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Original Article

Global Longitudinal Strain of Healthy Iranian Women Aged 20–60 Years

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ABSTRACT

Background: Despite the widespread use of different imaging and provocative protocols for heart disease, diagnosis and treatment remain a serious concern. Thus, we aimed to evaluate global longitudinal strain (GLS) among healthy Iranian women aged between 20 and 60 years.

Methods: In this cross-sectional study, 360 healthy Iranian women were enrolled. Transthoracic echocardiography was performed for all the subjects to evaluate GLS and global circumferential strain (GCS). These values were compared between the subjects based on age groups.

Results: The mean GLS and GCS values were −20.95 ± 2.32% and −20.71 ± 1.81%, respectively. GLS and GCS had significant negative correlations with age ($r = 0.813$, $P < 0.001$ and $r = 0.837$, $P < 0.001$). Moreover, GLS was significantly low in the 50–60 age group (−17.22 ±0.71%) and high in the 20–29 age group (−22.73 ± 1.39%), ($P = 0.001$). Furthermore, GCS was significantly low in the 50–60 age group (−17.92 ± 0.42%) and high in the 20–29 age group (−21.99 ± 0.86%), ($P = 0.001$)

Conclusions: In the present study, normal GLS and GCS values were associated with the subjects' age insofar as normal GLS and GCS ranges were lower in the older age groups, whereas GLS and GCS ranges were higher in the lower age groups (20–29 y). ***(Iranian Heart Journal 2020; 21(2): 77-83)***

KEYWORDS: Echocardiography, Global longitudinal strain, Global circumferential strain, Healthy subject

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Noninvasive methods for detecting patients with the risk of heart disease remain a clinical challenge despite the widespread use of different imaging and provocative protocols. [1] More than 50% of the patients referred to cardiology departments for coronary angiography show normal or nonobstructive coronary artery disease. [1] Severe coronary artery disease is known to lead to left ventricular (LV) dysfunction; nonetheless, the left ventricular ejection fraction (LVEF) is usually normal in the early stages of heart disease. [2] It is, therefore, essential to devise a more sensitive and noninvasive index and, ultimately, a protocol for the early detection of LV dysfunction. [3] Longitudinal motion and longitudinal deformation are the most sensitive indices of coronary artery disease inasmuch as what is impaired first by this disease is longitudinal function. [4-6]

Speckle-tracking echocardiography has enabled the quantitative measurement of myocardial dynamics via image-based analyses. [7] This technique confers the global assessment of LV function through global radial strain, global longitudinal strain (GLS), and global circumferential strain (GCS) [8,9] in conjunction with regional measurements such as the trans-mural distribution of strain, [10] radial synchrony, [11] and tissue characterization. [12]

Little is known about the impact of demographic features such as age, gender, race, and ethnicity as well as anthropometric variables on layer-specific longitudinal strain in healthy individuals. To the best of our knowledge, there is no prospective study on GLS and GCS assessment in the Iranian population. Accordingly, in the present study, we sought to evaluate the effect of age in healthy Iranian women on multilayer longitudinal strain and to determine the normal range values based on age decades.

METHODS

Target Group

This prospective cross-sectional study was conducted in the Cardiology Department of Shariati Hospital, Tehran, Iran, from November 2016 to May 2017. The GLS and GCS parameters were measured via echocardiography among healthy Iranian women and compared based on demographic features. The subjects were selected from among the companions or sitters (aged between 20 and 60 years) of patients with heart disease at our hospital. The subjects gave written informed consent for participation in the study. Companions or sitters were excluded from the study if they met one of the following criteria: age below 20 years or more than 60 years, heart disease, diabetes mellitus, hypertension, hyperlipidemia, drug consumption for any systemic disease, incomplete data, and refusal to give consent for participation in the study.

Study Design

The study flowchart is illustrated in Figure 1. A total of 486 healthy volunteers, who fulfilled the study inclusion and exclusion criteria, were included. The subjects were selected based on the sample size formula introduced in a study by Klejin et al. [13] From the 486 women, 360 completed the study. The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences, and written informed consent was obtained from all the participants.

Risk factors for cardiovascular disease were evaluated through a direct cardiovascular physical examination. Hypertension was defined as a minimum systolic blood pressure of 140 mm Hg, a minimum diastolic blood pressure of 90 mm Hg, a self-reported history of hypertension, or the use of antihypertensive drugs. Diabetes mellitus was defined as a minimum fasting glucose level of 126 mg/dL, a self-reported history of diabetes mellitus, or the use of antidiabetic medication. Hyperlipidemia was defined as a minimum total cholesterol level of 240 mg/dL, a self-reported history of hypercholesterolemia, or the use of lipid-lowering therapy. Smoking was recorded at the time of the interview based on pack per year. Coronary artery disease was defined as a history of typical angina pain or acute coronary syndrome, myocardial infarction, coronary artery bypass grafting, percutaneous coronary intervention, or noninvasive positive tests for coronary artery disease. Atrial fibrillation was recorded based on ECG at the time of entrance or reported by the person him/herself.

Transthoracic echocardiography was performed using a Phillips EPIC device in the hospital based on the standard protocol. The thickness of the interventricular septum and the posterior wall, the LV end-diastolic diameter, and the anterior-posterior diameter of the left atrium were measured from the parasternal long-axis view. Additionally, LVEF was measured using the biplane modified Simpson rule, the LV mass was calculated using a valid method and indexed based on the body surface area (LV mass index), and the left atrial volume was calculated based on 3D echocardiography and indexed based on the body surface area. Significant valvular disease was defined as regurgitation or stenosis in the mitral or aortic valve with moderate-to-severe degrees.

In the apical 4-chamber view of 2D echocardiography, the Doppler at the edge of the mitral valve was used to measure the transmitral flow, which comprised peak early velocity (E), the deceleration time (DT), late velocity (A), and the E/A ratio. Peak early diastolic velocity (e') was measured from the lateral annulus and the septal mitral annulus.

The speckle-tracking analysis was conducted off-line using available software. LV myocardial deformation was assessed on the longitudinal axis of 2D gray-scale loops by automatically tracking myocardial speckles after hand-picking the landmark. GLS was calculated from the mean longitudinal strain negative peak of 17 ventricular segments from the apical 4-, 3-, and 2-chamber views. At least 3 heart rate cycles were recorded at a minimum rate of 100 frames per second, and the average was evaluated for the strain analysis. The opening and closing times of the aortic valve were measured from the LV Doppler profile and entered the speckle-tracking strain profile to exclude post-systolic components. GLS is reported negatively, so a higher amount denotes a shorter systolic period and a better systolic function.

Data Analysis

The data were analyzed and reported only for the subjects who completed the trial. The statistical analyses of the data were performed using SPSS software, version 22 (SPSS Inc, Chicago, IL, USA). For the comparison of the qualitative variables between the groups, the χ^2 test was performed. The normal distribution of all the studied parameters was checked using the Kolmogorov–Smirnov test. The Student *t*-test was utilized for the variables with normal distributions, and the Mann–Whitney test and the Wilcoxon test were performed for the variables with non-normal distributions. Moreover, for more than 1-group comparison, the one-way ANOVA test was employed. Additionally, the Pearson correlation was applied to determine the relationship between the variables. A 2-tailed *P* value of less than 0.05 was considered statistically significant.

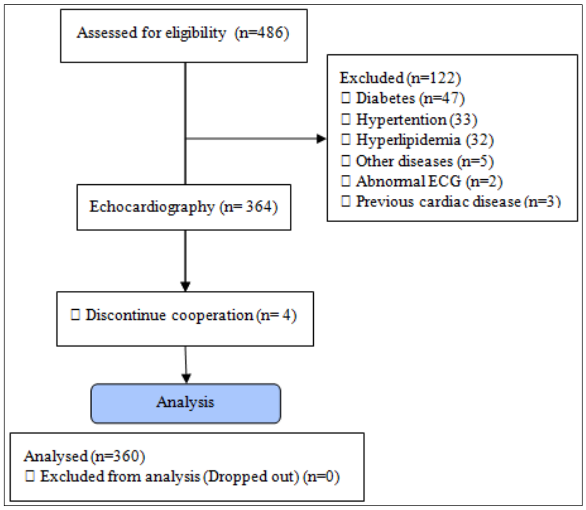

Figure 1: Study flowchart

RESULTS

The mean age of the volunteers was 34.32 ± 8.97 years (20–60 y). With respect to age, 41.66% of the women (150/360) were in the 20–29 age group, 33.33% (120/360) in the 30–39 age group, 15% (54/360) in the 40–49 age group, and 10% (36/360) in the 50–60 age group. The mean GLS and GCS were −20.95 ± 2.32% and −20.71 ± 1.81%, correspondingly. GLS and GCS had significant negative correlations with age (r = 0.813, P < 0.001 and r = 0.837, P < 0.001) (Fig. 2).

Moreover, GLS was significantly low in the 50–60 age group (−17.22 ± 0.71%) and high in the 20–29 age group (−22.73 ± 1.39%), (P = 0.001). Furthermore, GCS was significantly low in the 50–60 age group (−17.92 0.42%) and high in the 20–29 age group (−21.99 ± 0.86%), (P = 0.001) (Table 1).

DISCUSSION

In the present study on healthy Iranian women aged between 20 and 60 years, we found that GLS and GCS had significant negative correlations with advancing age. In other words, an increase in the continuous variable of age was allied to a decrease in GLS and GCS. Therefore, in older ages, the systolic period is prolonged and systolic function is impaired.

An investigation by Menting et al [14] reported a GLS value of −20.8 ± 2.0% in healthy subjects and showed no significant change in GLS with advancing age. However, by grouping age with a cutoff point of 55 years, Menting and coworkers observed a lower strain value in their older subjects (−20.2 ± 2.0% for > 55 y vs −21.0 ± 2.0% for ≤ 55 y; P = 0.029). They also found that GLS was significantly lower in their male patients as well as in those with higher systolic and diastolic blood pressures, higher body surface areas, larger LV end-systolic and end-diastolic volumes, and lower LVEFs. In contrast, we found that GLS and GCS had significant negative correlations with advancing age.

Table 1: Studied variables based on age groups

Variable / Age Group	20–29 (n=150)	30–39 (n=120)	40–49 (n=56)	50–60 (n=36)	*P* value
GLS (mean±SD) (%)	-22.73 ± 1.39	-20.85 ±1.71	-18.67 ± 0.61	-17.22 ±0.71	0.001
GLS (min, max) (%)	-25, -18.5	-25.3, -18.9	-19.9, -17.7	-18.4, -16.5	
95% CI for the mean GLS (low, upper limit) (%)	-22.95, -22.51	-21.16, -20.54	-18.83, -18.5	-17.47, -16.9	
GCS (mean±SD) (%)	-21.99 ± 0.86	-20.88 ±1.5	-18.61 ± 0.73	-17.92 ±0.42	0.001
GCS (min, max) (%)	-23.4, -19.8	-24.9, -18.7	-19.6, -17.8	-18.4, -17.1	
95% CI for the mean GCS (low, upper limit) (%)	-22.13, -21.85	-21.15, -20.61	-18.81, -18.4	-17.07, -17.7	

GLS, Global longitudinal strain; GCS, Global circumferential strain

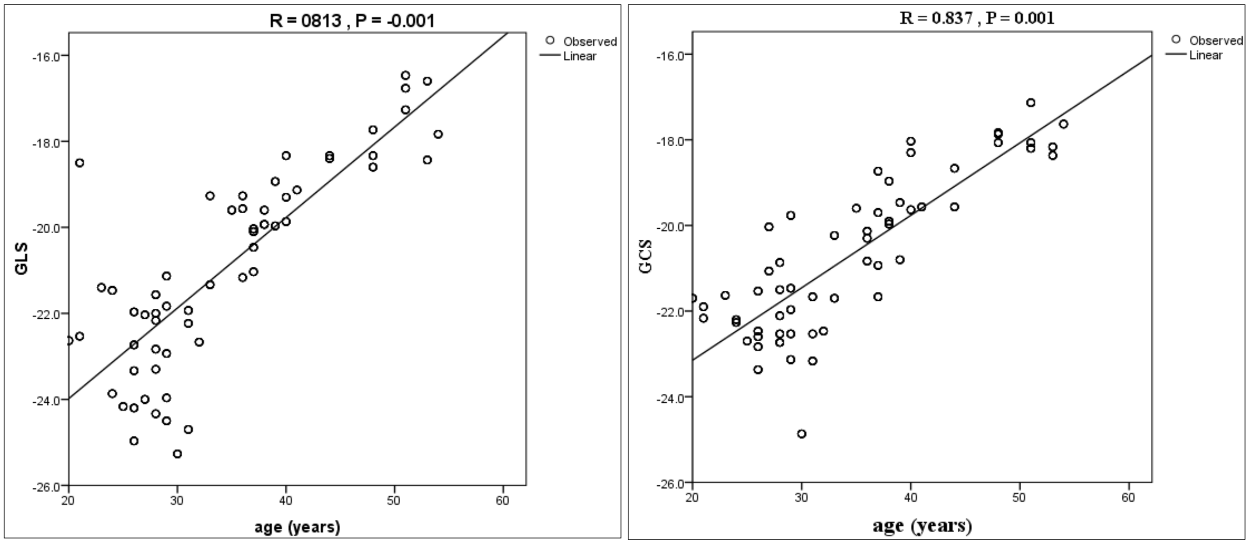

Figure 2: Correlation between age and GLS and GCS
GLS, Global longitudinal strain; GCS, Global circumferential strain

Sun et al [15] reported longitudinal and circumferential strain values of −20.4 ± 3.4% and −22.9 ± 3.1% in their healthy subjects and demonstrated that their adult female subjects had slightly higher circumferential and longitudinal strain values than their male counterparts (−23 ± 3% vs −22 ± 3% and −21 ± 3% vs −20 ± 3%, respectively). Sun and colleagues also observed that circumferential and longitudinal strain values were slightly lower in their older patients. Further, they observed a drop in GLS and a rise in GCS, whereas there was no change in radial strain with advancing age. In their investigation on healthy subjects, Yingchoncharoen et al [13] showed a GLS range of −22.1 to −15.9 and a GCS range of −27.8 to −20.9; moreover, they found no significant correlation between aging and GLS and GCS. In discordance with their results, we found that GLS and GCS had significant negative correlations with advancing age. These differences between our results and those reported by Sun et al [15] and Yingchoncharoen et al [16] may be due to different sample sizes and different inclusion and exclusion criteria—especially dissimilarities in demographic features. Therefore, this difference in the correlation between advancing age and GCS and GLS indicates the important effect of demographic characteristics on GCS and GLS patterns based on age, which warrants further prospective longitudinal research on different samples with different races.

In their study on 1266 healthy individuals, Dalen et al [17] showed that the mean GLS and the mean strain rate were −17.4% (±2.3) and −1.05 s (−1) (0.13) in their female subjects and −15.9% (2.3) and −1.01 s (−1) (0.13) in their male subjects. They also reported a reduction in deformation indices in tandem with advancing age. These results chime in with the findings of the current study.

Given the association between aging and higher blood pressure and body surface area, it appears plausible that advancing age may have a significant negative correlation with strain. What, however, should be considered in the interpretation of our results is that we did not include healthy individuals over the age of 60 years. Indeed, had we recruited subjects aged over 60 years, our analysis might have yielded even more robust negative correlations between advancing age and the parameters of GLS and GCS. Needless to say, this assumption should be investigated in other subjects with limited exclusion criteria, although finding healthy individuals above 60 years of age without any history of or risk factors for cardiovascular disease is a formidable challenge.

CONCLUSIONS

In light of the results of the present study, it appears that normal GLS and GCS values are associated with age inasmuch as normal GLS and GCS ranges were lower in our older age groups, while GLS and GCS ranges were higher in our lower age groups (20–29 y). The correlation between advancing age and GCS and GLS underlines the meaningful effect of demographic features on the patterns of these echocardiographic parameters based on age. Further prospective longitudinal studies with limited exclusion criteria on different samples with different races are required to shed more light on this issue.

REFERENCES

1. Patel M.R., Peterson E.D., Dai D., Brennan J.M., Redberg R.F., Anderson H.V. Low diagnostic yield of elective coronary angiography. New Engl J Med. 2010;362:886–895.

2. Parato V.M., Mehta A., Delfino D. Resting echocardiography for the early detection of acute coronary syndromes in chest pain unit patients. Echocardiography. 2010;27:597.

3. Radwan H1, Hussein E1. Value of global longitudinal strain by two-dimensional speckle tracking echocardiography in predicting coronary artery disease severity. Egypt Heart J. 2017 Jun;69(2):95-101. doi: 10.1016/j.ehj.2016.08.001. Epub 2016 Aug 29.

4. Tsai W.C., Liu Y.W., Huang Y.Y. Diagnostic value of segmental longitudinal strain by automated function imaging in coronary artery disease without left ventricular dysfunction. J Am Soc Echocardiogr. 2010;23:1183–1189

5. Hoit B.D. Strain and strain rate echocardiography and coronary artery disease. Circul Cardiovasc Imag. 2011;4:179–190

6. Jasaityte R., Heyde B., D'hooge J. Current state of three-dimensional myocardial strain estimation using echocardiography. J Am Soc Echocardiogr. 2013;26:15–28.

7. Mor-Avi V, Lang RM, Badano LP, Belohlavek M, Cardim NM, Derumeaux G, et al. Current and evolving echocardiographic techniques for the quantitative evaluation of cardiac mechanics: ASE/EAE consensus statement on methodology and indications endorsed by the Japanese Society of Echocardiography. J Am Soc Echocardiogr 2011; 24:277-313.

8. Cho GY, Marwick TH, Kim HS, Kim MK, Hong KS, Oh DJ. Global 2-dimensional strain as a new prognosticator in patients with heart failure. J Am Coll Cardiol 2009;54:618-24.

9. Brown J, Jenkins C, Marwick TH. Use of myocardial strain to assess global left ventricular function: a comparison with cardiac magnetic resonance and 3-dimensional echocardiography. Am Heart J 2009;157:102.e1-5.

10. Matre K, Moen CA, Fannelop T, Dahle GO, Grong K. Multilayer radial systolic strain can identify subendocardial ischemia: an experimental tissue Doppler imaging study of the porcine left ventricular wall. Eur J Echocardiogr 2007;8:420-30.

11. SuffolettoMS, Dohi K, Cannesson M, Saba S, Gorcsan J III. Novel speckletracking radial strain from routine black-and-white echocardiographic images to quantify dyssynchrony and predict response to cardiac resynchronization therapy. Circulation 2006;113:960-8.

12. Knirsch W, Dodge-Khatami A, Kadner A, Kretschmar O, Steiner J, B€ottler P, et al.

Assessment of myocardial function in pediatric patients with operated tetralogy of Fallot: preliminary results with 2D strain echocardiography. Pediatr Cardiol 2008;29:718-25.

13. Kleijn SA, Aly MF, Terwee CB, van Rossum AC, Kamp O. Reliability of left ventricular volumes and function measurements using three-dimensional speckle tracking echocardiography. Eur Heart J Cardiovasc Imaging 2012;13:159 – 68

14. Menting ME1, McGhie JS1, Koopman LP2, Vletter WB1, Helbing WA2, van den Bosch AE1, Roos-Hesselink JW1. Normal myocardial strain values using 2D speckle tracking echocardiography in healthy adults aged 20 to 72 years. Echocardiography. 2016 Nov; 33(11):1665-1675. doi: 10.1111/echo.13323. Epub 2016 Aug 22.

15. Sun JP, Lee AP, Wu C, et al. Quantification of left ventricular regional myocardial function using two-dimensional speckle tracking echocardiography in healthy volunteers–a multi-center study. Int J Cardiol. 2013;167:495–501.

16. Yingchoncharoen T, Agarwal S, Popovic ZB, Marwick TH. Normal ranges of left ventricular strain: a meta-analysis. J Am Soc Echocardiogr. 2013;26:185–91.

17. Dalen, Havard, et al. "Segmental and global longitudinal strain and strain rate based on echocardiography of 1266 healthy individuals: the HUNT study in Norway." European Heart Journal-Cardiovascular Imaging 11.2 (2010): 176-183.