Gender Differences in Ventricular Remodeling and Function in College Athletes, Insights from Lean Body Mass Scaling and Deformation Imaging

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Several studies suggest gender differences in ventricular dimensions in athletes. Few studies have, however, made comparisons of data indexed for lean body mass (LBM) using allometry. Ninety Caucasian college athletes (mixed sports) who were matched for age, ethnicity, and sport total cardiovascular demands underwent dual-energy x-ray absorptiometry scan for quantification of LBM. Athletes underwent comprehensive assessment of left and right ventricular and atrial structure and function using 2-dimensional echocardiography and deformation imaging using the TomTec analysis system. The mean age of the study population was 18.9 ± 1.9 years. Female athletes (n = 45) had a greater fat free percentage (19.4 ± 3.7%) compared to male athletes (11.5 ± 3.7%). When scaled to body surface area, male had on average 19 ± 3% (p <0.001) greater left ventricular (LV) mass; in contrast, when scaled to LBM, there was no significant difference in indexed LV mass −1.4 ± 3.0% (p = 0.63). Similarly, when allometrically scaled to LBM, there was no significant gender-based difference in LV or left atrial volumes. Although female athletes had mildly higher LV ejection fraction and LV global longitudinal strain in absolute value, systolic strain rate and allometrically indexed stroke volume were not different between genders (1.5 ± 3.6% [p = 0.63] and 0.0 ± 3.7% [p = 0.93], respectively). There were no differences in any of the functional atrial indexes including strain or strain rate parameters. In conclusion, gender-related differences in ventricular dimensions or function (stroke volume) appear less marked, if not absent, when indexing using LBM allometrically. **(Am J Cardiol 2015;116:1610−1616)**

Despite several years of investigation, the extent of gender differences in ventricular dimension and function in athletes remains a subject of debate.[1−11] Part of the controversy may be related to that only few studies took into account body composition when scaling cardiac dimensions. In this study, we sought to determine, in college athletes, whether gender-related differences in ventricular dimensions persisted after adjustment for lean body mass (LBM). In second intention, we sought to compare gender-associated differences in functional parameters including ventricular and atrial strain analysis.

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Methods

In 2008, 315 Caucasian college athletes were included in the preseason cardiac screening process at Stanford University using the AHA-12 point questionnaire, electrocardiogram, and a screening echocardiogram. Of these, 124 participants volunteered to undergo dual-energy x-ray absorptiometry (Norland XR 26 Mark II/HS, Norland Corporation, Wisconsin) for assessment of body composition. Of these subjects, we selected 90 subjects (45 men and 45women) and were matched according to age, ethnicity or race, and total cardiovascular demand.[12] We excluded subjects who participated in sports in high dynamic and static component such as rowing, cycling, and triathlon as these were asymmetrically distributed among genders.[12] The sport disciplines included the following: baseball, softball, La Crosse, short distance track running, wrestling, synchronous swimming, sailing, and fencing. Height and weight were measured using standard techniques. Body surface area (BSA) was calculated with Dubois formula. We present also data from 50 age-, gender-, and race-matched sedentary subjects for reference of the values in our laboratory. Body mass index (BMI) was calculated using a standard formula, weight divided height squared (kg/m^2). LBM was estimated using dual-energy x-ray absorptiometry scan.

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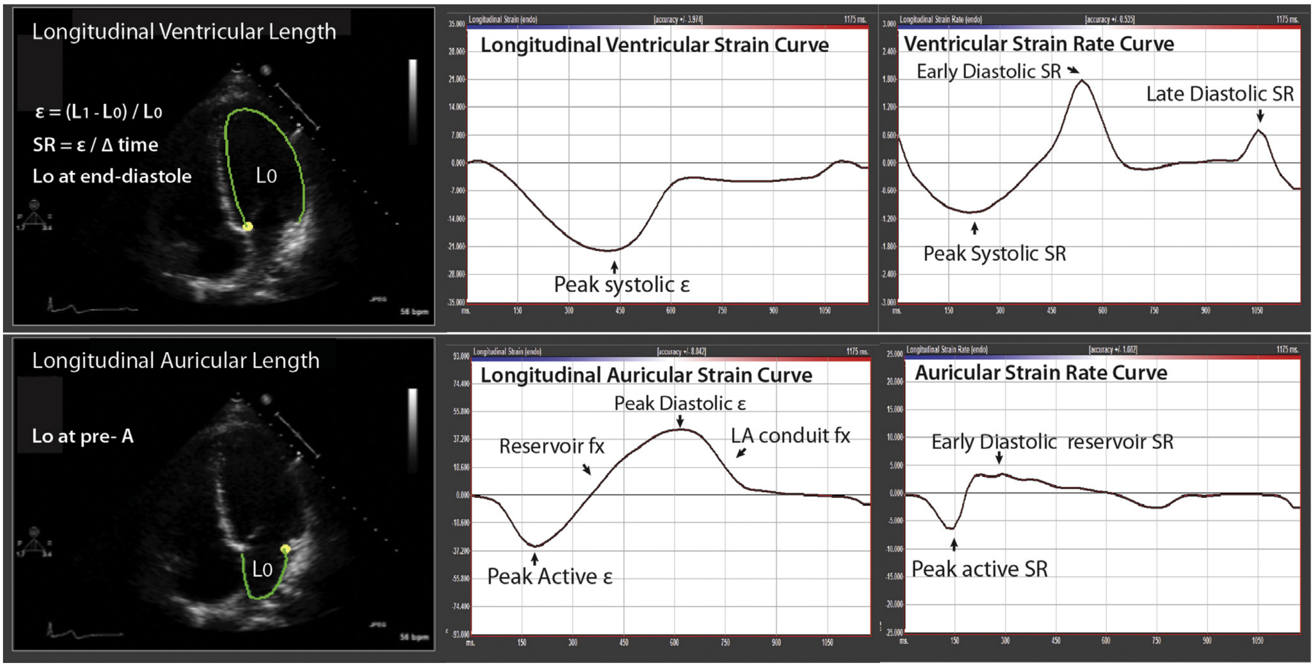

Figure 1. Left ventricular and left atrial strain and strain rate measurements. After LV and LA myocardium is traced *(the green contours)*, the software automatically tracks the ventricular or atrial wall on subsequent frames. Adequate tracking can be verified and corrected by adjusting the region of interest or the contour. Each curve shown in the middle and the right is the average curve of 6 segments. The curve starts from the beginning of the QRS in left ventricle *(upper)* and from the beginning of the p wave in left atrium *(lower)*. ε = strain; SR = strain rate; fx = function; LA = left atrial.

All subjects underwent standard transthoracic 2-dimensional (2D) and color Doppler echocardiography using the Philips IE33 system (Philips Medical Imaging, Eindhoven, The Netherlands) and a 3.5-MHz transducer. The echocardiograms were blindly interpreted by an experienced reader (GG) according to the American Society of Echocardiography (ASE) guidelines.[13] Left ventricular (LV) wall thickness and diameters were measured from the long-axis views using 2-dimensional (2D) measurements at the upper papillary level to avoid any chordal attachments; septal bands were also excluded from the septal wall measurements. LV mass was calculated in diastole by estimating LV mass on the basis of area−length (AL) formula.[13] LV end-diastolic and end-systolic volumes were calculated using the 5/6 AL method as the 4-chamber (4C) end-diastolic volume often underestimates ventricular volumes; we used the 5/6 constant for the volume calculation to have the same constant as for the LV mass calculations. LV ejection fraction was obtained using the Simpson method in 4C view. SV was derived using the difference between end-diastolic and end-systolic volumes using the AL method. Right ventricular (RV) end-diastolic area was measured in the apical 4C view. Tricuspid annular plane systolic excursion was measured using a 2D manual method. Atrial volumes were calculated using the apical 4C views using the AL method.[14]

Analysis of LV, RV, and atrial (left and right) global longitudinal strain (GLS) was performed from apical 4C views, using vendor-independent software (TomTec Imaging System, Unterschleissheim, Germany) as shown in Figure 1. For LVGLS, the 6 segments in the apical 4C view were averaged, whereas the 3 lateral segments were averaged for RVGLS measurements. For ventricular strain measurements, the beginning of the QRS was used as the point of reference. For the atrial GLS measurements, we used the beginning of the p wave as the reference point to allow good discrimination of the atrial systole component, conduit function, and reservoir function (Figure 1).[15]

Scaling of cardiac dimensions, volumetric and mass data to LBM was performed using allometric co-efficients. The choices of co-efficients were based on the previous reports especially the studies of George et al and Bella et al.[16−18] We also verified that in our study population, the allometric co-efficients used were body size independent (BSI); to

Table 1
Anthropometric measures of the study population

Characteristic	Female (n=45)	Male (n=45)	P-value
Age (years)	18.6 ± 0.8	19.2 ± 1.3	0.01
Height (cm)	168 ± 6	182 ± 7	<0.001
Mass (kg)	63 ± 9	83 ± 11	<0.001
Body mass index (kg/m^2)	22.2 ± 2.6	24.9 ± 2.7	<0.001
Body surface area (m^2)	1.71 ± 0.12	2.06 ± 0.17	<0.001
Percentage fat (%)	19.5 ± 3.6	11.6 ± 3.8	<0.001
Lean body mass (kg)	50 ± 5.6	72.5 ± 8.4	<0.001
Lean body mass to body surface area ratio (kg/m^2)	29.2 ± 1.6	35.2 ± 2.0	<0.001
Sport Classification*			
High moderate (%)	10 (22)	9 (20)	1.0
Low moderate to moderate (%)	35 (78)	36 (80)	

* Sports classification is based on Task Force classification based on total cardiovascular demands. Because of the diversity of sports we combined low moderate and moderate sport classification. combined low.