

CARDIOVASCULAR ADAPTATIONS AND CARDIAC RISKS IN FEMALE FOOTBALL PLAYERS

AN OUTLINE OF STILL UNCHARTERED TERRITORY

– *Written by Carmen Adamuz, Qatar, Silvia Castelletti, Italy, and Guido Pieles Qatar*

At the recent European Women's Football championships the world could witness again the high level of professionalism, skill and physical fitness of Europe's best players and this has highlighted again the question as to whether we as health care professionals looking after these players have been part of this development. For the cardiologist that meant checking and ascertaining if the same level of care is being delivered to the female footballers that is now standard practice in the men's game. Any sports cardiologist working in this area will have to be critical and acknowledge that this is not the case, apart from some forward-thinking clubs with the resources to provide excellent sports cardiology care. Anyone who wants to develop a sports

cardiology service in this area requires as the most important prerequisite: scientific data to make evidence-based decisions on prevention and treatment of cardiac disease in female athletes. This includes gender specific knowledge on cardiac training adaptation and risk and potential causes of sudden cardiac events. These topics have not been sufficiently explored yet, but important insights can help stratify risk and differentiate between physiological and pathological adaptations in female football players.

In contrast to this there is a growing body of evidence on the cardiovascular adaptations and health benefits for women of playing football at recreational level. Exercise is known to exert a preventive

effect on the development of lifestyle-related deficiencies and football training interventions targeting a broad health response are highly relevant for women of all ages, including postmenopausal women. Thus, recreational football, 'fitness football' and 'walking football' may have a worldwide impact on women's health and in cardiovascular prevention able to engage inactive postmenopausal women to become active, reduce morbidity and increase life expectancy.

SUDDEN CARDIAC DEATH IN FEMALE FOOTBALL PLAYERS

It is known that athletes have a 2.8 – 5.3% higher risk of sudden cardiac death (SCD) than their non-athlete peers¹. The incidence



Image: Illustration.

of SCD in male football players varies depending on study population; according to a recent large study it is approximately 6.8/ 100000 person-years², but the correct incidence of SCD in female football players remains unknown. Previous studies have shown consistently that female athletes have a lower risk for sudden cardiac events during sports³ than their male counterparts. Interesting gender differences come from one study⁴; according to this there is a higher incidence of sudden arrhythmic death syndrome (SADS) in structurally normal hearts in women, but lower incidence of structural cardiomyopathies and importantly, lower frequency of death associated to exercise. The mean age of SCD is comparable to that of men. It needs to be noted however, that no football specific data exist, furthermore, there are no registries that would reliably capture SCD events in recreational women's football players, a rapidly increasing population.

FOOTBALL AS A PROFESSIONAL SPORTS FOR WOMEN: IS IT THERE A DISTINCTIVE FEMALE FOOTBALL PLAYER'S HEART?

Playing football has several cardiovascular, metabolic and musculoskeletal beneficial

effects⁵ both, for men and women. It also induces electrophysiological and structural cardiac adaptations in response to the increased hemodynamic load associated with the sport, the most common adaptive changes are increase in vagal tone and cardiac chamber size.

There are only a few studies evaluating the sex differences in cardiac adaptation to exercise^{6,7,8,9} and even fewer exploring the influence of the type of sport or ethnicity^{10,11}. Despite the limited research it is clear that the hearts of female football players have different structural and electrical adaptations to the rigors of the specific football training compared to their male peers; and these changes, identified as exercise-induced cardiac remodeling, are also influenced by the age, race of the players and the intensity of training and/or length of sports career among others factors¹².

PHYSIOLOGICAL ADAPTATIONS OF THE FEMALE FOOTBALL PLAYER HEART

Usually, female athletes display fewer quantitative electrocardiographic changes than male athletes, common are shorter PR interval and QRS duration and longer QT interval. They mainly display T-wave

inversions, usually visible in leads V1-V2¹³. A balanced increase in heart dimensions is also observed in female athletes, although the absolute cardiac dimensions are smaller than males, with the largest cavities found, as in males, in endurance athletes. In contrast to male athletes, however, left ventricular wall thickness rarely increases in females above the general population's upper limits. Increased left ventricle wall thickness has been observed mainly in black female athletes. Also, atria may be enlarged in athletes, but this is less pronounced in women compared to men¹³.

What is known about the cardiac adaptation of football female athletes comes from four different studies^{10,11,14,15}. Among them, the one conducted by Churchill et al. represents the largest one, including 122 athletes¹⁰, while the remaining three studies included small populations^{11,14,15}. One of them focused only on the ECG changes¹⁴ and one included Afro-Caribbean, specifically Ghanaian, female soccer players¹¹.

Electrocardiographic adaptations in female football players

Electrocardiographic (ECG) changes reflect and precede the morphological changes^{16,17}.

Similarly to the changes in ECG observed in the general female sports population and compared to male athletes, female football players have shorter PR and QRS intervals but longer corrected QT intervals¹⁰. However, all ECG parameters are mainly within normal ranges except the resting heart rate¹⁴.

The comparative analysis of the ECG changes observed between male and female football players from the elite soccer teams in USA¹⁴ has shown that compared to men, women football players demonstrate a lower prevalence of ECG findings related to the chamber size adaptation, such as: left and right voltages criteria for hypertrophy, incomplete right bundle branch block and early repolarization pattern¹⁰. The latter, however, represents, along with sinus bradycardia, the most common training-related ECG pattern in female football players compared to men¹⁴. Compared to their counterpart, the ECGs of female soccer players display a higher prevalence of abnormalities (11% vs 0 in male cohort)¹⁰. These consisted mainly of abnormal T wave inversions, septal Q waves and inferior ST-segment depression.

The presence of inverted T waves in the anterior leads (V1-V3) is a common finding in female football players and female athletes in other sports^{10,13}. As such also, the international recommendations on the ECG interpretation in athletes do not suggest further investigation in the presence of this abnormality if the athlete is asymptomatic and there is no family history of cardiomyopathy or sudden death¹⁸. In contrast, the presence of T wave inversion in the anterolateral (V3-V6) and inferior (II, III, aVF) leads is less common and should warrant further investigations¹⁸. A similar piece of evidence has also been shown in West African female football players¹¹: a higher prevalence (35%) of ECG voltage criteria for left ventricle hypertrophy¹¹ (with QRS duration relatively short -mean 80 ms-)¹¹ was found that was even higher when comparing the adolescent players with the adults' athletes (42% vs 25%), whilst in literature the prevalence reported is 8% and 12% among female black and white athletes respectively¹⁹.

Morrison et al¹⁴ have shown that both the newer Seattle and International ECG screening criteria reduce the number of false positive ECG during pre-participation screening from 25% to 0% compared to the

TABLE 1

Study	Year	Female athletes	Elite	Age	Ethnicity n, (%)
Morrison B et al ¹⁴	2022	81	Yes	21±4	77 (95) Caucasian
Churchill TW et al ¹⁰	2021	122	Yes	21±5.4	87 (71) Caucasian
Pambo P et al ¹¹	2021	75	Yes	19.1± 3.7	75 (100) Ghanaian
Zacher J et al ¹⁵	2020	19	Yes	22.9±4.61	19 (100) Caucasian

Table 1: Selected studies on cardiac adaptation in female football players.

older ESC criteria in elite female footballers¹⁴ and hence the latest international criteria for ECG interpretation should be used when assessing the female athlete.

Morphological adaptations

Although at a lower percentage than in their male counterparts, female football players frequently exceed normal ranges for structural cardiac parameters responsive to exercise-induced remodeling, including body surface area-indexed left ventricular (LV) mass (51% of female athletes' vs 59% of males), indexed LV volume (77% of female vs 68% of males), and LV wall thickness (30% of females vs 41% of males)¹⁰. The increase of these parameters is age-dependent in female football players. Women have lower maximum wall thickness and only 1% of female football players exceed 12 mm of left ventricular (LV) wall thickness¹⁰, therefore the observation of a left ventricular wall thicker than 12 mm should raise suspicion of a possible underlying cardiomyopathy.

The LV systolic function is normal in female football players, showing higher values compared to males¹⁰. A study comparing female football athletes with physically inactive controls, showed no significant differences in other LV functional parameters such as global LV systolic strain¹⁵.

The majority of the female football players present normal cardiac remodelling with either eccentric hypertrophy or normal LV geometry, whilst the observation of concentric remodelling is more common in male football players. Also, the right ventricular diameters are more commonly increased among male football players compared to female football players.

There is limited evidence on the impact of ethnicity on the cardiovascular

adaptations of female football players. Importantly, among West African female football athletes, no structural heart disease has been found in those with inverted T waves and ECG-derived voltage criteria for LVH. These changes correlate poorly with LV wall thickness, cavity size, or RWT¹¹. No differences have been noted between adolescents and adult Ghanaian female players in the left ventricular mass index, whilst relative wall thickness is higher in adolescents compared with adults¹¹.

While these studies provide important guidance on how to differentiate between physiological and pathological adaptation in elite female footballers, these observations require further evaluation as they have been reported so far in small and selected study populations (Table 1). Additional research is needed to better understand the specific football induced cardiovascular adaptations in female players, with attention to different ethnicities, ages and training load among others.

CARDIOVASCULAR ADAPTATIONS BENEFITS FOR WOMEN PLAYING RECREATIONAL FOOTBALL

Over the last 15 years several studies and meta-analysis have demonstrated that not only playing competitive football at professional level but recreational football is associated with cardiovascular adaptations and multiple health benefits in previously sedentary women of all ages and data in this growing and important population can inform population based efforts to increase physical activity and exercise in women.

Football is a versatile, multifaceted training able to improve simultaneously cardiovascular, metabolic and musculoskeletal fitness providing broad-

spectrum fitness and health benefits, not only similar to other exercise regimens but superior in certain areas. Playing one hour of recreational small-side football requires more than 100 fast runs with multiple changes of direction and speed, multiple strength training elements and hundreds of specific intense actions such as dribbles, shots, tackles, turns and jumps²⁰. This intense and diverse type of training combines elements of high-intensity interval training (HIIT), endurance training and strength training, providing an optimal stimulus for cardiovascular, metabolic and musculoskeletal fitness; and has been demonstrated to induce greater cardiac adaptations than participation in moderate continue aerobic exercise.

A weekly regime of two sessions of 45-60 minutes of recreational small-sided football training for 12-16 weeks seems to be sufficient to induce structural and functional cardiac adaptations such as improvement in systolic and diastolic cardiac function affecting both ventricles and changes in cardiac dimensions, including thickening of the posterior wall and biventricular enlargement²¹. This training regime has also numerous metabolic and musculoskeletal benefits for middle-aged untrained women²¹, similar to those observed in middle-aged and older untrained men²². Importantly, it can reduce the risk of certain chronic diseases like hypertension, heart disease, stroke, and type 2 diabetes. The majority of these effects occurred independently of age and cardiovascular benefits were already observed after only 12 weeks of training.

Heart rate (HR) modulation is another important positive adaptive mechanism of recreational football. According with a recent meta-analysis²³, previously sedentary women experience an average reduction of resting heart rate (RHR) of 2.95 bpm playing small-field football for 12 weeks. The observed effect of football playing on RHR is higher effect than the effect of running during the same period. The study has shown that even less than 2 weeks of recreational football training are beneficial to observe RHR reduction. This effect is slightly lower than the reduction observed in men during the same period (5 bpm), which may be explained because untrained women display a reduced activity profile while playing recreational football compared to their male counterparts, with shorter sprints and more time standing



Image: Players warm up during the TFF Women Programme at Champions Festival prior to the UEFA Champions League 2022/23 final. Istanbul, Turkey, June 2023..

still. Despite this reduced activity, the women's heart rate distribution expressed as percentages of recreational football playing time in different heart rate zones is remarkably similar to the distribution observed in untrained men²⁰. During a 60 minutes of small-sided football session the average heart rates of healthy women and groups of patients raises to 80%–85% of maximal heart rate (HRmax), with 15%–50% of total training time in the highest aerobic training zone, above 90% HRmax, which has a considerable training effect²⁴. The result is a remarkably higher improvement of VO₂max than observed in running: 16% increment on VO₂max in playing recreational football vs 10% in running²¹, in absolute terms it is 3.51 ml/kg/min after 4 months playing football²⁴. Compared with no-exercise controls, the oxygen uptake of women enrolled in recreational football interventions lasting 3–4 months increases an average of 3.51 ml/kg/min²⁴.

Playing recreational football has also significant effect on blood pressure

(BP) reduction, with greater effect in hypertensive vs normotensive women²⁵ and to an extent of 11mmHg (on systolic BP) and 7mm (on diastolic BP) in subjects with mild hypertension and also in those with pre-hypertension²³. The positive effects were similar for age groups of 18–45 and 45-60 years old, although the benefits on SBP reduction was larger on the second group and it is larger in women compared to men. Some of the proposed physiological mechanisms involved on the DBP reduction are increased muscle capillarization, decreased arterial stiffness and increased cardiac relaxation time²⁶. The observed reductions on BP for hypertensive women are comparable with the effect of taking one standard dose of blood pressure-lowering drug, which has a significant clinical impact if we consider that each 10 mmHg reduction of BP in women 40-69 years old is associated with an approximately 30% decrease in risk of death from stroke or ischaemic heart disease²⁷. When compared to other recreational sports, football training may

be more beneficial than some continuous moderate exercise to reduce BP, for example it is a more efficient exercise than swimming to reduce BP in hypertensive women²⁸.

Women participating in a training program of 12–16 weeks (2×60min sessions/week) also benefit from a reduction in total fat mass of 1–3kg, interestingly, this effect is greater in women compared to men and women in the 18–45 age group tend to respond better than older age groups (45–65 and 65+)^{23,28,29}. Although playing recreational football seems to have only mild effects on the metabolic profile in women, even small improvements on lipid profile, glucose concentration and glucose tolerance, may provide additional benefits on the cardiovascular health of women reducing the cardiovascular risk profile³⁰.

Middle-aged postmenopausal women are at higher risk of lifestyle related diseases including higher prevalence of physical inactivity, decline in fitness and health status with increased prevalence of cardiovascular diseases and type 2 diabetes in addition to impaired musculoskeletal health^{31,32,33}. Pilot studies involving these age groups as well as elderly women suggest the feasibility and benefits of specific football training programmes such as “Walking football” and the “Football Fitness” concept for women^{25,34}.

Structured football training for non-athletes

The so-called “Football Fitness” concept consists of 1-hour training sessions with a 10–15 min injury preventing warm-up followed by 20–25 min of small-sided drills and pair-based technical exercises and ended by 20–30 min of small-sided football game with one ball and two goals, but with rule adjustment according to the participant group. In Denmark, the Football Fitness concept is being offered for all adult women by local football clubs with a low membership fee, as these teams are not participating in tournaments. Usually, these teams train two times 1-h per week year-round, as recommended based on the available scientific results. The implementation of the Football Fitness concept has been evaluated scientifically, interestingly more than three-fourths of the participants in the programs were women³⁵. Apart from the cardiovascular and other physiological benefits of regular Football Fitness training, research has demonstrated that Football Fitness is a

motivating and socially engaging activity and works well for women in all age groups, irrespective of social background, physical fitness and skill level³⁵. The majority of these women had not played football before and, interestingly, the recruitment covered two or three generations of women that started playing together. After 18 weeks of training approximately 45% of original participants remained active, and large health effects were observed²⁵. Thus, Football Fitness appears to be a feasible concept with considerable potential to recruit inactive women into physical training and is considered to be a very promising component of the “Exercise is medicine”³⁶. The “Football is Medicine” concept is a holistic model including the components of football training, the fitness and global health adaptations of football training; the use of football training in the prevention, treatment and rehabilitation of non-communicable diseases and the psycho-social elements of training football according with the Football Fitness concept.

Walking football in the other hand is less physically demanding while still is engaging to play and has demonstrated to provide cardiovascular benefits such as blood pressure improvement and lipid profile modification³⁴, being a good opportunity for the elderly participation in exercise, although most of the studies up to date have been performed with male participants and therefore additional research is needed to evaluate the benefits of walking football in elderly women or its possible role in cardiac rehabilitation for different group of patients i.e. heart failure.

FUTURE AREAS OF CARDIAC RESEARCH IN PROFESSIONAL AND RECREATIONAL WOMEN'S FOOTBALL

The increasing popularity of women's football and the relative lack of scientific data calls for more research into the female footballer's heart. Topics to explore include gender specific knowledge on cardiac training adaptations including the ECG peculiarities in women of different age and ethnicities, risk and potential causes of sudden cardiac events in female football players, and the benefits of screening and other forms of cardiac prevention. This data will inform clinical practice but also help answer the question if a gender specific sports cardiology approach is warranted.

Another field of research is recreational women's football, in particular data is

needed to assess the benefits and risks of recreational football of different formats on women with cardiovascular pathologies, women in different hormonal and physiological situations such as pregnancy, different age groups, in particular postmenopausal and elderly woman.

Specifically due to the significant increase of cardiovascular diseases in postmenopausal women, studies are needed to examine the efficacy and safety of recreational football in different formats on all indices of cardiovascular health such as endothelial function, coronary flow reserve, parameters of myocardial mechanics, blood pressure, carotid intima-media thickness and coronary calcium score to quantify the benefits of the game on the long term cardiovascular morbidity in women and subsequently develop an evidence based approach in integrating football as a cardiovascular prevention and cardiac rehabilitation strategy for women.

References

Available at www.aspetar.com/journal

Maria-Carmen Adamuz M.D., Ph.D.

Consultant Cardiologist

Aspetar Orthopedic and Sports Medicine Hospital

Doha, Qatar

Silvia Castelletti M.D.

Cardiology Department

IRCCS Istituto Auxologico Italiano

Milan, Italy

Guido Pieles M.D., Ph.D.

Head of Sports Cardiology and Screening

Aspetar Orthopedic and Sports Medicine Hospital

Doha, Qatar

Contact: guido.pieles@aspetar.com