Hammami et al. Arch Sports Med 2018, 2(1):87-93
DOI: 10.36959/987/234 | Volume 2 | Issue 1

Archives of Sports Medicine

Research Article Open Access

Cardiac Remodeling Profile in High-Level Women Soccer Players: A Preliminary Study

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Abstract

Background: The cardiac remodeling is variable according to the type of sport, which makes difficult the appreciation of what amounts to cardiac adaptation compared to what amounts to the pathological; this is the case for the soccer player who is subjected to variable isometric and isotonic constraints.

Objective: A preliminary cross-sectional study aimed to investigate cardiac remodeling in the Tunisian high-level women soccer players.

Methods: Echocardiographic characteristics were compared between high-level soccer players and healthy sedentary women, matched for age and body surface area, N = 40, and according to the post for the soccer group.

Results: Women soccer players have more dilated left ventricles (left ventricle diastolic diameter 48.07 mm vs. 45.57 mm respectively, $p = 0.03$, $d = 0.7$) with more hypertrophied walls (the septal thickness in diastole is respectively 8.74 mm and 7.96 mm, $p = 0.02$, $d = 0.73$). Their left ventricular mass was significantly higher (131.74 g vs. 116.43 g, $p = 0.05$, $d = 0.59$). This cavity dilation also affects significantly the other cardiac cavities, namely the right ventricle and the two atria. The cardiac remodeling was done in the way of hypertrophy in defenders and expansion in the attackers.

Conclusion: Cardiac remodeling for Tunisian women soccer players was in the direction of ventricular dilation associated with some parietal hypertrophy. Wider studies are needed to clearly define all aspects of this remodeling with a greater number of women soccer players.

Keywords

Cardiac remodeling, Athletes heart, Soccer, Women, Echocardiography

Abbreviations

AWV: A-Wave Velocity; AT: Acceleration Time; BMI: Body Mass Index; BSA: Body Surface Area; CG: Control Group; DBP: Diastolic Blood Pressure; DT: Deceleration Time; EWV: E-Wave Velocity; EF: Ejection Fraction; ET: Ejection Time; EG: Experimental Group; FS: Fractional Shortening; HR: Heart Rate; IST: Interventricular Septum Thickness; IVRT: Isovolumetric Relaxation Time; LA: Left Atrium; LAA: Left Atrium Area; LATD: Left Atrium Transverse Diameter; LV: Left Ventricle; LVDV: Left Ventricular Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; LVEDD: Left Ventricular End-Diastolic Diameter; LVESD: Left Ventricular End-Systolic Diameter; LVM: Left Ventricular Mass; LVPWIVS: Left Ventricular Posterior Wall Interventricular Septum; LVPWT: Left Ventricular Posterior Wall Thickness; LVSV: Left Ventricular Systolic Volume; MET: Metabolic Equivalent of Task; MRD: Mitral Ring Diameter; PHT: Pressure Half Time; PW: Posterior Wall; PWIVS: Posterior Wall Interventricular Septum; RA: Right Atrium; RAA: Right Atrium Area; RATD: Right Atrium Transverse Diameter; RH: Right Heart; RV: Right Ventricle; RVEDD: Right Ventricular End-Diastolic Diameter; RVL: Right Ventricular Length; SBP: Systolic Blood Pressure; ST: Septal Thickness; TD: Two-dimensional; TM: Time Motion; TRD: Tricuspid Ring Diameter

Introduction

Sport cardiology has many roles. It decides immediate participation or return to play, controls the exercise intensification in cardiac rehabilitation, prevents of sudden cardiac death in sports domain, optimizes cardiovascular performance and provides the well-being of athletes [1]. A regular training put the heart to a pressure overload in the case of static effort or to a volume overload in the case of dynamic effort [2]. Intense physical training is characterized by functional and morphological cardiac changes, that have been termed the "athlete's heart" [3-6]. Cardiac adaptations to physical exercise have been widely studied with echocardiography [7], so generally it describes the normal upper limits of the athlete's heart [5].

Cardiovascular system has to be adapted to the physical exercise depending for a large part on the performed exercise type. So, sports could be classified according to the type and intensity of the exercise [2]. The degree of change in cardiac dimensions varies between athletes and training methods [8] and the nature of the sport practiced [9]. In addition, cardiac adaptations depend on exercise classification, which can be divided into 2 types according to Morganroth hypothesis [8]: The first is endurance exercise with predominant isotonic physiology typically results in Eccentric Left Ventricle (LV) remodeling and the second is an isometric one typically characterized by Concentric LV remodeling [3]. However, Morganroth's original hypothesis has been criticized, owing to the fact that other factors like ethnicity, age, sex, genetics, body size and race influence cardiac remodeling [3,4]. Furthermore, it has to be noted that most sports are actually not only a static or a dynamic exercise, but a mixture of both, characterized by a variable combination of endurance and strength exercise [9].

Broadly, exercise with high intensity modifies heart by increasing of mass, wall thickness and diameters of chambers [4]. Training extremely raises cardiac output through tachycardia, augmented stroke volume, and increased Ejection Fraction (EF). Systemic and pulmonary arterial pressures rise and vascular resistances decline [10]. Consequently, those modifications will let the athlete improve his tolerance to the effort [2]. Moreover, cardiovascular adaptations mechanism is different between endurance athletes and ball-trained athletes (e.g., running and soccer) despite the technical training skills. The training in soccer includes dynamic and static exercises, as a result a combination of eccentric and concentric enlargement in athletes' heart [11]. The rhythm of the game imposes on soccer players an intermittent type of effort. This sport is performed first aerobically, like accelerations and ball kicking and second anaerobically, so as to satisfy requests for rapid recovery between high-intensity efforts and to conserve a high level of performance for the whole match [12]. Adult professional soccer players, who are involved in both isotonic and isometric forms of exercise, have increased wall thickness, chamber dimensions, aortic root size and LV mass compared with healthy controls [13]. The practice of a regular physical activity in general and a soccer specifically for women of different ages allows a positive improvement of the cardiac adaptations, inducing a considerable effect for the state of health [14-16].

Most of the echocardiographic studies interested in the cardiac remodeling in soccer are limited to male athletes. However, in recent years, female participation in high level competitions has been continuously growing, which makes an assessment of the cardiac remodeling in the female athlete indispensable. So, this study aimed to analyze ultrasound cardiac remodeling to establish a preliminary profile in Tunisian high-level women soccer players.

Methods

Participants

During 12 weeks, women soccer players of different football team of the northwest region of Tunisia participated in this study. These teams belong at the Tunisian woman professional national level. The annual average of the competitive matches stands at around 30 games, and the number of The Metabolic Equivalent of Task (MET) of training is approximately 80 METs-hours per week. Twenty female soccer players that make up the experimental group (EG) participated in the study. The control group (CG) is recruited from voluntary nursing students from the Higher School of Nursing of Kef and composed of 20 inactive participants. The EG was selected for the realization of a project developed by the regional football league and which required our intervention. This project aims to create physical and physiological profiles of female soccer players in the country. No dropout has recorded by the participants. All participants have filled a standardized and pre-set questionnaire on their overall health status: Age, Weight, Height, Body Mass Index (BMI), Blood Pressure, Number of Hours of Training per Week and Number of Years of Training. They were informed and have given their consent to take part at this study and have had a general clinical examination, an electrocardiogram at rest and a Doppler cardiac ultrasound by the same examiner.

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Received: January 11, 2018: **Accepted:** February 27, 2018: **Published online:** March 01, 2018

Citation: Hammami N, Sayahi K, Salhi A, et al. (2018) Cardiac Remodeling Profile in High-Level Women Soccer Players: A Preliminary Study. Arch Sports Med 2(1):87-93

Table 1: Descriptive and clinical characteristics of participants (EG and CG).

	EG (n = 20)		CG (n = 20)		
	Mean ± SD	*Extremes*	*Mean ± SD*	*Extremes*	*p value*
Age (yrs)	22.1 ± 3.06	(18-27)	23.8 ± 2.88	(20-30)	NS
Body mass (kg)	61.5 ± 9.84	(48-85)	60.2 ± 8.04	(45-84)	NS
Height (cm)	164 ± 7.76	(155-181)	163 ± 5.61	(154-170)	NS
BMI (kg/m²)	22.6 ± 2	(19-26)	22.6 ± 3.17	(19-33)	NS
HR (bpm)	64 ± 12.89	(43-90)	80 ± 15.6	(60-121)	0.001
SBP (mmHg)	116 ± 11.61	(95-140)	112 ± 9.38	(95-130)	NS
DBP (mmHg)	66 ± 7.82	(50-80)	69 ± 7.36	(55-85)	NS
BSA (m²)	1.69 ± 0.16	(1.47-2.08)	1.66 ± 0.11	(1.40-1.96)	NS

BMI: Body Mass Index; BSA: Body Surface Area; DBP: Diastolic Blood Pressure; HR: Heart Rate; SBP: Systolic Blood Pressure; NS: Non-Significant by t-test ($p < 0.05$).

The study was conducted according to the Declaration of Helsinki and the protocol was fully approved by the Clinical Research Ethics Committee following the instructions of Protecting Human Subject Research Participants by American National Institute of Health before the commencement of the assessments.

Experimental protocol

Echocardiographic measures were conducted using "GE Brand Logiq 500 pro" device. In the patient at rest, a study in Time Motion (TM) and Two-dimensional (TD) mode was made to determine the Septal Thickness (ST) and the Posterior Wall (PW), Left Ventricular End-Diastolic Diameter (LVEDD), Left Ventricular End-Systolic Diameter (LVESD) on the recommendations of the American Society of Echocardiography. On the Left Atrium (LA), the surface in apical four cavities, and the cross-sectional diameter in TM mode in cross-sectional major axis have been calculated. Other parameters were measured: The LV Fractional Shortening (FS), the EF of LV in Simpson Biplane, the Diameters of the Mitral and Tricuspid Rings (MRD, TRD) in apical section four cavities, the Right Atrium (RA) surface and the End-Diastolic Diameter of the RV (RVEDD) in cross section and its length in apical section.

LV mass was calculated according to the PENN convention [17]. In addition, measurement of the transmitral filling flow was obtained by pulsed Doppler in four-cavity apical section by positioning the Doppler sample at the top of the mitral funnel. The E-Wave Velocity (EWV), the A-Wave Velocity (AWV), the Deceleration Time (DT) of the E-Wave, the Ejection Time (ET), the Pressure Half Time (PHT) and the Isovolumetric Relaxation Time (IVRT) are systematically calculated. All echocardiographic measurements were made by the same doctor.

Statistical analysis

Statistical analysis was performed using SPSS statistical program version 22.0. The results are expressed as mean ± standard deviation by noting the two extremes. After studying the normality of the distribution, the differences between the two groups were analyzed by the Student's *t*-test for the quantitative variables (The Effect Size values were calculated by Cohen's *d*), and by the Chi-Two test for the qualitative variables. The threshold of significance is considered at $p < 0.05$.

Results

Clinical features

Participant's descriptive and clinical statistics are summarized in Table 1. Statistically, among these parameters, only Heart Rate (HR) is different between groups at $p < 0.05$. It was lower in the EG than the CG ($p = 0.001$, $d = 1.11$).

Echocardiographic characteristics

Comparisons between EG and CG

Cavitary diameters (Table 2): The LV is more dilated in the EG (LVEDD, $p = 0.03$, $d = 0.7$). The Left Ventricle Diastolic Volume (LVDV) and Left Ventricle Systolic Volume (LVSV) are more important in the EG comparing to the CG (LVDV, $p = 0.05$, $d = 0.64$; LVSV, $p = 0.03$, $d = 0.7$). The LA is more dilated in the EG through the Left Atrium Transverse Diameter (LATD, $p = 0.05$, $d = 0.62$) and the Left Atrium Area (LAA, $p = 0.004$, $d = 0.96$) measures. The MRD measured in apical section four cavities is greater in the EG without the difference being significant at $p < 0.05$. Right cavities are also more dilated in EG ($p = 0.004$, $d = 0.96$) following the Right Atrium Area (RAA) values. The Right Ventricular End-Diastolic Diameter (RVEDD) and the Right Ventricular Length (RVL) and the Tricuspid Ring Diameter (TRD) was significantly greater in the EG compared to CG (respectively, $p = 0.022$, $d = 0.75$; $p = 0.006$, $d = 0.93$ and $p = 0.02$, $d = 0.75$).

LV hypertrophy (Table 2): The End-Diastolic Thickness of the Interventricular Septum (IST) was more important in EG ($p = 0.02$, $d = 0.73$). In addition, a significant difference ($p = 0.05$, $d = 0.58$) was reported in EG for the average Left Ventricular Mass (LVM) measures. However, there was no pathological myocardial hypertrophy in both groups.

Table 2: Echocardiographic parameters (TM and TD modes).

	EG (n = 20)		CG (n = 20)		
	Mean ± SD	*Extremes*	*Mean ± SD*	*Extremes*	*p value*
RATD (mm)	24.62 ± 2.33	(18.80-27.30)	24.37 ± 2.20	(19.70-28.00)	NS
LATD (mm)	33.10 ± 4.42	(26.00-41.20)	30.62 ± 3.40	(24.20-35.9)	0.05
LAA (cm²)	16.39 ± 3.24	(12.52-25.29)	13.71 ± 2.21	(11.24-19.32)	0.004
RAA (cm²)	13.67 ± 2.54	(9.91-21.43)	11.38 ± 2.21	(5.78-14.80)	0.004
LVEDD (mm)	48.07 ± 3.88	(42.10-55.60)	45.57 ± 3.23	(39.00-50.60)	0.03
LVESD (mm)	27.97 ± 3.25	(23.30-35.90)	27.25 ± 3.37	(20.90-32.70)	NS
IST (mm)	8.74 ± 1.16	(6.30-10.80)	7.96 ± 0.96	(6.50-10.00)	0.027
LVPWT (mm)	7.12 ± 0.84	(5.40-9.00)	6.72 ± 1.06	(4.50-8.50)	NS
PWIVS (mm)	1.22 ± 0.15	(0.82-1.43)	1.20 ± 0.18	(0.84-1.68)	NS
LVPWIVS (mm)	0.32	(0.27-0.46)	0.31	(0.24-0.46)	NS
FS (%)	41.29 ± 4.11	(32.14-47.86)	39.78 ± 5.84	(31.59-53.86)	NS
EF (%)	57.60 ± 4.79	(48.72-68.26)	58.26 ± 4.67	(51.05-65.91)	NS
MRD (mm)	36.33 ± 3.45	(27.70-41.20)	34.65 ± 2.76	(27.80-39.20)	NS
TRD (mm)	38.65 ± 3.82	(33.40-45.30)	35.88 ± 3.52	(31.50-42.10)	0.02
RVEDD (mm)	25.43 ± 3.54	(17.50-30.50)	22.65 ± 3.81	(16.60-29.90)	0.022
RVL (mm)	73.41 ± 7.75	(64.80-91.00)	66.58 ± 6.91	(57.80-81.60)	0.006
LVDV (ml)	133.89 ± 30.95	(90.10-219.90)	116.39 ± 23.07	(70.40-159.30)	0.05
LVSV (ml)	57.70 ± 16.30	(37.00-101.80)	48.19 ± 9.92	(32.90-72.40)	0.032
LVM (g)	131.74 ± 32.49	(72.51-167.96)	116.43 ± 18.27	(69.35-150.04)	0.05

NS: Non-Significant (p < 0.05); EG: Experimental Group; CG: Control Group; EF: Ejection Fraction; FS: Fractional Shortening; IST: Interventricular Septum Thickness; LAA: Left Atrium Area; LATD: Left Atrium Transverse Diameter; LVDV: Left Ventricular Diastolic Volume; LVEDD: Left Ventricular End-Diastolic Diameter; LVESD: Left Ventricular End-Systolic Diameter; LVM: Left Ventricular Mass; LVPWIVS: Left Ventricular Posterior Wall Interventricular Septum; LVPWT: Left Ventricular Posterior Wall Thickness; LVSV: Left Ventricular Systolic Volume; MRD: Mitral Ring Diameter; PWIVS: Posterior Wall Interventricular Septum; RAA: Right Atrium Area; RATD: Right Atrium Transverse Diameter; RVEDD: Right Ventricular End-Diastolic Diameter; RVL: Right Ventricular Length; TD: Two-dimensional; TM: Time Motion; TRD: Tricuspid Ring Diameter.

Table 3: Echocardiographic parameters (Doppler) of participants (EG and CG).

	EG (n = 20)		CG (n = 20)		
	Mean ± SD	*Extremes*	*Mean ± SD*	*Extremes*	*p value*
EWV (cm/s)	1.10 ± 0.15	(0.87-1.36)	1.06 ± 0.22	(0.79-1.63)	NS
AWV (cm/s)	0.53 ± 0.08	(0.38-0.70)	0.60 ± 0.14	(0.38-0.86)	NS
IVRT (ms)	72.20 ± 12.25	(47.00-95.00)	65.05 ± 17.96	(36.00-107.00)	NS
PHT (ms)	86.60 ± 15.12	(59.00-107.00)	82.40 ± 17.61	(47.00-107.00)	NS
AT (ms)	62.80 ± 25.73	(10.00-131.00)	48.20 ± 24.81	(8.00-83.00)	NS
DT (ms)	532.85 ± 141.53	(296.00-883.00)	481.90 ± 142.72	(237.00-676.00)	0.022
ET (ms)	593.15 ± 142.62	(356.00-830.00)	479.20 ± 122.54	(296.00-735.00)	0.01

NS: Non-Significant (p < 0.05); AT: Acceleration Time; AWV: A-Wave Velocity; CG: Control Group; DT: Deceleration Time; ET: Ejection Time; EWV: E-Wave Velocity; EG: Experimental Group; IVRT: Isovolumetric Relaxation Time; PHT: Pressure Half Time.

Doppler test (Table 3): The Mitral E-Wave DT and the ET was more elongated in EG with a statistically significant difference compared to CG (respectively, $p = 0.02$, $d = 0.35$ and $p = 0.01$, $d = 0.85$).

Comparisons according to game position

The echocardiographic parameters are compared ($p < 0.05$) according to the game position occupied by the soccer player in distinguishing those who occupy a defensive, in midfield or an offensive position. For almost all echocardiographic variables, only the MRD values were lower for women defenders than the others (37.65 ± 2.29 mm for Defenders; 37.39 ± 2.69 mm for Midfielders; 31.85 ± 3.17 mm for Forwards; $p = 0.007$).

Discussion

All cardiac adaptations to intense physical exercise define the athlete's heart. It is well known that the morphological and functional modifications and remodeling of cardiac chambers are the result of high-volume, high-intensity and regular sport activity. The generation of a large and sustained cardiac output and enhance the extraction of oxygen from exercising muscle are facilitated by these central and peripheral cardiovascular adaptations [18].

Cardiac remodeling, which varies according to the type of sport, sometimes makes the appreciation of what amounts to cardiac adaptation compared to what amounts to the pathological very difficult [1]; This is even more true for the soccer player who is constrained either by isometry or by isotonicity, with some variation depending on the position occupied and according to the period of the game [19]. The main focus of this study was to investigate and explore the cardiac remodeling in soccer women players in Tunisia. In our study, regarding the left cavitary dilation, we found that the average of women soccer players LVEDD is 48.07 mm; no athlete had a LV greater than 55 mm. This LVEDD is significantly higher than that of the control subjects ($p < 0.05$). The mean of LVEDD relative to BSA was 28.51 mm/m² with extremes ranging from 22.83 to 31.45 mm/m². These findings are similar to those of Pelliccia, et al. [20] that found a left ventricular dilatation (≥ 55 mm) in 8% of the athletes without exceeding 66 mm in all cases when they compared the subgroup (female athlete with left ventricular dilatation) to the rest of the athletes and concluded that they were older, with a larger BSA and practicing 15 types of sport, but in 77% of the cases the sporting activity was of the enduring type. None of these athletes had left ventricular dysfunction during follow-up.

In another context, previous studies have proved that LV remodeling due to physical activity is physiological as the diastolic and systolic function remains normal or even supernormal. LA enlargement is seen as physiological as well by extrapolation, even though data confirming this statement is lacking [21,22]. Data from the literature concerning the LA are not very homogeneous and argue either for absence of modification of the left atrium or for moderate dilation. This is probably related to the mode of measurement of the LA in ultrasound which is different from one study to another [21]. In this study, we found that the LATD is 33.10 mm with extremes of 26 and 41 mm. The average LAA is 16.39 cm². The LA of our women players is significantly more dilated than that of the CG. These results corroborate with those of Pelliccia, et al. [20] that found an LATD at 32.2 mm with extremes of up to 46 mm in a series of 600 female athletes. In addition, Pelliccia, et al. [23] did not notice dilatation of the LA even among the population who had significant parietal hypertrophy. But, in a much more recent series studying 1777 competitive athletes, Pellicia, et al. [24] noted that left-sided diameter values is greater than 40 mm in 20% of them, and proposed a threshold of 45 mm for women and 50 mm for men.

In the case of the parietal hypertrophy, we found that the mean IST in the women players was 8.74 mm whereas it is only 7.96 mm in the non-athletes ($p = 0.027$). The PW is slightly thicker in soccer players (7.12 mm versus 6.72 mm). These results comply with the findings of Pellicia, et al. [20] that proposed unambiguous threshold values in women that have never been exceeded 12 mm. In general, the LVPWT is moderately increased however the thickness of the interventricular septum stays in most cases less than 12 mm in women athletes and 16 mm in adult male athletes [3]. In the study of Spirito, et al. [25], of the 947 athletes involved in 27 sports, 16 had thicknesses between 13 and 16 mm: They practiced rowing, canoeing or cycling. In a series of 149 professional cyclists [26], 22 had thicknesses between 13 and 15 mm. The sports that increase the parietal thickness of the LV are cycling, rowing, swimming, and to a lesser extent weightlifting, wrestling, tennis, cross-country, skiing and Soccer. Moreover, this study presented a significant increase ($p = 0.05$) in the mean LVM in women players. This finding supports the hypothesis that LVM is always increased in high-level athletes compared to control groups [22,27-29]. An increase in the left ventricular mass indexed from 50 to 100% is observed, with an eccentric geometry in the endurance and a rather concentric geometry in the resistive [30]. The meta-analysis of Pluim, et al. [22] of 59 studies and 1451 athletes confirmed that the increase in parietal thickness was less in endurance athletes than in athletes in isotonic disciplines. In cases, fortunately rare, where the thicknesses are between 13 and 16 mm, the diagnosis must hesitate between physiological or pathological hypertrophy. It will then be necessary to continue the examination and to obtain numerous complementary indications [31]. The use of other techniques can sometimes prove very useful. However, most often the first provider of suspicious hypertrophy of the athlete remains the error of measurement, whose consequences can be dramatic, at a time when sport is for some a profession, and for others a source of balance. Thus, more attention needs to be paid to false tendons and to the apparatus under a tricuspid valve, paradoxically more difficult to identify in harmonic mode than in fundamental mode.

Concerning the LV systolic function, this research showed that the mean of the Left Ventricular Ejection Fraction (LVEF) is 57.60 versus 58.26% in the CG. Only one athlete had a LVEF less than 50%. In the literature, the LVEF can be superimposed on that of the controls in the athletes' series [22]. However, it is not rare to have individual values of potentially disturbing LVEF, around 50%, or more rarely between 45% and 50%, at rest. It is likely that the match between the charge and the cavity volume at rest may explain a low EF while the intrinsic contractile function of the LV is normal [22]. In the Abergel, et al. series [32], out of 286 cyclists, 20 athletes had a left ventricular EF between 42 and 50%. In a series of 156 professional American footballers, athletes with a LVEF at rest between 50% and 55% (representing 40% of the population), had a normal response (homogeneous hypercontractility) during the effort cardiac echocardiography [33] in practice. In the presence of a diminished LV fraction, effort ultrasound seems today the best approach to not alarm wrongly, even if the data from the literature are still few.

The remodeling of the right cavities was taken into account in our study. The RV cavity increases in size more pronounced on its longitudinal axis for soccer players. The average diameter of the RV and the length of the RV are greater in women players against in the CG ($p < 0.05$). Moreover, there is a significant dilation of the RA in EG ($p < 0.05$). In the literature, moderate dilatation of right cavities is often reported without alteration of RV function [34]. Acquired MRI data confirm the dilatation and the increase of the RV mass in the athlete, which affects the two ventricles in a harmonious and balanced manner. Generally, the RV remodeling has been little discussed in the literature comparing to left heart, with similar results to those of Bennani, et al. [35] and Pela, et al. [36]. In the recent years, the structural and functional adaptations of the right heart (RH) have been studied, highlighting the complex interaction with the left heart [3]. The RH clearly participates in the process of enlargement of the athlete's heart, with an increase in internal diameters and thickness of its free walls. RV shows greater inflow and outflow dimensions in athletes compared with sedentary controls, with no significant difference in the systolic function. D'Andrea, et al. [3] documented that RH measures were all significantly greater in highly-trained endurance athletes, compared to age and sex matched strength-trained athletes.

We also studied cardiac remodeling based on the role played by the players in the field, and it could be argued that female defenders who are often subjected to a resistance effort tend to have a hypertrophied heart, whereas attackers who are subject to endurance efforts tend to dilated heart ($p < 0.05$) by referring to MRD. These findings support in part literature studies focusing on the role of the Soccer position in males players in the cardiac remodeling [19,37].

Despite this study provides results that could help to draw an idea about the cardiac remodeling in the high-level soccer women players, this study has some limitations:

- A small number of the study population.
- Studied players do not have an important seniority in the sport. This seniority is an average of four years.
- The evolution of the cardiac remodeling in the soccer player throughout the sport season has been not studied.

For this, a larger study including a great number of women soccer players is expected.

Conclusion

In conclusion, the cardiac remodeling in the football women players is translated by a cavitary dilatation that concerns both Atria and two ventricles associated with LV hypertrophy. The predominance of this or that phenomenon is associated in part with the position occupied by the women soccer player. To our knowledge, studies linking cardiac remodeling to football players are rare or almost absent. So, larger studies focusing on the RV, with the larger numbers are needed to get a complete the profile of cardiac remodeling in Tunisian high-level women soccer players specifically and worldwide women soccer players generally.

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DOI: 10.36959/987/234 | Volume 2 | Issue 1