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Original Research Articles

Analysis of Cortisol Concentration Changes Induced by Stress in Kickboxing K1 Competition

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Abstract

Background: Kickboxing is a sport that imposes significant physical and psychological stress on athletes, often pushing them to the limits of their physical endurance and mental resilience. This study focuses on analyzing changes in cortisol concentration, a key stress hormone synthesized in response to stress caused by physical and mental effort during kickboxing competitions in the K1 format. **Methods:** The study was conducted on 20 kickboxing athletes following K1 rules, in accordance with the Helsinki Declaration and the approval of the ethical committee. Cortisol concentration levels were measured before and after fights, and statistical analyses were performed using PQ Stat software to compare pre- and post-fight levels. **Results:** The results indicate a significant increase in cortisol concentration levels after the fight, suggesting a strong impact of kickboxing training on cortisol levels. This may indicate the body's natural response to intense physical effort, highlighting the role of cortisol in energy mobilization and adaptation to increased training demands.
Conclusions: Monitoring of steroid hormones - cortisol seems to be essential in coaching practice, and understanding these responses allows athletes to optimize their preparations for competitions.

Keywords: Kickboxing, Cortisol, Stress Response, Physical Stress, Psychological Stress

Introduction

Kickboxing fights generate high physical and psychological stress, often pushing the boundaries of physical fitness and mental endurance (1,2). Kickboxing is not merely a sport, but also a profound study of the dynamics of human stress and resilience (3). A key element of this research is cortisol, a steroid hormone crucial in the body's response to stress, which also plays significant roles in various bodily functions, including the regulation of blood sugar levels, metabolism, inflammation, and memory formation (4–6). In a broad research perspective, various studies are conducted during kickboxing fights in the field of hormonal changes and physiological analyses, and more recently, neurophysiological analyses (7–11). Cortisol measurements have often been performed in combat sports, with such practices taking place in judo (6,12,13), boxing (14), and various kickboxing competition formats (3).

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Kickboxing in the K1 format, characterized by rigorous physical requirements and acute fight stress, presents an ideal scenario for studying the role of cortisol in the body's response to acute stress and physical effort. Stress during a fight is a complex phenomenon, involving both physical and psychological aspects. The fight poses unique challenges to the fighter, activating the body's defense mechanisms, putting it into a state of heightened readiness for action (15–18).

Previous studies have emphasized the impact of various forms of exercise on cortisol levels (6,19–22), yet there remains a gap in understanding how combat sports like kickboxing in the K1 format specifically affect these dynamics. This article aims to fill this gap by investigating changes in cortisol concentration among kickboxing athletes during fights under K1 rules, thus providing insight into the acute stress response induced by this demanding sport.

This study not only contributes to the development of sports sciences but also offers valuable implications for stress management, sports training, and our understanding of the body's resilience mechanisms.

Material and Methods

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the Regional Medical Board in Kraków (approval No. 287/KBL/OIL/2020).

Study Design

The detailed study design is presented in Figure 1.

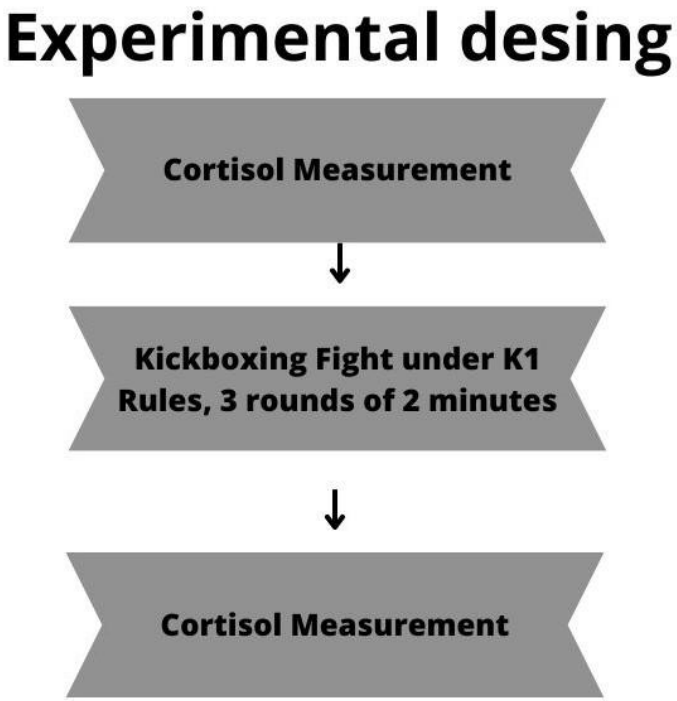

Figure 1. Experimental Desing

Participants

The study was conducted on a group of 20 kickboxing athletes specializing in K1 rules fights. The sample size was calculated using G*Power software, assuming a significance level of 5%, statistical power at 80%, and aiming for 95% confidence intervals. The participants had an average age of 25.55 ± 3.46 years, body mass of 78.6 ± 7.68 kg, and body height of 176.89 ± 4.43 cm. Selection of athletes for the study was based on specific inclusion and exclusion criteria (Table 1).

Table 1. Inclusion and Exclusion Criteria for Participation in the Study

Inclusion Criteria	Exclusion Criteria
Minimum of 5 years of training experience	Presence of chronic diseases affecting training capacity
Good health condition	Use of doping substances
Positive recommendation from a coach	Lack of consent to participate in the study
Minimum of 4 competition starts per year	Presence of injuries preventing participation in training and competitions
Consent to participate in the study	Less than 5 years of training experience

K1 Fight

The kickboxing fight under K1 rules took place in a ring with internal dimensions of 6x6 meters, lasting 3 rounds of 2 minutes each, with 1-minute breaks between rounds. Competitors competed according to the rules of the World Association of Kickboxing Organizations (WAKO) (1), equipped with 10 Oz gloves, protective helmets, and shin and foot guards. The entire match was supervised by a ring referee.

Cortisol Measurement

Cortisol concentration was measured by a qualified diagnostician. Blood was drawn from the antecubital vein. The drawing procedure took place under controlled conditions in the morning to minimize the impact of natural fluctuations in cortisol levels throughout the day. The first blood sample was taken before the kickboxing fight to establish a baseline level of cortisol. The second sample was taken immediately after the fight. Serum cortisol levels were determined using the enzyme-linked immunosorbent assay (ELISA) technique.

Statistical Analysis Methods

Statistical analysis of the collected data was performed using PQ Stat software version 1.8.4. Basic descriptive statistics were calculated: arithmetic mean, standard deviation, minimum value, maximum value. A one-way analysis of variance (ANOVA) for dependent groups was used to compare cortisol levels before and after the fight. Before choosing the test, the conformity of variable distributions was checked using the Shapiro-Wilk test, and the homogeneity of variances was confirmed with the Levene's test. The effect size was represented by the Eta2 value. A p-value of <0.05 was considered statistically significant.

Results

Before the kickboxing fight, the average cortisol level in the study group was 11.95 ug/dl, with a standard deviation of 2.64 ug/dl. The range of cortisol values (min-max) before the fight varied from 5.3 ug/dl to 17.5 ug/dl. After the K1 fight, the average cortisol level increased to 17.8 ug/dl, with a standard deviation of 2.79 ug/dl. The range of cortisol values after the fight also increased, reaching from 8.8 ug/dl to 21.8 ug/dl. These results indicate a significant increase in cortisol levels after the kickboxing fight, as confirmed by an F statistic value of 207.10 and a p-value of <0.001, indicating a statistically significant difference. The effect size (ES) was 0.91, suggesting a strong effect of the kickboxing fight on cortisol concentration levels (Table 2, Figure 2).

Table 2. Cortisol Measurement Results Before and After the K1 Kickboxing Fight

Cortisol (ug/dl)	X	SD	Min	Max	F	p	ES
Before	11.95	2.64	5.3	17.5	207.10	<0.001	0.91
After	17.8	2.79	8.8	21.8			

X- Mean, SD- Standard Deviation, Min-minimum, Max-maximum, p- p-value, ES- Effect Size

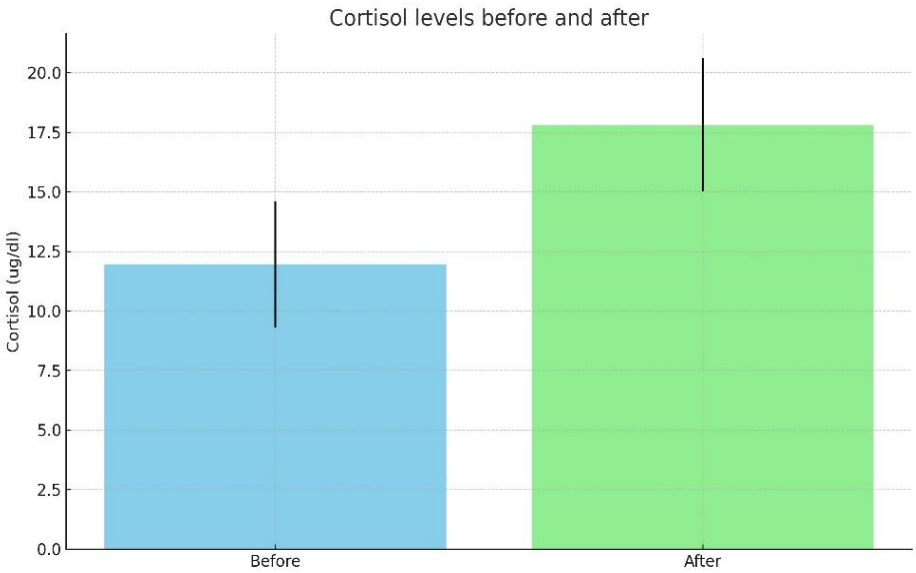

Figure 2. Cortisol Concentration Before and After the Kickboxing Fight

Discussion

Cortisol levels are conditioned by the circadian rhythm, which is under the control of the central nervous system, with its highest concentration in the blood noted in the morning hours and the lowest during nighttime. Cortisol affects the metabolism of carbohydrates, proteins, and fats in the body (13). During physical exertion, it plays a crucial role in regulating exercise metabolism. Alongside hormones such as insulin, glucagon, adrenaline, and growth hormone, cortisol participates in metabolic processes and can also affect protein metabolism, hence it is attributed a catabolic action. It is a stressogenic hormone, whose concentration can increase as a result of physical effort, physical training, pre-competition states, or an increase in internal temperature. Physical effort at an intensity of about 80%VO2max causes an increase in cortisol concentration, and an intensity of about 60% VO2max is considered the threshold intensity for its stimulation (24).

However, it should be emphasized that short-term or pulsatile efforts modify the increase in cortisol concentration to a lesser extent than aerobic work, but the adrenal response to anaerobic effort is much more pronounced than in the case of aerobic exercises. The synthesis of cortisol after a single effort or series of efforts, as occurs in judo tournament fights, is a diagnostic indicator informing about the judoka's ability to tolerate endurance-oriented loads (13).

Cortisol concentration is often used as a criterion for the adrenal cortex's reaction to maximal physical efforts. It's noteworthy that post-exercise cortisol concentration can be either positive or negative. Among rowers, no changes in cortisol levels were observed after exercise on a hand ergometer, while tennis players showed minor changes, and sprinters showed an increase in cortisol concentration after physical effort. This reaction is caused by specific physical effort, in which cortisol's response to anaerobic efforts is higher than in other athletes.

The results of conducted studies provide significant evidence of an increase in cortisol concentration after intense kickboxing fights, which is consistent with expectations regarding the body's response to physical and psychological stress, confirmed in literature (25,26). Also, in other combat sports such as judo, a significant increase in cortisol concentration was observed, which aligns with the obtained results (13). Cortisol, often called the "stress hormone," plays a key role in the body's response to stress, mobilizing energy resources, which is essential in situations requiring a quick physical reaction (27). The increase in cortisol level after a K1 fight can be interpreted as an adaptive response of the body, enabling better coping with intense effort (27). However, prolonged elevated levels of cortisol can have negative health effects, including weakening the immune system, increasing the risk of cardiovascular diseases, and metabolic disorders (28). Therefore, understanding the mechanisms underlying these changes and developing stress management and recovery optimization strategies for athletes is crucial to minimize potential negative effects. The stress experienced during sports competition is a complex phenomenon that can significantly affect cortisol levels, mainly due to the combination of physical and psychological stress. The fight requires a high level of vigilance, quick decision-making, and adaptation to pain and fatigue, which increases stress levels (29). This increased stress activates the hypothalamic-pituitary-adrenal (HPA) axis, leading to increased cortisol production (30).

Competition conditions and fighting in the ring can cause a higher cortisol concentration level than training fights due to high expectations, the presence of an audience, the pressure to succeed, competition, and the official nature of the events may additionally introduce an element of psychological stress (31).

Psychological stress, combined with the physical stressor of the fight itself, intensifies the body's response, leading to increased HPA axis activation and higher cortisol production than during training, where conditions are less stressful and more controlled. Additionally, K1 rules fighting presents the most contact-intensive form of combat among all kickboxing competition formats (32). This aspect means that the exchange of strikes is intense and the sensation of receiving blows painful, which may further elevate the stress level for the fighter. However, further observations and analyses are required to more precisely verify the occurring changes.

Limitations of the Study

The main limitation of the study was the absence of a control group that would perform the fight under standard training conditions. The study does not consider the subjective perception of stress by participants, which may vary independently from objective cortisol measurements. Focusing solely on cortisol level may not fully reflect the body's stress response, omitting other stress biomarkers.

Conclusions

Intense physical and psychological stress associated with the fight causes a significant increase in cortisol levels in athletes' bodies. This increase is interpreted as a natural adaptive response to stress. However, prolonged exposure to high levels of cortisol can have negative health consequences, highlighting the need for further research on stress management and recovery in combat sports. Monitoring steroid hormones - cortisol seems to be essential in coaching practice, and understanding these responses allows athletes to optimize their preparations for competitions.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: All data are included in the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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