Medicina Sportiva (2017), vol. XIII, no 1, 2827-2832
Journal of the Romanian Sports Medicine Society

Do we need new echocardiographic methods for left ventricle systolic function evaluation in athlets?

Irina Popescu[1,2], Silvia Mancas[1,2], Ioan Serbescu[3], Cristian Mornos[1,2], Adina Ionac[1,2]
[1]*Institute of Cardiovascular Diseases Timisoara, Romania*
[2]*Victor Babes University of Medicine and Pharmacy Timisoara, Romania*
[3]*County Hospital, Sportive Medicine Ambulatory, Timisoara, Romania*

Abstract. The aim of our study was to evaluate left ventricular (LV) systolic function in a team of elite rugby players using new echocardiographic techniques: Tissue Doppler, two-dimensional (2D) Speckle tracking and three-dimensional (3D) echocardiography. *Material and Method.* Twenty six male athletes from the regional rugby players' team were evaluated. The team was divided in two groups of athletes based on the predominance of dynamic aerobic or anaerobic effort performed: thirteen of them (group 1) - anaerobe effort, the others thirteen (group 2) - aerobic effort. All athletes underwent a complete physical exam, complete 2D and 3D transthoracic echocardiographic exam at rest. Standard 2D measurements, Tissue Doppler parameters, 2D speckle tracking global longitudinal strain (2D GLS) and 3D global longitudinal strain (3D GLS) were evaluated. *Results.* There were statistically significant differences between the two groups of athletes. Those in group 1 had higher body mass index (BMI) (p=0.002), left atrial area (LAA) (p=0.006), 3D left ventricular enddiastolic and endsystolic volume (LVEDV3D and LVESV3D) (p=0.006 respective p=0.011), 3D left ventricular mass (LVMass3D) (p=0.002), pulse Doppler diastolic A'velocity of lateral mitral annulus (A'lat) (p=0.004), left atrial diameter (LAD) (p=0.001), pulse Doppler systolic velocity of medial mitral annulus (S'med) (p=0.01), mitral annular plane systolic excursion (MAPSE) (p=0.033) than those in group 2, who had higher diastolic E' velocity of lateral (E'lat) and medial (E'med) mitral annulus (p=0.047 respective p=0.021). There were no significant differences of 2D GLS respective 3D GLS between the two groups (p=0.59, respective p=0.27). Athletes who had greater LV hypertrophy and LV mass indexed higher had a better response in tests of anaerobic exercise capacity. There was a statistically significant association between the 3D ejection fraction (EF) and anaerobic and aerobic exercise capacity. *Conclusions.* Our study revealed interesting interrelations between 2D GLS, 3D GLS, and LV hypertrophy and test results of effort capacity in a group of elite rugby players.

Key words: *athletes, speckle tracking, 3D echocardiography.*

Introduction

New echocardiographic techniques such as two-dimensional (2D) Speckle tracking and three-dimensional (3D) echocardiography have already demonstrated an important role in evaluation of left ventricular (LV) systolic function in elite athletes (1-4). 3D echocardiography had a continuous development, reaching from a method reserved for research in specialized laboratories, to a relatively affordable method with multiple implications in clinical practice. This method proved its usefulness in evaluating the cardiac volumes (left ventricle LV, right ventricle RV, left atrium LA) as well as systolic and diastolic function of LV. Analysis of myocardial contraction and intracardiac dissincronism, evaluation of the morphology of valves (mitral, aortic, tricuspid valve and less pulmonic), intracardiac shunts are other important indications. (5).

In our study we analyze the LV systolic function (ejection fraction EF, myocardial deformation-strain) using the standard 2D echocardiography and speckle tracking method with 2D and 3D echocardiography respectively. 2D speckle tracking technique (called 2D strain echocardiography) is based on tracking the dynamics of multiple myocardial dots (basically a fingerprint of the myocardial wall) throughout the cardiac cycle and post processing the data with the help of a special program. These dedicated softs allow the calculation of deformation and rotation of LV myocardium. The most widely used parameter, which we have used in our study, an important component of ventricular systolic function, is longitudinal deformation (global longitudinal strain GLS).This parameter defines the total deformation during the cardiac cycle length, being expressed in percentage. The value of GLS is calculated using the arithmetic average of all segments analyzed of the LV (6-7).

Three-dimensional speckle tracking echocardiography has as major advantage the fact that manages tracing the movement of all myocardial dots, and of those who are lost in the assessment of complex 2D motion, so long as these remain dots inside 3D volume purchased. Another advantage over 2D method is that time for images acquisition shall be reduced by two thirds (8).

These techniques have been already described in athlete's heart evaluation. Most studies have shown an increase of global longitudinal strain (2D GLS) after high-intensity physical training, assessed using speckle tracking method (2). Three-dimensional echocardiography also showed the best physiological adaptation changes of heart in different types of sports exercise (4).

LV physiologic hypertrophy appears as change of heart morphology at complex exercise intensive training. Thus, it is well known that dynamic endurance efforts, in which predominantly is aerobic effort, produce alterations of LV morphology by increasing diameters and volumes (eccentric hypertrophy), while static efforts, endurance, anaerobic produce especially thickening of the LV walls (concentric hypertrophy). In practice, there is not accurate a type of physical workout or a model of sport in that effort to be solely aerobic or anaerobic type (dynamic or static) and for this reason, changes at the level of the heart are both "load" and "pressure" combining concentric hypertrophy with increased LV diameters (9-10).

The aim of our study is to analyze the LV systolic function using 2D and 3D strain deformation parameters in a team of athletes, in order to find a parameter witch link the LV function with the effort capacity stress tests of the athletes.

Material and Method

Twenty six male athletes from the regional rugby players' team were evaluated in the Institute of Cardiovascular Diseases Timisoara, Romania. The team consists in two groups of athletes based on predominance of dynamic aerobic or anaerobic performed effort. First thirteen of them (group 1) are in defense line and are engaged mostly in anaerobe effort (strength players). Next thirteen (group 2) are in attack line and perform predominantly dynamic aerobic effort (runners). All athletes underwent a complete physical exam, complete 2D and 3D transthoracic echocardiographic exam at rest. Their physical performance was evaluated with specific protocols of exercise testing. Within the clinical examination were measured: weight (W), height (H), body surface area (BSA) (after diagram Du Bois) (11), and body mass index (BMI).

Using the indirect method for measuring those 5 envelops of adipose tissue: 1/3 of the brachial triceps, sub scapular, flank, abdominal and upper 1/3 of the thigh were previously calculated (12):

> Adipose tissue (AT)% = the sum of the five envelopes (mm) x 0.15 + 5.8 + BSA (m^2); Adipose tissue (AT) (kg) = W x AT%; Active (lean) mass (AM) = W (kg) – AT; Optimal AM = G x 89%; Optimal adipose tissue (optimal AT) = AM x 11%; Optimal body weight (optimal W) = optimal AM + optimal AT.

Standard transthoracic bidimensional (2D) echocardiographic study was performed by an experienced echocardiographer using a Vivid E9 ultrasound machine (GE Healthcare) with an M5S probe. All athletes were examined in the left lateral position, before the exercise tests.

Standard 2D measurements - LV diastolic diameter (LVDD) and LV systolic diameter (LVSD), interventricular septum (IVS) and posterior wall (PW) thickness - were obtained in the parasternal long axis view (13). LV mass was automated calculated according to the ASE recommendations (14). LV end diastolic and end systolic volumes (LVEDV, LVESV) were obtained in the apical four chamber view (13). LV ejection fraction (EF) was calculated using the Simpson biplane method. Resting LV diastolic function was assessed by E and A wave velocities, E/A ratio from the mitral inflow, according to the EAE recommendation (13). Left atrium (LA) volume was assessed in ventricular end-systole by the modified Simpson's monoplane method in the apical four-chamber view according to the guidelines (15).

Pulsed tissue Doppler imaging data were obtained from a 2 mm sample volume placed at the lateral mitral annulus, medial mitral annulus and lateral tricuspid annulus in the apical 4 chamber view recorded during an end-expiratory apnea period.

Mitral respective tricuspid annular plane systolic excursion (MAPSE respective TAPSE) was calculated by the difference between end-diastolic and end-systolic measurements (mm) (16,17).

For 2D Speckle tracking evaluation, global longitudinal strain (2D GLS) was computed from high frame rate (>50 frame/sec) apical views (four chambers, two chambers and three chambers) using speckle tracking analysis (Echo Pac, Version 12BT, GE Healthcare). 2D GLS was obtained by averaging the segmental strain curves of all 17 segments of LV and was represented in a color coded bull's eye plot (18-20).

Real time three dimensional (3D) echocardiography data set acquisitions were acquired by the same examiner using a 3V matrix array transducer (GE Healthcare). A full volume data set of the LV was acquired from apical view, consisted in four consecutive beats ECG-gated sub volumes at the end of expiration and breathe holding. Two or three datasets for patient were obtained, stored and exported to an off-line workstation for further analysis (Echo Pac, Version 12BT, GE Healthcare). With a specific software algorithm (4D AutoLVQ^{TM} – GE Healthcare), LV volumes, LV EF, LV Mass and 3D global longitudinal strain (3D GLS) were calculated according to actual recommendations (21-23).

All steps were followed as described in the previous studies: automatic slicing of the entire full LV volume dataset; automatic alignment of all the three planes from apical view; identification of LV endocardial border both in diastole and systole (automatic with manual correction if necessary) with calculation of LVEDV and LVESV; analysis and data display (EF % = LVEDV-LVESV/LVEDV x100); further evaluation of LV mass and strain were calculated using automatic border detection of pericardium (with optional manual correction); LV Mass = (LV pericardial volume –LV endocardial volume) x1.05. 3D; LV mass was indexed for height powered to 2.7.

3D GLS was automated generated and presented in regional and average strain curves and also in color-coded 17 segments bull's eye plot (23).

Physical performance evaluation. Following clinical examination, 12-lead electrocardiogram and resting echocardiography, patients underwent an exercise test with cycle ergometer (Astrand treadmill test for maximal oxygen consumption (VO_2max) evaluation) (24-25). The aerobe capacity was measured in a 6 minute cycle ergometer test with a constant workload (2,5W x Body weight (kg) and cadence (60 r.p.m.). The heart rate in the last 10s was measured; the specific values obtained were indexed on body weight (kg) and then compared with ideal values (%). The values above 75% indicate a good athlete's aerobe endurance capacity.

Although the physical functional status was analyzed by measuring the HR in minute 5 of intense effort (P1) and in minute 1, 2 respective 4 of relaxation period (P2, P3 and P4). The lowest values of the sum of P1, P2, P3 and P4 show good effort tolerability. Aerobe effort was also evaluated with systolic tension time test (STT test). HR and systolic blood pressure (SBP) were measured in minute 6 of maximal effort and STT value was calculated with formula: STT/watt/body weight = (HR min6 x SBP min6)/(W/kg).

Athletes were also tested for anaerobe capacity evaluation. Szoghy-Cherebetiu test at cycle ergometer was used (workload of 7,5%/body weight with 90 rpm) (12). Total mechanical work (TTR %) was calculated at 10s of effort, 20s and 45s of effort. Grades of Excellent (E), Very good (FB), good (B) and medium (M) were allocated depending on obtained values (12).

Statistical analysis of the data was performed with SPSS 17 software. Clinical and echocardiographic characteristics as well as physical performance measurements were expressed using mean and standard deviation for continuous variable and proportions for non-continuous variable. Bivariate analysis was conducted with all continuous variables with independent samples t- test and with non-continuous variables with a Chi-square test. Regression analysis with Pearson's correlation coefficient was used to evaluate the relation between 3D echocardiographic parameters and other variables.

Results

Clinical, physical and echocardiographic characteristics of entire group of athletes were illustrated in Table I. Bivariate data analysis showed statistically significant differences between the two groups of athletes that are discussed below (Table II).

Those in group 1 had higher body mass index (BMI) (p=0.002), left atrial area (LAA) (p=0.006), 3D left ventricular enddiastolic and endsystolic volume (LVEDV3D and LVESV3D) (p=0.006 respective p=0.011), 3D left ventricular mass (LVMass3D) (p=0.002), pulse Doppler diastolic A'velocity of lateral mitral annulus (A'lat) (p=0.004), left atrial diameter (LAD) (p=0.001), pulse Doppler systolic velocity of medial mitral annulus (S'med) (p=0.01), mitral annular plane systolic excursion (MAPSE) (p=0.033) than those in group 2, who had higher diastolic E' velocity of lateral (E'lat) and medial (E'med) mitral annulus (p=0.047 respective p=0.021).

There were no significant differences of 2D GLS respective 3D GLS between the two groups (18.23±2.1% vs. -17.77±2.2%, p=0.59, respective -15.46±3% vs. -16.76±1.9%, p=0.27).

Table I. Clinical, physical and echocardiographic characteristics of entire group of athletes

Characteristics	Media±SD	Characteristics	Media±SD
Age (years)	25.77±3.32	E' lat (m/s)	0.1742±0.04053
Height (H) (cm)	182.88±7.02	A' lat (m/s)	0.0754±0.02570
Weight (W) (kg)	101.77±15.15	S' med (m/s)	0.1485±0.20728
BMI (kg/m^2)	30.37±3.75	E' med (m/s)	0.1215±0.02257
BSA (m^2)	2.23±0.18	A' med (m/s)	0.0777±0.01751
W optim (kg)	82.96±9	MAPSE (mm)	20.04±1.90
AT (kg)	24.25±6.59	TAPSE (mm)	29.88±4.81
Exces AT (kg)	10.65±7.92	2D GLS (%)	-18.01±2.12
AM (kg)	77.08±10.31	3D GLS (%)	-15.99±2.70
AM deficit (kg)	-6.49±6.72	3DLVEDV (ml)	166.12±25.37
LVEDD (cm)	5.28±0.43	3DLVESV (ml)	71.27±13,95
LVESD (cm)	3.47±0.36	3D EF(%)	0.56±0.03
IVS (cm)	1.19±0,11	3D LVMass(mg)	139.92±12.81
PW (cm)	1.17±0,12	Mmod LVMass(mg)	303.13±50.02
LVEDV (ml)	145.38±37.86	iMmod LVMass (mg)	136.89±16,73
LVESV (ml)	59.34±15.75	P1 (b/min)	143.75±9.44
iLVEDV (ml)	67.11±9.16	P2 (b/min)	101.75±11.66
iLVESV (ml)	27.63±3,88	P3 (b/min)	90.75±9.24
4C EF(%)	.5838±0.0444	P4 (b/min)	81.75±15.40
LAD (cm)	4.05±0.50	TTR10 (%)	79.30±9.06
LAA (cm^2)	22.17±3.55	TTR20 (%)	75.32±7.98
LAV (ml)	69.12±17.73	TTR45 (%)	67.54±9.08
E (m/s)	0.8527±0.15280		
A (m/s)	0.4200±0.09042		
S' lat (m/s)	0.1063±0,01974		

Table II. Statistically significant differences between the studied variables
(between the two groups of athletes)

Group 1 > Group 2
Height (p-value=0.007, Independent-samples t test, 95% CI)
Weight (p-value<0.001, Independent-samples t test, 95% CI)
BMI (p-value=0.002, Independent-samples t test, 95% CI)
BSA (p-value<0.001, Independent-samples t test, 95% CI)
Woptim (p-value=0.004, Independent-samples t test, 95% CI)
AT (p-value=0.001, Independent-samples t test, 95% CI)
AM (p-value=0.001, Independent-samples t test, 95% CI)
LAA (p-value=0.006, Independent-samples t test, 95% CI)
A'lat (p-value=0.004, Independent-samples t test, 95% CI)
3D LVEDV (p-value=0.006, Independent-samples t test, 95% CI)
3D LVESV (p-value=0.011, Independent-samples t test, 95% CI)
3D LVMass (p-value=0.002, Independent-samples t test, 95% CI)
LAD (p-value=0.001, Mann-Whitney test, 95% CI)
S'med (p-value=0.01, Mann-Whitney test, 95% CI)
MAPSE (p-value=0.033, Mann-Whitney test, 95% CI)
Group 1 < Group 2
E'lat (p-value=0.047, Independent-samples t test, 95% CI)
E'med (p-value=0.021, Independent-samples t test, 95% CI)
AM Deficit (p-value=0.001, Mann-Whitney test, 95% CI)

Analyzing categorial variables (those of physical performance) we have determined that there are differences between the categories of TTR10calif and: IVS thickness (p-value = 0.026, One Way ANOVA test, 95% CI), PW thickness (p-value = 0.026, One Way ANOVA test, 95% CI) A' lat (p-value = 0.019, One Way ANOVA test, 95% CI) iMmodeLVmass (p-value = 0.021, One Way ANOVA test, 95% CI). Thus, athletes with greater LV hypertrophy and greater LV indexed mass had a better response on anaerobic effort tests.

There was a statistically significant association between 3DEF and TTR, respectively STT; TTR45calif and 3DEF (p-value = 0.016, Chi2 test, 95% CI); STTcalif and 3DEF (p-value = 0.044, Chi2 test, 95% CI). In other words, the athletes with higher 3DEF had a better results both at aerobic and anaerobic effort tests.

Discussion and Conclusion

Our study reveals some important aspects: athletes with more pronounced LV hypertrophy had a better response to the evaluation tests of anaerobic exercise (TTR was better as LV hypertrophy was higher). In addition, athletes who have achieved better ratings at evaluation tests of aerobic and anaerobic effort had a higher LV EF, evaluated with 3D echocardiography.

Another interesting finding in our study was the fact that there were no significant differences of 2D GLS respective 3D GLS between the two groups of athletes. This can be explained by the reality that in our team the defense line of athletes was not so different by the attack line and they all have both aerobe and anaerobe type of training protocols.

This aspect we consider that it is a limitation of our study, the relatively small number of analyzed athletes (in fact the entire lot of professional rugby union regional team) are not enough to constitute a homogeneous group in terms of the type of effort unfolded.

In literature, we found that, recently, D´Ascenzi compared 2D GLS and 3D GLS between athletes and healthy individuals and discovered that longitudinal strains did not differ between athletes and controls, neither by 2D nor by 3D speckle tracking echocardiography (STE) but 3D longitudinal strain values were lower ($p < 0.0001$), as compared with 2D STE ($p < 0.001$) (26)

DÁndreea et al. studied the effects of different effort training protocols on LV strain indices. They showed no differences of 2D GLS between endurance and strength athletes. Also they demonstrated a positive association between E'lat, E'med and LVEDV (p-value<0.001) and an independent correlation between 2D GLS and sum of LV wall thickness (p-value<0.005) (27). In our study we also find a significant correlation of 2D GLS with IVS (p-value=0.035) and PW (p-value=0.002) thickness.

Our study showed the importance of complete evaluation of the athletic heart using new echocardiographic technique (3D echocardiography, Speckle tracking method). As in other important studies, we demonstrated the relationship of interdependence between 2D GLS, LV hypertrophy and the results to athlete's performance evaluation tests. Myocardial deformation parameters, 2D GLS and 3D GLS did not statistically differ between our groups of athlets.

References

1. Baggish AL, Yared K, Wang F, Weiner RB, Hutter AM Jr, Picard MH, WoodMG (2008). The impact of endurance exercise training on left ventricular systolic mechanics. *Am J Physiol Heart Circ Physiol*; 295: H1109-16.
2. Butz T, van Buuren F, Melwig KP Langer C, Plehn G, Meissner A, Trappe HJ, Horstkotte D, Faber L (2011). Two-dimensional strain analysis of the global and regional myocardial function for the differentiation of pathologic and physiologic left ventricular hypertrophy: a study in athletes and in patients with hypertrophic cardiomyopathy. *Int J Cardiovasc Imaging*; 27: 91-100.
3. Stefani L, Pedrizzetti G, De Luca A, Mercuri R, Innocenti G, Galanti G (2009). Real-time evaluation of longitudinal peak systolic strain (speckle tracking measurement) in left and right ventricles of athletes. *Cardiovasc Ultrasound*; 7: 17.
4. Vitarelli A, Capotosto L, Placanica G, Caranci F, Pergolini M, Zardo F (2013). Comprehensive assessment of biventricular function and aortic stiffness in athletes with different forms of training by three-dimensional echocardiography and strain imaging. *Eur Heart J Cardiovasc Imaging*; 14(10): 1013-20.
5. EAE/ASE Recommendation for Image Acquisition and Display Using Three-Dimensional Echocardiography, *Eur Heart J – Cardiovasc Imag* (2012); 13: 1-46.
6. Mornos C, Ionac A (2011). *Ecocardiografia Doppler tisular si Speckle tracking*, Brumar Ed, Timisoara, pp 93-96, 98.
7. Marwick TH (2006). Measurement of strain and strain rate by echocardiography: ready for prime time? *J Am Coll Cardiol*; 47(7): 1313-27.

8. De Isla LP, Balcones DV, Fernandez-Golfin C et al (2009). Three-dimensional-wall motion tracking: a new and faster tool for myocardial strain assessment: comparison with two-dimensional-wall motion tracking. *J Am Soc Echocardiogr*; 22: 325-30.
9. Fagard RH (1997). Impact of different sports and training on cardiac structure and function. *Cardiol Clin*; 15: 397-412.
10. D'Ándreea A, Galderisi M, Sciomer S, Nistri S, Agricola E, Ballo P (2009). Echocardiographic evaluation of the athlete's heart: from morphological adaptation to myocardial function. *G Ital Cardiol*;10:533-44.
11. Du Bois, Du Bois, *Arch Intern Med* 1916; 17: 863-71.
12. Dragan I (2002). *Medicina sportiva*, Editura Medicala, Bucuresti.
13. Lang RM, Biering M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA (2006). Recommendation for chamber quantification. *Eur J Echocardiogr*; 7: 79-108.
14. Devereaux RB, Alonso DR, Lutas EM, Gottlieb GJ, Campo E, Sachs I (1986). Echocardiographic assessment of left ventricular hypertrophy:comparison to necropsy findings. *Am J Cardiol*; 57: 450-8.
15. Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H (1989). Recommendation for quantification of the left ventricle by two-dimensional echocardiography. American Society of Echocardiography Committee on Standards, Subcommittee on Quantitation of Two-Dimensional Echocardiograms. *J Am Soc Echocardiogr* ; 2: 358-67.
16. Galderisi M, Henein MY, D'hooge J, Sicari R, Badano L, Zamorano JL (2011) On behalf of the European Association of Echocardiography. Recommendation of the European Association of Echocardiography: How to use echo-Doppler in clinical trials: different modalities for different purposes. *Eur J Echocardiogr*; 12: 339-53.
17. Olsen NT, Jons C, Fritz-Hansen T, Mogelvang R, Sogaard P (2009). Pulsed-wave tissue Doppler and color tissue Doppler echocardiography: calibration with M-mode, agreement and reproducibility in a clinical setting. *Echocardiography*; 26: 638-44.
18. Kaul S, Tei C, Hopkins JM, Shah PM (1984). Assessment of right ventricular function using two dimensional echocardiography. *Am Heart J*; 128: 301-7.
19. Korinek J, Kjaergaard J, Sengupta PP, Yoshifuku S, McMahon EM, Cha SS (2007). High spatial resolution speckle tracking improves accuracy of 2-dimensional strain measurements: an update on a new method in functional echocardiography. *J Am Soc Echocardiogr*; 20: 165-70.
20. Dalen H, Thorstensen A, Aase SA, Ingul CB, Torp H, Vatten LJ (2010). Segmental and global longitudinal strain and strain rate based on echocardiography of 1266 healthy individuals: the HUNT study in Norway. *Eur J Echocardiogr*; 11: 176-83.
21. Muraru D, Badano LP, Piccolo G, Gianfagna P, Del Mestre L, Ermacora D (2010). Validation of a novel automatic border detection algorithm for rapid and accurate quantitation of left ventricular volumes based on Three-dimensional echocardiography. *Eur J Echocardiogr*; 2: 359-68.
22. Langeland S, Rabben SI, Heimdal A, Gerard O (2010). 4D Strain: validation of new 3D speckle tracking and left ventricular tool in simulated echocardiographic data. *Eur J Echocardiogr*; 11(suppl 2): Abstract P658.
23. Galderisi M, Esposito R, Schiano-Lomoriello V, Santoro A, Ippolito R, Schiattarella P(2012). Correlates of global area strain in native hypertensive patients: a three-dimensional speckle-tracking echocardiography study. *Eur J Echocardiogr*; 13: 730-38.
24. Noakesa TD, Myburgha KH, Schalli R (1990). Peak treadmill running velocity during the VO2 max test predicts running performance. *Journal of Sports Sciences*; 8 :35-45.
25. Apostol A, Ionescu A, Vasilescu M (2013). Aerobic versus Anaerobic-comparative studies concerning the dynamics of the aerobic and anaerobic effort parameters in top athletes. *Medicina Sportiva*; 9(2): 2130-2140.
26. D'Ascenzi F, Solari M, Mazzolai M, Cameli M, Lisi M, Andrei V (2016). Two-dimensional and three-dimensional left ventricular deformation analysis: a study in competitive athletes; *Int J Cardiovasc Imaging.*; 32(12): 1697-1705.
27. D'Andrea A, Cocchia R, Riegler L, Scarafile R, Salerno G, Gravino R (2010). Left ventricular myocardial velocities and deformation indexes in top-level athletes; *J Am Soc Echocardiogr*; 23(12): 1281-8.

Corresponding author
Irina Popescu
Institute of Cardiovascular Diseases Timisoara, Romania
E-mail address: *irinap75@yahoo.com*

Received: January 21, 2017
Accepted: May 10, 2017