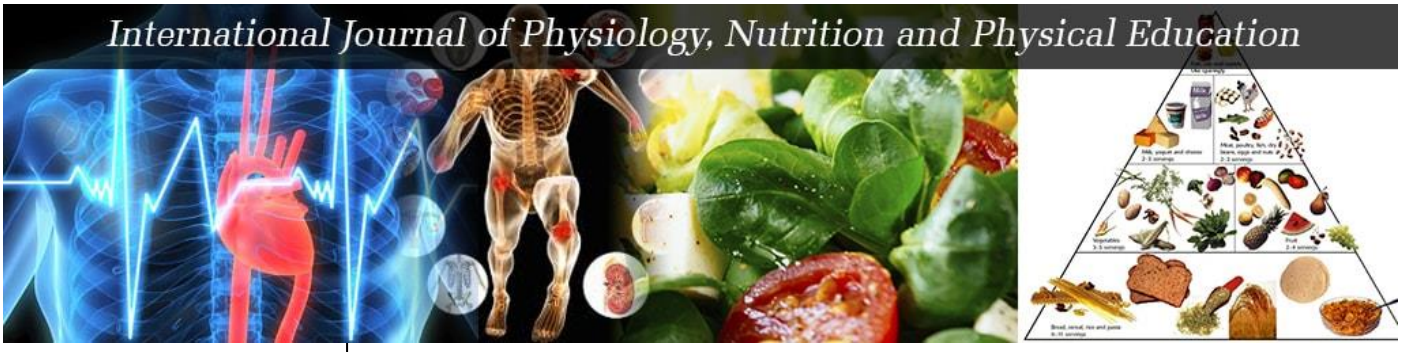

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Stress hormones and sports performance: A critical analysis

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Abstract
Background: In sports event stress is performing in a form of acute or episodic in response of pre competition or post competition match. The hormonal imbalance is the influencing factor for acquiring stress in sports performance.
Aim: To review scientific literatures related to stress hormones and sports performance.
Method: Researchers collected scientific evidences through electronic databases; Pubmed, Embase, Medline, Google Scholar, Google Advance Search, PsycINFO, ROAJ, DOAJR, Web of Science and critically analyzed all the entire relevant article according to the nature of this study.
Findings: It was observed that there are some results in stress hormone on volleyball players. Most of the research are related with cortisol hormone and identified most popular stress hormone. But there are contraindications among the researchers. Another widely studied stress hormone is catecholamine and volleyball performance.
Conclusions: A certain level of stress is needed for optimal performance. Too little stress expresses itself in feelings of boredom and not being challenged. Competitive stress does not necessarily impair performance and can in certain circumstances enhance it. Optimum level of stress one gets the benefits of alertness and activation that improves performance.

Keywords: Stress, stress hormones, HPA axis, sports performance, volleyball

1. Introduction
Physical activity and physical exercise are beneficial most of the time; it can also be seen as a "stress factor" in men and women sports performance. In general physical stress can be classified as acute or chronic, and stress hormones can be used to assess the metabolic alterations caused by exercise [Mastorakos *et al*. 2005] [10]. A sports match represents a very intensive form of exercise which is form of physical stressor. It can lead to activation of the hypothalamo-pituitary-adrenal (HPA) axis and the sympathetic nervous system, thus inducing changes in the concentration of different hormones [Dmitrasinovi *et al*, 2016] [39]. Activation of HPA axis stimulates cortisol release from the adrenal glands, and through its influence on the hypothalamus, stimulating the release of adrenocorticotropic hormone (ACTH) from the anterior pituitary gland [Gleeson, 2007] [38]. Prolonged intensive exercise can induce the body's specific inflammatory response followed by transitory leukocytosis and change in the leukocytes differential count [Lippi *et al*. 2010] [37]. The interpretation of a situation as being stressful leads to the activation of the hypothalamic-pituitary-adrenal (HPA) axis, and ultimate secretion of cortisol and catecholamines in humans. The end products of HPA activation (cortisol and catecholamines) are easily measurable in blood, urine and saliva [Lupien SJ. 2013] [7].
Stress as a process which containing four stages. First, the individual and placed a demand that can be physical or psychological, second stage is the perception regarding to the demand which is different for each individual. Third step is response occurs as demand lodged and the last stage is behavior of individual the stress caused by this process [Weinberg and Gould 2001] [2]. In women, the chronic hypercortisolism was found to be associated with isolated exercise-induced amenorrhea [Drinkwater *et al*. 1986] [11].
The stressful situation is interpreted and it triggers the activation of the hypothalamic-pituitary-adrenal (HPA) axis. Thereby neurons in the hypothalamus releases a hormone called corticotropin-releasing hormone (CRH).

The release of CRH triggers the subsequent secretion and release of another hormone called adrenocorticotropin (ACTH) from the pituitary gland, also located in the brain. When ACTH is secreted by the pituitary gland, it travels in the blood and reaches the adrenal glands, which are located above the kidneys and triggers secretion of the so-called stress hormones. The acute secretion of glucocorticoids and catecholamines constitutes the primary mediators in the chain of hormonal events triggered in response to stress. When these two hormones are secreted in response to stress, they act on the body to give rise to the fight-or-flight response whereby one would, for instance, experience an increase in heart rate and blood pressure.

Volleyball is an extremely dynamic sports that requires motor skill, precision, different combinations of moves, quick thinking and featuring a set of requirements that can generate very stressful situations [Bueno and Di Bonifacio, 2007] [3]. In high-level volleyball competition, players often have to deal with tuff situations that cause physiological as well as bio-chemical stress [Noce and Samulski, 2002] [5]. Nascimento Jr. *et al*. (2014) [4] emphasize that women and Liberos are more susceptible to pre-competitive psychological stress. Morgan *et al*. (1987) [6] stated that the stress is a multi-factor phenomenon that entails inter communication and affects the psychological, physiological and biochemical performance of theathletes (Figure 1)

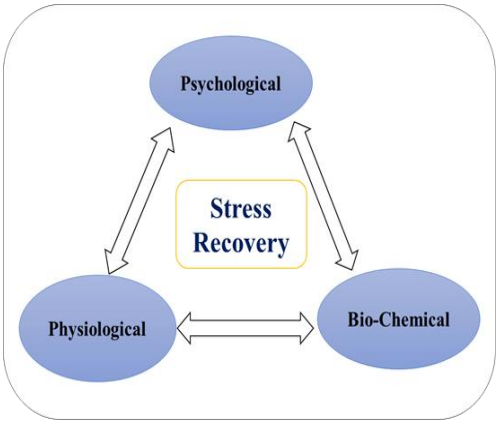

Fig 1: Three-dimensional system of stress (Morgan *et al*. 1987) [6].

2. Aim of the Study

The specific aim of this systematic review study was to explore the impact of stress hormones on sports performance.

3. Methods

3.1 Acquisition of Evidence

In this systematic review study a thorough online searching procedure was applied for acquisition of evidence. The electronic databases: PubMed, Embase, Medline, Google Scholar, Google Advance Search, PsycINFO, ROAJ, DOAJR and Web of Science were carefully searched for the purpose of reviewing the literatures.

3.2 Inclusion and Exclusion Criteria

Studies related to the objective of this paper were included in this project whereas studies which were not directly matched with the concept of analysis were excluded from the process. Inclusion criteria were included with the areas of stress hormones, stress hormones and sports performance, stress hormones and volleyball performance.

3.3 Selection Procedure of Review Articles

In the first attempt, a total 207 article with full text were assessed on the basis of eligibility criteria. Out of which only 86 papers were fulfill the objective of this study. Searches were limited to the years 1990 to 2017. The final databases searches were conducted on November 2017. Eligibility of articles was assessed on the basis of eligibility criteria first at the level of the title, abstract, source and then the full text article. Detail selection procedure adopted for this study is presented in the Figure-2.

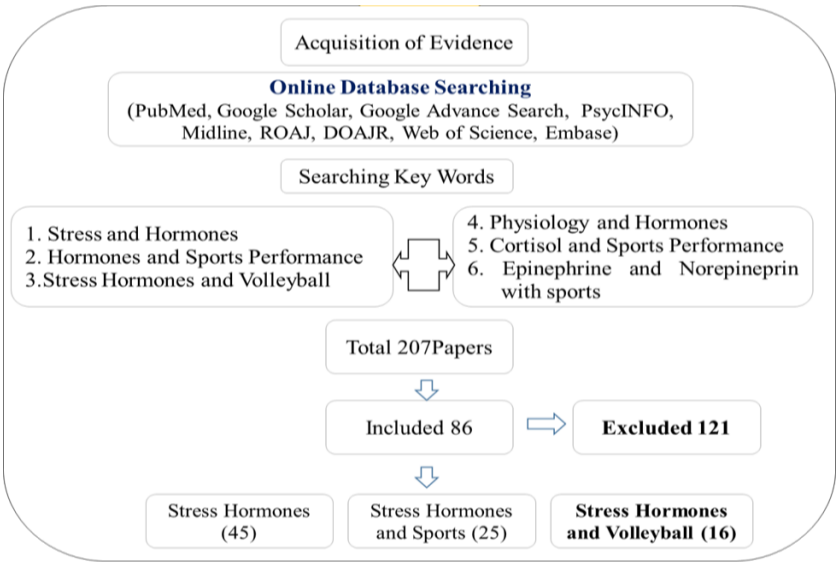

Fig 2

4. Impact of stress hormones

Cortisol is an important steroid hormone produced in the adrenal cortex layer band [Acevedo *et al*. 2007] [25]. This hormone mediates training adaptations and is usually regarded as the primary catabolic hormone, because it decreases protein synthesis and increases protein breakdown [Crewther *et al*. 2006] [26]. Cortisol secretion is regulated by the hypothalamic-pituitary-adrenal axis [Eskandari and Sternberg, 2002] [27] and depends on the circadian rhythm with maximal concentration early in the morning decreasing during the day [Kanaley *et al*. 2008] [28]. Studied investigated the effect of immobilization stress (immobilization of 3 hours) on testicular steroidogenesis found an 82% reduction in testosterone levels and significantly elevated levels of plasma cortico sterone [Orr *et al*. 1994]. [20]

5. Impact of stress hormones on sports performance

Cortisol is a marker of exercise recovery in competitive sports. Chronic stress prolongs the recovery process, which may potentially widen a window of susceptibility for illness and injury among competitive athletes [Perna and McDowell, 1995] [8]. Cortisol plays an important role in tissue remodeling in response to exercise [Kraemer and Ratamess, 2005] [29]. Cortisol enables as a strong anti-inflammatory compound and takes part in control energetic metabolism by the functions of motor cortex [Mulla *et al*. 2005] [30]. The level of cortisol in saliva reflects the level of serum free cortisol in the blood, and thus may be an indicator of the body's adrenocortical response to exercise [Rantonen *et al*. 2000] [31]. Allgrove *et al*. (2008) [32] showed that the concentration of salivary cortisol immediately after exercise did not change in compared to baseline levels. On the other hand, Crewther *et al*. (2013) [33] studying on rugby players during six-week training program and focused on endurance loads with parallel training work-outs integrating agility, speed, and improving cardiovascular fitness, reported no significant differences in any of cortisol concentrations in saliva. Tsai *et al*. (2012) [34] examined that significant increase of serum cortisol concentration in the training stages compared to the two week recovery stage among elite male weightlifters. Cortisol affects metabolism by contributing to the maintenance of blood glucose levels during exercise. Cortisol does this by acting on the skeletal muscle and the adipose tissue to increase the mobilization of amino acids and lipids as well as by stimulating gluconeogenesis [Wolfe, 2001] [12]. While cortisol levels increase during exercise, most of the changes and effects of this hormone occur during the early recovery period after the exercise bout [Hackney and Viru, 1999] [13]. Cortisol, testosterone levels increases linearly in response to physical exercise until a specific threshold of exercise intensity is reached, with peak concentrations generally occurring at the end of physical activity [Wilkerson, 1980] [19]. Ahtiainen *et al*. (2003) [24] found a significant correlation between the increase of testosterone and cortisole hormone caused by physical training and the muscle cross-sectional area. Athletic and artistic events are naturalistic stressors that have been recognized to elicit dramatic changes in cortisol secretion [Eubank *et al*. 1997] [41]. Competition events have been shown to increase stress, reflected by higher cortisol levels [Moreira *et al*. 2013] [44]. Filaire *et al*. (2001) [43] reported salivary cortisol increased during a major competition in judo with a similar response reported for volleyball and basketball players prior to a significant match. Mazdarani *et al*. (2016) [48] reported that official basketball competition increases cortisol concentrations. Khodami *et al*. (2014) [51] report suggests intense exercise training increased cortisol level which effects on the immune system. Cortisol levels were higher after evening exercise in comparison to morning exercise and recovery period after evening exercise is faster [Erdemir *et al*. 2013] [47]. HPA axis activation during exercise associate stimulation of hypothalamic corticotropin-releasing hormone (CRH) and arginin-vasopressin (AVP) secretion and release of ACTH from pituitary corticotroph cells preceding the increase of cortisol [Smoak *et al*. 1991] [49]. Aerobic exercise increased the levels of ACTH as approximately 36% in post-exercise immediate period [Karacabey *et al*. 2005] [50]. Schmikli *et al*. (2017) [9] studied reported that resting ACTH levels after maximal exercise were reduced.

The vasopressin (AVP) and the corticotropin-releasing hormone (CRH) neurons in the paraventricular nucleus of the hypothalamus (PVN) and the locus ceruleus (LC) norepinephrine (NE)-sympathetic system neurons in the brainstem are the central commanders of this stress system [Mastorakos, 2005] [10]. Increase in plasma lactate and humoral mediators such as interleukins and angiotensin that have been implicated in the activation of the HPA axis during intense physical exercise [Wittert G. (2000)] [14]. The beta-endorphins factors released into the circulation during intense exercise, influence the hypothalamic functions, including the regulation of reproduction via their inhibitory effect on GnRH release [Speroff, 1989] [15]. The endogenous opioids (beta-endorphin) and ACTH are derived from proopiomelanocortin (POMC) and corticotropin releasing hormone (CRH) stimulates the secretion of these factors. CRH such as opioids inhibits the hypothalamic-pituitary-gonadal axis, and physical stress stimulates the release of these factors [Torpy, 1998] [17]. Catecholamines, acting through both alpha- and beta-adrenergic (norepinephrine and epinephrine) receptors, are potent physiological stimulators of testosterone production [Mayerhofer *et al*. 1992] [18]. In a study that evaluated the hormonal responses of a group of professionals and amateur male runners during endurance training, it was observed that there was an increase in cortisol two days before the marathon only in the group of amateur runners, whereas anabolic effects were observed in professionals [Bobbert, 2012] [21]. This might be due to better physical conditioning, which may be associated with reduced pituitary-adrenal activation in response to the training volume [Luger, 1987] [22]. Similarly to that in chronic users of glucocorticoids, an investigation of the effects of chronic hypercortisolism in highly trained athletes revealed down regulation of the alpha isoform of the glucocorticoid receptor in peripheral blood mononuclear cells [Bonifazi, 2009] [23]. Mediation practice increases the construction of hormones i.e. HGH (human growth hormone), cortisone, melatonin and serotonin etc in the body and these assists the encouraging effect on sporting performances [Dhayal 2015] [40].

6. Impact of stress hormones on Volleyball performance

Li *et al*. (2012) [35] demonstrated that the salivary cortisol concentrations and the ratio of cortisol/total protein in volleyball players were markedly higher compared with control groups. Prolonged strenuous training may elicit a sustained stress and induce a suppressive effect on mucosal immunity in regularly and intensively trained adolescent athletes. Cortisol level increased significantly and adrenocortical changes influenced during volleyball competition, where as no changes were observed in androgen levels [Filaire *et al*. 1999] [52]. Salivary cortisol concentration will increase more drastically in losers compared to winners

in amateur players during a volleyball match [Ebrahimpour *et al*. 2011] [53]. The quantification of plasma concentration of endogenous stress markers reduces in the levels of total catecholamines, noradrenaline and cortisol. These changes were accompanied by increases in the concentration of free testosterone and in the testosterone/cortisol ratio Practice of Volleyball and Tennis match positively increased the salivary level of cortisol during inter collegiate competition [Edwards *et al*. 2010] [5]. The routine morning training session comprising a warm-up followed by volleyball practice seems to activate the sympatho-adrenal-medullary system, with a subsequent increase of alpha-amylase, but does not affect oral immunity in 14-18-year-old boys [Bruzda *et al*. 2017] [56].

7. Conclusions

A certain level of stress is needed for optimal performance. Too little stress expresses itself in feelings of boredom and not being challenged. Competitive stress does not necessarily impair performance and can in certain circumstances enhance it. At an optimum level of stress one gets the benefits of alertness and activation that improves performance.

8. Acknowledgement

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9. Limitation of the Study

The main considering factors in this critical analysis were limited procedure of searching browsers, small ranged of full text article boundary. Future research is more emphasis on specific sports performance with influence stress hormonal secretion.

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