



The effect of competition load in terms of the CK enzyme and cortisol hormone indicators related to overtraining syndrome among professional football players: an analytical study

El efecto de la carga competitiva en términos de los indicadores de la enzima CK y la hormona cortisol relacionados con el síndrome de sobreentrenamiento en jugadores de fútbol profesional: un estudio analítico

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Abstract

Objective: The research aimed to conduct a comprehensive analysis by evaluating the system of biochemical, physical variables as multiple images to diagnose the stages of Overtraining Syndrome (OTS) for Iraqi Professional League football players for the (2023-2024) season.

Research methodology: Used a descriptive survey methodology to analyze and track the balance of adaptation mechanisms (effort exerted and adequate recovery). Physical demands were measured during matches, and athletes were measured biochemical immediately after the effort of the match, as well as after 72 hours of rest, to identify and analyze the kinetics of biochemical indicators and the sequential changes occurring throughout a full season.

Results: The hormonal system's ability to maintain its balance even when the muscular and nervous systems are under stress means that relying solely on the hormonal system may not provide a complete picture of the syndrome. In other words, the absence of obvious hormonal changes does not necessarily mean that athletes are not experiencing overtraining syndrome; it may simply indicate the body's ability to recover hormonally. The accumulation of stress causes an imbalance that first manifests in the indicators of muscular and nervous recovery mechanisms, making these indicators more sensitive in the early detection of overtraining syndrome and its stages from a hormonal perspective.

Conclusions: The research concluded that Overeffort Syndrome (OTS) is not merely a hormonal imbalance but a genuine problem in physiological adaptation mechanisms.

Keywords

Competition load; CK enzyme; cortisol hormone; football players; non-functional overreaching (NFOR).

Resumen

Objetivo: Esta investigación tuvo como objetivo realizar un análisis exhaustivo mediante la evaluación del sistema de variables bioquímicas y físicas, considerando múltiples indicadores para diagnosticar las etapas del Síndrome de Sobreentrenamiento (SST) en jugadores de la Liga Profesional de Fútbol de Irak durante la temporada 2023-2024.

Metodología: Se utilizó una metodología de encuesta descriptiva para analizar y monitorear el equilibrio de los mecanismos de adaptación (esfuerzo físico y recuperación adecuada). Se midieron las exigencias físicas durante los partidos y los parámetros bioquímicos de los atletas inmediatamente después del esfuerzo físico, así como tras 72 horas de descanso, para identificar y analizar la cinética de los indicadores bioquímicos y los cambios secuenciales que se producen a lo largo de una temporada completa.

Resultados: La capacidad del sistema hormonal para mantener su equilibrio incluso cuando los sistemas muscular y nervioso están bajo estrés implica que basarse únicamente en el sistema hormonal puede no proporcionar una imagen completa del síndrome. En otras palabras, la ausencia de cambios hormonales evidentes no significa necesariamente que los atletas no estén experimentando el síndrome de sobreentrenamiento; simplemente puede indicar la capacidad del cuerpo para recuperarse hormonalmente. La acumulación de estrés provoca un desequilibrio que se manifiesta inicialmente en los indicadores de los mecanismos de recuperación muscular y nerviosa, lo que hace que estos indicadores sean más sensibles para la detección temprana del síndrome de sobreentrenamiento y sus etapas desde una perspectiva hormonal.

Conclusiones: La investigación concluyó que el síndrome de sobreesfuerzo (SSE) no es simplemente un desequilibrio hormonal, sino un problema real en los mecanismos de adaptación fisiológica.

Palabras clave

Carga de competición; enzima CK; hormona cortisol; jugadores de fútbol americano; sobreesfuerzo no funcional (NFOR, por sus siglas en inglés).

Introduction

Continuous monitoring of players' responses to increasing workload demands is crucial for understanding their potential impact on player health (Mustar et al., 2025). Professional football is associated with a high injury burden, with pooled estimates in men's professional football indicating an overall rate of approximately 8.1 injuries per 1000 hours of match-related exposure (Xie & Cai, 2026). (Elsayed et al., 2026; Alaqdawi et al., 2025) emphasized the importance of regularly monitoring players' physiological adaptations.

The success of professional athletes depends on a structured training program and adequate recovery periods (Souza et al., 2018; Andriana et al., 2025). This success also depends on providing vocabulary that leads the player to overload, but it is also necessary to avoid combining overload with insufficient recovery. (Meeusen et al., 2013). Therefore, the believes that the difficulty of the training process lies in regulating this balance (the load exerted and the required recovery). This requires precise and continuous scientific monitoring throughout the season of the physical, physiological, and psychological changes that occur in the athlete, as they are subjected to high physical and psychological demands in matches and training. Consequently, fatigue and effort are inevitable outcomes. Herein lies the challenge for the coach and their support team: there are specific stages in the overload mechanism (adaptation mechanisms) that the athlete may go through, and the coach must consider their details scientifically and precisely. The first stage is achieving functional adaptation by subjecting the athlete to high-intensity training doses, closely monitoring them, and providing sufficient rest for recovery, which leads to the functional overload stage. Overreaching (FOR) The second stage is to avoid bringing the player into a state of maladaptiveness due to the imbalance between intensity and volume on one hand and rest, methods and duration of recovery on the other. Without monitoring and regulation, this may translate into a decrease in performance level or a feeling of fatigue, muscle pain and injuries, and thus entering the stage of Non-Functional Overreaching (NFOR). What is more dangerous is continuing in this stage without detecting the imbalance for a long period between the load and recovery. This leads us to Overtraining Syndrome (OTS) (Meeusen et al., 2013; Jerri, et al., 2024). The definitions also indicate that the difference between Overtraining Syndrome (OTS) and Functional Overreaching (FOR) is the amount of time required for recovery and performance recovery, not the type or duration of the stress (Hauswirth & Mujika, 2013). This aligns with the view that recovery and rest periods are crucial, as athletes experience high effort during matches and endure long competitive periods involving extensive travel between provinces, frequent training sessions, and matches in close succession. This, coupled with limited use of appropriate recovery methods and insufficient rest, leads to psychological and physiological stress with long-term negative effects on athletes, potentially resulting in NFOR/OTS. Therefore, determining the necessary recovery time after intensive training or matches should not be based solely on observation, as this approach fails to provide a scientifically accurate answer. It is difficult to ascertain an athlete's true condition and recovery time without considering individual differences. This question can be answered by employing scientific methods, analyzing specific biochemical indicators related to the OTS phases, thus providing a precise understanding of the athlete's condition and their return to homeostasis after performance. Athletes experiencing OTS exhibit a myriad of physiological and psychological symptoms, including chronic fatigue and decreased performance. Depression, apathy towards training, insomnia, and injuries are also among the symptoms. Some research suggests that these symptoms may be largely attributable to a dysfunction in the neuroendocrine system (Anderson et al., 2016). This system is also a valuable factor to analyze when determining whether an athlete may be suffering from OTS (Hackney, 2006; Radi et al., 2020; Radhi, & Obaid, 2020). Hence, the researcher's idea to study: an aspect of the endocrine system through a very important hormone in the biochemical assessment of athletes, namely cortisol. This hormone and its levels can be used as indicators of stress and recovery. Coaches can use these parameters with other indicators to optimize workloads and avoid overwork (OTS) (Michailidis, 2014; Anderson et al., 2016), who stated that it is possible to scientifically and systematically monitor the fatigue experienced by athletes through the cortisol hormone during rest and after effort, also confirmed this. The concentration of cortisol increases two to three times after an hour of physical effort compared to its concentration at rest, and it is considered an indicator of OTS when its concentration at rest is high (Hauswirth & Mujika, 2013). Second: Studying the movement of creatine kinase (CK) enzyme as a useful indicator in providing information about the athlete's health

status (recovery) (Hauswirth & Mujika, 2013). It is also a promising tool for assessing muscle recovery in athletes (Barth et al., 2019).

Third: Studying the physical demands during the match. Studies show that measuring the distances covered and the intensity exerted in matches determines the amount of physical stimulation and without knowing this load, we cannot explain why disturbances in the adrenal axis and changes in hormone kinetics occur (Felipe et al., 2022).

Research problem

A range of subjective and objective factors contribute to decreased performance levels associated with Non-Functional Overreaching (NFOR) as a result of the intense training athletes endure (Yaguachi-Alarcón et al., 2026). Early detection of NFOR is a significant challenge for sports scientists and coaches. An athlete unable to recover from the applied training load will experience a range of physiological effects; for example, the immune system becomes weakened, increasing the likelihood of illness. This is evidenced by the prevalence of upper respiratory tract infections among athletes (Benavides Pando et al., 2023). Studies have also shown that a survey of elite runners revealed that 60% of females and 64% of males reported experiencing at least one previous episode of NFOR/OTS, and approximately 34% of 231 swimmers aged 13-18 in four countries reported experiencing NFOR/OTS (Meeusen et al., 2013).

Based on his review of some studies and his experience as a coach in the Iraqi Professional League, the found that there are questions without scientific answers. A real problem facing coaches and players in the football season is the lack of any analytical study of some biochemical indicators related to overtraining syndrome and recovery for Iraqi professional league players. There are periods in which the players' performance level drops, injuries increase, and they feel fatigued and unwilling to train, along with muscle pain, without knowing the real reasons. Consequently, appropriate treatments are not provided. As a result, this period, if not addressed and recovered from, leads to the player being exposed to overtraining syndrome, because the frequent matches in short and crowded intervals affect the injury rates of elite football players compared to matches with a long rest period (Lotfy Elgayar et al., 2025). (Bryliński et al., 2022) indicated that, according to studies, between 5% and 64% of professional athletes suffer from OTS.

Research Objectives

- Identify the levels of the biochemical variables of cortisol and CK enzyme, and the differences between these levels after effort and at rest, among Iraqi Professional Football League players.
- Identify the kinetic differences in the biochemical variables of cortisol and CK enzyme after effort among Iraqi Professional Football League player
- Identify the kinetic differences in the biochemical variables of cortisol and CK enzyme at rest among Iraqi Professional Football League players.
- Identify some of the physical variables of Iraqi Professional Football League players.

Method

Research Methodology

Used the descriptive survey method.

Community and sample research

The research population consisted of players from Iraqi Professional Football League clubs during the 2023-2024 season. The research sample was selected purposively from a group of 20 players from Al-Talaba Club in the Iraqi Professional Football League, excluding goalkeepers. The following conditions were applied to the induction sample:

- The same players were present for all consecutive biochemical measurements throughout the season.



- Eight players who did not complete all measurements in the first and second phases were excluded.
- Five players who refused to commit to undergoing measurements consecutively throughout the season were excluded.
- The researcher included players who started the match from the beginning in the measurement matches.
- Players who started the match but did not complete the measurement match were excluded.
- Seven players met the above conditions when measuring the biochemical variables.

Table 1. Shows the total sample size, the number of players who met the conditions, and the number of blood doses measured are shown.

Total Research Sample	Sample That Completed the Conditions	Number of Measurements at Rest	Number of Measurements After Effort	Total Number of Blood Doses (Samples)	Number of Blood Doses (Samples) That Completed the Conditions	Pilot Study Sample	Excluded Players
20	7	6	6	108	84	7	13

Sample description for anthropometric and functional anthropometric measurements

Table 2. Sample description for anthropometric and anthropometric measurements

Variables	Unit of Measurement	Mean	Standard Deviation	Skewness Coefficient	Highest Value	Lowest Value
Height	cm	177.5714	7.13809	0.943	189.00	171.00
Age	--	28.1429	3.02372	0.468	33.00	25.00
Total Body Water	L	46.3571	5.67123	1.096	56.20	41.10
Protein	Kg	12.6429	1.52519	1.049	15.30	11.10
Minerals	Kg	4.3557	0.55133	0.889	5.30	3.79
Fat Mass	Kg	9.7286	1.56920	0.587	12.30	7.90
Weight	Kg	73.1000	8.13593	0.847	86.20	65.30
Muscle Mass	Kg	36.1857	4.58382	1.061	44.20	31.70
Body Mass Index (BMI)	Kg/m ²	23.1286	1.30348	-0.680	24.40	21.10
Fat Percentage	%	13.3429	2.13062	0.928	17.30	10.70
Fat-Free Mass	Kg	63.3714	7.75472	1.092	76.90	56.10
Evaluation	P	83.7143	4.30946	-0.094	90.00	77.00

The InBody device was used for anthropometric measurements of the sample, and the arithmetic means, standard deviations, skewness coefficient, and highest and lowest values were calculated as shown in Table (2). Cortisol concentration in the blood was measured.

Results Analysis

- Normal blood cortisol levels before 10:00 AM: 101.2 - 535.7 nmol/L
- Normal blood cortisol levels after 5:00 PM: 79.0 - 477.8 nmol/L

Creatine Kinase (CK) Measurement

- Results Analysis.
- The normal range for CK is between 30 and 200 IU/L

Method of Performing the Biochemical Variables Test

By the Shadows of Beirut Medical Laboratory for Analyses, under the supervision of a specialized medical team.

The blood analysis is performed as follows:

The test is performed following these steps:

- Clean the skin.
- Apply a tourniquet over the area until the veins become swollen with blood.

- Insert the needle into the puncture site.
- Draw a 3cc blood sample from the vein.
- Remove the tourniquet and withdraw the needle from the vein.
- Apply a sterile plaster to the puncture site.

Place the blood sample in a Gel Clot Activator Tube. This tube contains a gel activator that is uniformly sprayed onto the surface of the serum, significantly reducing clotting time. The gel can withstand high temperatures, maintaining stability during storage and transport. After centrifugation, the gel solidifies, completely separating the serum from the fibrin cells, acting like a barrier. This effectively prevents the exchange of substances between the serum and the cells, thus improving serum collection efficiency and obtaining high-quality serum, resulting in more accurate test results. The serum remains stable for more than 48 hours without any noticeable changes in its biochemical properties or chemical composition. The tube can then be used directly in the sample analysis equipment. Label the tube with the player's name and place it in a cooler box for safe transport. Separate the samples using a centrifuge at 6000 RPM for 10 minutes to separate the mixtures. Then, use an Abbott Architecture I 1000 analyzer to measure the results.

used the (18Hz) GPS PLAYERTEKTEAM device to extract the physical variables measured during the matches, which included (total distance, total speed distance, highest speed, number of speeds covered, and number of high power exerted in the match).

The PLAYERTEKTEAM device measures the total distance covered during a match (walking and running). This is a simple way to assess an individual's contribution to a collective effort. The device's units of measurement for this variable are kilometers or miles.

Sprint Distance and Number of Sprints

The PLAYERTEKTEAM device measures the total sprint distance covered during a match or training session in meters or yards. Sprint distance is calculated when a player covers 5 meters or more per second, and the number of sprints is also recorded.

Power Plays:

The PLAYERTEKTEAM device provides an indicator of the number of high-intensity events, such as acceleration and powerful movements, and measures them in watts. These events are indicated when the player performs high-intensity movements, exerting a power output estimated at 20 watts per kilogram, which represents the peak power threshold.

Top speed: The player's peak speed during a match or training session, and the units of measurement for this variable (m/s, mph, km/h).

The units of measurement for this variable are (m/s, mph, or km/h).

Main Experiments

The followed a number of steps as follows:

- 1- Special forms were distributed to the players to obtain written consent for follow-up measurements.
- 2- The players' health and freedom from any hormonal or other diseases were confirmed through comprehensive examinations and targeted hormone tests on November 1, 2023.
- 3- Anthropometric and physiological measurements were conducted on Sunday, November 19, 2023, at 9:00 AM at the Specialized Clinic for Therapeutic Nutrition and Obesity Treatment.
- 4- Biochemical marker measurements were taken six times in the first phase and six times in the second phase, sequentially throughout the 2023-2024 Iraqi Professional Football League season, as follows:
 - The first measurement was taken, and 3 cc of blood was drawn from the players during the fifth round of the Iraqi Professional League. Immediately after the match on (Friday) on 24/11/2023 at 9:00 PM.



- The second blood test, involving the withdrawal of 3cc of blood from the players, was conducted after the fifth round of the Iraqi Professional League; 72 hours after the match, on Monday, November 27, 2023, at 9:00 PM, before training and while the players were resting.
- The third blood test, involving the withdrawal of 3cc of blood from the players, was conducted after the eleventh round of the Iraqi Professional League, immediately after the match, on Sunday, December 24, 2023, at 7:00 PM.
- The fourth blood test, involving the withdrawal of 3cc of blood from the players, was conducted after the eleventh round of the Iraqi Professional League; 72 hours after the match, on Wednesday, December 30, 2023, at 7:00 PM, before training and while the players were resting. The fifth blood test, involving the withdrawal of 3cc of blood from the players, was conducted during the 18th round of the Iraqi Professional League, immediately after the match on Wednesday, March 6, 2024, at 8:15 PM.
- The sixth blood test, involving the withdrawal of 3cc of blood from the players, was conducted after the 18th round of the Iraqi Professional League, 72 hours after the match, on Friday, March 9, 2024, at 8:15 PM, before training and during rest.
- The seventh blood test, involving the withdrawal of 3cc of blood from the players, was conducted during the 23rd round of the second stage of the Iraqi Professional League, immediately after the match, on Sunday, May 5, 2024, at 5:00 PM. The eighth blood test, involving the withdrawal of 3 cc of blood from the players, was conducted after the 23rd round of the Iraqi Professional League; 72 hours after the match, on Tuesday, May 8, 2024, at 5:00 PM, before training and while the players were resting.
- The ninth blood test, involving the withdrawal of 3 cc of blood from the players, was conducted after the 31st round of the Iraqi Professional League, immediately after the match, on Saturday, June 8, 2024, at 5:00 PM.
- The tenth blood test, involving the withdrawal of 3 cc of blood from the players, was conducted after the 31st round of the Iraqi Professional League; 72 hours after the match, on Tuesday, June 11, 2024, at 5:00 PM, before training and while the players were resting. The eleventh blood test, involving the withdrawal of 3 cc of blood from players, was conducted immediately after the match of the 37th round of the Iraqi Professional League on Sunday, June 23, 2024, at 7:15 PM.
- The twelfth blood test, involving the withdrawal of 3 cc of blood from players, was conducted 72 hours after the match of the 37th round of the Iraqi Professional League on Monday, June 26, 2024, at 7:15 PM.
- All blood tests conducted immediately after matches were performed at the stadiums of the Iraqi clubs participating in the Professional League.
- All blood tests conducted 72 hours after matches were performed at the training ground of Al-Talaba Club.
- Physical measurements were taken of the variables (total distance, total speed distance, highest speed, number of speeds covered, and number of high power exerted in the match) for the players during the matches in the measured rounds (fifth, eleventh, and eighteenth) in the first stage and the rounds (twenty-third, thirty-first, and thirty-seventh) in the second stage of the Iraqi Professional League (2023-2024).

Findings

Presentation, analysis of the results:

Table 3. Show the statistical description of the enzyme variant (ck) for the six measured matches

CK Enzyme	Mean	Standard Deviation	Skewness Coefficient	Mean After 72 Hours	Standard Deviation	Skewness Coefficient
First Match	396.57	181.88	0.891	700.57	351.61	0.216
Second Match	407.42	161.14	0.774	660.14	376.00	0.343
Third Match	437.71	72.41	0.363	843.00	242.28	0.564
Fourth Match	466.28	127.46	0.279	702.42	283.57	0.074
Fifth Match	415.85	58.35	1.18	759.28	262.12	0.663
Sixth Match	418.14	127.17	1.07	743.57	270.00	0.427



Table 4. Statistical description of the cortisol hormone variable for the six measured matches

Cortisol	Mean	Standard Deviation	Skewness Coefficient	Mean	Standard Deviation	Skewness Coefficient
First Match	608.20	161.26	1.26	179.60	62.30	0.297
Second Match	536.28	43.95	1.46	179.65	56.48	0.55
Third Match	570.71	41.08	0.67	167.52	36.44	0.353
Fourth Match	631.28	81.37	0.732	166.28	32.99	0.060
Fifth Match	594.00	63.28	0.944	229.14	19.70	0.712
Sixth Match	603.00	88.13	0.391	190.00	39.52	0.225

Presenting the results of the significant differences between the measurement of the effort and rest dimensions, the difference in arithmetic means and standard deviations, the t-test for biochemical variables, and presenting the highest and lowest values and the arithmetic mean for the physical and functional variables:

Table 5. Shows the significance of the differences between the measured effort and rest dimensions, the arithmetic means, standard deviations, and the t-test for biochemical variables in the six matches

Matches	Biochemical Variables	Unit of Measurement	Arithmetic mean of difference	Standard deviation of differences	Standard Error	Calculated t-Value	Significance Level*	Significance of Differences
First	CK	U/L	304.00	317.08	119.84	2.537	0.044	Significant
	Cortisol	nmol/L	428.600	128.50	48.56	8.825	0.000	Significant
Second	CK	U/L	252.71429	262.80710	99.33	2.544	.044	Significant
	Cortisol	nmol/L	356.62857	43.21939	16.33	21.832	.000	Significant
Third	CK	U/L	405.28	224.49106	84.84	4.777	.003	Significant
	Cortisol	nmol/L	403.18	50.98733	19.27	20.921	.000	Significant
Fourth	CK	U/L	236.14	308.29554	116.52	2.027	.089	Significant
	Cortisol	nmol/L	465.00	112.03571	42.34	10.981	.000	Significant
Fifth	CK	U/L	343.42	271.95334	102.78	3.341	.016	Significant
	Cortisol	nmol/L	364.85	58.73792	22.20	16.434	.000	Significant
Six	CK	U/L	325.42	242.59765	91.69	3.549	.012	Significant
	Cortisol	nmol/L	413.00	104.06408	39.33	10.500	.000	Significant

Table 6. Shows the statistical description of the highest and lowest values and the arithmetic mean for the physical and functional variables in the six matches.

Matches	Physical and Functional Variables	Unit of Measurement	Lowest Value	Highest Value	Arithmetic Mean
First	Total Distance	Kilometer	8.22	12.41	10.78
	Sprint Distance	Meter	750	1200	901
	Maximum Speed	Kilometer/Hour	29.39	32.98	31.34
	Power Count	Watt	72	91	80
Second	Total Distance	Kilometer	8.50	11.30	9.52
	Sprint Distance	Meter	713	1190	885
	Maximum Speed	Kilometer/Hour	30.10	33.12	30.94
	Power Count	Watt	71	95	80
Third	Total Distance	Kilometer	8.83	11.78	9.72
	Sprint Distance	Meter	420	1180	771
	Maximum Speed	Kilometer/Hour	27.18	30.99	29.28
	Power Count	Watt	70	89	78
Fourth	Total Distance	Kilometer	8.90	11.20	10.08
	Sprint Distance	Meter	590	1280	842
	Maximum Speed	Kilometer/Hour	28.90	34.60	30.85
	Power Count	Watt	72	90	80
Fifth	Total Distance	Kilometer	8.97	9.88	9.34
	Sprint Distance	Meter	450	840	625
	Maximum Speed	Kilometer/Hour	26.32	31.42	29.39
	Power Count	Watt	78	85	80
Six	Total Distance	Kilometer	9	11.78	9.73
	Sprint Distance	Meter	400	1180	674
	Maximum Speed	Kilometer/Hour	27.18	30.99	29.28
	Power Count	Watt	76	83	79

Table 7. Mauchly's Test of Sphericity and Significance Level for the Six Measurem

Indicator	Unit of Measurement	Mauchly's Test	Sig.	Homogeneity Significance
CK Enzyme Measurements Post-Effort	U/L	0.007	0.178	Non-significant and Homogeneous
CK Enzyme Measurements at Rest	U/L	0.052	0.665	Non-significant and Homogeneous



The results in the table above indicate the homogeneity of variance for the six post-effort measurements, making them suitable for comparison within one sample.

Table 8. Results of the (F) Test for Repeated Measures among the Six Measurements

CK Enzyme Indicator	Sum of Squares	Degrees of Freedom	Mean Squares	F Value	Sig.	Significance
Between Measurements Post-Effort Measurements	21721.33	5	4344.26	0.251	0.936	Non-significant
Error Post-Effort Measurements	519461.00	30	17315.367			
Between Measurements Measurements at Rest	141238.405	5	28247.681	0.347	0.880	Non-significant
Error Measurements at Rest	2443812.095	30	81460.403			

Table 9. Mauchly's Test of Sphericity and Significance Level for the Six Measurements

Indicator	Unit of Measurement	Mauchly's Test	Sig.	Homogeneity Significance
Cortisol Post-Effort Measurements	nmol/L	0.008	0.188	Non-significant and Homogeneous
Cortisol Measurements at Rest	nmol/L	0.028	0.487	Non-significant and Homogeneous

Table 10. Results of the (F) Test for Repeated Measures among the Six Measurements

Cortisol Indicator	Sum of Squares	Degrees of Freedom	Mean Squares	F Value	Sig.	Significance
Between Measurements Post-Effort Measurements	38331.219	5	7666.244	1.152	0.355	Non-significant
Between Measurements Measurements at Rest	18801.693	5	3760.339	2.371	0.063	Non-significa

The results in the table above indicate the homogeneity of variance for the six resting measurements, making them suitable for comparison within one sample.

Figure 1. Show the Results of measurements (post-effort and rest) of the Creatine Kinase (ck) enzyme index

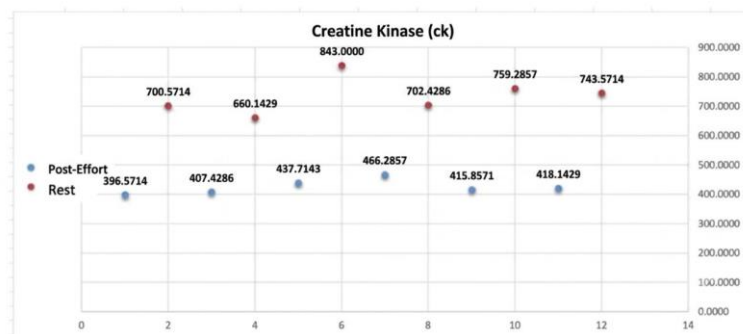


Figure 2. Show the Results of measurements (post-effort and rest) of the cortisol hormone index

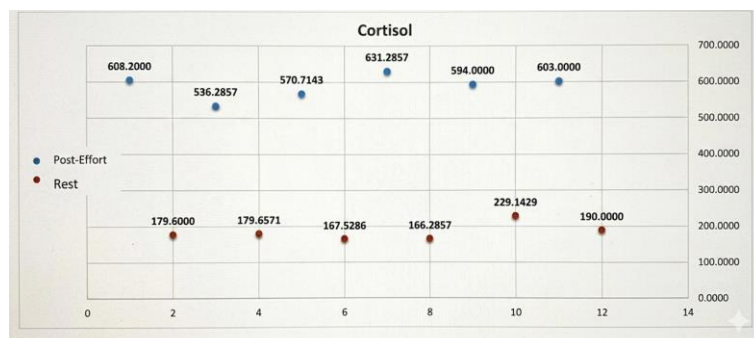


Figure 3. Results of the kinetic differences in the enzyme (ck) and hormone (cortisol) post-effort and at rest for the six measured matches



Discussion

After obtaining the results of measurements of the biochemical and physical of Iraqi professional football players during the football season, the aforementioned tables reveal the significance of the differences in the hormones cortisol and creatine phosphokinase between measurements taken immediately after effort and at rest, across all matches.

The study results confirm that there are differences between the measurements, but these differences are relative. (Mougios, 2007). The aimed to determine the kinetic characteristics of these biochemical variables and whether the player returns to a state of homeostasis and achieves full recovery 72 hours after the match, taking into account that the kinetics of the hormones and enzymes under study may be relatively small and not readily detectable by the SPSS test, but they are still as they are based on established medical parameters.

The different stages of biological adaptation processes are characterized by clear variation. While the stresses of physical loads lead to clear catabolic processes in the functions of various body systems, periods of rest and the cessation of stress target anabolic and repair processes. This means that there are different phases that a player goes through. When performing matches and exerting high workloads, there is a response from the internal biological systems. During this phase, many waste products are left behind, representing catabolic processes. Changes also occur during rest and post effort, aiming to restore the internal functional state to normal, which reflects anabolic processes. The aims to determine the activity and kinetics of the hormones and enzymes under study after effort and at rest. It should be noted that the normal values for cortisol are (79.0-477.8) nmol/L and for phosphokinase (30-200) U/L.

Creatine kinase (CK) activity is one of the typical metabolic parameters described as athletic markers used by coaches and athletes to monitor and characterize their strength and performance (Mougios, 2007). The figure (1) illustrates the kinetic differences in CK levels after exercise and rest in the measured matches of the research sample. It was found that professional football players experienced a gradual accumulation of CK enzyme concentrations after matches. Directly measured CK concentrations after match effort ranged between 396.57 U/L and 466.82 U/L, values higher than the normal range for creatine kinase (CK) in the body, which is 30-200 U/L. This is expected, as a significant increase in CK levels is a normal phenomenon after intense performance (Pedersen et al., 2019) due to the player's exposure to certain factors. Internal tears, which serve as an indirect indicator of muscle damage (Baird et al., 2012), are attributed to football-specific activities such as rapid acceleration and deceleration, leading to a significant amount of eccentric loading (Varley et al., 2017). The concentrations of CK measured 72 hours after matches, during rest, ranged between 660.14 U/L and 843.00 U/L, nearly double the measurements taken immediately after the match. This indicates a continuous accumulation of effort byproducts from the end of the match until the 72-hour measurement period. This suggests a different concept of recovery and the time required a player to return to normal. It is worth noting that the research sample was given two days of rest after the match: one day of passive rest and one day of active rest, meaning they did not engage in strenuous physical activity until the second measurement. Despite this, a significant increase in CK levels was observed, which is attributed to damage to the cell membrane and cell damage or destruction in players (Khaitin et al., 2019).

This means that a player may be able to run and perform the required tasks after 72 hours because the central nervous system temporarily compensates for the deficiency by recruiting motor units. However, biochemically, the muscle tissue is torn and in a state of continuous breakdown. Without proper monitoring, mechanically damaged tissue is forced to produce force, which causes non-contact injuries. As (AlOtaibi et al., 2026) confirmed, the return of CK enzyme markers takes time, and with continued repeated stress, these markers increase cumulatively without decreasing. This means that the muscle cell membrane is still experiencing continuous chemical bleeding. Furthermore, including the player in another match based solely on apparent performance indicators empties the concept of recovery of its true and scientific meaning and exposes the exhausted muscle tissue to additional mechanical load, leading to acute structural failure and increased susceptibility to injuries.

The believes that this knowledge will lead us to fundamental facts concerning the causes of damage to the player, as well as a realistic understanding and management of the recovery process, as it will clarify the hidden picture of the damage caused by the competitive load. We observed, through tables (3-10), the high physical demands to which the player is subjected. The total distance covered in the match ranges from (8.22 to 12.41 km) and the speed ranges from (400 to 1280 m). The number of energy expended ranges from (70-95) movements, and the highest speeds reach (26.32 - 34.60 km/h). This leads to a response from the functional systems due to the high external load. In addition, its impact on devices in order to meet high demands.

Based on the findings and scientific evidence, concludes that these high demands have significantly contributed to muscle tissue damage. Therefore, players need sufficient recovery time before participating in training sessions or matches. However, the opposite often occurs in the Iraqi Professional League due to its new system, which disregards player recovery from competitive demands and forces players to play frequent matches with intervals of 72-96 hours between them in many season fixtures. According to the research findings and the competition system, there is no balance between the effort and the necessary recovery time for players to return to their normal state. This has led to numerous problems, including decreased performance and a high incidence of injuries. The frequency of matches places significant pressure on physiological systems, resulting in fatigue, decreased strength, muscle damage, and subsequent pain (Varley et al., 2017). The Iraqi Football Association aimed to develop the competition and changed the league system to ensure this development would positively impact the performance of national teams and elevate their Asian and international standing. However, according to the researcher's perspective, this has not been the case. Based on the research findings, the competition and the players are harmed, given that the players are the cornerstone of the development process. Therefore, match scheduling must be based on precise scientific programs that consider the impact of match pressure on the players' physiological systems, which reflect the true state of their health. This did not happen due to the frequent matches played in close succession, which did not take into account the necessary recovery period. This period is directly linked to increased damage to muscle tissue (Freitas et al., 2014), resulting in fluctuating performance levels and a high number of injuries that directly affect the competition's development. Furthermore, believes that those responsible for the competition did not consider the limits of the players' human capacity. Through experimentation and results, some players suffered muscle injuries. In the field experiment, one player played a match, and 72 hours later, measured his CK enzyme. The results showed that he was at the peak of muscle damage due to a fivefold increase in blood CK enzyme levels above normal. Just one day later, he played another match, demonstrating high physical demands, and suffered another muscle injury. This pattern was repeated the situation...

Therefore, attributes the short recovery period granted to athletes, as well as the failure to consider the effects of competitive effort on them, to an imbalance between high load and adequate rest. This leads to increased damage to the cell membrane, injuries, and the development of overtraining syndrome. For this reason, fitness coaches must design scientific recovery programs using equipment and tools that accelerate recovery. According to the specialized coach should not rely solely on the use of recovery equipment and tools, as these are insufficient. Human capacity is limited, and a sufficient number of days and recovery period may be required for tissue repair and rebuilding. Insufficient recovery time has been linked to an increased risk of injury in European club competitions and international tournaments (Russell et al., 2016). Therefore, the coach must monitor players closely and scientifically to determine recovery time and conduct regular biochemical analyses of the CK enzyme, which has been shown to be



the most reactive to stress in football (Freitas et al., 2014). Furthermore, the coach should monitor players exhibiting signs of overload, whether psychological or physical.

The figure (2) illustrates the dynamic differences in cortisol concentrations after effort and rest in professional football players. The cortisol response immediately after match effort ranged between 536.28 nmol/L and 631.28 nmol/L, values higher than the normal range of 79.0–477.8 nmol/L. Cortisol concentrations measured 72 hours after matches and during rest ranged between 166.28 nmol/L and 229.14 nmol/L, which are within the normal range. Cortisol is secreted by the adrenal cortex (Santana, 2015). The believes that the increased cortisol secretion in the study sample, measured immediately after effort, is due to their exposure to high physical demands and the effort of the match. This aligns with (Santana, 2015). The concentration of the hormone increases with the duration of high-intensity effort and after physical activity. Cortisol release increases because it accelerates metabolic processes, especially those related to carbohydrates. The hormone speeds up the conversion of liver glycogen to glucose, leading to hyperglycemia. Cortisol's effects in increasing blood glucose ensure a sufficient supply of glucose to the brain and nerve tissues during prolonged physical effort, thus mitigating the effects of physical effort on central nervous system fatigue.

Also believes that the results of the first measurement in the research sample reflect an efficient response to the stress experienced by the athletes. This increase can be considered an indicator of the stress experienced by the athlete and the body's response to stress, as continued exercise leads to increased sympathetic nervous system stimulation, increased cardiac output, and increased respiratory rate. The second measurement, taken after 72 hours of rest, showed that cortisol secretion returned to normal levels. This indicates the hormone's regular function in the athletes, as stopping exercise leads to its return. The body's state before exercise indicates a direct and regular correlation between the neuromuscular center and changes in hormone secretion from the glands. Cortisol concentrations tend to decrease over time, especially during rest (Tremblay et al., 2004).

According to the foregoing and the tables and Figure (3) presented for the first post-exercise measurement of the six matches, it is clear that there are no statistically significant differences between the measurements of either cortisol or CK enzyme. Similarly, the tables for the second rest measurement of the six matches, regarding the kinetic results of the differences between the six measurements of cortisol or CK enzyme, indicate that there are no statistically significant differences between the measurements. The believes that this idea is based on the concepts of physiological adaptation and recovery mechanisms in the research sample. The considers the kinetic results of cortisol and CK enzyme for the six matches post effort and for the six matches after 72 hours of rest to reflect a similar kinetic response. That is, the pattern of change in the levels of the indicators (cortisol and phosphokinase) follows a similar trajectory in all matches, whether after the match or after 72 hours. This indicates that the body responds to the demands of the matches in a consistent and predictable manner.

The explains the similarity in kinetics and the numbers that appeared in the first measurement post effort for biochemical indicators as being due to the mechanism of a healthy physiological response to the effort of the match. The results of the match-specific effort became clear through measuring the physical demands on the players, which were mostly relatively similar. This means that the player was subjected to repeated effort with almost the same load. Consequently, the physiological response mechanism for the indicators was also similar and repetitive in the six measured matches. Therefore, based on the results of the indicators and their comparison with normal values, believes that the physiological response is effective. Since the kinetics were relatively similar from the beginning of the season to its end, this means that the research sample has efficient systems for the physiological response to effort. This is also evidence of hormonal adaptation, which helps maintain optimal performance despite repeated pressures throughout the season. As for the numbers that appeared in the second measurement at rest for indicators of the hormonal response, they reflected the concept of hormonal balance in the research sample. The results indicated a state of hormonal recovery, which was evident from the return of the hormone cortisol to its baseline at rest, meaning that there are no processes Based on the foregoing and the almost identical kinetic results that emerged, we can conclude that there is a balanced and healthy hormonal response during the recovery phase in the research sample.

Regarding the CK enzyme, the results showed a relatively similar response in enzyme kinetics during the recovery phase. However, this response reflected an increase in cumulative fatigue and muscle damage. This occurred in all the measured matches from the beginning to the end of the season for the research sample due to the high physical demands and pressures of the matches.

Analyzing and understanding the kinetics of biochemical indicators associated with overtraining syndrome in players during the season is of great importance in the world of football. Players are subjected to training loads and frequent matches that increase the state of overtraining. Despite the difficulties in diagnosing the syndrome, we relied on indicators that have proven sensitive in the early detection of the syndrome's stages. Believes that the main reason for players entering the OTS/NFOR phase is a disruption in recovery mechanisms and a misbalance between the two sides of the balance. The first side of the balance is the exertion, and the second side is the required recovery. If the exertion side of the balance exceeds the recovery side, this leads to an imbalance and consequently to the OTS/NFOR phase.

And found solutions to the research gap by knowing the indicators of both sides of the scale more accurately because overtraining syndrome is a multifaceted and complex process and cannot be diagnosed based on a single indicator. It is not only a hormonal disorder, but it is a syndrome that may affect different body systems such as the musculoskeletal system, the nervous system, and others. These systems may be affected to varying degrees, and symptoms may appear in one area without another. Therefore, focusing only on one system without considering the rest of the systems, as well as some other indicators such as (performance, injuries), is not a solution. Looking at one side of the scale while ignoring the other can lead to misdiagnosis. The prevailing hypothesis for the syndrome is that it leads to hormonal imbalances, particularly in cortisol. This is supported by research, but it is just one aspect. Many studies have focused on changes in hormone levels as the sole and sufficient indicators for understanding and diagnosing the mechanism of overtraining syndrome in athletes. However, our study, based on its results, showed that this hypothesis does not provide a comprehensive view for early detection or even for identifying instances of overtraining syndrome. Based on the hormone results, which indicated that the sample had hormonal balance with a 0% imbalance (i.e., within normal ranges), along with a healthy response to exertion and recovery from the beginning to the end of the season, the believed that the athletes might have been exposed to OTS/NFOR. Therefore, the relied on a more comprehensive approach using a scale for adaptive mechanisms to diagnose the stages of overtraining syndrome through a more sensitive indicator reflecting physiological stress: the muscle breakdown enzyme CK.

The results revealed that 100% of the athletes they showed signs indicating that they had entered the non-functional access stage based on an abnormally high (ck) enzyme level after three days of rest in the sample. This explains the player's need for more rest, which did not happen, and as a result, stress (muscle damage) accumulated beyond the body's ability to adapt. This condition was associated with an increase in sports injuries, which gives evidence that the players suffered from poor adaptation mechanisms and an imbalance in the two sides of the balance, and as a result, the player entered the (OTS/NFOR) stage.

Hypothesis Supporting the Researcher's Opinion

First: The Cytokine Hypothesis

With high training intensity and insufficient rest (overtraining), tissue damage (muscles, tendons, and joints) occurs. This damage stimulates the release of cytokines, increasing their levels to reduce inflammation and support recovery. This hypothesis also suggests that overtraining leads to a chronic inflammatory response in the body. This inflammation can contribute to fatigue, muscle pain, and a weakened immune system. If it continues without adequate rest, it can become an excessive and chronic inflammatory response, suppressing the immune system and making the athlete more susceptible to injuries and inflammation (Vrhovski, 2016).

Connection with the Researcher's Balance: The sustained elevation of the CK enzyme after the recovery period supports the cytokine hypothesis because this elevation indicates muscle damage. This damage leads to an inflammatory response, and the continued elevation means increased cytokine levels and inflammatory response disrupt the recovery process, leading to chronic fatigue, delayed recovery, and ultimately, OTS/NFOR.

Based on these findings and interpretations, the proposes the following:



First, the hormonal system's ability to maintain its balance even when the muscular system is under stress means that relying solely on the hormonal system may not provide a complete picture of the syndrome. In other words, the absence of obvious hormonal changes does not necessarily mean that athletes are not experiencing OTS; it may simply indicate the body's capacity for hormonal recovery. Second, the accumulation of stress causes a disruption that first manifests in the indicators of muscle recovery mechanisms. This makes these indicators more sensitive for the early detection of OTS and its stages from a hormonal perspective.

Conclusions

- Overtraining syndrome is not simply a hormonal imbalance, and hormonal indicators alone are insufficient for diagnosing it.
- Overtraining syndrome is an imbalance in the adaptation mechanisms, particularly the recovery period after exertion.
- The CK enzyme is an important indicator for assessing the efficiency of repair processes and determining the recovery phase of the adaptation balance.
- The CK enzyme is a biomarker for muscle fatigue.
- The occurrence of OTS/NFOR is common during the football season.
- The professional league schedule does not take into account the limits of players' human capabilities.
- Normal hormone levels do not necessarily mean that a player is in optimal health.
- Overtraining syndrome can manifest as chronic muscle fatigue.
- Football players maintain a regular hormonal balance despite the high demands of matches throughout the season.

Recommendations

- Adopt the concept of a balance between exertion and adequate recovery in the continuous monitoring of players.
- Adopt a comprehensive and multifaceted approach to player monitoring.
- Continuously monitor CK enzyme levels after exertion and during recovery phases to assess the muscle's recovery response.
- Adjust training load programs when signs of overtraining appear.
- Continue multifaceted research and conduct similar studies to understand the specific response to exertion and recovery.
- Give paramount importance to recovery requirements and adequate rest for players, as imbalances often occur on the recovery side.
- Adjust the professional league schedule to align with player health and ensure sufficient rest.
- Focusing on a multifaceted system of variables is crucial for diagnosing and providing a complete picture of overtraining syndrome, as well as for the early detection of imbalances between exertion and adequate rest.

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