**Echocardiographic aspects of north-African male and female soccer players in Morocco**

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ABSTRACT

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| **Aims:** Intense and prolonged sports activities lead to cardiovascular adaptations known as "athlete's heart." Our study aimed to explore the echocardiographic characteristics of athlete's heart in North African soccer players.**Methods:** This descriptive study was conducted by the Non-Invasive Explorations Department at the Rabat Military Hospital and focused on 53 category A players from the men’s and women’s soccer teams of the “Force Armed Royal” sports association. The research analyzed various parameters, including the end-diastolic diameter and parietal thickness of the left ventricle, the basal diameter of the right ventricle, atrial surface areas, as well as the systolic and diastolic functions of the LV.**Results**: The average age of the participants was 23.5 ± 4 years, with 35.8% (19) being women and 64.2% (34) being men. Left ventricular dilatation was observed in 17% (9) of the players, with an average diameter of 44 ± 4 mm in women and 52 ± 4 mm in men. 39.6% (21) of the players had right ventricle dilatation. The left ventricular systolic function varied from 51% to 76%, with 7.5% (4) of players displaying mildly reduced systolic function. When comparing the two genders, men had a significantly larger right ventricular diameter and a greater left ventricular end-diastolic diameter than women, with p-values of <0.001 and 0.038, respectively.**Conclusion:** In our study, the predominant findings were dilatation of the left cardiac chambers without any associated ventricular hypertrophy, while left ventricular ejection fraction remained preserved and diastolic function was notably supranormal. These results are consistent with existing literature, particularly studies involving footballers that share similar characteristics to our cohort. |

***Keywords:*** *Athlete Heart; Echocardiography; Soccer player; cardiac*

1. INTRODUCTION

The term "athlete's heart" (AH) describes the various adaptations in the cardiovascular system that occur as a result of prolonged, intense physical exercise. Regular participation in strenuous exercise induces cardiac remodelling characterised by distinct electrocardiographic and echocardiographic features. These include increases in ventricular size and volume, left ventricular (LV) mass and wall thickness, and improved diastolic function [1].
When assessing AH, it is important for clinicians to recognise that it is a unique physiological state rather than a pathological condition. The athlete's heart is normal and has adapted to the demands of intense physical activity through specific morphological and functional changes [2]. However, these adaptations can sometimes mimic signs of potentially arrhythmogenic structural heart disease, such as hypertrophic cardiomyopathy and dilated cardiomyopathy. This highlights the importance of careful investigation of AH to differentiate between normal physiological adaptations and underlying structural heart disease. It is therefore crucial to establish standards tailored to the elite athlete population within sports medicine screening programmes. The aim of our study is to establish the echocardiographic profile of North African athletes by examining both male and female footballers and to compare the findings with the existing literature.

2. material and methods

1. Population:

This is a cross-sectional study conducted between December 2020 and February 2021 by the Non-Invasive Explorations Department at the Mohammed V Military Teaching Hospital in Rabat, Morocco. It aimed to perform routine echocardiographic evaluations of category A players from the Royal Armed Forces Sports Association (AS-FAR) male and female soccer teams. All athletes included in the study were free of cardiovascular disease and were actively participating in national and international competitions. The study was carried out at the AS-FAR sports center.

1. Inclusion criteria:

All young male and female players of the AS-FAR category A soccer team were included prospectively.

1. Exclusion criteria:

Athletes with incomplete echocardiographic data were excluded from our study.

1. Data collection:

All athletes included in the study had a routine cardiac evaluation, during which they underwent two-dimensional resting transthoracic echocardiography (TTE). TTE was performed with a GE Vivid S9 ultrasound scanner. Age, gender, body surface area (BSA) and the echocardiographic measurements were recorded by two operators on the athletes' follow-up files.

The acquisition of standard sections (parasternal long axis, parasternal short axis, apical 4 cavities, apical 2 cavities, apical 3 cavities) and quantitative measurements have been performed including:

* + A study of the left ventricular dimensions: parietal thicknesses and left ventricular end-diastolic diameter (LVEDD) in long-axis para-sternal section in 2D mode. LV mass was calculated from these data.
	+ A study of right ventricular dimensions: Right ventricle basal end-diastolic diameter (RVBEDD) on an incidence centered on the right ventricle.
	+ Quantification of left ventricular systolic function: measurement of left ventricle ejection fraction (LVEF) in Simpson biplane.
	+ Quantification of right ventricular systolic function: tricuspid annulus plane systolic excursion (TAPSE) in time-of-motion (TM) mode, S' wave in tissue Doppler at the tricuspid annulus.
	+ Analysis of diastolic function and left ventricular filling pressures:
		- E and A wave amplitude in pulsed Doppler at the mitral funnel.
		- Tissue Doppler E' wave at the lateral and septal mitral annulus.
		- Calculation of the averaged E/E' ratio.
	+ Left atrial dimensions: diameter in long-axis para-sternal TM mode, two-dimensional left atrium area (LAA) on apical 4-cavity incidence and right atrial dimensions; two-dimensional area on apical 4-cavity incidence.

Data on ventricular dimensions were indexed to the body surface area.

3. Statistical analysis:

Statistical analysis was carried out using Jamovi version 1.6 software. Normal distribution quantitative variables were expressed as mean and standard deviation. Abnormal distribution quantitative variables were expressed as median and quartiles. Qualitative variables were expressed as headcount and percentage. Quantitative variables were compared by Student's T-test. For qualitative variables, we used a Chi-2 test, or, failing this, a Fischer test when the validity conditionś of the Chi-2 were not met. The significance threshold́ was set at 0.05.

1. results

**1. Demographic data**

53 category A AS-far soccer players were included in our study. 34 of them were males and 19 were females. Their demographic characteristics are listed in Table 1.

**2 . Echocardiographic data (Table 2 and Table 3):**

**a- Left ventricular dimensions**

**-** LVEDD**:**

LVEDD ranged from 38 to 60 mm (mean 49.2± 5.2 mm) and indexed LVEDD from 21.7 to 38.2 mm/m2 (mean 27.5 ± 2.5 mm/m2). Only 17% (9 individuals) had a dilated LV with an indexed LVEDD> 30 mm/m2. When comparing the LVEDD between the two sexes, there was a statistically significant difference (*P* < 0.001). Male soccer players demonstrated increased left ventricular dilatation compared to female players.

**-** Parietal thicknesses**:**

Mean septal diastolic thickness (SDT) was 7.9 ± 1.8 mm and posterior wall thickness (PWT) was 8 ± 1.5 mm. No parietal hypertrophy was noted in our population, nor was there any difference between male and female players ( *P* =0.2). Mean indexed LV mass was 75±19 g/m².

**b- Left ventricular systolic function:**

(LVEF) ranged from 51 to 76%, with a mean of 63±6.3. Only 7.5% of the players (4 individuals) were found to have a mildly reduced LVEF.

**c- Left ventricular diastolic function**

Diastolic function was normal in all athletes, or even enhanced. The mean E/A ratio was 1.9±0.4 and E/E' 2.9±0.6. 45.3% (24 individuals) had a restrictive mitral profile with an E/A ratio >2.

**d- Left atrial dimensions**

The mean LAA was 17±3 cm². The LA was dilated in 22.6% of players (12 individuals), (8.3% of females and 91.7% of males). Male athletes showed a higher level of left atrial dilation, demonstrating a statistically significant difference (*P* < 0.001).

**e- Right ventricle:**

Mean BDRV was 37.7 ±3.41 mm. Right ventricle was dilated in 39.6% (21 individuals) of the study population. There was a statistically significant difference between male and female players (*P* <0.001). However, right ventricle function was preserved in all players, with an S wave of 17.9±2.2 m/s.

**Table 1:** Demographic characteristics of AS-FAR category A soccer players.

**Characteristics Values**

 **(N= 53)**

**General characteristics:**

 Age (ans)θ 22 [20- 26]

 Femaleϕ  19 (35,8%)

 Maleϕ 34 (64.2%)

 BSA (m/m2)#  1,7 ± 0,14

θ expressed as median and quartiles.

ϕ expressed as percentage and headcount.

# expressed as mean and standard deviation.

**Table 2:** Echocardiographic characteristics of AS-FAR category A soccer players

 **Characteristics Values**

 **(N= 53)**

 LVEDD (mm)# 49,2± 5,2

 ILVEDD (mm/m2)# 27,5 ± 2,5

 SDT (mm) # 7,9 ± 1,8

 PWT (mm) # 8 ± 1,5

 RWT # 0,3 ± 0,05

 Indexed LV mass(g/m²)# 75 ± 19

 LVEF (%)# 63±6,3

 E/A # 1,9± 0,4

 LAA (cm2)# 17±3

 BRVD (mm) # 37,7 ±3,41

# expressed as mean and standard deviation.

**Table 3:** General Characteristics of Participants.

| **Parameter** | **Values (N=53)**  |
| --- | --- |
| Age (years) θ | 22 [20-26] |
| Female ϕ | 19 (35.8%) |
| Male ϕ | 34 (64.2%) |
| BSA (m²) # | 1.7 ± 0.14 |

θ Expressed as median and quartiles.
ϕ Expressed as percentage and count.
# Expressed as mean ± standard deviation.

1. dISCUSSION

Physiological adaptations of the cardiocirculatory system to intense physical activity can be confused with underlying cardiac pathologies presenting the same echocardiographic features. These morphological and functional changes have been the focus of much research over the past century. The first papers on adaptive cardiac remodeling appeared in the late 1800s and early 1900s, when scientists observed dilated heart chambers and bradycardia in populations of athletes [3,4]. The advent and evolution of echocardiography has enabled a better assessment of these changes, which occur during intense and prolonged physical exercise, making it possible to differentiate between an AH and a pathological heart in an ever-growing population of athletes.

The present study looked at echocardiographic data from 53 Moroccan footballers of both sexes, playing for the AS-FAR soccer team, who underwent TTE as part of their routine follow-up.

*1- Left ventricular dimensions*

In our study, the exercise induced LV remodeling primarily manifested as left ventricular dilatation, with mean LVDED ranging from 38 to 60 mm, with 17% of the population having a dilated LV > 31 mm/m2 (Normal Range < 31 mm/m² for male subjects and < 32 mm/m² for female subjects [5]). Regarding wall thickness, our athletes did not exhibit left ventricular hypertrophy, as the maximum wall thickness did not exceed 12 mm. This finding may be attributed to the nature of our population, which consisted exclusively of soccer players. Given that soccer is a sport characterized by a strong dynamic component, it typically results in greater cavity dilation relative to wall thickening.

A study conducted by Pelliccia and his team involving a cohort of 1,309 Italian athletes [6], with an average age of 24, participating in 38 different Olympic disciplines, demonstrated significant ventricular remodeling characterized by alterations in ventricular dimensions and wall thickness. The research revealed that 45% of the athletes exhibited an increased LVEDD exceeding 54 mm, with 14% of participants recording values greater than 60 mm. Additionally, wall thickness was rarely observed to exceed 12 mm, occurring in only 1.7% of the athletes. Other studies have reported significantly elevated DTDVGs of up to 73 mm in cyclists [7]. These results are therefore comparable to our findings.

*2- Left ventricular systolic function*

In our study, LVEF was preserved or only slightly reduced, remaining above 50% in 7.5% of the players. Several studies [8-10] have reported similar findings, documenting marginally reduced left ventricular systolic function in some athletes. For instance, Churchill et al. [8] examined 238 soccer players and found that LVEF ranged from 47% to 75% in female athletes and from 49.6% to 77% in male athletes.

In a recent study by Boraita et al. [11], involving 624 athletes, the researchers investigated the mechanisms behind the decline in LVEF observed in some athletes. They explained this phenomenon as a result of the need for a minimal percentage of left ventricular end-diastolic volume to sustain a normal resting systolic ejection volume. The study concluded that the decline in LVEF among elite athletes is more indicative of a physiological adaptation rather than pathological remodeling.

*3- Left ventricular diastolic function*

In our population, diastolic function was preserved in all athletes; however, 50% exhibited a restrictive profile, characterized by an E/A ratio greater than Several studies [12-14] have reported normal or even supranormal left ventricular diastolic function in athletes.

 *4- Left atrium*

In a large study conducted by Pelliccia et al. [15], involving 1,777 athletes, the anteroposterior diameter of the left atrium ranged from 23 to 50 mm, with 20% of the athletes exhibiting dilatation greater than 40 mm and 2% showing significant dilatation exceeding 45 mm. The authors concluded that left atrial dilation was secondary to left ventricular dilation. These findings are consistent with our study, which noted dilated left atrial dimensions in 22.6% of our population.

 *5- Right ventricle*

The right ventricle responds to exercise in a manner similar to the left ventricle, leading to an increase in right ventricular size while maintaining both systolic and diastolic function. In our study, the mean basal diameter of the right ventricle was 37.7 ± 3.41 mm, with 39% of the athletes exhibiting right ventricular dilatation while preserving systolic function.

Our results align with findings from the literature. In a study by Zaidi et al. [16] that assessed right ventricular remodeling by comparing 300 African-American athletes with 375 Caucasian athletes and 153 control subjects, it was found that the majority of athletes exhibited larger right ventricles. This dilatation could potentially be misinterpreted as arrhythmogenic right ventricular cardiomyopathy.

 *6.Impact of gender on cardiac changes*

Morphological changes in the heart are influenced by several factors, including gender. Over the past two decades, most studies investigating AH have focused predominantly on male athletes, with only a few, specifically addressing female athletes. However, the increasing participation of women in high-level competitions and their impressive performances have led researchers to place greater emphasis on studying the female athlete's heart. The study conducted by Pelliccia et al. [17] stands out as one of the largest studies published in this area, evaluating 600 female athletes without structural heart disease who participated in 27 different types of competitive sports at both national and international levels.

In this study, the heart chamber diameters were observed to be within normal limits, with LVDED measuring less than 54 mm and only 4% of participants exhibiting a dilated LV greater than 60 mm. As for wall thickness, female athletes typically have heart walls no thicker than 11 mm, and none of the participants in this study demonstrated parietal hypertrophy. These findings are consistent with our own results, which showed that female athletes had non-dilated left ventricular cavities and non-hypertrophied walls.

**Limits of the study**

The primary limitations of our study include the small sample size, the absence of certain key demographic and echocardiographic data, and the lack of a control group. To address these limitations and reduce potential bias, future research should involve a larger cohort of athletes and include a control group of non-athletes for comparison.

1. Conclusion

TTE is a crucial tool in evaluating an AH, making it essential to understand the limits of normal adaptation versus potential pathology. In our study, the primary changes observed were left cardiac chambers dilatation with no accompanying ventricular hypertrophy, while LVEF remained preserved and diastolic function was supranormal. These findings align with those reported in the literature, particularly in studies involving footballers, similar to our cohort.

**Consent**

As per international standards or university standards, Participants’ written consent has been collected and preserved by the author(s).

**DISCLAIMER (ARTIFICIAL INTELLIGENCE):** Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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