

Frequency of extrasystoles in healthy male employees

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SUMMARY To determine reference values for ectopic activity 147 actively employed healthy men aged from 15 to 65 years were examined by 24 hour Holter monitoring during their ordinary daily activities. Age was the only risk factor significantly associated with supraventricular and ventricular extrasystoles. During a six year follow up only two men died. In both the frequency of ventricular extrasystoles had been high, but neither of them died from cardiovascular disease.

Because the distribution of the frequency of extrasystoles in the study group was highly skewed a percentile distribution was used to determine normal values. This distribution showed that 95% of men aged 15-39 years had <2.9 ventricular extrasystoles per hour and the same proportion of men aged 40 years or older had <36 ventricular extrasystoles per hour. For field studies values above the 90th percentile (that is more than 10 ventricular extrasystoles per hour for men 40 years or older) may be a more appropriate cut off point.

Ambulatory electrocardiographic monitoring of cardiac arrhythmias is commonly used in the clinical evaluation and prognostic assessment of ischaemic heart disease.^{1,2} The importance of recording cardiac arrhythmia, in particular ventricular extrasystoles has been established by several studies.³⁻⁵ Reliable population reference values are needed. We have measured the frequency of ectopic activity, both ventricular and supraventricular, in a healthy screened sample of working men aged 15 to 65 during their regular daily activities. Their work varied from unskilled labour to administrative managerial posts. The aim of the study was to establish criteria for normal values of ectopic activity in a male working population and to assess the prognostic importance of such ectopic activity.

Subjects and methods

160 working men aged 15-66 years were selected from the payrolls of four large Swedish companies. Seventy three per cent were blue collar workers and 27% were white collar workers. They were included in the

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study if they were free from clinical signs of heart disease and other chronic disorders such as treated hypertension, diabetes, or hypercholesterolaemia and had a normal standard resting electrocardiogram. Thirteen men were excluded because they were on regular medication. Table 1 summarises the mean values and standard deviations of clinical variables.

A 24 hour ambulatory electrocardiogram was recorded with an Avionics Cardiocorder Model 400 in the normal work and home setting of each man. He recorded his activities for each of the 24 hours in a diary. The tapes were analysed by means of Avionics Composite Electrocardioscanners Model 650 after scanning with Reynolds Pathfinder Highspeed ECG Analysers. All suspected abnormalities were printed on electrocardiographic paper and reviewed by an independent cardiologist according to standardised procedures.¹

Mean heart rates were calculated and the numbers of supraventricular and ventricular extrasystoles were counted per hour. The criteria for classification of ventricular ectopic beats were the following: absence of P wave; QRS configuration different from the regular complex; QRS width >0.12 s; prematurity and compensatory pause. Extrasystoles that did not meet these criteria were classified as supraventricular.

Table 1 *Clinical characteristics of the study group*

<i>Characteristic</i>	<i>Mean (SD)</i>	<i>Range</i>
Age (yr)	44.1 (14.1)	15-66
Systolic blood pressure (mm Hg)	132.0 (14.9)	105-188
Diastolic blood pressure (mm Hg)	79.4 (10.1)	50-115
Serum cholesterol (mmol/l)	5.9 (0.9)	3.8-8.6
Alcohol consumption (kg absolute alcohol/year)	3.2 (3.6)	0.0-16.0
Relative weight (weight (kg)/height (cm) - 100)	0.99 (0.13)	0.73-1.45
Proportion smokers	47%	Occasional to > 25 cigarettes per day
Proportion ex-smokers	24%	

All men were followed for six years, during which time deaths were recorded. The number of expected deaths was calculated by computing 5 year age group, calendar year, and gender specific person-years and multiplying these by the national death rates in 1978-83 and summing up the fractional contributions.⁶

STATISTICAL METHODS

Because of the skewed distribution of the frequency of extrasystoles in healthy subjects, non-parametric tests were generally used for statistical analyses. Thus, χ^2 analyses were applied to test the association between frequency of extrasystoles and different risk factors including age. We used analysis of variance test with repeated measurements to assess the change in frequency of extrasystoles and of heart rate during different types of activity. In this case attempts were made to reduce the skewness of the investigated distributions by the use of medians and of logarithmic transformations.

Results

For each individual the average number of extrasystoles per hour was calculated as the total number of extrasystoles divided by the number of recorded hours. Table 2 shows the results for different age groups. Because of the skewed distributions of the variables that we investigated the results are shown for subgroups defined by the increasing magnitude of the ectopic activity. The lowest group consists of those individuals who had no ectopic beats. The group limits were chosen primarily to conform with earlier studies, but also to show the distribution, which includes some very high values. Supraventricular extrasystoles were found in three-quarters and ventricular extrasystoles in almost half of the men; most of these cases were in the group with up to one extrasystole per hour.

The number of extrasystoles per hour increased significantly with age (Table 2). Except for one man, men aged < 45 years did not have as many as 20 ventricular extrasystoles per hour. Five out of 46

men over age 55 had an average of more than 20 supraventricular extrasystoles per hour during the study period.

The Figure shows the diurnal variation of mean heart rate and of median frequency of ventricular extrasystoles. An analysis of variance test showed that mean heart rate ($p < 0.001$), mean log frequency of ventricular extrasystoles ($p < 0.01$), and mean log frequency of supraventricular extrasystoles ($p < 0.05$) were significantly higher during working hours than during sleep. Because of the pronounced skewness of the distribution of ectopic beats in these healthy men it was not possible to calculate an equation that predicts the number of ventricular or supraventricular extrasystoles expected at a given age. Instead we give the age-adjusted expected number of extrasystoles in the 90th and 95th percentile (Table 3).

Thus in 90% of men under age 40 one would expect to find only occasional extrasystoles, that is less than one supraventricular or one ventricular extrasystole per hour. In 90% of men of 40 years or older, still quite modest numbers of extrasystoles are expected (6.5 supraventricular and 9.7 ventricular per hour). Five per cent of healthy men, however, do have extreme values—for example some men of 40 years or older have 19.2 supraventricular and 36 ventricular extrasystoles per hour.

Complex ventricular arrhythmia was rare, even in older men (Table 4). Only two of 70 men under age 45 had coupled or multiform ventricular extrasystoles. The R on T phenomenon was found in one man and a run of ventricular tachycardia in another; both were more than 45 years old.

We also analysed the association between the frequency of extrasystoles and clinical variables. There was no statistically significant increase in the frequency of supraventricular or ventricular extrasystoles in men with raised systolic or diastolic blood pressure, raised serum cholesterol, in those who were smokers, or in those who were overweight (Table 5). The frequency of supraventricular extrasystoles but not that of ventricular extrasystoles was significantly higher in men who reported drinking

Table 2 Proportions of men in different age groups showing ventricular and supraventricular extrasystoles. Percentages are given in parentheses

Extrasystoles	15-24 yr (n=17)	25-34 yr (n=26)	35-44 yr (n=27)	45-54 yr (n=31)	55-66 yr (n=46)	Total (n=147)
Supraventricular:						
0	6 (35)	11 (42)	10 (37)	7 (23)	3 (7)	37 (25)
0.1-0.9	9 (53)	15 (57)	15 (55)	19 (61)	16 (35)	74 (50)
1.0-4.9	0	0	0	4 (13)	15 (33)	19 (13)
5.0-19.9	0	0	0	1 (3)	7 (15)	8 (5)
20-	2 (12)	0	2 (7)	0	5 (11)	9 (6)
$\chi^2=48.6$	df=8*		p<0.001			
Ventricular:						
0	12 (70)	20 (77)	16 (59)	15 (48)	16 (35)	79 (54)
0.1-0.9	3 (18)	5 (19)	8 (30)	12 (39)	24 (52)	52 (35)
1.0-4.9	1 (6)	—	2 (7)	—	—	3 (3)
5.0-19.9	—	1 (4)	1 (4)	1 (3)	3 (7)	6 (4)
20-	1 (6)	—	—	3 (10)	3 (7)	7 (5)
$\chi^2=15.85$	df=8		p=0.045			

*For a better approximation to the assumption of the χ^2 test the three groups with highest frequencies were aggregated into one group. Hence the df is 8. According to Armitage this approximation of the χ^2 distribution is reasonable because relatively few expected frequencies are less than 5.²⁴ If, however, we maintain the more orthodox view that none of the expected frequencies should be less than 5, the table would be aggregated into 0 and >0 categories. In that case df is 4, and $\chi^2=15.6$, $p=0.0036$ for supraventricular extrasystoles and $\chi^2=14.9$, $p=0.0049$ for ventricular extrasystoles.

more than 2000 g of alcohol per year which corresponds to approximately 40 g of ethanol per week (Table 5).

We also attempted to analyse the significance of extrasystoles in relation to six years mortality. Only two men died during the follow up period (one from respiratory insufficiency, one from Boeck's sarcoid). At necropsy neither had evidence of ischaemic heart disease or other cardiovascular disease. Based on the age distribution seven deaths would have been expected in the study group, 2.6 of them from ischaemic heart disease. Since treated risk factors for, and clinical and electrocardiographic signs of ischaemic heart disease had been used as exclusion criteria, the study group was made up of healthy employed men. This and the fact that employed men in

general have a lower mortality than that of the average population explains the low death rate. Both men who died were over 60 years at the initial examination. Although they had only three and six supraventricular ectopic beats per hour respectively, they also had 227 and 39 ventricular ectopic beats per hour—that is more than the 95th percentile for men aged 40–66 years.

Discussion

We have investigated the frequency of ectopic activity in healthy employed men. Only age was significantly associated with both ventricular and supraventricular ectopy. Most workers agree that ventricular arrhythmias become more common with

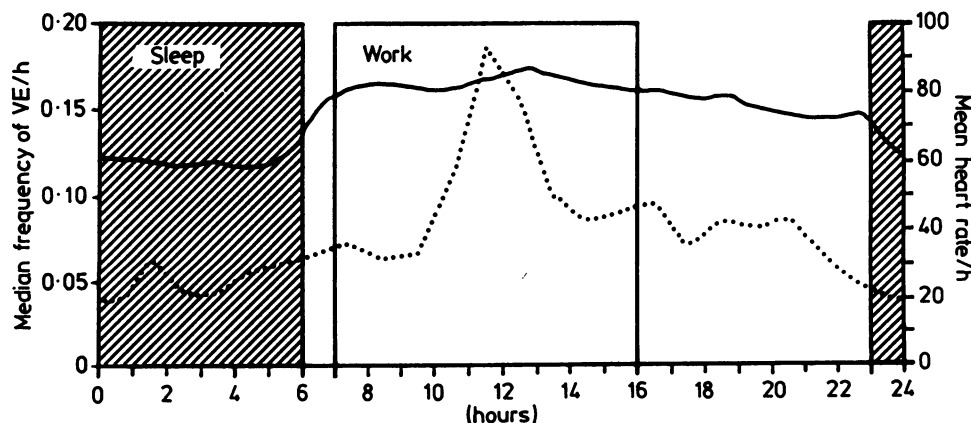


Figure Diurnal variation of mean heart rate and of median frequency of ventricular extrasystoles per hour in 147 healthy working men.

Table 3 Frequency of extrasystoles in healthy men for the 90th and 95th percentiles in the distribution of mean number of extrasystoles per hour

	15-39 yr		40-66 yr	
	SVE/h	VE/h	SVE/h	VE/h
90 ^o	0.6	0.4	6.5	9.7
95 ^o	21.0*	2.9	19.2	36.0

SVE, supraventricular extrasystoles; VE, ventricular extrasystoles.
*This figure is an approximation based on linear interpolation.

age.⁷⁻⁹ Brodsky *et al* and Sobotka *et al* found ventricular arrhythmias in 56% of young men and in 54% of young women.^{10 11} Fleg and Kennedy found ventricular arrhythmias in 80% of elderly people (aged 60-85).¹² Taylor and Stout found considerably more ectopic activity in elderly subjects than young healthy ones,¹³ but Dickinson and Scott found ventricular extrasystoles in as many as 41% of 100 monitored teenage boys.¹⁴

There is less agreement, however, about the absolute frequencies of ventricular extrasystoles in healthy men of various ages. Kostis *et al* recorded ventricular extrasystoles during 24 hours in patients who had undergone coronary angiography and who had less than 5-10% luminal obstruction of the coronary arteries.¹⁵ Only 28% of 40-49 year old men had ventricular extrasystoles. Hinkle examined 301 middle aged, actively employed men and found ventricular extrasystoles in 62% of 10 hour recordings.¹⁶ Clinical signs of heart disease were found in about one fifth of these men. The monitoring was

carried out in a hospital-like setting. Manger Cats *et al* found ventricular extrasystoles in 71% of 40-49 year old healthy men who were monitored for 24 hours.¹⁷ Bjerregaard examined 260 middle aged men and women for 24 hours and found ventricular extrasystoles in 57% of 40-49 years old subjects.¹⁸ Romhilt *et al* found ventricular extrasystoles in 46% of 24 hour recordings in healthy women aged 40-49 years.¹⁹ Except for the study by Kostis *et al* all the studies that we have mentioned used clinical examination, standard questionnaires, and resting electrocardiograms or other non-invasive techniques to select patients free from identifiable heart disease.

The explanation for the great divergence of reported results seems to be the differing criteria used to select healthy subjects. The more careful the examination procedure and the more rigorous the criteria for selection of a healthy group, the fewer the ventricular extrasystoles that are found. We monitored healthy subjects from a working population, after excluding subjects with risk factors. We wanted to describe a reference working population that would be an appropriate standard for use in general practice or in occupational health studies. This is the reason that we used easily applicable criteria for classification of ventricular extrasystoles. These include prematurity of and compensatory pause after the extrasystole; this will exclude occasional interpolated ventricular extrasystoles. In a careful re-examination of 50 of the 147 recordings we found only three interpolated ventricular extrasystoles out of a total of 3 134. This appears to be a negligible error in the recording of ventricular ectopic activity.

Table 4 Numbers of men showing multiform (M) or coupled (C) ventricular extrasystoles

Ventricular extrasystoles	15-24 yr (n=17)	25-34 yr (n=26)	35-44 yr (n=27)	45-54 yr (n=31)	55-66 yr (n=46)	Total (n=147)
0	—	—	—	—	—	—
0.1-0.9	—	—	—	2 (M), 1 (C)	10 (M), 3 (C)	13 (M), 4 (C)
1.0-4.9	—	—	1 (M)	1 (M)	1 (M)	2 (M)
5.0-19.9	—	—	—	1 (M)	1 (M), 2 (C)	2 (M), 2 (C)
20-166	1 (C)	—	—	—	1 (C)	2 (C)

Table 5 Associations between clinical characteristics and supraventricular and ventricular extrasystoles

Clinical characteristics	SVE			VE		
	χ^2	df	p	χ^2	df	p
Systolic blood pressure ≥ 160 mm Hg	1.54	4	0.82	1.84	4	0.76
Diastolic blood pressure ≥ 90 mm Hg	2.53	4	0.64	1.62	4	0.81
Smoking	6.48	4	0.17	1.83	4	0.77
Alcohol consumption > 2000 g/yr	10.12	4	0.04	3.01	4	0.56
Relative weight ≥ 1.0	3.87	4	0.42	3.65	4	0.45
Serum cholesterol mmol/l > (3.745 + 0.087 × age (yr))	3.02	4	0.56	6.08	4	0.19

SVE, supraventricular extrasystoles; VE, ventricular extrasystoles.

Our exclusion criteria reduced the range of coronary risk factor levels in the study group. This may in part explain the lack of association between risk factors and ventricular ectopic activity. The findings accord with those of another study, however, that showed no association between coronary risk factor levels and ectopic activity in healthy men.²⁰ In high risk groups, however, such associations have been shown.²¹⁻²³

There were only two deaths in the six year follow up, and neither was from ischaemic heart disease. Although both men who died had many ventricular extrasystoles per hour they were also older; thus no inferences about the prognostic significance of frequent extrasystoles can be drawn. The low mortality that we found may merely reflect the exclusion of men with risk factors. Reports on the prognostic significance of ectopic activity in healthy individuals are inconclusive. Demonstration of an unfavourable prognosis in some studies may be the result of inclusion of a higher proportion of individuals with heart disease or risk factors for heart disease.^{2 22 23} The calculation of an equation for the prediction of expected numbers of extrasystoles proved difficult. A multiple regression equation was computed of data derived from the logarithmic transformation of ventricular extrasystoles against values of clinical characteristics including age on the other. The point estimate for an individual with group means on clinical parameters was 1.85 ventricular extrasystoles per hour, but the 95% confidence intervals were approximately 0.10 to 26.0 ventricular extrasystoles per hour. This reflects both the skewed distribution of and great individual variability in the frequency of ventricular ectopy. The expected incidence of extrasystoles was also estimated from the 90th or 95th percentiles in different age groups. It was uncommon (1 in 20 men) to find more than 36 ventricular ectopic beats per hour in men aged > 40 years. This finding warrants further clinical investigation.

We regard the 90th percentile value of > 10 ventricular extrasystoles per hour in healthy men aged 40-66 years as indicating a high frequency on an ordinal scale. Because techniques and the methods for evaluation of ventricular ectopic activity are relatively constant this cut off point should be useful in comparative field studies.

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References

- 1 Chung EK. Clinical value of ambulatory rhythm monitoring. In: *Principles of cardiac arrhythmias*. Baltimore: Williams and Wilkins, 1977: 701-3.
- 2 Hinkle LE, Carver ST, Argyros DC. The prognostic significance of ventricular premature contractions in healthy people and in people with coronary heart disease. *Acta Cardiol (Brox)* 1974; suppl 18:5-32.
- 3 Ruberman W, Weinblatt E, Goldberg JD, Frank CW, Shapiro S. Ventricular premature beats and mortality after myocardial infarction. *N Engl J Med* 1977; 297: 750-7.
- 4 Lown B, Calvert AF, Armington R, Ryan M. Monitoring for serious arrhythmias and high risk of sudden death. *Circulation* 1975; 51-52 (suppl III): 189-98.
- 5 Rehnqvist N. Ventricular arrhythmias after an acute myocardial infarction. Prognostic weight and natural history. *Eur J Cardiol* 1978; 7: 169-87.
- 6 Anjou C-G, Andersson K, Axelson O, Edling C, Samuelsson P-J, Wigerts O. A computer system for occupational health epidemiology. Department of Medical Engineering, Linköping University, Linköping, 1980.
- 7 Hennekens CH, Lown B, Rosner B, Grufferman S, Dalen J. Ventricular premature beats and coronary risk factors. *Am J Epidemiol* 1980; 112: 93-9.
- 8 Glasser SP, Clark PI, Applebaum HJ. Occurrence of frequent complex arrhythmias detected by ambulatory monitoring. *Chest* 1979; 75: 565-8.
- 9 Sherman H, Sandberg S, Fineberg HV. Exponential increase in age-specific prevalence of ventricular dysrhythmia among males. *J Chronic Dis* 1982; 35: 743-50.
- 10 Brodsky M, Wu D, Denes P, et al. Arrhythmias documented by 24 hour continuous electrocardiographic monitoring in 50 male medical students without apparent heart disease. *Am J Cardiol* 1977; 39: 390-5.
- 11 Sobotka PA, Mayer JH, Bauernfeind RA, Kanakis C, Rosen KM. Arrhythmias documented by 24-hour continuous ambulatory electrocardiographic monitoring in young women without apparent heart disease. *Am Heart J* 1981; 101: 753-9.
- 12 Fleg J, Kennedy H. Cardiac arrhythmias in a healthy elderly population. Detection by 24 hour ambulatory electrocardiography. *Chest* 1982; 81: 302-7.
- 13 Taylor IC, Stout RW. Significance of cardiac arrhythmias in the aged. *Ageing* 1983; 12: 21-8.
- 14 Dickinson DF, Scott O. Ambulatory electrocardiographic monitoring in 100 healthy teenage boys. *Br Heart J* 1984; 51: 179-83.
- 15 Kostis JB, McCrone K, Moreyra AE, et al. Premature ventricular complexes in the absence of identifiable heart disease. *Circulation* 1981; 63: 1351-6.
- 16 Hinkle LE Jr, Carver ST, Stevens M. The frequency of asymptomatic disturbances of cardiac rhythm and conduction in middle-aged men. *Am J Cardiol* 1969; 24: 629-50.
- 17 Manger Cats V, Darmanata J, Durrer D. Complex ventricular premature beats in healthy middle aged men during 24 hour Holter tape recording [Abstract]. *Eur Heart J* 1981; 2 (suppl A): 13.
- 18 Bjerregaard P. Prevalence and variability of cardiac arrhythmias in healthy subjects. In: *Cardiac arrhythmias*

- in the active population.* Mölndal, Sweden: Hässle-Astra, 1980.
- 19 Romhilt DW, Chaffin C, Choi SC, Irby EC. Arrhythmias on ambulatory electrocardiographic monitoring in women without apparent heart disease. *Am J Cardiol* 1984; 54: 582-6.
 - 20 Clarke JM, Shelton JR, Hamer J, *et al.* The rhythm of the human heart. *Lancet* 1976; ii: 508-12.
 - 21 Orth-Gomér K. Ventricular arrhythmias and risk indicators of ischemic heart disease. *Acta Med Scand* 1980; 207: 283-9.
 - 22 Crow RS, Prineas RJ, Dias V, Taylor HL, Jacobs D, Blackburn H. Ventricular premature beats in a population sample. Frequency and associations with coronary risk characteristics. *Circulation* 1975; 51/52 (suppl 3): 111-215.
 - 23 Vedin JA, Wilhelmsson CE, Wilhelmssen L, Bjure J, Ekström-Jodal B. Relation of resting and exercise-induced ectopic beats to other ischemic manifestations and to coronary risk factors. *Am J Cardiol* 1972; 30: 25-31.
 - 24 Armitage P. *Statistical methods in medical research.* 2nd printing. Oxford: Blackwell Scientific Publications, 1973.