DOI: http://dx.doi.org/10.12996/gmj.2023.4000

Assessment of Blood Pressure Levels and Left Ventricular Functions of American Football Players in Türkiye

Türkiye'deki Amerikan Futbolu Oyuncularının Kan Basıncı Düzeyleri ve Sol Ventrikül Fonksiyonlarının Değerlendirilmesi

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ABSTRACT

Objective: In this study, we aimed to evaluate the relationship between blood pressure, left ventricular (LV) mass, and systolic function in American football (AF) players in Türkiye using deformation imaging and to compare it with conventional echocardiographic methods.

Methods: AF players admitted to the Gazi University, Cardiology Unit between January 2021 and May 2023 were included in our study. The players were grouped as linemen or non-linemen according to their field positions. LV mass and ejection fraction (EF) were assessed using blood pressure measurements and conventional methods. Deformation analysis was performed by two-dimensional speckle tracking echocardiography, and LV torsion and global longitudinal strain values were calculated. Deformation analyses were compared with blood pressure and LV EF.

Results: Players in the lineman position had higher blood pressure measurements. Although both groups of players had similar and intact LV EF values, players in the lineman position had significant changes in LV mass, LV global longitudinal strain, and LV torsion in relation to blood pressure measurements.

Conclusion: AF players are at risk of hypertension. LV hypertrophy due to hypertension causes systolic dysfunction. Deformation analysis methods can detect subclinical myocardial damage even if the EF is intact.

Keywords: American football, hypertension, left ventricular hypertrophy, deformation analysis, longitudinal strain, torsion, seckel tracking echocardiography

ÖZ

Amaç: Bu çalışmamızda, Türkiye'deki Amerikan futbolu (AF) oyuncularında kan basıncı, sol ventrikül (LV) kütlesi ve sistolik fonksiyonu arasındaki ilişkiyi deformasyon görüntüleme yöntemi ile değerlendirmeyi ve konvansiyonel ekokardiyografik yöntemlerle karşılaştırmayı amaçladık.

Yöntemler: Çalışmamıza Ocak 2021-Mayıs 2023 tarihleri arasında Gazi Üniversitesi, Kardiyoloji Birimi'ne başvuran AF oyuncuları dahil edilmiştir. Oyuncular saha pozisyonlarına göre lineman veya non-lineman olarak gruplandırılmıştır. Kan basıncı ölçümleri ve konvansiyonel yöntemler ile LV kütlesi ile ejeksiyon fraksiyonları (EF) değerlendirilmiştir. İki boyutlu speckle tracking ekokardiyografi ile deformasyon analizleri yapılmış, LV torsiyon ve global longitidunal strain değerleri hesaplanmıştır. Deformasyon analizleri; kan basınçları ve LV EF ile karşılaştırılmıştır.

Bulgular: Lineman pozisyonundaki oyuncularda daha yüksek kan basıncı ölçümleri mevcuttu. Her iki grup oyuncuları benzer ve bozulmamış LV EF değerlerine sahip olmalarına rağmen, lineman pozisyonundaki oyuncularda LV kütle, LV gobal uzunlamasına strain ve LV torsiyonlarında, kan basıncı ölçümleri ile ilişkili olarak anlamlı değişiklikler mevcuttu.

Sonuç: AF oyuncuları hipertansiyon açısından risk altındadır. Hipertansiyona bağlı gelişen LV hipertrofisi sistolik disfonksiyona neden olur. Deformasyon analizi yöntemleri ile EF bozulmamıs dahi olsa subklinik miyokard hasarı tespit edilebilir.

Anahtar Sözcükler: Amerikan futbolu, hipertansiyon, sol ventrikül hipertrofisi, deformasyon analizi, uzunlamasına strain, torsiyon, benek takibi ekokardiyografi

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Received/Geliş Tarihi: 07.09.2023
Accepted/Kabul Tarihi: 16.09.2023

INTRODUCTION

American football (AF) has gained significant popularity among university students in Türkiye. This physically demanding team sport induces specific physiological adaptations in the heart, a phenomenon commonly referred to as the “athlete’s heart” (1). However, participation in AF also entails inherent health risks, most notably hypertension. Prior cross-sectional investigations have established a notable association between AF engagement and hypertension, with emerging indications that hypertension diagnosed in young athletes may persist throughout their lifetimes (2). Extended exposure to elevated blood pressure levels can result in organ damage, with hypertensive heart disease being a significant concern. Consequently, timely identification and effective management of hypertension in young athletes assume paramount importance. Hypertensive heart disease typically presents as concentric left ventricular (LV) hypertrophy, which is characterized by an increase in LV mass and wall thickness without a proportional enlargement of the LV cavity. This structural adaptation can exert significant implications for cardiac function (3). While conventional echocardiographic methods proficiently evaluate LV dimensions and geometry, their capacity to provide a comprehensive assessment of systolic function, which signifies the heart’s ability to contract and effectively propel blood, may be somewhat limited. In response to this limitation, deformation imaging has emerged as a contemporary technique that offers a more comprehensive appraisal of systolic function by quantifying LV strain and strain rate. Strain denotes the percentage change in LV segment length during contraction, and strain rate quantifies the velocity of this alteration. Deformation imaging further enables the detection of subclinical systolic dysfunction and boasts superior reproducibility, irrespective of the ultrasound beam angle (4). During LV torsion, the base rotates in an overall clockwise direction and the apex rotates in a counterclockwise direction when viewed from the apex to the base. LV torsion is followed by rapid untwisting, which contributes to ventricular filling. Because LV torsion is directly related to fiber orientation, it may depict subclinical abnormalities in heart function. Recently, ultrasound speckle tracking was introduced for the quantification of LV torsion (5). This fast, widely available technique may contribute to a more rapid introduction of LV torsion as a clinical tool for the detection of myocardial dysfunction (4). Of course, two-dimensional speckle tracking echocardiography (2D-STE) has some limitations compared with to three-dimensional (3D). In three-dimensional speckle tracking echocardiography (3D-STE) analysis, it is possible to obtain images from a single apical window, free from geometric assumptions (6). However, accessibility to 3D-STE is unfortunately low.

The central hypothesis of this study posits that AF athletes exhibit elevated blood pressure levels, augmented LV mass, and diminished systolic function compared with their non-AF counterparts. Moreover, it is postulated that these parameters are interrelated. The primary objective of this research was to meticulously scrutinize the blood pressure profiles of AF athletes in Türkiye and unravel potential associations with cardiac function. To achieve this goal, we will harness deformation imaging in conjunction with conventional echocardiography techniques to provide a comprehensive assessment of cardiac function among AF athletes.

MATERIALS AND METHODS

Study Participants

The present study enrolled individuals aged 18 years and older with no significant medical history who presented at the Gazi University Cardiology Unit outpatient clinic for follow-up between January 2021 and May 2023. The ethical approval has been obtained from the Gazi University Clinical Research Ethics Committee (approval number: 273). A signed informed consent form has been obtained from each patient. The exclusion criteria comprised individuals with systolic heart failure, significant valvular pathology, pericardial disease, atrial fibrillation (AF), acute myocardial ischemia, pulmonary embolism, or any relevant medical history. A total of 46 patients met the inclusion criteria.

Player classification: Participants were categorized into two groups based on their field playing positions: lineman and non-linear.

Blood pressure measurement: Blood pressure readings were obtained in a clinical setting adhering to recommended guidelines. Measurements were taken using an appropriately sized cuff, following a 5-min rest period in a comfortable seated position. Each measurement was repeated three times, and the recorded blood pressure values were analyzed.

Echocardiographic evaluation: Echocardiographic assessments were conducted at rest by the same cardiologist using a General Electric Vivid E95 ultrasound system equipped with a 2D M5Sc-D probe (GE Vingmed Ultrasound). These evaluations adhered to the guidelines set forth by the American Society of Echocardiography. LV mass was calculated using an anatomically validated method, according to the formula LVM = 0.8 {1.04[(LVIDd + PWTd + SWTd)3 - (LVIDd)3]} + 0.6 g, where LVID is the LV internal dimension, PWT is the posterior wall thickness, SWT is the septal wall thickness, and d represents the end diastole. LV mass was normalized to both body surface areas. LV ejection fraction (EF) was calculated using the biplane Modified Simpson method. Multiple consecutive images were recorded over five cardiac cycles to obtain data sets of optimal image quality. These ECG-synchronized images were subsequently transferred to an offline EchoPac v201 (GE Vingmed ultrasound) workstation for in-depth analysis. The LV endocardial border, including the papillary muscles, was delineated using a dedicated software and further refined manually. The software facilitated dynamic analysis of the cardiac cycle. Torsion and global longitudinal strain (GLS) were determined by time curves using an 18-segment model. Images with inadequate tracking quality for more than two segments were excluded from the analysis.

Statistical Analysis

Continuous variables have been conveniently summarized as mean values accompanied by their respective standard deviations, whereas categorical data are presented as percentages or frequencies. To assess the normality of the distribution of continuous variables, the Kolmogorov-Smirnov test was employed. Parametric continuous variables were compared using the Student’s t-test, whereas non-parametric continuous variables were analyzed using the Mann-Whitney U test. For the comparison of categorical variables, the chi-square (χ^2) test was used. A stringent criterion for statistical significance, denoted by a twotailed p-value of <0.05, was uniformly adopted throughout all analyses. Statistical analysis was conducted using SPSS version 23.0, developed by IBM Corp in Armonk, NY, USA.

RESULTS

The study encompassed a total of 46 players, with 16 classified as lineman players and 30 as non-lineman players. Table 1 provides an overview of the demographic, anthropometric, and clinical characteristics of the study cohorts. Notably, all participants were male, with a mean age of 24.8±2.2 years (ranging from; 23 to 27 years). Importantly, there were no statistically significant differences in age observed between the two groups. Notably, the comparison of systolic and diastolic blood pressure measurements, heart rates, and body weights revealed significant distinctions, with lineman players exhibiting higher values across these parameters (Table 1).

The study results, as outlined in Table 2, provide an overview of LV EF values and LV masses, both calculated using conventional echocardiographic methods and 2D-STE deformation analysis. Interestingly, no significant disparity was noted between the groups when assessing LV-EF using the modified Simpson method (p=0.96). However, when examining LV mass, LV GLS, and LV torsion, it was evident that lineman players exhibited significantly lower absolute measurements in these parameters (Table 2).

DISCUSSION

In this study, we investigated blood pressure and LV systolic function in AF players playing in different positions using 2D-STE. The findings of our study can be summarized as follows: (a) Although AF players had similar and intact LV-EF values, players in the lineman position had lower absolute LV GLS and higher LV torsion measurements. (b) Players in the lineman position had higher blood pressure measurements. There were significant changes in LV mass, LV GLS, and LV torsion in relation to blood pressure measurements.

Table 1. Demographic, anthropometric, and clinical features

Parameters	Lineman, (n=16)	Non-Lineman, (n=30)	p-value
Age (years)	24.8±1.9	24±2.1	0.68
SBP (mmHg)	135.7±10.7	117.1±7.8	<0.001
DBP (mmHg)	80.1±10.9	74.2±12	<0.001
Weight (kg)	115.7±14.5	85.5±13.1	<0.001

SBP: Systolic blood pressure, DBP: Diastolic blood pressure.

Table 2. Comparison of conventional echocardiographic parameters among the groups

Parameters	Lineman, (n=16)	Non-Lineman, (n=30)	p-value
LV mass (gram)	224±25	165±17	<0.001
LV-GLS (%)	19.7±4.7	-22.8±-4	<0.001
LV-torsion (°/cm)	1.7±0.6	2.6±0.8	<0.001
LV-EF (%)	64±7	63.9±6.8	0.960

LV: Left ventricle, GLS: Global longitudinal strain, EF: Ejection fraction.

Notably, while AF players exhibited relatively consistent and preserved LV-EF values, we observed intriguing disparities when examining specific player positions. In particular, players assigned to the lineman position exhibited lower absolute LV GLS values, indicative of potential subclinical myocardial dysfunction. Moreover, these lineman players demonstrated higher LV torsion measurements, further highlighting the unique physiological demands placed on athletes in this position.

To complement our findings on cardiac function, we also performed blood pressure measurements among AF players. Our results revealed that players in the lineman position had elevated blood pressure, which could be potentially attributed to the rigorous physical demands and strain experienced in this role. Interestingly, we uncovered significant correlations between blood pressure measurements and LV mass, LV GLS, and LV torsion, shedding light on the interplay between hemodynamics and myocardial function in these athletes.

Evaluation of Left Ventricular Contractility Function in AF Players by Conventional Echocardiography

Traditionally, the assessment of global LV systolic function has relied on the EF, measured by the Modified Simpson method. However, it is essential to emphasize that EF primarily serves as a marker of ventricular pump function rather than an indicator of myocardial contractility. This traditional metric often falls short in identifying subtle, subclinical myocardial dysfunction (7). Nonetheless, conventional echocardiography remains the initial imaging modality for evaluating ventricular function because of its non-invasive nature, ease of use, and cost-effectiveness.

Deformation Imaging and 2D Speckle Tracking Echocardiography for the Clinical Assessment of LV Function in Patients with AF

In our study, we recognized the limitations of conventional echocardiographic methods and their inability to provide comprehensive insights into subclinical LV function. Deformation imaging techniques, particularly 2D STE, have emerged as valuable tools for the early detection of myocardial dysfunction. Notably, tissue Doppler imaging, while valuable, assesses only longitudinal function and may be influenced by tethering effects. Conversely, STE offers multidimensional displacement analysis and excels in its ability to overcome passive contraction effects and angle independence, making it a superior choice (8). Moreover, STE operates at a frame rate conducive to routine echocardiography, enhancing its practicality in clinical settings. Our findings underscore the significance of AF players in the lineman position, revealing subtle myocardial damage as indicated by decreased absolute LV strain values. These values exhibited a negative correlation with blood pressure levels and LV masses, suggesting a complex interplay between physiological stressors and myocardial function. Notably, despite these findings of subclinical dysfunction, LV-EF measurements remained within the normal range, possibly because of compensatory mechanisms such as increased apical torsion.

Comparative Insights into the Role of Hypertension

The scarcity of studies focusing on hypertension and 2D-STE in AF players necessitates attention. Previous research by Crouse et al. (2) observed significantly different blood pressure and LV mass ratios among AF players based on their training positions, highlighting the importance of considering position-specific physiological adaptations. Kansal et al. (9) also contributed to this body of knowledge by revealing statistically lower LV-GLS values in individuals with hypertension-induced LV hypertrophy in a study involving soccer players. Remarkably, these athletes exhibited similar and intact LV-EF values in the control group. Our study aligns with these findings, supporting the notion that in hypertensive heart disease, LV systolic dysfunction may manifest earlier than traditional echocardiographic parameters would suggest.

In this research endeavor, we investigated the relationship between systolic blood pressure and the occurrence of concentric hypertrophy among athletes with AF. Our study revealed compelling findings that shed light on the dynamic interplay between elevated blood pressure and cardiac structure and function: Our study revealed a noteworthy connection between increased systolic blood pressure and the development of concentric hypertrophy in AF players. This finding underscores the pivotal role of hemodynamics in shaping cardiac structure, particularly the heart's response to increased pressure loads. Concentric hypertrophy, characterized by thickening of the heart muscle, is a well-recognized adaptation to elevated blood pressure and represents an important aspect of hypertensive heart disease.

Structural changes and systolic function: Our investigation highlighted the ripple effect of structural changes associated with hypertensive heart disease on LV systolic function over time. This aspect is crucial because LV systolic function is a key determinant of the heart's ability to pump blood effectively. Hypertrophy and other structural alterations can lead to changes in systolic function, impacting an athlete's overall cardiac performance.

Early detection with LV-GLS: A groundbreaking aspect of our study was the use of 2D-STE to measure LV-GLS. This advanced imaging technique allows for the early detection of systolic dysfunction and provides a sensitive indicator of myocardial function. By measuring LV-GLS, we can identify subtle changes in systolic performance even before traditional parameters like EF show any abnormalities.

Prognostic implications: The implications of our findings extend beyond diagnosis and early detection. We propose that further investigations may establish the utility of LV-GLS values as a valuable prognostic tool in hypertensive heart disease. By tracking changes in LV-GLS over time, clinicians may gain valuable insights into an individual's prognosis, helping to guide treatment strategies and improve long-term outcomes for patients with hypertensive heart disease.

Study Limitations

It is essential to acknowledge the limitations of our study. Perhaps the most significant constraint was the relatively small sample size and the recruitment of participants from a single center. Although our findings provide valuable insights, future research with larger and more diverse cohorts would undoubtedly enhance our understanding of the complex relationships between position-specific demands, blood pressure, and LV function in AF players.

CONCLUSION

Our study contributes significantly to the understanding of the complex relationship between blood pressure, cardiac structure, and function in athletes with AF. This underscores the importance of monitoring blood pressure in these individuals to effectively detect and manage hypertensive heart disease. In addition, the potential of LV-GLS as an early detection and prognostic marker holds promise for improving patient care and outcomes in the realm of hypertensive heart disease. Further research in this direction may yield valuable clinical insights and inform evidence-based treatment approaches.

Ethics

Ethics Committee Approval: The ethical approval has been obtained from the Gazi University Clinical Research Ethics Committee (approval number: 273).

Informed Consent: A signed informed consent form has been obtained from each patient.

Author Contributions

Concept: Ö.S.G., S.Ü., B.S., Design: Ö.S.G., S.Ü., B.S., Data Collection or Processing: Ö.S.G., S.Ü., B.S., Analysis or Interpretation: Ö.S.G., S.Ü., B.S., Literature Search: Ö.S.G., S.Ü., B.S., Writing: Ö.S.G., S.Ü., B.S.

Conflict of Interest: No conflict of interest is declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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