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ABSTRACT

Objectives The authors studied healthy UK Indian Asian and European white subjects to assess whether functional, structural and geometrical properties of the left heart are intrinsically related to ethnicity.

Background Quantitative assessment of cardiac function and structure is necessary to diagnose heart failure syndromes and is validated to refine risk prediction. A better understanding of the demographic factors that influence these variables is required.

Methods 458 healthy subjects were recruited from the London Life Sciences Prospective Population (LOLIPOP) study. They underwent 2-D and tissue Doppler echocardiography for quantification of left ventricular (LV) function, LV volumes, left atrial volume index (LAVI), left ventricular mass index (LVMI) and relative wall thickness (RWT).

Results Indian Asians had attenuated mitral annular systolic velocity (8.9 cm/s vs 9.5 cm/s, $p<0.001$), lower mitral annular early diastolic velocity (10.3 cm/s vs 11.0 cm/s, $p<0.001$) and higher E/Ea ratio (7.9 vs 7.0, $p<0.001$) compared to European white subjects. Although Indian Asians had significantly smaller left heart volumes and LVMI, they had a significantly higher RWT (0.37 vs 0.35, $p<0.001$). After adjustment for covariates, these ethnicity-related differences remained highly significant ($p<0.001$).

Conclusion Compared to European white people, Indian Asians had attenuated longitudinal LV function, higher LV filling pressure and demonstrated a greater degree of concentric remodelling independent of other demographic and clinical parameters.

INTRODUCTION

The echocardiographic assessment of left ventricular (LV) function and structure has significantly enhanced cardiovascular disease risk stratification. Traditional predictors of poor outcome such as LV ejection fraction (EF) and transmitral Doppler assessment of LV filling have been supplemented by tissue Doppler imaging (TDI). Clinically relevant TDI parameters have been validated as prognosticators of cardiovascular disease (CVD) risk such as peak systolic annular velocity (Sa), peak early diastolic annular velocity (Ea) and the estimate of LV filling pressure by measurement of transmitral early velocity to Ea ratio (E/Ea).[1–5] Increasing left atrial size is regarded as a morphophysiological expression of increased LV filling pressure and the prognostic importance of left atrial volume index (LAVI) has also been confirmed more recently, particularly in higher-risk groups.[6–10] Increased left ventricular mass index (LVMI) is a well established, powerful predictor of cardiovascular morbidity and mortality irrespective of aetiology[11 12] and alterations in LV geometry may also provide incremental prognostic information.[13 14]

The measurement of these parameters forms the cornerstone of recent guidelines concerning the echocardiographic diagnosis of diastolic heart failure[15] but their demographic determinants are poorly understood. Importantly, the influence of ethnicity upon LV function and LV filling pressure remains undefined particularly as reference data collected for LAVI and TDI parameters among healthy subjects has seldom been population based.[16 17] Although the relation of ethnicity with LVMI and LV geometry has been explored in large population studies, the published data have almost exclusively compared Afro-Caribbeans with European white subjects.

In this study we sought to evaluate the effect of ethnicity upon LV function, left heart structure and geometry using 2-D echocardiography and TDI in a healthy cohort of Indian Asian and European white subjects free of clinical CVD, traditional cardiovascular risk factors and significant coronary artery disease.

METHODS

Subjects were recruited between August 2004 and November 2007 from the LOLIPOP (London Life Sciences Prospective Population) study. LOLIPOP is an ongoing population based study of ~30 000 Indian Asian and European white men and women recruited from the lists of 58 general practitioners in west London. Assessment of participants was performed by a trained nurse using a standard protocol including questions on medical history, family history, cardiovascular risk factors, alcohol intake, physical activity and drug history (verified from the practice computerised records). Subsequently 2293 Indian Asian and European white subjects, aged 35–74 years and free from clinical CVD, were selected at random and enrolled into the LOLIPOP atherosclerosis cohort substudy. Participants were defined as Indian Asian if all four grandparents were born in the Indian subcontinent (India, Pakistan or Bangladesh) and European white if all four grandparents were born in northern Europe.

Consenting subjects had a physical assessment including blood pressure determination, anthropometric measurements (height, weight, waist-hip ratio, bioimpedance for lean body mass) and an

electrocardiogram. Subjects were then invited to undergo echocardiography, electron beam computed tomography (EBCT) for coronary calcium score determination (Agatston score) and provide fasting plasma and serum samples for biochemical analysis stored at −80°C. The study was approved by the Northwick Park Hospital and Ealing Hospital research ethics committees.

Echocardiograms were analysed in a subset of 458 healthy individuals having excluded subjects with a coronary calcium score >10 Agatston units, a prescription for cardioactive medications (antihypertensives, antianginals, hypoglycaemic agents, lipid lowering therapy, thienodypiridine antiplatelets) or any traditional cardiovascular risk factors (systolic BP >140 mm Hg, diastolic BP >90 mm Hg, total cholesterol >6.0 mmol/l, fasting glucose >7.1 mmol/l, body mass index (BMI) >30 kg/m^2, current smoking).

Echocardiography

Left ventricular dimensions and ejection fraction

Transthoracic two-dimensional (2-D) echocardiography was performed by experienced sonographers using a digital commercial harmonic imaging ultrasound system with an S3 3-MHz phased-array transducer (Philips IE33, Philips Medical Systems, The Netherlands) at a single centre. LV dimensions were obtained in the parasternal short axis view with measurement of the interventricular septal thickness in diastole, LV dimension in diastole, LV dimension in systole and LV posterior wall thickness in diastole. LV mass was calculated using the Devereux formula[18] and indexed to height to give LVMI. RWT was calculated as the sum of the interventricular septum thickness in diastole and the posterior wall thickness in diastole divided by the LV dimension in diastole.

LV end-diastolic volume index (LVEDVI) and LV end-systolic volume index (LVESVI) were measured using Simpson's apical biplane rule, with indexation calculated to body surface area (BSA). Tracing of the LV contour was performed carefully so as to exclude papillary muscles and trabeculations, as recommended by the American Society of Echocardiography.[18] LVEF was automatically calculated following acquisition of the LV volumes using the Simpson's method.

Left atrial volume index

Left atrial volume (ml) was calculated from three measurements of left atrial dimension using the formula for an ellipse[19 20] as $\pi/6$ (PLAX×A4C$_1$×A4C$_2$), where PLAX is the left atrial dimension measured in the parasternal long-axis view and A4C$_1$and A4C$_2$ are the horizontal and vertical measurements of the left atrium in the apical four-chamber view. The derived left atrial volume was then indexed to BSA to obtain the LAVI.

Tissue Doppler imaging

Myocardial velocities were measured online using a standard pulse-wave Doppler technique. TD images were acquired during a breath hold over two consecutive cardiac cycles using low-velocity high-intensity myocardial signals at high frame rate (>150 MHz). The imaging angle was adjusted to ensure as near parallel alignment of the beam as possible with the myocardial segment of interest. The sample volume was placed at the junction of the LV wall with the mitral annulus of the septal and lateral myocardial segments from the apical four-chamber view and inferior and anterior myocardial segments from the apical two-chamber view. Peak velocities (cm/s) during systole (Sa) and early diastole (Ea) were measured online from all four mitral annular sites segments and then averaged.

Transmitral flow and E/Ea ratio

The transmitral flow velocities were recorded using pulsed wave Doppler with the sample volume placed at the tip of the mitral valve leaflets in the apical four-chamber view. From the mitral valve inflow velocity curve the following measurements were made: peak E-wave velocity (cm/s) and its deceleration time (ms); peak A-wave velocity (cm/s); the ratio of E-wave to A-wave (E:A) velocities and the ratio of transmitral E-wave velocity and averaged Ea velocity (E/Ea).

Electron beam computed tomography

Coronary calcium imaging was performed using EBCT at a single centre with a modified GE Imatron C-150 (San Francisco, CA, USA) scanner specially equipped with high-resolution detectors. Scan time was 100 ms per slice, synchronised to 40% of the R-R interval. All areas of calcification within the borders of a coronary artery with an optical density above 130 Hounsfield units and an area greater than 1 mm^2 were computed. All calcium scores were calculated on an Aquarius workstation (TeraRecon, Inc, San Mateo, CA, USA). The output from EBCT scans was quantified into Agatston scores.

Statistical analysis

Continuous variables are summarised as the mean±1 SD. Continuous variables and their relation to ethnicity were assessed using Student's t-test and categorical data by χ^2 test. Three multivariate linear regression models were applied separately to the dependent variables of LV function and structure to assess the independent effects of ethnicity, age and gender. Differences in LV function were adjusted in model 1 for age and gender, in model 2 for age, gender and ethnicity and in model 3 for age, gender, ethnicity, systolic BP, diastolic BP, BMI, LVMI and RWT. Parameters of LV structure were analysed using the same regression models with the addition of RWT in model 3 and the omission of LVMI as a covariate when LV mass was itself examined as a dependent variable. Statistical analysis was performed using SPSS version 15 with values of $p<0.05$ considered statistically significant.

Interobserver variability

Echocardiographic measurements were repeated by two sonographers in 15 subjects to assess reproducibility and interobserver variability. The coefficient of variance was 11.7%, 11.5%, 5.8%, 9.9% and 3.7% for LAVI, LVMI, EDVI, ESVI and LV EF, respectively. For the TD parameters mean Sa velocity, mean Ea velocity and mean E/Ea ratio the coefficient of variance was 11.4%, 8.7% and 8.0%, respectively.

RESULTS

Risk factors

The clinical characteristics and cardiovascular risk factor profiles of the 458 subjects are summarised by ethnicity (table 1). Compared to European white subjects, Indian Asians had significantly higher BMI, fasting triglycerides and lower HDL-cholesterol. Age, blood pressure, total cholesterol, fasting glucose and coronary artery calcification did not differ significantly between the two groups.

Left ventricular function

Although LV EF and E/A ratio were identical between Indian Asian and European white subjects, significant differences existed in longitudinal myocardial systolic and early diastolic function (table 2). European white subjects had higher Sa and Ea

Table 1 Clinical characteristics according to ethnicity

	European white subjects (n=199)	Indian Asian subjects (n=259)	p Value
Age (years)	51.8±8.5	50.6±8.5	0.11
Male (%)	60	53	0.15
Systolic BP (mm Hg)	119±11	117±12	0.18
Diastolic BP (mm Hg)	75±8	75±7	0.98
BMI (kg/m^2)	24.4±2.7	25.0±2.6	0.04
Lean body mass (kg)	53.7±10.4	48.1±9.0	<0.001
Total cholesterol (mmol/l)	5.3±0.7	5.1±0.8	0.06
HDL-cholesterol (mmol/l)	1.5±0.4	1.3±0.3	<0.001
LDL-cholesterol (mmol/l)	3.2±0.6	3.2±0.7	0.71
Glucose (mmol/l)	5.0±0.5	5.1±0.5	0.16
Triglycerides (mmol/l)	1.0±0.7	1.4±0.8	<0.001
Agatston score (Au)	0.4±1.3	0.4±1.4	0.96

Au, Agatston units; BMI, body mass index; BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

velocities than Indian Asians (9.5 cm/s vs 8.9 cm/s, p<0.001). After multivariate linear regression analysis for age, gender, systolic BP, diastolic BP, BMI, LVMI and RWT, Asian race remained independently associated with lower Sa and Ea velocities (table 3). These differences remained significant even when alternative indices of body size, such as lean body mass and height, were entered into the model instead of BMI. The E/Ea ratio was significantly higher among Indian Asians (table 2) owing to their relatively lower Ea velocity but similar transmitral Doppler E velocity compared to European white subjects. This difference in the E/Ea ratio remained statistically significant (p<0.001) after adjustment for covariates (table 3).

The independent effects of age and gender upon LV function are also depicted in table 3. Increasing age was associated with an increase in LV EF but significantly reduced Sa velocity. Ageing was associated with attenuated Ea velocity, E/A ratio and increased E/Ea ratio. Gender was not associated with LV EF, E/A ratio or Ea velocity; however, reduced Sa velocity and increased E/Ea ratio were independently associated with female sex.

Left heart structure and geometry

There were marked differences between European white and Indian Asian subjects with regard to left heart structure (table 4). European white subjects had significantly greater LA volumes, LV mass and LV volumes even after indexation for body size. Indian Asians had evidence of a greater degree of concentric remodelling with significantly higher RWT compared to European white subjects (037 vs 0.35, p<0.001). Multivariate models (table 5) confirmed that ethnicity remained independently associated with LV volumes, LVMI, LAVI and RWT. Additional models performed with LV mass and LA volume indexed to lean body mass also confirmed that Indian Asian ethnicity remained independently associated with lower LV mass and smaller LA size.

Weak linear associations were observed between E/Ea ratio and LAVI for European white (r=0.2, p=0.005) and Indian Asian (r=0.2, p=0.02) subjects. There was also a positive correlation between LAVI and LVMI in both Europeans (r=0.5, p<0.001) and Indian Asians (r=0.4, p<0.001).

Advancing age was independently associated with smaller LV volumes, whereas LVMI, LAVI and RWT all increased significantly with age (table 5). Female gender was associated with smaller LV volumes and lower LVMI compared to males; however, there was no significant effect of gender upon LAVI or RWT.

Table 2 Parameters of left ventricular systolic and diastolic function according to ethnicity

	European white (n=199)	Indian Asian (n =258)	p Value
Ejection fraction			
Bi-plane Simpson's EF (%)	62±5	62±6	0.55
Transmitral Doppler			
Transmitral E-wave (cm/s)	71.8±14.0	74.0±16.6	0.14
Transmitral A-wave (cm/s)	62.5±13.8	66.0±17.2	0.02
E/A ratio	1.2±0.3	1.2±0.4	0.61
E-deceleration time (ms)	210.3±49.8	201.8±45.5	0.06
Tissue Doppler			
Sa (cm/s)	9.5±1.6	8.9±1.5	<0.001
Ea (cm/s)	11.0±2.1	10.3±2.1	<0.001
E/Ea ratio	7.0±1.5	7.9±2.1	<0.001

EF - ejection fraction
Sa - mitral annular systolic velocity
Ea - mitral annular early diastolic velocity

DISCUSSION

This is the first population-based study demonstrating that ethnicity-related differences exist in the function, structure and geometry of the healthy left ventricle. Compared to European white subjects, we observed Indian Asians to have reduced longitudinal systolic and diastolic mitral annular velocities, a greater E/Ea ratio, markedly smaller left heart volumes and lower LV mass. However, traditional parameters of systolic and diastolic function, such as LV EF and the E/A ratio, were unaffected by ethnicity. A greater degree of concentric remodelling was evident among Indian Asians, compared with European white subjects. The influence of gender and ageing upon heart function and structure was also confirmed in this study.

To the best of our knowledge ethnicity-related differences in systolic and diastolic properties of the left ventricle have not been previously reported among healthy individuals. The recently published ASCOT substudy did demonstrate significantly worse TDI parameters of diastolic function among hypertensive African-Caribbeans compared with European white subjects living in the UK.[21] However, the absence of a reference normotensive group and data concerning duration of hypertensive status precluded definitive conclusions to be reached regarding the independent influence of ethnicity upon myocardial function. There are no obvious explanations for the relatively attenuated longitudinal function and higher LV filling pressure in Indian Asians who have lower LV mass, similar blood pressure, serum glucose and degree of coronary artery calcification compared with their European white counterparts. Adjustment for different parameters of body size such as height and lean body mass did not account for the observed disparity either.

In this present study Indian Asians demonstrated a greater degree of concentric remodelling, expressed as the RWT, compared to European white people. Concentric remodelling of the left ventricle tends to manifest in situations of pressure overload resulting in radial growth and thickening of the myocyte. However, there was no significant difference in BP between the two groups and in the multivariate analysis RWT was not significantly influenced by either systolic or diastolic BP. Ethnicity-related differences in cardiac geometry have been previously reported,[22 23] again independently of standard clinical and haemodynamic variables.

Compared with the European white people, migrant Indian Asians living in the UK are known to have significantly higher risk of death from CVD[24 25] and incidence rates for congestive heart failure.[26] Peak Sa and Ea velocities are strong predictors of

Table 3 Relation of left ventricular function with demographic and clinical parameters by multivariate analysis

	LV EF		E/A ratio		Sa velocity (cm/s)		Ea velocity (cm/s)		E/Ea ratio	
	Parameter estimate*	p Value	Parameter estimate*	p Value	Parameter estimate*	p Value	Parameter estimate*	p Value	Parameter estimate*	p Value
Model 1										
Age	0.70	0.008	−0.14	<0.001	−0.24	<0.001	−0.94	<0.001	0.51	<0.001
Female gender	0.47	0.38	0.05	0.14	−0.52	<0.001	0.39	<0.033	0.41	0.02
Model 2										
Age	0.71	0.007	−0.14	<0.001	−0.26	<0.001	−0.98	<0.001	0.54	<0.001
Female gender	0.44	0.41	0.05	0.12	−0.47	0.001	0.46	0.010	0.35	0.04
Indian Asian ethnicity	0.38	0.47	−0.04	0.22	−0.61	<0.001	−0.95	<0.001	0.87	<0.001
Model 3										
Age	0.52	0.07	−0.13	<0.001	−0.34	<0.001	−0.95	<0.001	0.44	<0.001
Female gender	0.32	0.60	0.03	0.46	−0.46	0.005	0.32	0.11	0.64	0.001
Indian Asian ethnicity	−0.22	0.70	−0.02	0.65	−0.70	<0.001	−0.89	<0.001	0.93	<0.001
sBP	0.58	0.16	0.02	0.46	0.25	0.03	0.09	0.50	0.21	0.10
dBP	−0.37	0.33	−0.05	0.03	−0.21	0.05	−0.20	0.11	−0.04	0.74
BMI	0.38	0.21	−0.06	0.002	−0.06	0.53	−0.30	0.003	0.20	0.03
LVMI	−0.71	0.03	−0.02	0.94	−0.11	0.24	−0.09	0.23	0.20	0.06
RWT	0.79	0.005	−0.04	0.04	0.21	0.007	−0.11	0.23	0.03	0.78

*Change in parameter estimates Sa velocity, Ea velocity and E/Ea ratio with a 1 SD increment in age (8.5 years), sBP (11.4 mm Hg), dBP (7.3 mm Hg), BMI (2.67 kg/m^2), LVMI (22.1 g/m) and RWT (0.07).
BMI, body mass index; dBP, diastolic blood pressure; LVMI, left ventricular mass index; RWT, relative wall thickness; sBP, systolic blood pressure. Remaining abbreviations as for table 2.

outcome in patients with established heart disease,[1 2] with Ea appearing to be the superior of the two.[3 27] The E/Ea ratio, which eliminates the effects of ageing and LV relaxation, correlates closely with LV filling pressure.[28 29] Although E/Ea performs less well at estimating end-diastolic pressure in patients with decompensated heart failure,[30 31] this ratio has proved to still be a strong predictor of outcomes in these patients and in those with post-myocardial infarction.[4 5 32] Concentric remodelling is associated with worse cardiovascular outcomes,[13 14] as well as impairment in systolic[33] and particularly diastolic function.[34] Whether the less favourable LV function and evidence of greater cardiac remodelling observed among Indian Asians are markers of increased CVD risk or simply representative of differing normal reference values in these ethnic groups can only be determined after long-term follow-up of this cohort.

Whereas the E/Ea ratio represents a snapshot of LV filling pressure, an enlarged LA provides physiological and morphological evidence of a chronic elevation in end-diastolic LV pressure. The relation between LA volume and prognosis has been confirmed in patients with pre-existing cardiovascular disease such as atrial fibrillation,[6] LV dysfunction[7] and myocardial infarction.[8 9] The relation of LA volume with ethnicity has not been examined sufficiently to date. Although similar LA dimension has been reported between African-Caribbean and white individuals there are no published data comparing LA volumes between ethnic/racial groups in a population setting. LAVI was smaller in the Indian Asian population we studied compared to European white people. A similar correlation existed between LAVI and E/Ea ratio in both ethnicities suggesting that the smaller LA volume in Indian Asians is likely to be because of their comparatively smaller heart size rather than a reflection of chronically lower filling pressures. The disparity in LA volume was not attenuated by its indexation to lean body mass.

Table 4 Left heart structural and geometrical parameters according to ethnicity

	European white subjects	Indian Asian subjects	p Value
LAV (ml)	30.8±10.4	25.0±7.7	<0.001
LAV indexed to BSA (ml/m^2)	16.3±4.8	14.2±4.0	<0.001
LAV indexed to LBM (g/kg)	5.8±1.7	5.3±1.6	0.004
LVM (g)	159.2±45.3	132.4±33.4	<0.001
LVM indexed to height (g/m)	92.1±24.7	80.2±18.9	<0.001
Relative wall thickness	0.35±0.07	0.37±0.07	<0.001
EDV indexed to BSA (ml/m^2)	43.7±10.4	35.4±8.6	<0.001
ESV indexed to BSA (ml/m^2)	16.6±4.8	13.4±4.2	<0.001

EDV, end-diastolic volume; ESV, end-systolic volume; LAV, left atrial volume; LVM, left ventricular mass.

Increased LV mass has been shown to be a powerful independent predictor for cardiovascular morbidity and mortality in individuals previously free of clinical cardiovascular disease.[35] Studies assessing the independent effect of race/ethnicity upon LVMI have predominantly been conducted between African-Caribbean and white populations. However, there are very few data with respect to LV mass in Indian Asians. In a study by Kumaran *et al* echocardiography was performed in 435 subjects living in Mysore, South India.[36] The mean LV mass in men and women was 149 g and 125 g, respectively, similar to the values obtained in our study (145 g vs 118 g), and noted to be lower than published values in Western populations. The study also confirmed that the positive correlation between increased LV mass and risk of CVD exists also in individuals of Indian Asian ethnicity, with significantly higher LV mass observed in the 45 subjects with known CVD compared to controls. In our study, Indian Asian subjects had lower LVMI compared to European white subjects which, as with their smaller left atria, appears to be largely a consequence of their overall smaller heart size. Indexation to lean body mass again did not attenuate the observed differences in LV mass.

We demonstrated that LV mass progressively increased with age and that LVMI was significantly lower in females than males after adjustment for confounders including BMI. Although LA dimension has been shown to increase with ageing,[37 38] studies have not yet confirmed that increasing age is associated with volumetric increases in LA size.[16 39] However, in our population ageing was independently associated with larger LAVI, commensurate with the higher LV filling pressures observed in older subjects. Advancing age attenuated Sa and Ea velocities but augmented LV EF, a documented phenomenon of ageing[17] that

Table 5 Relation of left heart structure and geometry with demographic and clinical parameters by multivariate analysis

	EDVI (ml/m^2)		ESVI (ml/m^2)		LVMI (g/m)		LAVI (ml/m^2)		RWT	
	Parameter estimate*	p Value	Parameter estimate*	p Value	Parameter estimate*	p Value	Parameter estimate*	p Value	Parameter estimate*	p Value
Model 1										
Age	−0.86	0.07	−0.55	0.01	3.85	<0.001	0.11	<0.001	0.01	<0.001
Female gender	−5.7	<0.001	−2.3	<0.001	−14.96	<0.001	−0.57	0.17	−0.004	0.51
Model 2										
Age	−1.2	0.007	−0.66	0.001	3.48	<0.001	0.10	<0.001	0.01	<0.001
Female gender	−5.1	<0.001	−2.1	<0.001	−14.23	<0.001	−0.42	0.31	−0.006	0.36
Indian Asian ethnicity	−8.0	<0.001	−3.1	<0.001	−9.95	<0.001	−2.00	<0.001	0.02	<0.001
Model 3										
Age	−1.4	0.002	−0.76	<0.001	2.7	0.003	0.78	<0.001	0.01	<0.001
Female gender	−4.1	<0.001	−1.7	<0.001	−12.5	<0.001	−0.19	0.65	−0.003	0.68
Indian Asian ethnicity	−6.8	<0.001	−2.5	<0.001	−11.4	<0.001	−2.2	<0.001	0.02	0.001
sBP	−0.25	0.71	−0.26	0.42	2.4	0.07	0.33	0.28	0.002	0.65
dBP	−0.51	0.41	−0.17	0.56	−2.3	0.07	−0.40	0.16	0.001	0.98
BMI	−1.3	0.008	−0.61	0.008	8.4	<0.001	1.3	<0.001	0.01	0.002
LVMI	2.4	<0.001	1.1	<0.001			2.05	<0.001	0.02	<0.001

*Change in parameter estimates with a 1 SD increment in age (8.5 years), sBP (11.4 mm Hg), dBP (7.3 mm Hg), BMI (2.67 kg/m^2) and LVMI (22.1 g/m). Abbreviations as for table 3.

may represent a compensatory response to impaired longitudinal function. Gender-related differences were observed in LV function with women having significantly lower Sa velocity and higher LV filling pressure than men.

CONCLUSION

Ethnicity-related differences exist in cardiac structure and sensitive parameters of LV function. We studied a highly phenotyped cohort in whom the effects of confounding factors have been largely obviated. Demographic influences need to be considered during the echocardiographic evaluation of patients, particularly in those in whom the assessment of LA volume, LV volumes, LV mass, longitudinal function and LV filling pressure are essential to identify the syndrome of heart failure, whether in the presence or absence of normal systolic function.

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Competing interests None.

Ethics approval This study was conducted with the approval of the Northwick Park and Ealing Hospitals Research Ethics Committees.

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Correction

Khattab AA, Hamm CW, Senges S, *et al*. Sirolimus-eluting stent treatment for unprotected versus protected left main coronary artery disease in widespread clinical routine: 6-month and 3-year clinical follow-up results from the prospective multicentre German Cypher Registry. *Heart* 2007;**93**:1251—5. This article was printed with an incorrect DOI. The DOI should be 10.1136/hrt.2006.104703.

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