Myocardial Strain Quantification in Athletes by Speckle Tracking Echocardiography

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Abstract

Introduction: The measurement of strain indicates the deformity percentage of a particular myocardial segment.

Objective: To establish the normal values of two-dimensional strain in the different myocardial segments of the left ventricle (LV) in athletes by echocardiography.

Material and Methods: We studied 63 athletes (professional soccer players), with mean age of 20.3 ± 5.9 years, compared to 63 healthy subjects, matched for age and sex. The strain was quantified by two-dimensional echocardiography, by using the speckle tracking technique in 12 segments of the left ventricle, in apical views of 4 and 2 chambers.

Results: The athletes showed high values of two-dimensional strain ranging from 14.9 to 24.9%. The average strain values by region in athletes studied were 17.1% (basal region), 19.2% (middle region), 23.3% (apical region), showing a significant increase in myocardial strain from the base to apex ($p < 0.005$). No significant differences were observed when comparing the values found in athletes with the group of normal subjects.

Conclusion: In professional soccer players, the values of the two-dimensional myocardial strain in the LV ranges around 15-25%, increasing from the ventricular base to apex and the same behavior is observed in normal population.

Keywords: Athletes; Echocardiography / instrumentation; Myocardium / Pathology; Ventricular Function / physiology.

Introduction

It is known that physical exercise improves cardiovascular functional capacity, a factor of great importance in primary and secondary prevention of cardiovascular diseases.

Several studies attest the various benefits that physical activity promotes in the population adopting changes in lifestyle, including physical activity permanently, without bringing great changes in cardiac dynamics. With respect to high performance athletes undergoing intense physical training, they often present morphological and functional adaptations in the heart. Generally, in athletes subjected to resistance training physiological changes occur in the left ventricle characterized by increased size of chamber, wall thickness, and left ventricular mass[1,2]. Most of echocardiographic studies have evaluated the ejection fraction and mitral transvalvular flow rate to find a relationship between cardiac hypertrophy and systolic and diastolic function of the left ventricle. However, these hemodynamic variables do not provide any direct information about the myocardial motion and function, and the inclusion of new techniques such as two-dimensional strain appeared to improve the assessment[3].

In this study, we evaluated a group of athletes (professional soccer players) to determine the normality values of the two-dimensional strain by means of echocardiography. In parallel, we compared the strain values in this group of athletes with a control group of normal subjects matched for age and sex.

Echocardiography is a well known tool in the analysis of regional and global systolic ventricular function. The measurement of two-dimensional strain by echocardiography by using the speckle tracking technique is relatively new and allows analyzing the deformity in each myocardial segment by two-dimensional echocardiography. The technique relies on the identification of speckles (bright points in the myocardium) in any ventricular segment during cardiac cycle. The variation of movement of these points, frame by frame, and the speed at which they move, allow calculating the strain of the relevant segment (Figure 1). The analysis of the displacement between these points provides the strain curve and the motion vectors in all directions. There is no need for Doppler parameters, which allows analyzing apical

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Received on: 14/01/2013; accepted on: 11/03/2013.

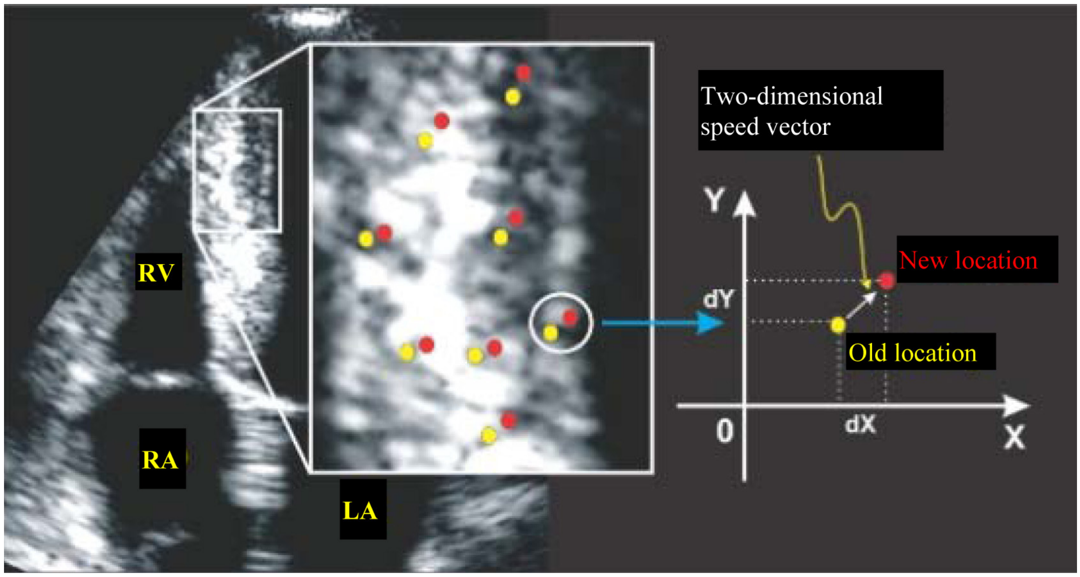

Figure 1 - *Schematic illustrating the principle of speckle tracking echocardiography. A computer program identifies bright spots in the myocardium and follows them frame by frame. Knowing the initial and final position and the displacement rate of the point, we can quantify the deformity of the analyzed segment.*

regions, as they are not affected by the acoustic incidence angle, allowing assessing the left ventricle stain in various anatomical views (longitudinal, radial and circumferential). This technique allows also to evaluate tangential plans and to measure the displacement between points in the epicardium and endocardium in the longitudinal direction (shear strain longitudinal radial) and transversal direction (shear strain circumferential radial)[3].

Another advantage of the technique in relation to the strain measured by Doppler echocardiography is the lower inter- and intra-observer variability. The contractile, longitudinal, and radial functions had already been well assessed by echocardiography; however the quantification of helical contractile function or ventricular twist was difficult. The new technique of two-dimensional strain has been shown to be very promising in quantifying those parameters, not previously assessed by echocardiography[4,5].

Objective

To establish normal values of two-dimensional strain in the different myocardial segments of the left ventricle in athletes (professional soccer players) by echocardiography with speckle tracking, and compare them with the population of normal individuals.

Materials and Methods

63 athletes were selected between January and February 2010, at which time they are subjected to routine examinations by the soccer clubs in the preseason, all being males with average age of 20.3 years (± 5.9 years) without previous co-morbidities.

All patients were referred to a specialized laboratory service to perform transthoracic echocardiography, including the two-dimensional longitudinal strain by speckle tracking technique. The echocardiographic examinations were performed in Vivid7 (General Electric, Milwakee, WI, USA). The images were captured in the apical 4- and 2-chamber view, and apical longitudinal, properly synchronized with ECG of good quality, and stored for later analysis with appropriate software (EchoPAC Dimension v7.1.x, GE Healthcare Technologies Ultrasound), according to Figure 2. Twelve myocardial segments were analyzed in each patient. The subjects were evaluated at rest, without having training immediately before the exam.

The control group consisted of 63 healthy subjects matched for age and sex, who sought the laboratory for cardiac check-up. In this group, we considered the following exclusion criteria: blood hypertension, valve disease, coronary artery disease, diabetes mellitus, cardiomyopathy, use of drugs with cardiovascular action, and poor image quality on echocardiography.

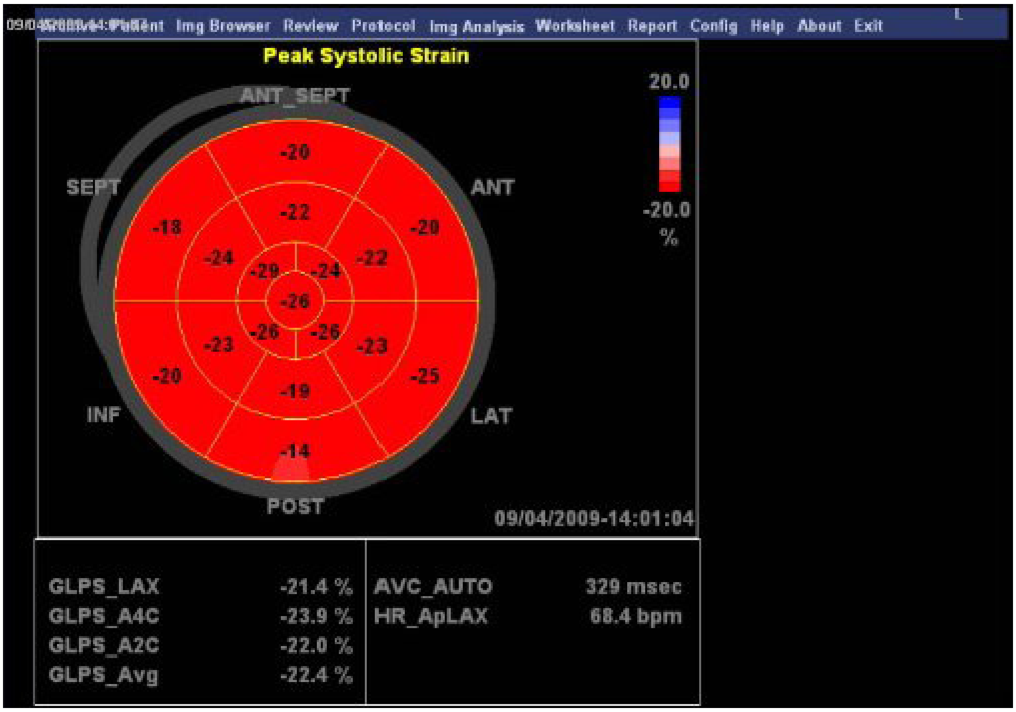

Figure 2 - *Map on Bull'sEye showing strain values obtained by speckle tracking echocardiography with the program EchoPAC (GE Healthcare Technologies Ultrasound).*

Results

The evaluated athletes showed two-dimensional strain values ranging from 14.9 to 24.9%. The average strain values by region in the athletes analyzed were 17.1% (basal region), 19.2% (middle region), 23.3% (apical region), showing a significant increase in myocardial strain from base to apex ($p < 0.005$), as shown in Table 1.

No significant differences were observed when comparing the values found in athletes with the group of normal subjects.

Discussion

Numerous studies on cardiac evaluation by echocardiography in athletes have been published; however, the literature is quite scarce in the evaluation with new echocardiographic techniques, especially with speckle tracking, in this population.

Some studies evaluating ultra-marathoners, soon after the marathon (89 km), demonstrated reduced values of global strain and ejection fraction in these individuals[6]. The same was not observed in athletes who performed conventional marathons, where the strain values did not change compared to baseline, even in older runners[7].

Other studies have demonstrated that resistance and long lasting exercise promotes changes in cardiac function, as well as in size and left ventricular volume, reduced systolic function, and development of wall motion abnormalities[8]. On the other hand, a study in rowing athletes, who perform short lasting exercises at high intensity, showed an increased systolic function assessed by speckle tracking[2]. One of the differences between the studies mentioned above and ours, which may explain why the two-dimensional strain values were similar in both groups, is the time when the echocardiogram was performed. In these studies, subjects were evaluated immediately after intense physical activity, some as strenuous as the ultra-marathon, while our athletes were evaluated at rest.

A very interesting study was published by a French group, assessing professional cyclists. In this group, there was a decreased apical radial strain compared to control group (sedentary population). The hearts of athletes are associated with specific adaptations, including lower apical strain and shear strain, without changes in global systolic and diastolic function of the left ventricle. These mechanical changes may improve cardiovascular adjustments to exercise by increasing radial strain and twist in response to exercise, which can be a key to the diastolic filling and cardiac performance in athletes[9]. Again, the evaluation of these athletes was performed approximately 15 minutes after intense physical activity.

Our study demonstrated that, at resting conditions, professional soccer players show no change in the values of longitudinal

Table 1 - Values of longitudinal strain (%) per segments in several walls of the left ventricle

	Septal	Lateral	Anterior	Inferior
Basal	16.1 ± 3.1	14.9 ± 6.7	17.6 ± 4.7	19.8 ± 3.8
Middle	19.4 ± 3.1	17.0 ± 4.2	20.1 ± 3.7	20.3 ± 3.5
Apical	22.7 ± 4.6	21.1 ± 4.5	24.3 ± 5.2	24.9 ± 4.5

myocardial strain when compared to normal population. More studies are needed in this group, immediately after physical activity, to more completely assess the myocardial strain.

Conclusion

This study evaluated myocardial strain rates obtained by means of two-dimensional strain by speckle tracking technique in a group of professional soccer players. In this group, the values of two-dimensional strain in the left ventricle ranged from 14.9% to 24.9%, increasing from ventricular base to the apex. This behavior was similar to that observed in the general population (control group), with no statistically significant differences between the two groups.

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