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RESEARCH ARTICLE

Proposal for a Monitoring Protocol Based on Certain Morpho-biological Parameters to Predict Muscle Injuries During a Macrocycle in Algerian Professional Football Clubs - Case Study: Chabab Aures Batna

Biskri Abdelmalik[1*], Biskri Mustapha[2]

[1,2] University of Algiers 3, Algeria /Institute of Physical Education and Sports

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***Corresponding Author:**

malikojudo@gmail.com

ABSTRACT

This approach is related to the need to refine fundamental knowledge in evaluating and identifying various injuries and traumas, enabling effective management of the recovery process. Indeed, the importance of morphological and biomedical monitoring in football remains essential. Therefore, we implemented a proactive approach in the form of a protocol to prevent muscle injuries among the professional club CAB Batna, consisting of 25 players during a sports season. Specifically, we conducted anthropometric measurements and blood sampling. For data interpretation, we used standard deviations and significance means as statistical tools. The results revealed that the frequency of injuries showed a very high percentage of injuries and traumas among forwards (49.20%), followed by defenders (28.57%), and lastly, midfielders (17.46%) of CAB. The lowest percentage of trauma was recorded among the two goalkeepers (4.76%). These figures provide specific insights into risk factors.

INTRODUCTION

Football is an extremely popular and competitive sport where professional players face intense physical and athletic demands. According to Dr. Hassainia Noureddine (2024), muscle injuries pose a major challenge for professional footballers, potentially compromising their performance, career, and overall well-being. To prevent these injuries and improve player health, it is essential to implement a tailored morpho-biological monitoring protocol.

The biological monitoring of performance athletes remains crucial. However, it is often overlooked by clubs across all categories and levels, despite numerous coaches and physicians raising concerns about injuries and trauma among football players, which they view as significant obstacles to achieving their set goals.

According to Dr. Veronique Billat (1998), no one can objectively identify the exact causes of underperformance in football players. The changes in biological markers studied in the monitoring protocol will serve as reliable indicators reflecting the general health status of CAB professional footballers during the sports season. These markers will enable the early detection of physiological imbalances, fatigue, overtraining, and potential muscle injuries, thereby contributing to muscle injury prevention.

This research focuses on developing and evaluating a biomedical and morphological monitoring protocol tailored to the context of professional football, with the goal of predicting and reducing muscle injuries among players of the Club Athlétique Batna (CAB). By combining a multidimensional approach, including medical evaluations and anthropometric measurements, this protocol aims to provide precise tools for detecting potential risks of muscle injuries and implementing appropriate interventions to prevent them.

The expected results of this study will determine the effectiveness of the biomedical and physical monitoring protocol in reducing muscle injuries among CAB professional football players. These results could also provide valuable insights for healthcare and sports professionals, as well as football clubs, aiding them in developing strategies for muscle injury prevention and enhancing player health and performance.

Finally, this research will contribute to advancing knowledge in the field of biomedical and physical monitoring for professional footballers by identifying specific risk factors for muscle injuries and proposing adapted preventive measures. The findings of this study may also serve as a foundation for future research, paving the way for new perspectives on the development of more effective monitoring protocols to prevent muscle injuries in professional footballers.

Muscle injuries are a frequent and concerning issue in professional football. They can lead to periods of unavailability for players, thereby compromising both individual and team performance. Preventing and managing these injuries are therefore essential to ensure the health and performance of professional footballers.

RESEARCH ORGANIZATION

Problem Statement:

The biological and morphological monitoring of performance athletes remains crucial and forms the preliminary basis of our research. Dr. Hassainia Noureddine's doctoral thesis (2024) demonstrates that systematic monitoring reveals that this epistemology is neglected across all categories and levels within Algerian clubs, despite numerous coaches and physicians highlighting the issue of injuries and trauma among football players, which they consider a significant obstacle to achieving set goals.

In the case of our research sample, CAB Batna, no one is capable of objectively identifying the exact causes of underperformance among our footballers. Researchers have turned to selecting biochemical markers to provide insight into physiological states, such as fatigue, overtraining, and injuries, in the simplest manner possible.

Furthermore, a review of FAF (Algerian Football Federation) medical records revealed that clubs often disregard this roadmap, neglecting certain crucial biochemical parameters despite their importance. This oversight could lead to an increase in injuries during the sports season, affecting athletes' recovery and resulting in individual or collective underperformance of the football team.

Several questions can be posed in the form of a general problem and derived questions:

- Does effective biomedical monitoring help maintain general health during a football team's sports season?
- Is there an analogy between the frequency and topography of injuries encountered by high-level Algerian footballers and those of world-class footballers?

Hypotheses:

Implementing a regular and rigorous monitoring protocol for professional football players of CAB, including biological and morphological examinations, will allow for the rapid detection of muscle injuries throughout the season.

Objectives:

- Develop a proactive biomedical and morphological monitoring protocol to prevent muscle injuries in football players.
- Detect morpho-biological imbalances.
- Implement tailored preventive measures based on the information gathered during the morpho-biomedical monitoring.

Tasks:

To achieve the objectives of this study, the following tasks have been defined:

- ✓ Perform descriptive anthropometric measurements, including body weight and height.
- ✓ Conduct biological and hematological examinations at the beginning and end of the season.
- ✓ Monthly monitoring of pathologies encountered by football players, involving the club's physician, nurse, and physiotherapist.
- ✓ Analyze and interpret the collected results.

Sample

Twenty-five male athletes, competing at the national N1 level and in apparent good health, participated in this experiment. They had an average age of 26.28 ± 3.59 years, an average height of 179.84 ± 4.96 cm, and an average weight of 76.36 ± 6.15 kg.

The participants were informed about the study's methods, tasks, and objectives. They provided written consent, committing wholeheartedly to all stages of this research.

HUMAN AND MATERIAL RESOURCES USED:

Human Resources: During the experiment, the human resources that contributed to the study's realization were as follows:

- A football player (participant sample).
- A high-level football coach.
- An assistant coach with a TSS (Specialized Technical Certificate) in football.
- A general practitioner for blood sampling, supported partly by the central laboratory team at CHU Batna.
- The laboratory team from the "Meriem Bouattoura" Health Enterprise Hospital in Batna.
- A cardiologist from Dr. Mohamed ZAABOUB's cardiology clinic in Batna.
- A physiotherapist from the functional rehabilitation and physiotherapy clinic of Nouredine CHIOUKH.
- A nurse.

Material Resources:

The materials used for this study include:

Anthropometric Measurements: Based on the methods of Vandervael (1980).

Methodological Equipment:

- A 4th-generation synthetic field (tartan).

- A natural grass training field, used for two training sessions per week.
- A well-equipped weightlifting room.
- A small recovery pool.
- A massage room located in the football stadium.

Note:

During the first phase of the season, CAB players trained four times a week on the tartan synthetic field and twice a week on natural grass. Following a change in coach during the second phase, the training schedule was modified to 3–4 sessions per week on the tartan field and only one session per week on natural grass.

Method for Calculating Physical Development Indices:

1. **Body Surface Area (m^2)**
2. **Energy Expenditure Index (cm^2/kg)**
3. **Kaup Index**

The higher this index, the more robust the athlete. For interpreting the results, we referred to the DAVENPORT scale (Vandervael, 1980).

Very Thin	**1,40 to 1,80**
Thin	1,81 to 2,14
Average	2,15 to 2,56
Corpulent	2,57 to 3,05
Obese	3,05 and above

Procedure and Organization of the Experiment

To conduct the scheduled blood sampling, we used:

- A three-piece disposable syringe with a painless, pyrogen-free needle sterilized with ethylene oxide.
- Two standard test tubes:
- The first with anticoagulant (for the CBC).
- The second, dry (for biochemical analysis).
- A tourniquet.

The biochemical analyses of the blood samples were carried out at the central laboratory of CHU Batna using a BECKMAN COULTER SYNCHRON CX9 Clinical System ALX.

The hematological analyses were conducted at the laboratory of the "Meriem Bouattoura" Health Enterprise Hospital in Batna using a MEDONIC CA 530 MIMER 9-parameter system.

Instructions for the BECKMAN COULTER SYNCHRON CX9 Clinical System ALX are provided in the appendix.

Organization of the Experiment

The experiment is organized into three stages, each consisting of a specific set of tasks.

Biochemical and Hematological Analyses

The analyses conducted on the football players include three blood samples taken throughout the sports season.

Blood Biochemical Analysis

This analysis was conducted jointly by the central laboratory of CHU Batna and the laboratory of the "Meriem Bouattoura" Health Enterprise Hospital in Batna using a specialized device mentioned earlier (cf. materials used). The biochemical parameters analyzed included blood urea, plasma calcium, plasma potassium, plasma sodium, plasma magnesium, serum iron, blood glucose, cholesterol, and triglycerides.

The standards for these parameters are specific to the equipment used (see appendix). The hematogram (Complete Blood Count - CBC) examination was conducted at the laboratory of the "Meriem Bouattoura" Health Enterprise Hospital in Batna using a specialized device, MEDONIC CA 530 MIMER 9-parameter system. The protocols, methods, and tools used for sampling, whether for biochemical or hematological analysis, were consistent across all three stages or phases of the study, with one exception: during travel, the collection of health information about the football players was limited to the presence of the doctor and nurse accompanying the team.

The Statistical Method (Schwartz, 1992)

Statistical measurements on our sample were conducted using the position parameter "Mean," the dispersion parameter "Standard Deviation," and the comparison test "Student's T-Test." For statistical data processing, we employed descriptive and multivariate statistical analysis using SPSS.

- **Analysis of Variance (ANOVA):** This was used to compare the same sample multiple times to track the dispersion within our study group.
- **Correlation Analysis:** Applied to certain parameters related to muscle bioenergetics.
- Student's T-Test
- The T-Test has the advantage of being suitable for studying small sample sizes ($n < 30$). In our specific case, the measurement series are paired since they are performed on the same individuals. The T-Test is applied when comparing two series of a quantitative variable from the same sample, with each pair of values forming a matched pair.

Presentation and Interpretation of Results

- If the T-value is less than the critical value from the T-table for the degrees of freedom ($n - 1$) and the significance level (e.g., 5%), the means do not differ significantly.
- Otherwise, the means differ significantly, and the significance level indicated by the table for the calculated T-value determines the degree of significance.

INTERPRETATION OF RESULTS

Study of Calculated Anthropometric Indices for All Players

Table 1: Variation in anthropometric indices between the beginning and end of the sports season for the entire CAB football team.

(n = 25)	Beginning of the Season $x \pm \sigma$	End of the Season $x \pm \sigma$	ANOVA
Body Weight (kg)	76,36 ± 6,15	73,40 ± 6,16	***
Body Surface Area (m^2) Izakson	1,96 ± 0,10	1,90 ± 0,19	*

Energy Expenditure Index (cm²/kg)	257,54 ± 8,82	263,95 ± 9,54	***
Kaup Index (g/)	2,36 ± 0,12	2,26 ± 0,12	***

$x \pm \sigma$ = Mean and Standard Deviation

Values are expressed as mean ± SD. Significance level: ∗ = P < 0,05 ; ∗∗∗ = P < 0,001.

The comparison of anthropometric indices for all CAB football players revealed significant trends of reduction in the studied parameters, such as body weight, Izakson index, and Kaup index, favoring the early season period, which began in July 2010, compared to the end of the season in May 2018. These decreases in indices were generally statistically highly significant (Table 1). Furthermore, the table indicates a statistically highly significant increase (P < 0.001) in the Energy Expenditure (EE) index. This index is inversely proportional to body surface area, meaning that the lower the index, the lesser the energy loss, providing insight into energy expenditure after 10 months of competition

Study of Calculated Anthropometric Indices by Playing Positions

For Goalkeepers:

Table 2: Variation in calculated anthropometric indices of goalkeepers between the beginning and end of the sports season.

(n = 2)	**Beginning of the Season** $x \pm \sigma$	**End of the Season** $x \pm \sigma$	**Trend of Variation**
Body Weight (kg)	79,50 ± 7,78	77,00 ± 8,49	(↓)
Body Surface Area (m²) [Izakson]	2,03 ± 0,13	2,00 ± 0,14	(↓)
Energy Expenditure Index (cm²/kg)	255,11 ± 8,06	260,31 ± 10,32	(↑)
Kaup Index (g/cm²)	2,37 ± 0,08	2,30 ± 0,11	(↓)

$x \pm \sigma$ = Mean and Standard Deviation.

(↓) and (↑) = Upward or Downward Variations in the Studied Indices.

For goalkeepers, as shown in Table 2, the results followed the general trend, indicating a decrease in all studied parameters and an increase in energy expenditure values from the beginning of the season compared to the end of the sports season. However, these changes were not statistically verified due to the sample size of only two goalkeepers.

For Defenders:

Table 3: Variation in calculated anthropometric indices of defenders between the beginning and end of the sports season.

(n = 9)	**Beginning of the Season** $x \pm \sigma$	**End of the Season** $x \pm \sigma$	**ANOVA**
Body Weight (kg)	78,78 ± 5,47	76,44 ± 5,53	***
Body Surface Area (m²) [Izakson]	2,00 ± 0,08	1,90 ± 0,29	Ns
Energy Expenditure Index (cm²/kg)	254,80 ± 8,40	259,56 ± 8,80	***
Kaup Index (g/cm²)	2,39 ± 0,12	2,28 ± 0,12	*

$x \pm \sigma$ = Mean and Standard Deviation

Significance Level : ns = Not Significant.∗ = P < 0,05 ; ∗ = P < 0,05 ; ∗∗ = P < 0,001 ;

The results in Table 3, comparing data collected from defenders at the beginning and end of the season, indicate that the trend of decrease aligns with the general case of CAB football players. Thus, there is a statistically significant reduction in body weight.

- Beginning:78,78 ± 5,47
- End: 76,44 ± 5,53
- P<0,001 and an increase in the Energy Expenditure Index.
- Beginning: 254,80 ± 8,40
- End : 259,56 ± 8,80
- P<0,001), as well as a slight decrease in the Robustness Index.
- Beginning:2,39 ± 0,12
- End : 2,28 ± 0,12

P<0,05.

Despite the decreases in the Physical Development Index among defenders, the results are not statistically significant.

For Midfielders:

Table 4: Variation in calculated anthropometric indices of midfielders between the beginning and end of the sports season.

(n = 8)	Beginning of the Season $x \pm \sigma$	End of the Season $x \pm \sigma$	ANOVA
Body Weight	74,75 ± 6,65	71,63 ± 5,80	**
Body Surface Area (m^2) [Izakson]	1,92 ± 0,12	1,89 ± 0,11	**
Energy Expenditure Index (cm^2/kg)	257,14 ± 9,47	263,80 ± 7,76	**
Kaup Index	2,39 ± 0,14	2,29 ± 0,10	**

$x \pm \sigma$ = Mean and Standard Deviation

Significance Level: ** = P < 0,01.

For the midfielders of the football club, all results are statistically significant at the chosen confidence level (Table 4). A decrease was observed in all the studied parameters when comparing the beginning and end of the season.

For Forwards:

Table 5: Variation in calculated anthropometric indices of forwards between the beginning and end of the sports season.

(n = 6)	Beginning of the Season $x \pm \sigma$	End of the Season $x \pm \sigma$	ANOVA
Body Weight	73,83 ±5,78	70,00 ± 5,59	**
Body Surface Area (m^2) [Izakson]	1,94 ± 0,11	1,90 ± 0,10	**
Energy Expenditure Index (cm^2/kg)	262,99 ± 8,41	271,96 ± 9,50	**
Kaup Index	2,28 ± 0,11	2,16 ± 0,12	*

$x \pm \sigma$ = Mean and Standard Deviation

Significance Level : * = P < 0,05 ; ** = P < 0,01.

Similarly to the midfielders of CAB, the same observations were noted among the forwards, showing a decrease in the studied parameters. Body weight, the Physical Development Index, the Energy Expenditure Index, and the Kaup Index changed significantly (Table 5).

Moreover, a significant normal increase in the Energy Expenditure Index was recorded between the studied periods, rising from **262.99 ± 8.41 cm²/kg** to **271.96 ± 9.50 cm²/kg** at **P < 0.01**.

Variations in Blood Glucose and Blood Lipids for the Entire Team

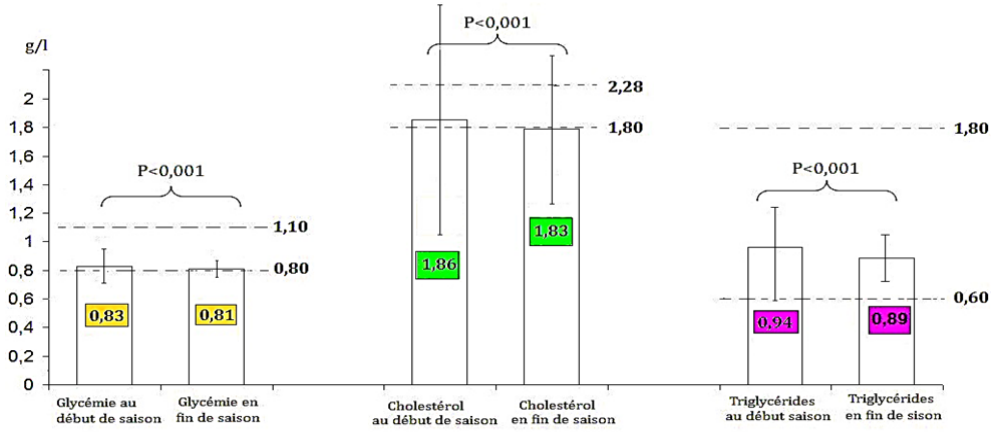


Fig. n° 1 : variations de quelques paramètres biochimiques entre le début et la fin de saison chez les footballeurs du CAB Batna.

Variations in Blood Glucose and Lipids Among Defenders

Variations in Blood Glucose and Lipids Among the Team's Defenders

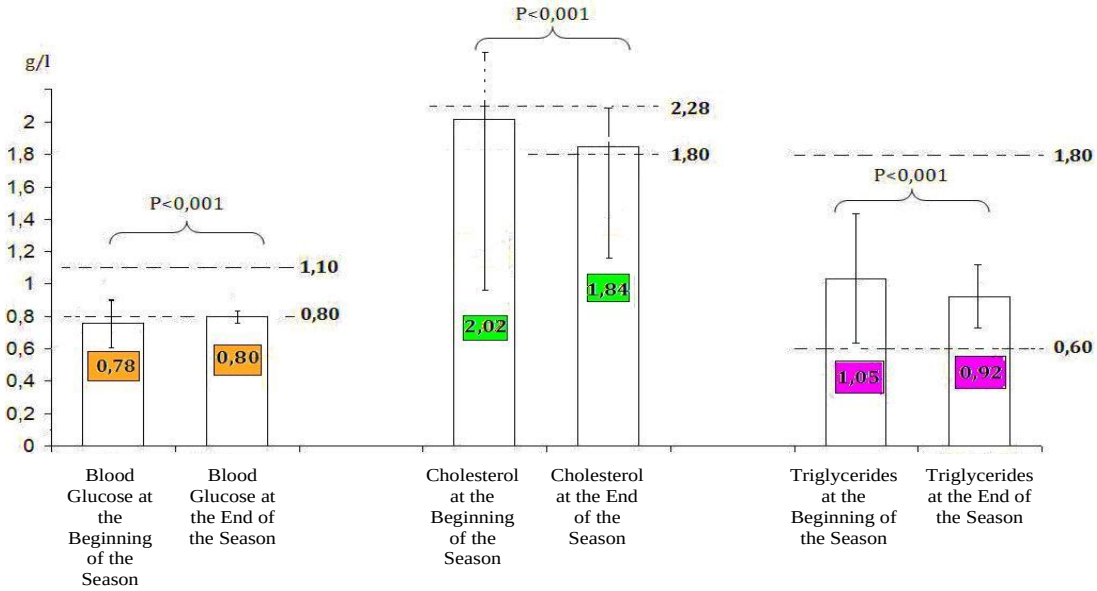


FIG 02: Variations in some biochemical parameters between the beginning and end of the sports season among defenders of CAB Batna.

Variations in Blood Glucose and Lipids Among the Team's Midfielders

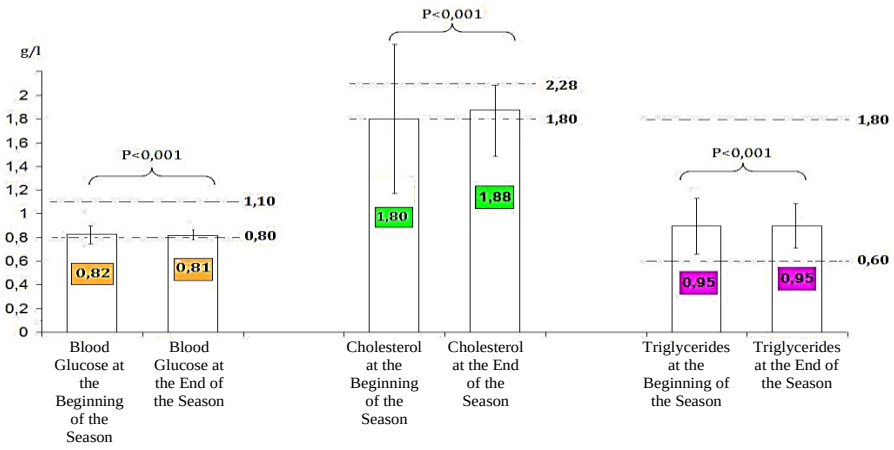


FIG 03: Variations in some biochemical parameters between the beginning and end of the sports season among midfielders of CAB Batna.

Variations in Blood Glucose and Lipids Among the Team's Forwards

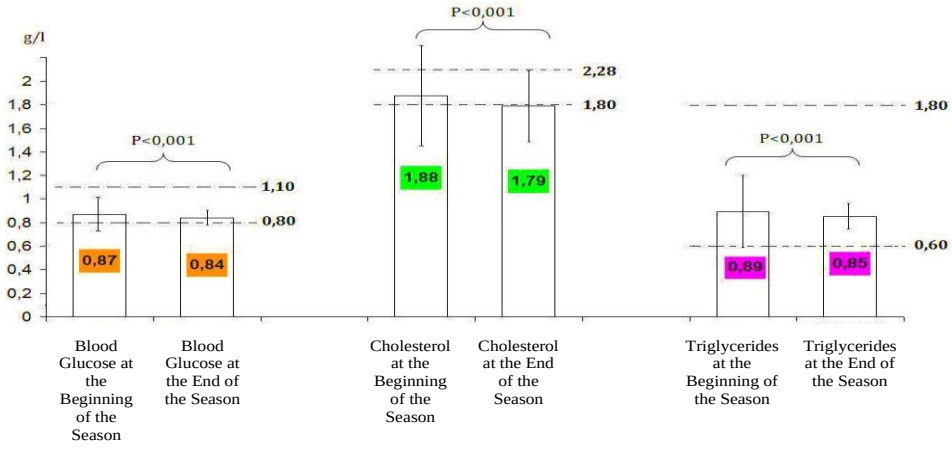


FIG 04: Variations in some biochemical parameters between the beginning and end of the sports season among the forwards of CAB Batna.

In Figures 1, 2, 3, and 4, a slight but statistically significant decrease was observed in all the biochemical parameters studied, including blood glucose, cholesterol, and triglycerides, for the entire CAB football team, as well as in the comparative study of playing positions.

Moreover, the results remained within the recommended physiological norms. It is also worth noting that the corollary study of triglyceride and blood glucose levels during the sports season for CAB showed an inverse correlation (**r = -0.580**).

This indicates a strong likelihood that the footballers' bodies utilized their own lipids and triglycerides as energy substrates to sustain the intense physical efforts required during the championship and Algerian Cup matches in the second half of the 2017/2018 sports season, compensating for the recorded hypoglycemia.

Additionally, this aligns perfectly with the comparative analysis of variations in body weight between the beginning and end of the season for CAB players (Tables 1, 3, 4, and 5), where a significant decrease (**P < 0.001**) was recorded for all players across all playing positions.

Variation in Oxygen-Carrying Capacity Among CAB Football Players During the 2017/2018 Sports Season

Table 20: Average variations in oxygen-carrying capacity among CAB football players during the 2017/2018 sports season.

Blood Parameters / Playing Position	Beginning of the Season $\overline{X} \pm \sigma$		End of the Season $\overline{X} \pm \sigma$	
	Hb (g/l)	**Htc %**	**Hb (g/l)**	**Htc %**
Defenders (n = 8)	151,50 ± 12,58	43,41 ± 3,92	150,13 ± 12,01	42,69 ± 1,78
Midfielders (n = 8)	150,25 ± 7,36	42,96 ± 2,31	149,25 ± 8,29	42,90 ± 2,08
Forwards (n = 6)	142,50 ± 3,94	40,78 ± 1,54	143,83 ± 9,17	42,37 ± 1,49
CAB Team (n = 22)	148,54 ± 9,16	42,53 ± 2,86	148,25 ± 9,85	42,80 ± 1,77

$\overline{X} \pm \sigma$= Mean and Standard Deviation
Hb = Hemoglobin
Htc = Hematocrit

Given the similarity in the average values of hematocrit and hemoglobin (Table 20) across all players by position and for the entire CAB team, we decided to present a single figure illustrating the oxygen-carrying capacity for the entire team and specifically for the forwards during the 2017/2018 season. To recall, the oxygen-carrying capacity of blood determines its ability to bind and transport oxygen from the lungs to tissues. It increases when hemoglobin levels rise but decreases when hematocrit levels increase. In the figure below, the shaded area represents the physiological conditions where the oxygen-carrying capacity is maximal, thereby promoting better tissue oxygenation. A high oxygen-carrying capacity indicates excellent recovery potential.

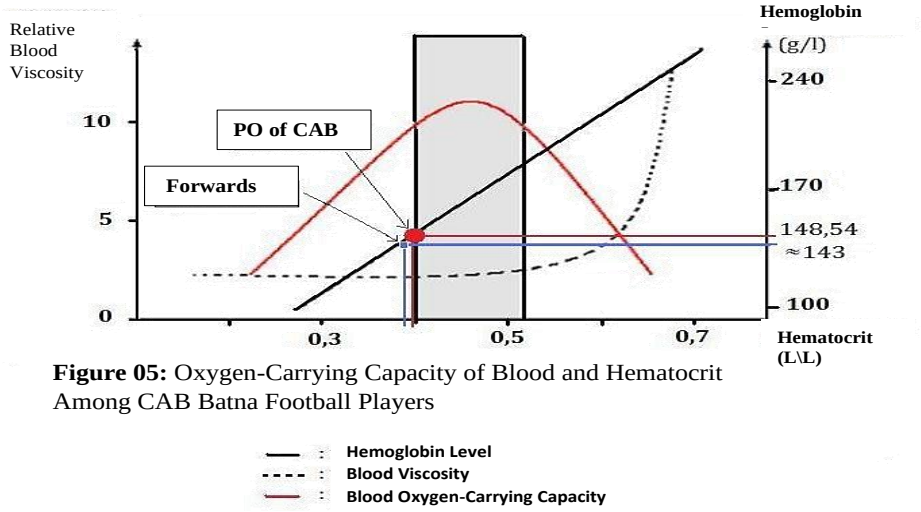


Figure 05: Oxygen-Carrying Capacity of Blood and Hematocrit Among CAB Batna Football Players

According to Figure 5, the oxygen-carrying capacity of our football players is insufficient. It remains within the lower limits of hemoglobin and hematocrit throughout the 2017/2018 sports season. However, it diminishes (leaving the shaded zone) among CAB forwards during the same period. Based on the values in the graph, the relative oxygen-carrying capacity of the forwards does not recover (reduced recovery).

The 2017/2018 sports season led to a decrease in the oxygen-carrying capacity, thereby limiting the blood's ability to bind and transport oxygen in the studied subjects. This reduction in the blood's oxygen-carrying capacity coincides with the physical effort exerted throughout an entire football season.

There were likely structural tissue damages and disruptions not only at the intracellular level, affecting ionic and gaseous exchanges, but also at the blood level. Consequently, the post-effort decrease in oxygen-carrying capacity can be interpreted as a biochemical marker or indicator of fatigue, particularly among the forwards of the CAB team.

SUMMARY

Injuries and Traumas Recorded Among CAB Football Players During the 2017/2018 Sports Season

This subchapter, which we consider highly important and useful, aims to shed light on the connection between our working hypotheses. Firstly, it explores the link between athletic performance and injuries, and secondly, the typology of injuries related to the playing surfaces used in the National 2 league.

In collaboration with the doctor, physiotherapist, and nurse, we gathered data on the frequency, type, and location of injuries. Based on this information, we created three figures illustrating the frequency of injuries for the entire CAB team, injuries by playing position, and their typology.

Frequency of Injuries Among CAB Football Players

The study of injury frequency among CAB players revealed notable statistics during the 2017/2018 sports season (Figure 13). Sprains were identified as the most common injuries, accounting for 31.75%, followed by muscle contractures at 17.46%, and muscle tears at 12.70%.

Additionally, various other injuries, such as wrist, finger, and toe sprains, tendinitis, periostitis, and different inflammations, along with illnesses such as flu, tonsillitis, diarrhea, gastritis, or dental

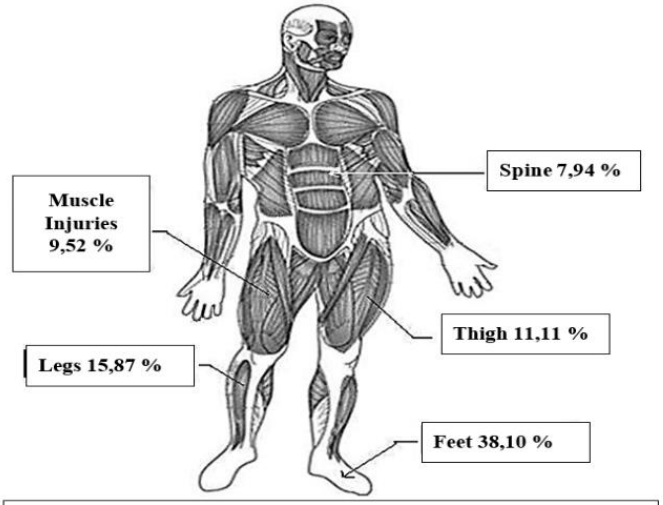
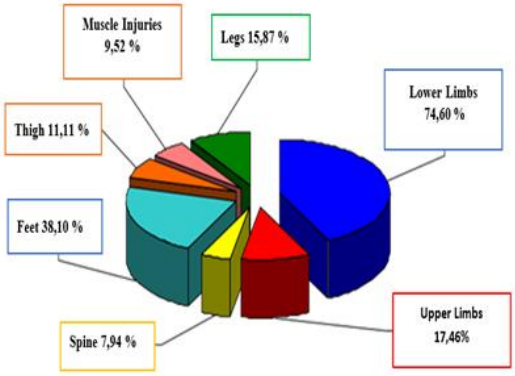
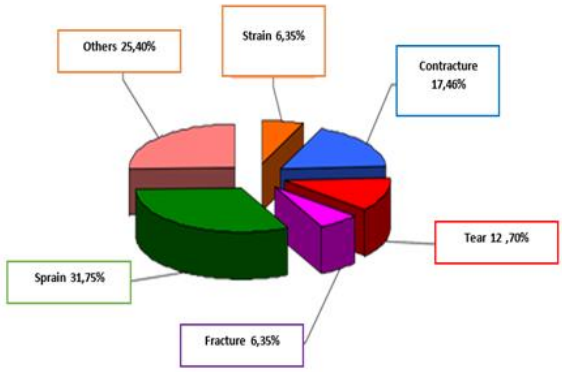


Fig 6: Topography of Injuries Among CAB Batna Football Players

issues, accounted for 25.40% of the traumas experienced by CAB players during the 2017/2018 sports season.

General Topography of Injuries Among CAB Football Players During the 2017/2018 Sports Season





CONCLUSION

This article investigated the effectiveness of a biomedical and morphological monitoring protocol aimed at preventing muscle injuries among professional football players at CAB Batna. The results provided valuable insights into the importance of regular, personalized monitoring to prevent and mitigate the risks of muscle injuries in the specific context of professional football.

The study revealed that rigorous biomedical monitoring, including regular assessments of blood parameters such as blood urea, cholesterol, triglycerides, sodium, potassium, plasma calcium, plasma magnesium, and blood glucose, was crucial for detecting markers of muscle injury risk. By identifying these biochemical markers, it is possible to take preventive measures and implement strategies to minimize injury risks.

In parallel with biomedical monitoring, individualized physical monitoring played a key role in preventing muscle injuries. Regular evaluations of muscle strength, flexibility, endurance, and balance helped identify muscle imbalances and weaknesses that could predispose footballers to injuries. By recognizing these imbalances, it becomes possible to implement targeted training programs aimed at strengthening weak muscles and restoring muscle balance, thus reducing the risk of injuries.

In conclusion, the practical implications of this research are significant. Football clubs can implement similar monitoring protocols, incorporating regular biomedical and physical assessments, to prevent muscle injuries in their players. This will help improve the health and performance of professional footballers by minimizing injury risks that could negatively impact their sports careers.

Finally, this doctoral thesis has paved the way for new research perspectives in the field of biomedical and physical monitoring for professional footballers. Future studies could further explore the underlying mechanisms of muscle injuries, develop more advanced monitoring tools, and assess the long-term effectiveness of monitoring protocols in other football clubs.

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