

Use of GPS in the quantification of the training load in football

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Abstract:

The GPS, considered a new technology, is increasingly at the service of professional football clubs to develop the future of the game, insofar as it allows the evaluation of distances, speeds and accelerations as a function of time.

This study aims to clarify the use of this device in order to facilitate its use.

Indeed, the results collected by the GPS not only allow the analysis of the game, but they also provide information on the physical state of each game position, whether after each preparation or in relation to the desired level.

KEY WORDS: GPS; TRAINING LOAD; FOOTBALL.

المخلص:

يعتبر نظام تحديد المواقع تقنية حديثة وضعت شيئا فشيئا في خدمة فرق كرة القدم المحترفة لتطوير مستقبل اللعبة، وذلك بقياس المسافات المقطوعة، السرعات و التسارعات تبعا للزمن.

هدفت هذه الدراسة إلى توضيح كيفية استعمال هذا الجهاز لتسهيل استخداماته من جهة، ولتقنين حمولة التدريب من جهة أخرى.

لا تسمح النتائج المتصل عليها من خلال هذا الجهاز فقط بتحليل مجريات اللعبة، إنما تعلمنا كذلك بالحالة البدنية حسب موقع كل رياضي بعد كل تحضير أو حتى مقارنة مع المستوى المرغوب الوصول له.

الكلمات المفتاحية: نظام تحديد المواقع، حمولة التدريب، كرة القدم.

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1-Introduction:

The purpose of the training is to allow the sportsman in general and the footballer in particular to demonstrate his technical and tactical abilities as best and as long as possible during the match but also throughout the sports season. These abilities ensure the durability of brief, intense and repeated efforts throughout the match, and thus allow the expression of the footballer in all situations of the match. Sports performance during a match is, in fact, conditioned by several qualities (Paillard, 2010). Today we cannot separate the body from the mind or even physical training from mental training. (Reiss, 2017, 615). Therefore, it is necessary to work in synchronization the physical and the mental so that they are at the service of the technical-tactical capacities.

Sports training is a complex action exerting a systematic and specific effect on the level of optimal performance in a situation of trial and competition (Carl, 1989, 218). Sports training exerts an external and an internal load that modifies homeostasis and forces the body to mobilize adaptation mechanisms that improve more and more at the end of each training session.

There is no valid quantitative measure of the constituents of training load for all forms of motor effort or their subcategory, since training load categories differ completely in method, content and training means. However, it would be necessary to succeed in reducing this diversity to one and the same form of motor effort. (Weineck, 1999, 19).

At each training session or sports discipline a dominant in terms of physical quality, this is why the measurement differs: for the force we use the kilogram, the Newton, %1RM, for the impulse: the Newton/second, for the speed of movement: the distance in meters, the meter/second, for the acceleration the meter/S², the heart rate, the time...

Several methods have emerged to control training and prevent overtraining: Some of them are objective such as: the heart rate method using the formula of Banister 1975, Calvert & al 1976, from Banister and Hamilton 1985, Morton & al 1990, Busso & al 1991, Candau & al 1992, from Edward 1993, Mujika & al 1996, Busso & al 1997, Banister & al 1999, Millet & al 2002, Busso & al 2002, Busso 2003, of Lucia 2003, Avalos & al 2003, Wood & al 2005, Hellard & al 2006, Desgorces 2007.

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Target heart rate methods through the Karvonen formula and from maximum heart rate formulas (Astrand & Ryming 1954, Haskell and Fox, 1970, Inbaret 1994, Tanaka & al 2001, Robergs and Lanwher 2002, Gellish & al 2007...), the methods of lactatemia, of the percentage of the VMA, of the maximum repetitions (Brzycki, Epley, Lander, O'Conner et al, Lombardi, Mayhew et al, Wathen). (Jimenez Alfonso & De Paz, 2008, 12), VO2max, methods of distances travelled, speeds and accelerations using a stopwatch, accelerometer, radar, photoelectric cells... GPS using the method of Casamichana 2013. (Hourcade, 2019, 43). Other methods are, however, subjective, such as Foster's 1998 effort difficulty perception method, Robinson's 2004 perceptual mood index (Coquart 2016, 79 and 191). The condition index (Hooper & al, 2005, 109).

2- General objective of the study:

The objective of this study is to elucidate the role of GPS (Global Positioning System) as a sophisticated means of quantifying the training load in football.

Hypothesis:

GPS helps to give accurate indicators of training load in football.

3- Procedural definition of the concepts mentioned in the research:

- Artificial intelligence:

Artificial intelligence (AI) consists of implementing a number of techniques that allow machines to imitate a form of real intelligence. AI is being implemented in a growing number of application areas. (futura-sciences, 2022)

- Training load:

Letzelter (1978) spoke of training load norms, which are now called "training load constituents". These quantitatively and qualitatively determine the overall load and define the specificity of the training considered. (Letzelter, 1978, 34). They are five in number: The intensity of the stimulus which consists of a force exerted by the latter.

The density of the stimuli, which designates the temporal relationship between the phases of load and the phases of recovery.

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The duration of the stimulus, in other words the duration of application of a stimulus or a series of stimuli.

Stimulus volume, it's the duration and number of stimuli per training session.

The training frequency which represents the number of training sessions per day or per week.

- The GPS :

The Global Positioning System (GPS) is a utility that belongs to the United States, it provides positioning, navigation and time reference services, called "PNT services" (positioning, navigation, and timing). (gps.gov, 2022).

It is a satellite geolocation system used to determine the geographical coordinates of any point on the surface of the globe. Its accuracy can reach 1 meter. (futura-sciences, 2022)

- **Principle of operation:**

The operating principle of GPS is based on measuring the distance of a receiver from several satellites (the satellites are distributed in such a way that 4 to 8 of them are always visible).

Each satellite transmits a signal, picked up on Earth by the receiver, to very precisely measure the distance separating the transmitter from the receiver thanks to the travel time. With the reception of signals from four satellites (three to obtain the point of intersection of the three spheres, a fourth for time synchronization). (futura-sciences, 2022)

The signals picked up by the receiver are processed by a mobile terminal which also stores the cartography, in order to make it easier for the user to know his position and the direction in which he is heading. Maps could not be viewed without navigation software. This software contains one or more maps of a specific geographical area, most often a country or a continent. Navigation assistants are stand-alone GPS devices, as they embed the navigation software, the receiver and the terminal in the same box. The receiver is able to calculate the speed of propagation of the waves emitted to deduce the distance which separates them. The combination of mapping software makes it possible to obtain an efficient route guidance system (display of a map with directions and audio guidance). It is developed in different forms: in-car system, autonomous box with integrated receiver, personal assistant or smartphone associated with a GPS receiver.

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Table N°1: Characteristics of the main studies relating to the analysis of the movements of the footballer, from 1976 to 2016

Références	Année de publication	Saison sportive concernée	Matériel de recueil de données	Pays de l'équipe observée	Niveau de compétition	Système de jeu	Domicile Extérieur	Métère, Surface de jeu	Période d'observation	Présentation des données
Tierney, P.J et al.	2016	2014-2015	GPS Stat sports®	U21 U18 Angleterre	Championnats + Elite Jeunes	4-4-2/4-3-3 3-5-2/3-4-3 4-2-3-1	Non précisés	Herbe	Avril à Mai	Zones de vitesse (km.h ⁻¹) Accélérations+Décel
Suarez-Antones, L. et al.	2015	2013-2014 ?	GPS GPSports® SPI Pro X	Espagne	Division 1+ Coupes N et Euro	4-4-1-1	Non précisés	Non précisées	7 mi-temps seulement	Zones de vitesse (km.h ⁻¹) Distance (m.min ⁻¹)
Bradley, P. et al.	2013	2010-2012 ?	Prozone Sports LMS v3.0 (multi-caméras)	Angleterre	Division 1+2+3	Standardisé	Non précisés	Non précisées	Standardisée	Zones de vitesse (km.h ⁻¹) Distance (m)
Bradley, P. et al.	2011	2006-2007	Prozone Sports LMS v3.0 (multi-caméras)	Angleterre	Division 1	4-4-2 4-5-1 4-3-3	Non précisés	Non précisées	1 saison	Zones de vitesse (km.h ⁻¹) Distance (m)
Deila, A. et al.	2010	2005-2006	Amisco Profil	France	Division 1	Non précisés	Non précisés	Non précisées	1 saison	Zones de vitesse (km.h ⁻¹) Distance (m)
Di Salvo, V. et al.	2007	2002-2004	Amisco Profil v.1.0.2	Espagne	Division 1+ Champ. Ligue	Non précisés	Non différenciés	Non précisées	2 saisons	Zones de vitesse (km.h ⁻¹) Distance (m)
Barros, M.R.L. et al.	2007	2001-2004	DVideo®	Brazil	Division 1	Non précisés	Domicile + Extérieur	20-30°C	3 saisons	Zones de vitesse (km.h ⁻¹) Distance (m)
Burgess, et al.	2005	2002-2003	Track Performance®	Australie	Division 1	Non précisés	Non précisés	Non précisées	1 saison	Zones de vitesse (km.h ⁻¹) Distance (m.min ⁻¹)
Mohr, M. et al.	2003	2001-2002 ?	Caméras VHS (Panasonic NV-M50)	Italie Danemark	Division 1+ Champions Ligue	Non précisés	Non précisés	Non précisées	3 périodes (début, milieu, fin)	Zones de vitesse (km.h ⁻¹) Distance (m)
Riant, E. et al.	2000	1998-1999 ?	Caméra (Sony TR 75E)	Angleterre Amérique du Sud	Division 1 International	Non précisés	Non précisés	Non précisées	Non précisée	Zones de vitesse décrites Distance (m)
Bangubo, J. et al.	1991	1988-1990 ?	Multi-Caméras (pas de référence)	Danemark	Division 1+2	5-3-2	Domicile	Non précisées	milieu de 2 ère partie de saison	Zones de vitesse (km.h ⁻¹) Distance (m)
Eklund, B.	1986	1982-1983	Tapeage à la main sur plan (Echelle 1:400)+ TV	Suède Allemagne Angleterre	Division 1+2+3+4	Non précisés	Non précisés	20-30°C	Printemps/ Eté Automne	Quelques données de distance (m/min)
Withers, R. T. et al.	1982	1978-1979	Caméra + magnétophone	Australie	Division 1	Non précisés	Domicile + Extérieur	Non précisées	Non précisée	Zones de vitesse décrites Seuls enroulés
Reilly, T. & Thomas, V.	1976	1974-1975 ?	Tapeage à la main sur plan	Angleterre	Division 1	4-3-3	Domicile + Extérieur	Non précisées	Non précisée	Zones de vitesse décrites Distance (m)

Source : (Hourcade, 2019, 18).

Centre-backs seem to be the ones who travel the least distance. Full-backs have, on average, greater distances covered than central defenders and forwards, without reaching those of midfielders. Centre-backs cover less distance than full-backs (9333-10980m vs. 10152-11474m). Midfielders have greater distances than defenders (backs) and forwards (11,300 vs. 10,095 and 10,374 m). The forxards display distances covered of very unequal values according to the studies. They cover an average of 10374m during a football match, the distances evolve according to the system of play and the offensive animation of the team. (Hourcade, 2019, 18-19).

• **Composition:**

The GPS is composed of 3 distinct parts, also called segments: (techno-science, 2022)

➤ **The space segment:**

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It currently consists of a constellation of 30 satellites (NAVSTAR for Navigation Satellite Timing And Ranging), with 6 different trajectories. They follow an almost circular orbit at an altitude of 20,000 to 20,500 km, which they cover in 11 hours 58 minutes at a speed of 13,000 km/h.

➤ **The control segment:**

This is the part that controls and monitors the system. It is composed of 5 American ground stations of the 50th Space Wing of the Air Force Space Command, based at Schriever Air Force Base in Colorado (the master station is based in Colorado Springs) in the base of Cheyenne Mountain. Their role consists in recording all the information emitted by the satellites, to calculate the positionings.

➤ **The user segment:**

It brings together all civil and military users who only receive information from satellites. The receivers are passive, and the system cannot therefore be saturated: the maximum number of GPS users is unlimited.

Previous and similar studies:

The use of GPS has shown that defenders and centre-forwards are those who run the shortest distance during the match, unlike midfielders. On the other hand, for the distance covered in sprints, the midfielders are outstripped by the attackers. Their physical profile and their training must therefore be different. (Ignasse, 2012). The following table shows the different studies using sophisticated equipment to measure match load.

Table N°2: Characteristics relating to the analysis of the movements of the footballer between 2000-2010

Setting \ Player	Football team
HID: High Intensity Distance	14-19km/h (3.9-5.3m/s) (from 10% in 2000 to 15% in 2010)
VHID : Very High Intensity Distance	>19km/h (5.3m/s) (from 4% in 2000 to 8% in 2010)
Speed	18, 21, 23, 25 km/h (5, 5,83, 6,4 et 6,94m/s)
Acceleration/deceleration	2, 3, 4, 5 et 5.5m/s ² -2, -3, -4, -5 et -5.5m/s ²

Source : Synthesis established by the author according to Hourcade 2019

4- The methodological procedures used in the study:

4-1 Method and tools:

This study took place on February 28, 2019 at the Sidi Moussa center, Blida in Algeria on trainee federal physical trainers, during their 2nd grouping

- The scientific foundations of the tool:

The collection of was carried out through recordings on the FieldWiz GPS sensors during a training session based on reduced or small games.

-Experimental protocol :

The player wears a shirt which in turn has the GPS sensor on just at the start of the exercise and then off just at the end.

-The GPS used in football:

The footballer moves on the field in all directions, the 3D positioning thus gives his coordinates via his receiver which is in space, in a 3-axis reference (X, Y, Z). Advanced Sport Instruments (ASI) is a Swiss company based in the Olympic capital Lausanne, created in 2011, its expertise was forged from the passions of the two founders: sport and electronics in order to develop the equipment to be used in sport such as: FieldWiz, AdMos, AdMosLive, Custom.. (ASI, 2022)

Among the different brands of GPS, we will present the Feilwiz not for commercial purposes, but rather because we had the opportunity to experience it within the training center of the Algerian football federation: Sidi Moussa.

-The FieldWiz GPS Tracker:

The FieldWiz is an electronic system for monitoring and measuring strategic and physical performance. It measures team performance and retrieves important match and training data and helps staff make informed decisions and improve strategies.

It also allows you to perform periodization, view entire matches, analyze trends, training loads but also the positions and movements of players... FieldWiz follows FIFA International Match Standard recommendations in electronic performance and tracking systems. (fieldwiz-benelux, 2022)

-The components :

They are: a connected shirt, a sensor and a docking station.

Graph N° 1. Components of the Fieldwiz GPS sensor



Source : <https://fieldwiz-benelux.com/>

-The analyze.fieldwiz platform:

It is a software for processing data collected by the FieldWiz GPS tracker.

Graph N° 2. Interface of the analyze.fieldwiz platform



Source: <https://analyze.fieldwiz.com>

-Data collected:

- **Positioning and movement data:**
 - ✓ Total Distance
 - ✓ Distance per speed zone
 - ✓ Maximum speed
 - ✓ Average speed
 - ✓ High Intensity Distances
 - ✓ Sprint statistics
 - ✓ Heat map, field positioning

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- ✓ % Distance in Field Areas
- ✓ Accelerations in m/s^2
- ✓ Decelerations in m/s^2
- **3.3.2. Heart rate data:**
 - ✓ Heart rate in beats per minute.
 - ✓ Maximum heart rate
 - ✓ Average heart rate
 - ✓ HR zones based on individual max HR
 - ✓ HR individual work target

-Statistical tools:

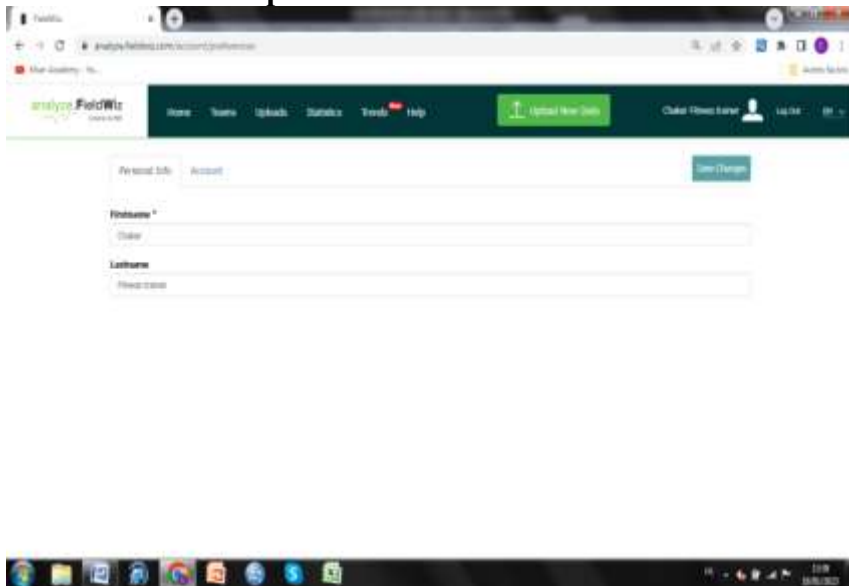
In this part we are going to present a recording which was made at the internship of the fitness federal trainer promotion 2019, of which I myself was an intern.

4-2 Presentation and Analysis of Results:

The processing of the GPS recording goes through the following steps:

- Create an analyze.fieldwiz account:

Graph N° 3. Creation of a count



Source: <https://analyze.fieldwiz.com/>

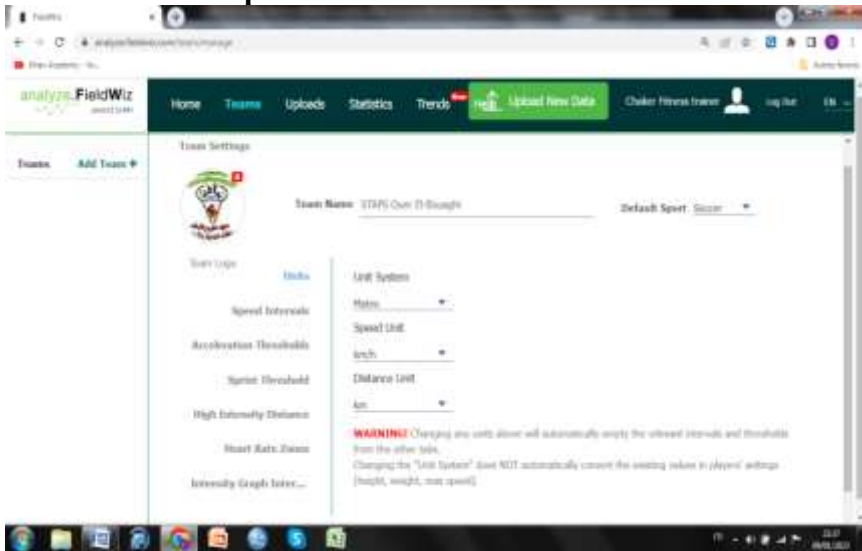
- Create a team:

We named it: STAPS Oum El-Bouaghi, adding the logo and the type of discipline practiced while choosing the units we want to follow and then we register.

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Graph N° 4. Creation of a new team

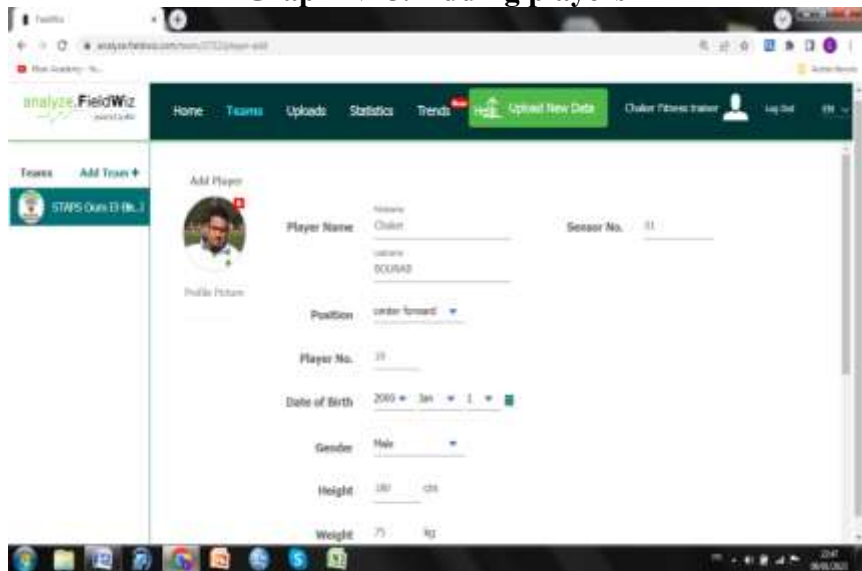


Source : Screenshot taken by the author

- Add players:

Mention the name, first name, date of birth, weight, height, game position, shirt number, GPS sensor number, then register each player.

Graph N° 5. Adding players



Source : Screenshot taken by the author

- Import GPS recording:

Upload new data and select the type of GPS used

Graph N° 6. Importing GPS recordings



Source : Screenshot taken by the author

- **Naming and defining statistics:**
Position the four corners of the field on the map.

Graph N° 7. Adjusting the terrain on the map



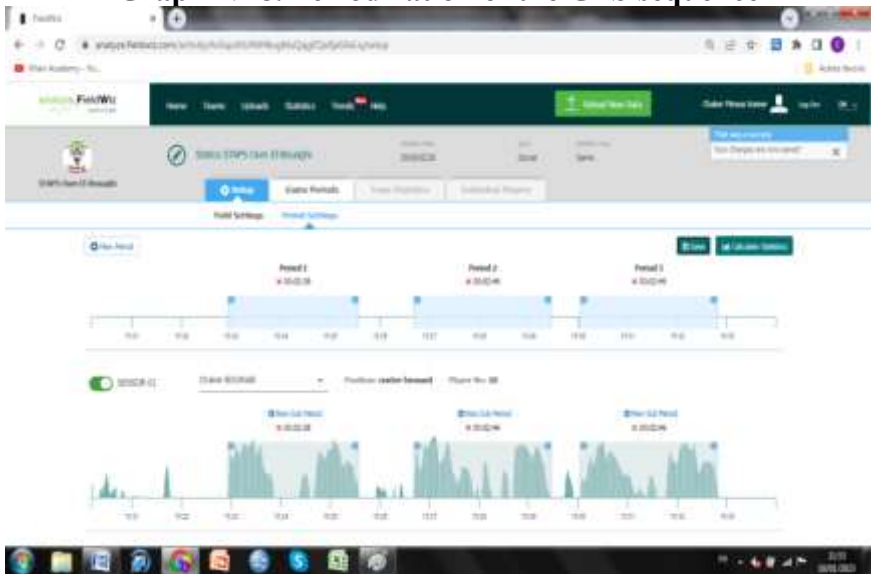
Source : Screenshot taken by the author

- **Divide the sequence into periods:**
To facilitate the study, the GPS sequence is divided and then recorded over periods according to the player's activity. This phase ends with registration.

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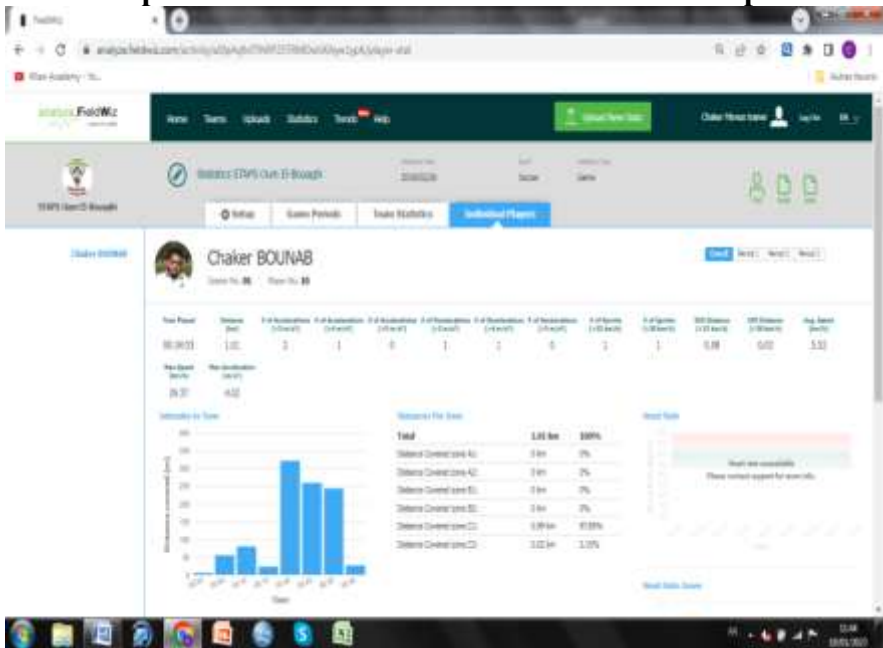
Graph N° 8. Periodization of the GPS sequence



Source : Screenshot taken by the author

- 4.7.Statistics:
- Individual statistics:

Graph N° 9. Creation of individual statistics 1st part



Source : Screenshot taken by the author

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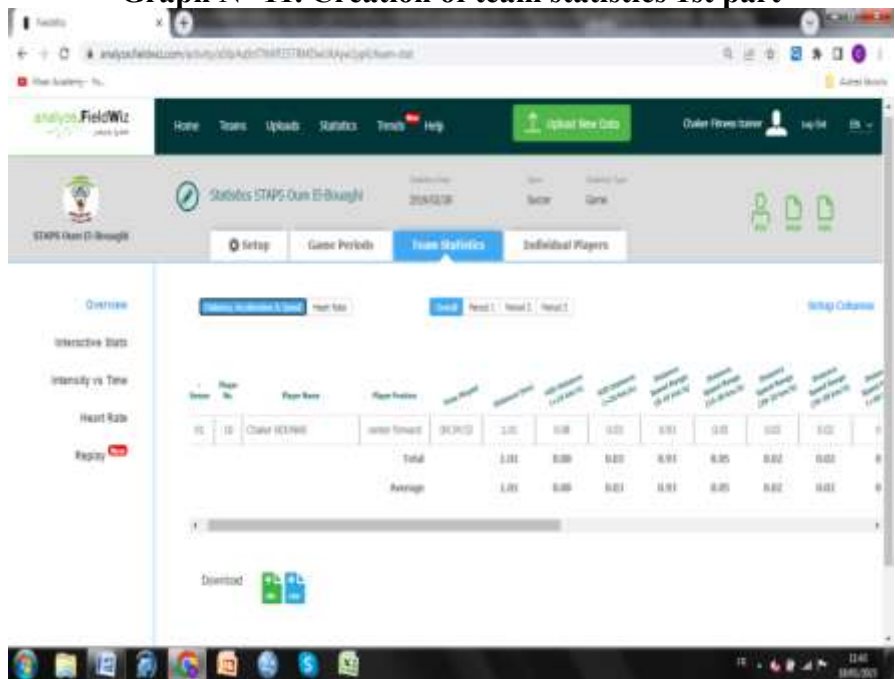
Graph N° 10. Creation of individual statistics 2nd part



Source: Screenshot taken by the author

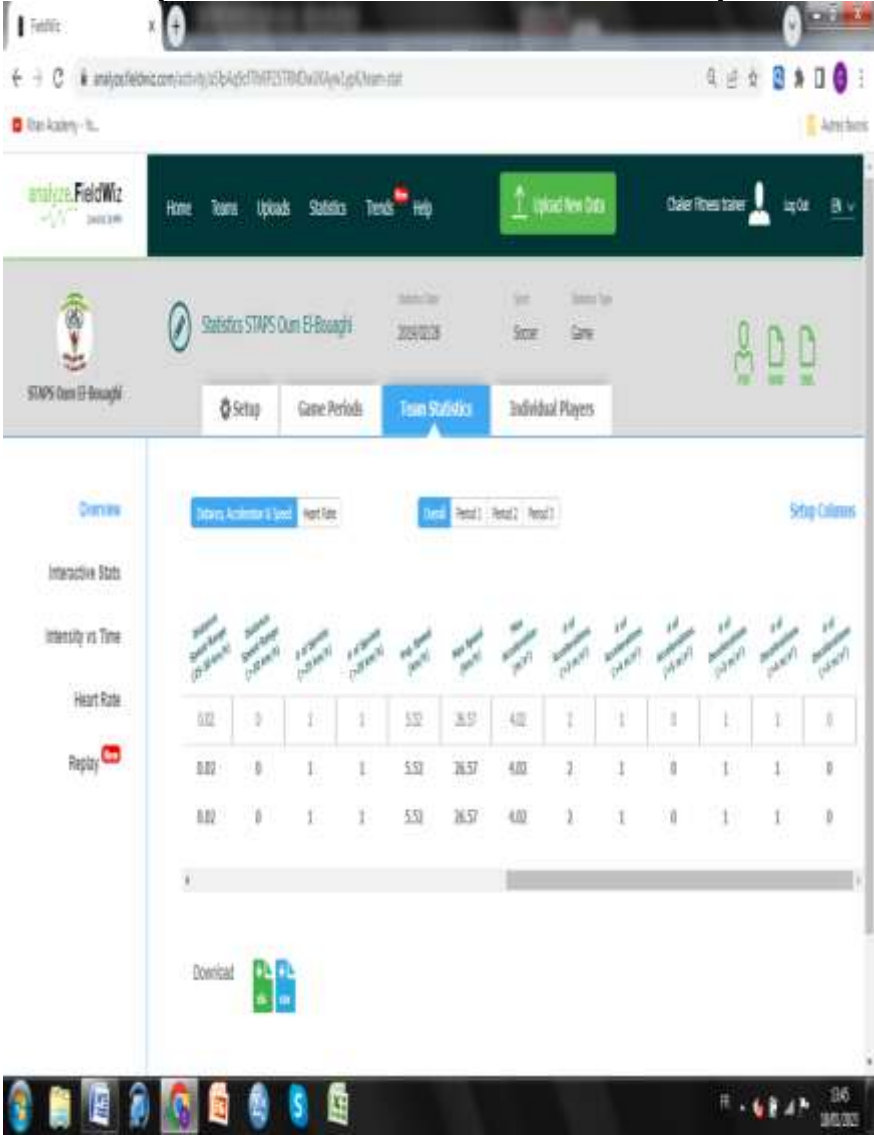
- Team statistics:

Graph N° 11. Creation of team statistics 1st part



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Graph N° 12. Creation of team statistics 2nd part



Source: Screenshot taken by the author

- Presentation of the results in PDF form:

We can present the results as a PDF document by clicking on the upper right icon.

Graph N° 13. GPS report cover page in PDF form



STAPS Oum El-Bouaghi
Statics STAPS Oum El-Bouaghi

Game Report

28.02.2019



Chaker BOUNAB

www.asi.swiss

Source : Screenshot taken by the author

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Graph N° 14. 1st player 1st period GPS report, 1st part



Source : Screenshot taken by the author

Graph N° 15. 1st player 1st period GPS report, 2nd part



Source : Screenshot taken by the author

4-3 Discussion and interpretation of the results:

The results obtained by using GPS will be presented in the form of distance, speed and acceleration varied according to time, which will be compared with the results of the same team, the opposing team, the previous match or with reference results, as we can compare the results of a player with his same team.

Conclusion:

The evolution of the presentation material of the situations makes it possible to get closer and closer to the real situations in football. By dint of this illustration, we confirm the effectiveness of the GPS device insofar as it makes it possible to give indicators of the training load through the evaluation of the distances covered, the average and maximum speed of the race and the acceleration/deceleration of players in a match, It is also possible to draw up the physical profile of footballers according to their playing position.

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