European Heart Journal (2001) **22,** 676–683
doi:10.1053/euhj.2000.2284, available online at http://www.idealibrary.com on IDEAL®

Left ventricular systolic dysfunction in 75-year-old men and women

A population-based study

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Aims To determine the prevalence of left ventricular systolic dysfunction in 75-year-old men and women.

Methods and Results In a population-based random sample of 75-year-old subjects (n=433; response rate 70·1%) the left ventricular systolic function was determined using two echocardiographic methods: (1) wall motion in nine left ventricular segments was visually scored and wall motion index was calculated as the mean value of the nine segments and (2) ejection fraction as measured by the disc summation method. Presence of heart failure was determined by a cardiologist's clinical evaluation. Wall motion index was achievable in 95% of the participants while ejection fraction was measurable in 65%. Normal values were obtained from a healthy subgroup (n=108) and left ventricular systolic dysfunction was defined as the 0·5th percentile of the wall motion index (i.e. <1·7). In participants in whom both ejection fraction and wall motion index were achievable, wall motion index <1·7 predicted ejection fraction <43% with a sensitivity and specificity of 84·0% and 99·6%, respectively. The prevalence of left ventricular systolic dysfunction was 6·8% (95% CI, 5·6–8·0%) and was greater in men than in women (10·2% vs 3·4%, $P=0·006$). Clinical evidence of heart failure was absent in 46% of the participants with left ventricular systolic dysfunction.

Conclusions Left ventricular systolic dysfunction is common among 75-year-olds with a prevalence of 6·8% in our estimate. The condition is more likely to affect men than women. In nearly half of 75-year-olds with left ventricular systolic dysfunction there is no clinical evidence of heart failure.

(Eur Heart J 2001; 22: 676–683, doi:10.1053/euhj.2000.2284)

Key Words: Ventricular dysfunction, heart failure, prevalence, echocardiography, aged.

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Introduction

Heart failure is a growing problem in developed countries with a large ageing population[1,2], causing substantial morbidity and mortality[3]. The direct costs of heart failure in such countries have been estimated to be between 1 and 2% of the total health care budget, with a considerable share being attributable to hospitalization expenditures[3]. With optimal treatment, it is possible to reduce hospitalization and mortality[4,5]. Diagnosis of heart failure based solely on clinical data is often inaccurate[6]. In addition to criteria based on clinical signs and symptoms, objective evidence of cardiac dysfunction is recommended for an adequate diagnosis[7]. Left ventricular systolic dysfunction is a main finding in heart failure patients. Further, left ventricular systolic dysfunction can be found in asymptomatic persons without overt heart failure. This asymptomatic state is important to diagnose, since treatment can delay progress to overt heart failure[8,9]. Numerous studies have described the prevalence of heart failure based mainly on clinical criteria. However, limited epidemiological data are available concerning the prevalence of left ventricular systolic dysfunction in the general population and particularly in the elderly population. Therefore, the present study was designed to

Revision submitted 25 April 2000, and accepted 15 May 2000.

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0195-668X/01/080676+08 $35.00/0

determine the prevalence of left ventricular systolic dysfunction using two echocardiographic techniques in a population-based, random sample of 75-year-old men and women.

Material and methods

Study population

We invited a random sample of 618 men and women from the general population of all 75-year-old persons, living in the city of Västerås. This town, comprising a mixed population, is situated 120 km west of Stockholm with approximately 125 000 inhabitants (of whom 1019 were 75 years of age at the time of the study). The 433 subjects accepting the invitation (210 men and 223 women) constituted the study population, corresponding to a response rate of 70·1%. The reasons for non-participation were that the individual could not be reached (n=29), the person died before the investigation procedure was initiated (n=2), language difficulty or logistical problem (n=26), locomotive impairment (n=28), heart disease treatment already under way (n=13), other disease (n=41) or unknown (n=46).

All of the 433 participants and 62 (33·5%) of the 185 non-participants completed a questionnaire concerning previous diagnosis of cardiovascular and pulmonary disease, medication and smoking habits. There were no significant differences between the participants and non-participants on gender, previous smoking, self-reports of angina pectoris, myocardial infarction, hypertension, diabetes mellitus or use of regular cardiovascular or pulmonary medication. There were, however, fewer current smokers (10% vs 28%, $P<0{\cdot}001$) and fewer reported pulmonary emphysema (4% vs 10%, $P=0{\cdot}049$) in the group of participants. The study was approved by the ethics committee of the University of Uppsala, Sweden. All participants gave their informed consent.

Based on the Minnesota coding system[10], two physicians coded the standard 12-lead resting ECG. If the physicians' coding differed a consensus on coding was agreed. A symptom-limited exercise test on a bicycle ergometer was performed with 30 W as the initial load, and with the load increasing by 10 W every minute. A 12-lead computer-averaged ECG was registered continuously during exercise and during the first 4 min of the recovery phase. ST deviation was measured every minute from the incremental averaged ECG at 60 ms after the J-point.

A healthy subgroup (n=108) was defined as participants who did not fulfil any of the following criteria: use of regular cardiovascular or pulmonary medication, self-reported history of myocardial infarction (confirmed from medical records), angina pectoris, hypertension, atrial fibrillation, diabetes mellitus, asthma or chronic obstructive pulmonary disease, Minnesota code 1·1, 1·2, 1·3, 7·1, 4·1–4·4, 5·1–5·3 or 8·3 on the 12-lead resting ECG (i.e. abnormal Q-waves, left bundle branch block, ST-segment depression, T-wave inversion or atrial fibrillation/flutter) or ≥1 mm ST-segment depression in at least two adjacent precordial leads on the exercise ECG at the maximum workload or within 4 min during the recovery phase or echocardiographic findings: aortic peak flow velocity $>2\ \text{m}\,.\,\text{s}^{-1}$ or more than slight valve regurgitation.

Ischaemic heart disease was defined as self-reported history of myocardial infarction (confirmed from medical records), angina pectoris or evidence of myocardial infarction (i.e. abnormal Q-waves) on the resting 12-lead ECG (Minnesota code 1·1, 1·2, 1·3).

Echocardiography

The echocardiographic studies were conducted using an Acuson XP 128 system with participants in the left recumbent position. ECG and respiration were recorded simultaneously. A single physician (P.H.) with a 2-year experience of daily self-performed echocardiographic examinations carried out all of the studies. The physician was blind with respect to the participants' clinical data. Left ventricular ejection fraction was calculated on-line according to the biplane disc summation method (Simpson's formula)[11] in participants where at least 60% of the endocardial borders could be detected. One cardiac cycle was used at sinus rhythm; a mean of 3–5 cardiac cycles was used at atrial fibrillation. The measurements were made as close as possible to end-expiration. Two-dimensional mode, colour flow mapping and spectral Doppler investigations were performed and recorded on videotape. Visual scoring of left ventricular wall motion was executed off-line by the initial examiner. To avoid bias between the echocardiographic methods, visual scoring was conducted at least 1 month after the calculation of ejection fraction. We used a method first described by Heger *et al.*[12] and later modified by Berning *et al.*[13] to achieve the estimated wall motion index. The left ventricle was divided into nine segments examined in five standard projections (i.e. one longitudinal and two short axis views from the parasternal window and the four-chamber view, and the two-chamber view from the apical window). Each segment was assigned one score of +3 for hyperkinesia, +2 for normokinesia, +1 for hypokinesia, 0 for akinesia and −1 for dyskinesia. The average score for the nine segments constituted the wall motion index. If a segment could not be assessed in any of the different views, the wall motion index was not calculated.

Left ventricular systolic dysfunction was defined as cut-off values for wall motion index and ejection fraction, statistically derived from the healthy subgroup (see Results).

Valvular abnormality was defined as peak flow velocity $>3{\cdot}0\ .\ \text{ms}^{-1}$ across the aortic valve or at least moderate regurgitation of the aortic or mitral valves.

Intra- and inter-observer reproducibility was tested by having the initial examiner and another physician at our laboratory remeasure ejection fraction and wall motion index in 14 randomly chosen participants. On ejection fraction, the mean difference and coefficient of variation was 1·4 (SD 6·5) and 10·8%, respectively, for the same observer and 0·7 (SD 6·8) and 11·5%, respectively, between the two observers. The mean difference and coefficient of variation on wall motion index was 0·02 (SD 0·11) and 5·4%, respectively, for the same observer and 0·12 (SD 0·14) and 7·1%, respectively, between the two observers.

Clinical evaluation

A consultant cardiologist (I.L.) performed the physical examination. The consultant, the same for all participants, looked for signs associated with congestive heart failure, such as leg swelling, dilated neck veins, hepatomegaly, third-tone gallop and murmurs. In the same session he evaluated the self-reported history and symptoms of the participants. He was allowed to review the resting 12-lead ECG but was blind to the echocardiographic findings and the results from the exercise test. Based on these findings, without using any specific scoring system, the consultant classified the participants as having or not having clinical heart failure.

Statistics

The statistical analysis was performed using the SPSS statistical package for Windows. Either the chi-square test or the Fisher's exact test was used to compare categorical variables. Numeric variables with a normal distribution were compared by means of Student's t-test; non-normal distributed variables were compared with the Mann–Whitney U test. In the analysis of agreement between the echocardiographic methods, Cohen's kappa was used. The interval estimates for prevalence values were calculated as 95% confidence interval of proportion.

Results

The echocardiographic measurability of left ventricular systolic function

Table 1 shows some clinical characteristics of the participants. The left ventricular ejection fraction was measurable in 280 (64·7%) of the participants. Wall motion index was achievable in 412 (95·2%) of the participants, including all of the 280 participants in which ejection fraction was measurable. There was a significantly higher proportion of men in the group of 280 with a measurable ejection fraction than in the non-measurable group (54·3% vs 37·9%, $P=0·001$). Body mass index differed significantly between these groups for both men (24·8 vs 26·3, $P=0·001$) and women (24·8 vs 28·5, $P<0·0001$). No significant differences were noted between the groups concerning history of myocardial infarction, angina, hypertension, diabetes, current smokers, previous smokers and systolic and diastolic blood pressure. In 21 (4·8%) of the participants, neither ejection fraction nor wall motion index was attainable. This group had a lower proportion of men (23·8% vs 49·8%, $P=0·02$) and a higher body mass index (28·0 vs 25·7, $P=0·005$) compared with the group in which wall motion index or ejection fraction was achievable. No significant differences were found between these groups on history of myocardial infarction, angina, hypertension, diabetes, systolic and diastolic blood pressure and smoking habits.

Table 1 Characteristics of the participants (n=433)

	n (%)
Men/Women	210 (48·5)/223 (51·5)
Ischaemic heart disease	87 (20·2)
Myocardial infarction	41 (9·5)
Angina pectoris	56 (13·0)
Hypertension	122 (28·3)
Diabetes mellitus	34 (7·9)
Valvular abnormality	18 (4·2)
Atrial fibrillation	22 (5·1)
Pulmonary emphysema	17 (3·9)
Cardiovascular or pulmonary medication	205 (47·3)
Previous smokers	182 (42·0)
Current smokers	45 (10·4)
Body mass index (kg . m^{-2})*	25·8 ± 3·6
Heart rate (beats . min^{-1})*	67 ± 12
Systolic blood pressure (mmHg)*	165 ± 25
Diastolic blood pressure (mmHg)*	84 ± 10

*Values are mean ± SD.

Left ventricular systolic function in the healthy subgroup

In the healthy subgroup (n=108) the frequency distribution for wall motion index was positively skewed (Fig. 1), with a mean of 2·1 (SD 0·15, range 1·7–2·7) and a median of 2·0. The ejection fraction in this subgroup indicated a normal distribution (Fig. 2), with a mean of 62% (SD 6·3, range 47–73).

The definition of left ventricular systolic dysfunction

The cut-off level for ejection fraction was defined as 3 SD below the mean of the healthy subgroup (i.e. 43%). In the healthy subgroup the distribution of wall motion index was skewed (Fig. 1) even after several transformation attempts. We therefore used the 0·5th percentile for wall motion index as an approximate correspondent to 3 SD below the mean of the healthy subgroup. Left ventricular systolic dysfunction was thus defined as a wall motion index <1·7 with a corresponding cut-off level of <43% for the ejection fraction.

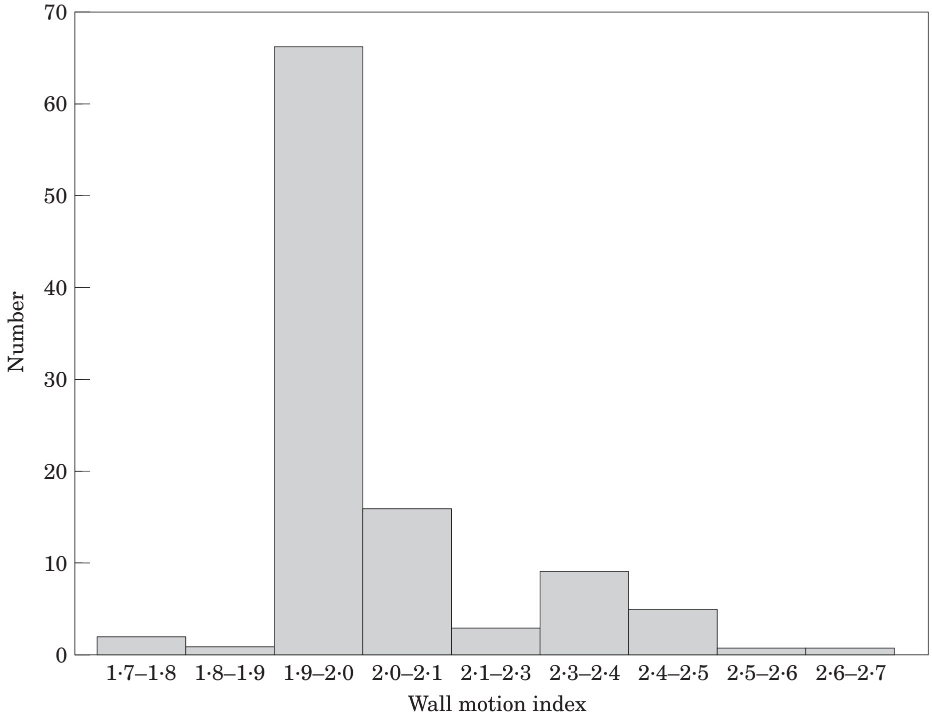

Figure 1 **Distribution of wall motion index in healthy participants (n=104).**

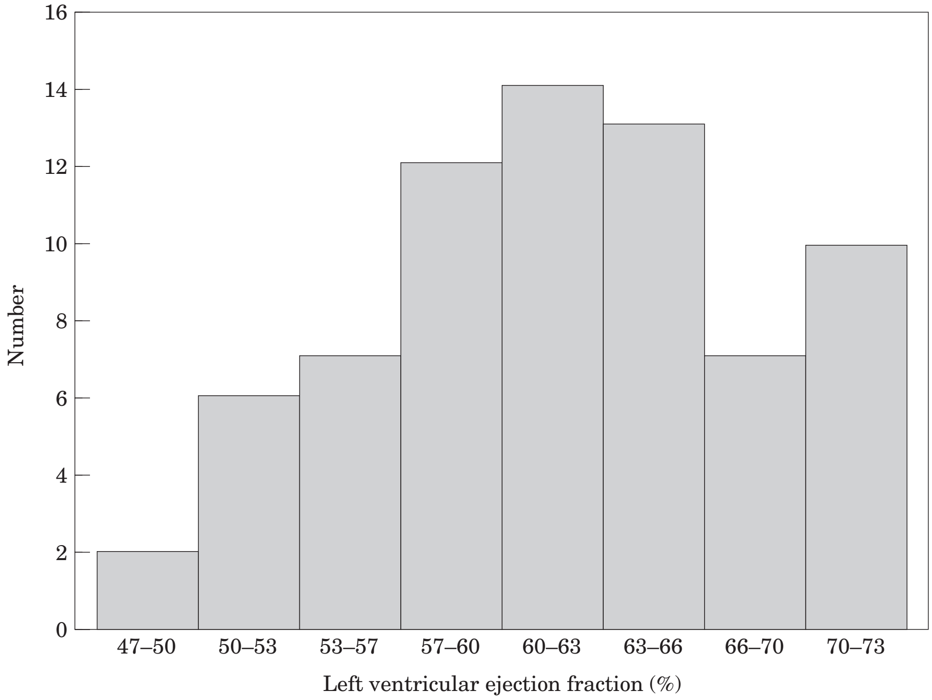

Figure 2 **Distribution of left ventricular ejection fraction in healthy participants (n=71).**

The prevalence of left ventricular systolic dysfunction

The overall prevalence of left ventricular systolic dysfunction (i.e. wall motion index <1·7) was 6·8% (n=28, Table 2). The prevalence rate was significantly higher in men than in women (10·2% vs 3·4%, *P*=0·006). In the participants with left ventricular systolic dysfunction the median wall motion index was 1·2 (range 0·4–1·6) and, when possible to measure, the mean ejection fraction was 32% (range 16–43, n=22).

Table 2 Prevalence of echocardiographically determined left ventricular systolic dysfunction in 75-year-old men and women

	Men		Women		Total	
	n	Prevalence % (95% CI)	n	Prevalence % (95% CI)	n	Prevalence % (95% CI)
LVEF <43%	19/152	12·5 (7·2–17·8)	6/128	4·7 (1·0–8·3)	25/280	8·9 (5·6–12·3)
WMI <1·7	21/205	10·2 (6·1–14·4)	7/207	3·4 (0·9–5·8)	28/412	6·8 (5·6–8·0)

LVEF=left ventricular ejection fraction; WMI=wall motion index.

Table 3 Characteristics of participants in the presence or absence of left ventricular systolic dysfunction (LVSD)*

	LVSD present % (no/total no of subgroup)	LVSD absent % (no/total no of subgroup)	*P*-value
Female	25 (7/28)	52 (200/384)	
Male	75 (21/28)	48 (184/384)	0·006
Previous smokers	68 (19/28)	40 (154/384)	0·004
Current smokers	14 (4/28)	10 (40/384)	0·52
IHD	86 (24/28)	16 (59/381)	<0·001
MI	79 (22/28)	5 (18/383)	<0·001
Angina	50 (14/28)	10 (39/383)	<0·001
Hypertension	48 (13/27)	27 (103/383)	0·018
Diabetes	22 (6/27)	7 (27/384)	0·015
Atrial fibrillation	18 (5/28)	4 (16/382)	0·01
Valvular abnormality	11 (3/28)	4 (14/384)	0·1
Pulmonary emphysema	11 (3/28)	3 (12/382)	0·075
Heart rate (beats . min^{-1})†	65 ± 16	67 ± 11	0·26
SBP (mmHg)†	154 ± 24	167 ± 25	0·012
DBP (mmHg)†	80 ± 10	85 ± 10	0·015
BMI (kg . m^{-2})†	24·3 ± 2·1	25·8 ± 3·6	0·03

IHD=ischaemic heart disease; MI=myocardial infarction; BMI=body mass index; SBP=systolic blood pressure; DBP=diastolic blood pressure.
*Left ventricular systolic dysfunction defined as wall motion index <1·7.
†Values are mean ± SD.

Agreement between the echocardiographic methods

Of the 280 participants in which both ejection fraction and wall motion index were achievable, there were five participants where wall motion index failed to predict the cut-off level for ejection fraction. More specifically, four participants had an ejection fraction of <43% (range 37–42) but a wall motion index of ≥1·7 (range 1·7–1·8); the fifth participant had a wall motion index of 1·5 (i.e. <1·7) but an ejection fraction of 43%. An analysis of agreement between biplane Simpson (ejection fraction) and visual scoring (wall motion index) in classifying the presence or absence of left ventricular systolic dysfunction yielded a kappa value of 0·88 (P<0·0001). The sensitivity, specificity and accuracy for a wall motion index of <1·7 to detect an ejection fraction of <43% was 84·0%, 99·6% and 98·2%, respectively. In the 280 participants in whom both methods were achievable no significant difference was observed in prevalence estimates of left ventricular systolic dysfunction between the disc summation method and the visual scoring method (8·9% vs 7·9%, P=0·53).

Characteristics of subjects with left ventricular systolic dysfunction

Table 3 shows some characteristics according to the presence or absence of left ventricular systolic dysfunction. Self-reported hypertension coexisted with ischaemic heart disease in 41% of participants with left ventricular systolic dysfunction. Ischaemic heart disease unaccompanied by self-reported hypertension was present in 44% of the participants with left ventricular systolic dysfunction and in 11% of the participants without this condition (P<0·001). Ischaemic heart disease, hypertension and diabetes singly or in combination were present in 92% of the participants with left ventricular systolic dysfunction.

***Table 4** Prevalence of echocardiographically determined left ventricular systolic dysfunction* with or without clinical heart failure*

	Men		Women		Total	
	n	Prevalence %	n	Prevalence %	n	Prevalence %
With clinical heart failure	10/205	4·9	5/207	2·4	15/412	3·6
Without clinical heart failure	11/205	5·4	2/207	1·0	13/412	3·2

*Left ventricular systolic dysfunction defined as wall motion index <1·7.

Clinical heart failure

In the consultants clinical examination 29 (6·7%) of the 433 participants were classified as having clinical findings indicating heart failure. The prevalence of clinical heart failure was higher in men than in women (9·5% vs 4·0%, P=0·022). Among the 29 participants diagnosed as having heart failure, 28 had an achievable wall motion index, of whom 15 (54%) had left ventricular systolic dysfunction. Thus, the prevalence of left ventricular systolic dysfunction accompanied with clinical heart failure was 3·6% (Table 4). The prevalence of left ventricular systolic dysfunction *without* clinical evidence of heart failure was 3·2% (n=13), i.e. clinical heart failure was absent in 46% of the participants with left ventricular systolic dysfunction. Of the participants with left ventricular systolic dysfunction, no significant differences were detected between the groups with or without clinical heart failure on ejection fraction (33% vs 35%, P=0·53) or wall motion index (1·2 vs 1·3, P=0·58).

Discussion

Epidemiological data are scarce concerning evidence of left ventricular systolic dysfunction in the general elderly population. We sought to investigate the prevalence of left ventricular systolic dysfunction using echocardiography in a well-defined and population-based group of subjects in an age relevant to clinical reality. The relevance of selecting people 75 years old is supported by the finding that the median age at presentation of heart failure was 76 years in a study investigating the incidence of heart failure in a London suburb[14].

In planning the present study, we opted to use two methods for assessing left ventricular systolic function. The biplane disc summation method is established and widely used to measure left ventricular ejection fraction. However, in our experience, this method is highly contingent on image quality, which reduces its applicability, especially in the elderly. Consequently, we added a previously described visual scoring method that has been shown to be obtainable in a great majority of subjects and to be valid and reproducible in measuring global left ventricular systolic function[13,15].

In deciding on a treatment with ACE inhibitors, a cut-off value for ejection fraction in common clinical use is 40%. Of the 280 participants with measurable ejection fraction, 7·2% (n=21) had an ejection fraction of <40% in our study. Using a universal cut-off level to indicate left ventricular systolic dysfunction is questionable, however. Evidence has been reported indicating systematic differences between centres in echocardiographic measurements of ejection fraction, suggesting a need for locally defined normal intervals[16]. This view is supported by the considerable difference in mean ejection fraction derived in healthy subgroups between our findings and what McDonagh *et al.* found[17] in a Glasgow survey (mean value of ejection fraction 62% vs 48%). In the light of these data, we elected to indicate left ventricular systolic dysfunction by choosing statistically derived cut off levels from our healthy subgroup. The actual levels, i.e. 3 SD below the mean for ejection fraction (<43%) and the 0·5th percentile for wall motion index (<1·7), were chosen to include only participants with clinically significant left ventricular systolic dysfunction.

When analysing the 280 participants in whom both the biplane disc summation method and visual scoring were achievable, excellent agreement between the methods in classifying the presence or absence of left ventricular systolic dysfunction was obtained. In these 280 participants, no significant difference in prevalence estimates of left ventricular systolic dysfunction was noted between the two methods. Accordingly, we resolved to use the wall motion index in the definition of left ventricular systolic dysfunction. This decision was based on the aforementioned excellent agreement between wall motion index and ejection fraction and the findings that wall motion index was obtainable in almost all participants, whereas ejection fraction was obtainable in only 65% of the participants. Even though there was excellent agreement between the echocardiographic methods it must be pointed out that the wall motion scoring index is not a method of measuring ejection fraction and is obviously more subjective than the disc summation method. The ultrasound machine used in this study was not equipped with native tissue harmonic imaging technology. Such technology improves the quality of the two-dimensional image considerably[18] and probably makes it possible to obtain the ejection fraction in a larger number of subjects.

We found that left ventricular systolic dysfunction is a common condition among 75-year-old subjects, with an overall prevalence of 6·8% in our estimate. This is slightly higher than the estimated 5·6% in a subgroup of 65–74-year-olds in a population-based study from Glasgow reported by McDonagh *et al.*[17]. The higher age of our participants could account for this difference. Another explanation could be the lower cut-off value (i.e. ejection fraction <30%) used in the Glasgow study. However, an ejection fraction of 30% corresponded to 2·7 SD below the mean for the healthy subgroup described in that study. Thus, from this point of view, their cut-off value was actually comparable to ours. In another population-based study from Rotterdam, Mosterd *et al*. reported a prevalence of left ventricular systolic dysfunction of 4·8% in participants aged 75–84 years[19]. This lower value could possibly be an expression of different echocardiographic methodology. The method of fractional shortening used in the Rotterdam study is restricted to measurement of motion in the basal parts of the anterior and posterior left ventricular wall. In the presence of regional wall motion abnormalities, fractional shortening is not reliable in estimating global left ventricular systolic function[20]. Our prevalence estimate is consistent with the 6·9% found in patients aged 75–79 years reported by Morgan *et al.* in a cross-sectional survey in Dorset, U.K.[21]. Since that study was based on an elderly patient population in a general practice setting, one would expect their prevalence value to be higher than that found in our general population. However, the Dorset study took place in 'a desirable retirement area likely to have had an inward migration of more affluent and possibly fitter elderly people'. We found that left ventricular systolic dysfunction is more common in men than in women, a finding consistent with previous studies[17,19,21]. Noteworthy is the high prevalence (86%) of ischaemic heart disease in the participants with left ventricular systolic dysfunction. This is in accordance with the 83% found in the Glasgow study[17]. A history of myocardial infarction was present in 79% of the participants with left ventricular systolic dysfunction, but only in 5% of the participants with left ventricular systolic dysfunction. This difference is not surprising in view of the well-known influence of myocardial damage on ventricular contractility.

Clinical heart failure was judged present in 6·7% of our 75-year-old men and women. Among the participants with clinical heart failure, 54% had left ventricular systolic dysfunction as compared with 28–49% reported in previous population-based studies[19,22,23]. The prevalence of clinical heart failure in our study corresponds with the 6·8% found in 75-year-old participants in a population-based Finnish Study[22]. In the Framingham study, congestive heart failure was diagnosed in 4·9% of individuals aged 70–79 years, which is a slightly lower estimate than in our study[24]. In the Rotterdam study, a considerably higher estimate of 13% was found in the subgroup of men and women aged 75–84[19]. In contrast to the 9·5% prevalence of heart failure in our 75-year-old men, a 13% rate was found in a Swedish study of younger men (67-year-olds)[25]. More important than the actual prevalence of clinical heart failure, is the finding that a large number of the participants with left ventricular systolic dysfunction do not exhibit clinical evidence of heart failure. This finding confirms the data from previous studies[17,19,21].

The estimated prevalence of left ventricular systolic dysfunction in our study should be regarded as a minimum estimate. If a higher cut off value of <1·9 for wall motion index (corresponding to the 2·5th percentile in the healthy subgroup) was used instead of <1·7, the overall prevalence of left ventricular systolic dysfunction would be 10·4%. This higher cut-off value had a sensitivity and a specificity of 94·1% and 98·4%, respectively, to predict an ejection fraction of <50% (corresponding to 2 SD below the mean for the healthy subgroup). We had a reasonably good response rate in our study. Although there was no difference in self-reported frequencies of cardiovascular disease, the non-responders who completed the questionnaire, in comparison with the participants, were more likely to be smokers. It is possible that subjects more affected with disease were less likely to respond at all. Furthermore, among the non-participants 13 reported heart disease under treatment as a reason not to attend. The drop-outs may have led us to under-estimate the prevalence of left ventricular systolic dysfunction and further reinforces our apprehension that the prevalence value is a lower bound estimate.

Conclusions

Left ventricular systolic dysfunction is a common condition among 75-year-olds, with a prevalence of 6·8% in our estimate. The condition is more likely to affect men than women. In nearly half of the participants with left ventricular systolic dysfunction, clinical evidence of heart failure is absent. Ischaemic heart disease, hypertension and diabetes, singly or in combination is present in more than 90% of our participants with left ventricular systolic dysfunction.

We are indebted to Petra Wahlén and Marie-Louise Engström for their help in data collection and to Stefan Sörensen for statistical advice.

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