indicates a much broader range of actions, including metabolic, immunological, osmoregulatory functions, and effects on behavior [3, 4].

Since prolactin can also be produced outside the pituitary gland, it is not classified solely as a circulating hormone. It also acts locally—both on the cells that secrete it (autocrine action) and on neighboring cells (paracrine action). In healthy adult women, prolactin levels typically range from 4 to 23 ng/mL, while in men they range from 3 to 15 ng/mL. These values may change under stimuli such as stress, sleep, food intake, sexual activity, and most importantly for the context of this review—intense physical exercise [4].

The most important functions of prolactin include:

- Regulation of lactation and development of the mammary gland,
- Modulation of the immune system (immunostimulatory effects),
- Influence on carbohydrate and lipid metabolism,
- Participation in the control of water-electrolyte balance (osmoregulatory function),
- Impact on neurotransmission and emotional behaviors (e.g., stress responses),
- Regulation of reproductive functions, including inhibition of the hypothalamic–pituitary–gonadal axis in hyperprolactinemic states.

Regulation of prolactin secretion

In the human body, prolactin secretion follows a circadian rhythm — the highest concentrations are observed at night, especially during the REM phase of sleep. The activity of hypothalamic neurons controlling prolactin secretion is influenced by various factors, both external and internal. These neurons can release substances that either stimulate (PRFs) or inhibit (PIFs) prolactin production. Both groups of factors act on lactotroph cells, regulating their activity. Prolactin is released in a pulsatile manner, and its secretion is primarily inhibited by dopamine, which serves as the main inhibitory factor. Dopamine acts by binding to D2 receptors located on the surface of lactotroph cells, leading to a decrease in prolactin secretion and downregulation of the genes responsible for its production. This effect is mediated through various intracellular signaling pathways. Dopaminergic neurons in the hypothalamus that transmit dopamine to the anterior pituitary are themselves regulated via a feedback mechanism — prolactin influences these neurons, limiting its own secretion through a short-loop feedback [6]. Increased prolactin secretion can result from weakened dopamine activity or the action of stimulating substances (PRFs), such as TRH, arginine vasopressin, vasoactive intestinal peptide, oxytocin, estrogens, pituitary adenylate cyclase, endogenous opioids, bradykinin, and substance P [7].

Mechanisms regulating the increase in prolactin secretion after exercise

Physical exercise acts as a specific physiological stressor, leading to activation of the hypothalamic–pituitary axis, which results in increased prolactin secretion.

Intense physical activity also raises cortisol levels, the stress hormone, which can stimulate prolactin release. However, after exercise, cortisol levels may decrease, potentially affecting subsequent changes in prolactin levels. During physical activity, blood prolactin levels typically rise, and the magnitude of this increase appears to depend on exercise intensity. Although the precise intensity threshold that triggers this hormonal response has not been definitively established, exercises exceeding the anaerobic threshold usually provoke a rapid and marked rise in prolactin concentration. Interestingly, in the case of very intense but short-duration exercise, the highest prolactin levels may be observed post-exercise during the recovery phase. Additionally, strong emotional stress can elevate prolactin levels even before exercise begins. During prolonged physical activity, the prolactin response remains steady, proportional to intensity. However, with very extended exercise duration, this hormonal response may progressively intensify [8]. Physical activity may also increase melatonin levels, a hormone regulating circadian sleep-wake rhythms. Melatonin released during sleep can affect the dopaminergic system, which in turn may lead to increased prolactin secretion. Exercise triggers a series of neuroendocrine mechanisms that influence the immune system, partly through increased hormone concentrations such as prolactin. Although prolactin's effects on immune cells are known, these require the presence of appropriate receptors on the cell surface. Few studies have examined how exercise-induced stress affects prolactin receptor expression in leukocytes. However, animal research suggests that elevated prolactin levels may lead to an increase in receptor numbers in various tissues. Based on this, it has been hypothesized that intense aerobic exercise could stimulate prolactin receptor expression in immune cells, which might explain the immunomodulatory effects of this hormone in the context of physical activity.

Intense physical exercise and prolactin levels

Intense anaerobic exercise, such as high-intensity interval training (HIIT), elicits a much stronger prolactin response than moderate, steady-state aerobic exercise. The effect of resistance or strength training on prolactin levels is poorly studied; however, some research suggests that prolactin levels may increase after such activity, during the recovery phase [9].

This sudden rise in prolactin reflects the neuroendocrine responses of the body to stress caused by physical exertion and the increased metabolic demands during intense training. Changes in prolactin concentration after HIIT demonstrate the complex interplay between exercise intensity, activation of the hypothalamic-pituitary axis, and hormonal regulation. This is significant for improving performance, recovery processes, and maintaining hormonal balance in the body [10]. Numerous studies have shown that intense, even short-term physical exercise causes a rapid, transient increase in prolactin levels. In a study by Hackney et al., results showed that prolactin levels significantly increase at night after physical exercise. This is caused by several factors. Prolactin has a natural circadian rhythm—its levels physiologically increase at night, especially during sleep (particularly in the REM phase). Physical exercise can"amplify" this natural nocturnal surge, e.g., by stimulating the pituitary gland and the hypothalamic–pituitary axis. Training, especially intense training, acts as a stress stimulus, triggering the release of dopamine, cortisol, and endorphins. These changes may delay the hormonal system's response, so prolactin does not increase immediately but only later—e.g., during nighttime recovery.

Body temperature increase and its subsequent decrease also affect the hormonal system. Some studies suggest that prolonged elevation of temperature after training may shift the peak of prolactin release [11].

In a systematic review by Hackney et al., published in *Sports Medicine*, attention was drawn to rising prolactin levels in response to physical activity in postmenopausal women. Particular focus was placed on prolactin changes in response to exercise of various types and intensities. Results indicate that acute, intense physical exercise causes a noticeable, though short-lived, increase in blood prolactin levels. The conclusion is that the greater the intensity and duration of exercise, the higher the peak prolactin concentration observed post-exercise. The increase usually lasts 15–60 minutes after activity [12]. Let us also consider a study by De Souza. The study involved groups of eumenorrheic (normal menstrual cycle) and amenorrheic (absence of menstruation) runners, analyzing their hormonal response (ACTH, cortisol, prolactin) to submaximal exercise (40 minutes at ~80% VO_2max) and maximal exercise. Before exercise, prolactin levels were lower in the amenorrheic group (~10 µg/L) compared to eumenorrheic women (~16.4 µg/L). After maximal (and submaximal) exercise, prolactin increased markedly in women with regular cycles (eumenorrheic), but the response was significantly blunted in amenorrheic women—despite similar blood lactate levels (~11.4 mmol/L).

The results suggest that the menstrual cycle phase is important when analyzing prolactin response to exercise—in eumenorrheic women, the phase does not alter ACTH and cortisol results but may affect prolactin. Activation of the adrenal glands (ACTH, cortisol) correlates with prolactin response—amenorrheic women showed a weakened reaction. Amenorrheic runners exhibit lower resting prolactin levels and a weaker response after exercise, possibly indicating neuroendocrine adaptation associated with chronic stress and HPA/HPO axis disturbances. Prolactin response to exercise may be partially dependent on adrenal function—reduced adrenal activity correlates with a smaller prolactin surge [13].

Moderate exercise

Moderate physical exercise, especially of an aerobic nature, performed regularly and at moderate intensity, does not cause a significant increase in plasma prolactin concentration [14]. The lack of a pronounced hormonal effect may result from neuroendocrine adaptation at the hypothalamic-pituitary level. In individuals who regularly engage in sports, certain adaptive mechanisms operate, which may cause prolactin levels to increase moderately rather than sharply despite intense exertion. These are physically active individuals who have improved their aerobic capacity. In women, the body effectively regulates this hormonal response to prevent negative effects of excessive prolactin elevation, such as impacts on reproductive functions and metabolism [15].

In a pilot study conducted by Dey et al. in 2014, the effect of regular physical activity in the form of daily yoga exercises on prolactin secretion levels was evaluated in two healthy 29-year-old women. The training program lasted eight weeks and included daily sessions of one hour each. After completing the intervention, a significant increase in serum prolactin levels was recorded—on average by over 200%. The results suggested that regular physical activity, especially of a relaxing and rhythmic nature (such as yoga), may stimulate the hypothalamic–pituitary axis and substantially increase prolactin secretion [16].

Table 1. The effect of different exercise intensities on prolactin levels

Type of Exercise	Intensity	Prolactin Response	Duration of Effect
Moderate (aerobic)	Below anaerobic threshold	Usually no significant increase; possible decrease with improved fitness	Short-term or no significant changes
Intense (>80% VO_2max)	Above anaerobic threshold	Marked, sharp increase (e.g., 200–230% rise)	Lasts 15–60 minutes post-exercise
Steady-state interval (HIIT)	Very high	Strong and immediate prolactin spike	Peak right after exercise, short duration
Variable-intensity interval	Variable	Slight, sometimes temporary decrease or no clear increase	Very short duration, atypical response

Table 2. Summary of research on the effects of exercise on prolactin levels.

Author (Year)	Type of Exercise	Population	Prolactin Response	Duration of Effect
Hackney et al. (2015)	Endurance cycling (ergometer)	Trained men	Nocturnal prolactin rise (+100–150%) after daytime training	Peak during night, normal by morning
Brisson et al. (1980)	30 min at 75% VO_2max (cycling)	Active vs. inactive women	+103% in trained, no increase in untrained	Immediate peak, decline within 30–60 min
De Souza et al. (1991)	Submax & max (40 min run)	Eumenorrheic vs. amenorrheic women	Marked increase in eumenorrheic; blunted in amenorrheic	Up to 1 hour post-exercise
Dey et al. (2014)	Yoga (1 h daily, 8 weeks)	Two healthy women (29 y.o.)	Over 200% increase after 8-week program	Chronic adaptation after training period
Moore et al. (2002)	Intense ergometer test	Men	Increased prolactin receptor expression on lymphocytes	Lasts several hours
Sylta et al. (2017)	HIIT (12-week protocol)	Well-trained cyclists	Prolactin not measured; rise in other hormones	—
Hackney et al. (2017)	Systematic review	Postmenopausal women	Intense bouts → short-term prolactin spike (~200%)	Typically 15–60 min post-exercise
Rojas Vega et al. (2012)	Review of various types	Men and women	HIIT: strong increase; Moderate aerobic: minimal or no change	Intensity-dependent

VO_2max – maximal oxygen uptake, used to express exercise intensity.

PRL (prolactin) – level expressed as the percentage change relative to the baseline value.

Studies indicate that exercise intensity and training status have the greatest impact on the hormonal response.

Some studies (e.g., Sylta 2017) did not measure PRL directly; however, their results can be indirectly related to hormonal patterns observed in other research.

Physiological significance of prolactin changes after exercise

1. **Regulation of the stress axis and metabolic adaptation**
2. Prolactin responds to physical stress by activating the hypothalamic–pituitary–adrenal (HPA) axis, working together with cortisol and ACTH. This enables better metabolic adaptation to exercise—for example, by supporting energy mobilization and maintaining internal homeostasis during intense physical load [17].
3. **Support of regeneration and immune response**
4. Studies have shown that prolactin increases the expression of its receptors on lymphocytes, suggesting its involvement in immune system activation after exercise. Few studies have analyzed how exercise-induced stress affects prolactin receptor expression in leukocytes. Animal research suggests that elevated prolactin levels may lead to an increased number of its receptors in various tissues. Based on this, it is hypothesized that intense aerobic exercise can stimulate prolactin receptor expression in immune cells, which could explain the immunomodulatory effects of this hormone in the context of physical activity. This may stimulate and influence regenerative processes, tissue healing, and act either anti-inflammatory or pro-inflammatory depending on physiological needs [18, 19].
5. **Thermoregulation and heat stress control**
6. The increase in prolactin correlates with the rise in body temperature during exercise. Research indicates this is a response mechanism to heat stress, potentially supporting the body's adaptation to fluid loss and changing environmental conditions [2].
7. **Neuroplasticity and nervous system protection**
8. There is evidence that prolactin may play a role in neurogenesis and protection of the central nervous system—by supporting the growth and differentiation of nerve cells. Its increase after exercise might therefore support central nervous system adaptation.
9. **Signaling adaptation to training load**
10. Repeated, chronic increases in prolactin levels may act as a marker of physiological load—elevated levels can signal excessive training stress or insufficient recovery. This has implications in the diagnosis of overtraining syndrome [17].

Effects of chronic prolactin elevation

Chronic and intense training may lead to sustained elevated prolactin levels, which can disrupt reproductive functions by inhibiting GnRH release and subsequently lowering LH, FSH, and sex hormone levels. In women, this can cause menstrual cycle disturbances, anovulatory cycles, or secondary amenorrhea; in men, it can result in reduced testosterone levels, decreased libido, and fertility issues. In both cases, decreased bone mineral density and metabolic disorders may also occur [9]. Elevated prolactin can affect metabolism, leading to insulin resistance, weight gain, and lipid abnormalities. Moreover, hyperprolactinemia may increase the risk of metabolic syndrome. It is also associated with symptoms of depression, anxiety, and cognitive disorders. High prolactin levels may influence the dopaminergic system, resulting in mood changes and cognitive impairments [20].

Conclusions

In summary, prolactin plays several important roles beyond lactation, and its dynamic response to physical activity reflects its significance in the body's adaptation to stress. The increase in prolactin during intense training is not accidental—it reflects the integration of the hormonal, nervous, and immune systems in response to exercise. This response may have a protective character, preparing the body for metabolic, physical, and immunological stress.

At the same time, individual hormonal sensitivity to load—depending on factors such as sex, training status, and exercise type—suggests the need for a more precise approach to training planning and biological response assessment. Persistent disturbances in hormonal axes related to chronic prolactin elevation may pose a silent threat to athletes' health—both physiologically and psychologically. Therefore, understanding the mechanisms of prolactin response to exercise, its role in homeostasis regulation, and the potential consequences of long-term deviations should be applied in training practice, especially concerning overtraining prevention, recovery support, and endocrine health protection.

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