AETIOLOGY OF CORONARY HEART DISEASE IN OLD MEN*

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In recent years much attention has been paid to coronary heart disease in middle-aged men, because in this group the incidence of and the mortality from the disease have increased very considerably. Yet coronary disease is also a very common cause of ill health and death in men who have retired, so that when the author had the good fortune to be allowed to make an epidemiological study of a group of Dublin men aged 65–85 years, he decided to concentrate on coronary heart disease. In an attempt to review recent trends in cardio-vascular disease in Ireland and so to provide a background for the present study, a separate analysis of mortality statistics in the Republic of Ireland over the past 30 years was also made (Acheson and Thornton, 1958; Acheson, 1960a). This showed that mortality there from coronary artery disease has increased thirty-fold in the past 30 years, while the mortality from cerebrovascular accidents has changed little.

MATERIAL AND METHOD

THE SAMPLE

The men were all pensioners on the list of Messrs. Arthur Guinness, Son and Co. Ltd. (Dublin), and their names were selected in a random manner as follows: every man aged between 75 and 85 was chosen, between the ages of 70 and 74 every third man was omitted from the list, and between the ages of 65 and 69 alternate men were omitted. This method of selection produced 267 names in all, and each man was sent a postcard inviting him to attend in the Company's medical department for clinical examination; the actual attendances (221) are shown

by age in Table I, together with the numbers who did not attend, because they refused, were ill, had left the country, or had died.

TABLE I
SAMPLE

Age (yrs)	Invited to attend	Attended		Unable to Attend through Illness or Death		Refused to Attend	
		No.	Per cent.	No.	Per cent.	No.	Per cent.
65–69	92	82	89	6*	7	3	3
70–74	100	86	86	11	11	3	3
75–79	40	29	72	10	25	1	2
80–85	35	24	69	10	29	1	3
Total	267	221	82	38*	14	8	3

* Also one man had left the country

CLINICAL EXAMINATION

All the men were seen by the author between January, 1957, and June, 1958. A full clinical history was taken, with particular reference to symptoms of cardiovascular disease; notes were also made of habits and past illnesses. A physical examination included a study of the circulatory system and a standard 12-lead electrocardiogram (ECG). Blood pressure was recorded in the recumbent position and the distance across the chest between the maximum cardiac impulse and the midline (Wood, 1956) was measured with a linen tape to the nearest $\frac{1}{4}$ inch. With this exception (*i.e.* locating apex beat), the methods used in conducting the physical examination conformed as closely as possible with those described by Hunter and Bomford (1956). The 58 men who did not suffer

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from angina pectoris and in whom no other contra-indication* to exercise was apparent were asked to walk backwards and forwards over Master's steps (Master and Oppenheimer, 1929; Master, Friedman, and Dack, 1942), each man wearing ECG terminals on his wrists and ankles, until moderate breathlessness developed. A record was kept of the time taken over the test and of the number of trips made (for details see Acheson and Acheson, 1958). The subject then lay down on the couch and was re-connected to the electrocardiograph; between 25 and 30 seconds elapsed between the time that the man had stopped work and the time that the subsequent ECG was commenced. The tracing after exercise was confined to Leads I, II, III, V₅, and V₆, which were recorded in series over a period of 5 to 7 minutes.

ANTHROPOMETRIC TECHNIQUES

The standing height of each man, in his stocking soles, was measured to the nearest $\frac{1}{4}$ inch and his weight was recorded without shirt or shoes, but wearing his trousers. From these measurements the ponderal index (Pearl, 1940; Sheldon, Stevens, and Tucker, 1940; Parnell, 1958) was calculated, using the formula:

$$\frac{\text{Height in inches}}{3 \sqrt{\text{Weight in pounds}}}$$

All the men had had their height and weight recorded when they first joined the brewery and these data were also available. Skinfolts were taken as being indicative of body fat, and these were measured in millimetres with a Harpenden skinfold caliper (Tanner and Whitehouse, 1955). The following sites on the left side of the body were studied:

- (a) Over the triceps midway between the shoulder and the elbow,
- (b) Beneath the lower angle of the scapula,
- (c) Above the iliac crest in the midaxillary line.

In order to obtain a fat "score" these were added and the total was transformed to a logarithmic scale using the formula† recommended by Edwards, Hammond, Healy, Tanner, and Whitehouse (1955) for eliminating skewness from the distribution.

A preliminary analysis of the first 129 case records showed a relationship between physique and coronary heart disease which will be described below. In order to investigate this further, the following additional anthropometry was carried out on 91 of the last 92 men to be examined: the chest

fully inflated and fully deflated; and on the left side of the body the flexed biceps, maximum calf diameter while standing normally, distance between the condyles of the humerus at the elbow, and between those of the femur at the knee. Circumferences were measured (in cm.) with a flexible steel tape, and the bone measurements were taken with a pair of stiff engineers' outside calipers, the distance between the points being read off a steel rule.

INTERPRETATION OF ELECTROCARDIOGRAMS

The electrocardiograms were all assessed by Dr. E. Donald Acheson. The reliability of his interpretations was examined by inviting each of three other experienced assessors‡ to make independent readings of a subsample of 56 tracings chosen at random; this showed that his error (as defined by Fletcher and Oldham, 1959) in distinguishing normal from abnormal tracings was 3 per cent. In terms of the specific diagnosis accorded to each abnormal tracing, the level of agreement was not nearly so high, ranging from 100 per cent. for atrial fibrillation through 50 per cent. for infarction to 20 per cent. for myocardial ischaemia. Full details of this study, together with several specimen tracings, are published elsewhere (Acheson, 1960b).

BIOCHEMICAL INVESTIGATIONS

Within 1½ hours of collection the specific gravity of the urine was measured and tests were made for protein and sugar. The serum was separated from the blood sample and albumin and globulin, sugar and cholesterol were estimated. Particular care was taken with the cholesterol estimations which were made by the techniques of Sackett (1925) and of Anderson and Keys (1956). A report giving full technical details together with particulars of the correlates of the serum cholesterol has already been published (Acheson, Hemmens, and Jessop, 1958). The reliability of the cholesterol estimations was checked by a simultaneous interchange of five specimens with the Courtauld Laboratory, Middlesex Hospital, London, which also used Anderson and Keys technique. The means were 229 and 235 mg./100 ml., and the correlation *r* between the two sets of readings was 0.88.

In addition serum proteins and lipoproteins were separated by paper electrophoresis, using a minor modification of the technique of Dangerfield and Smith (1955); the strips were scanned with an automatic reflectance scanner (Latner, Molyneux,

* The criteria of Wood (1956, p. 3) were taken as a basis for deciding whether symptoms presented by a patient were those of angina pectoris. Other contraindications included such different conditions as senility, varicose veins, osteo-arthritis of the hip, and Parkinsonism.
† $z = 100 \log_{10}$ (reading in 0.1 mm.—18).

‡ Dr. A. J. Thomas, United Cardiff Hospitals; Dr. Grant Lee, Radcliffe Infirmary, Oxford; and Dr. I. T. T. Higgins, M.R.C. Pneumoconiosis Research Unit, Penarth, Glamorganshire.

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and Rose, 1954; further details Acheson and Jessop, to be published). The electrophorograms were also kindly read for pre- β -lipoprotein by Dr. Elspeth Smith and all the strips she graded as scoring 2 and over (Smith, 1957) are classified in this study as showing pre- β -lipoprotein.

CLASSIFICATION OF HEAVINESS OF WORK

Each man gave details of the jobs he had performed during his working years together with the time he had spent at each. A list was then made of the jobs each man had held the longest and this was given to one of the Company's Medical Officers for classification into three groups, "Heavy", "Intermediate", and "Light", according to the physical effort involved.

RESULTS

PREVALENCE OF CORONARY HEART DISEASE

Table II shows the method of diagnosing coronary heart disease in 88 of the 221 men who attended. 62 of the 88 had abnormal ECGs. The electrocardiographic changes which were accepted as being indicative of coronary heart disease in this age group were: myocardial infarction; RST segment depression of 1 mm. or more, or T-wave inversion, or both, in left ventricular leads (in the absence of pathological Q-waves) in cases without aortic valvular disease; atrial fibrillation without other cause; and complete bundle branch block.

TABLE II

METHOD OF DIAGNOSING MEN WITH CORONARY HEART DISEASE

Signs	No. of Cases
ECG changes at rest only	39
ECG changes at rest and angina pectoris	19
ECG evidence of myocardial ischaemia after exercise	4
Angina pectoris only	26
Total	88

The number of men showing each of these patterns can be seen in Table III. There were also 26 men with angina pectoris, but without these ECG changes. Eleven of the 88 men with coronary disease (13 per cent.) had never had any cardiac pain, severe palpitations, or symptoms of cardiac failure.

TABLE III

ELECTROCARDIOGRAPHIC CHANGES ACCEPTED, IN THE ABSENCE OF CERTAIN CONTRAINDICATIONS, AS BEING INDICATIVE OF CORONARY HEART DISEASE

ECG Changes	No. of Cases
Myocardial Infarction	8
Atrial Fibrillation	9
Complete Bundle Branch Block (a) right (b) left	3 0
RST Segment Depression (>1.0 mm) and/or T-wave Inversion in Left ventricular Leads (a) at rest (b) after exercise only	38 4
Total	62

Of the 58 men who performed the exercise tolerance test satisfactorily, the subsequent ECG showed no signs of coronary heart disease in 22; in the ensuing analysis these men will be referred to as "healthy". Of the 133 who were not found to have coronary heart disease this leaves 111, who either had a normal ECG at rest but were considered unfit to perform the exercise for reasons other than angina pectoris, or whose ECG before or after exercise showed abnormalities other than those listed above; such men are described as "Indeterminate".

The age distribution of the 88 men described in Table II can be seen in Table IV, where it is shown that, although coronary disease is most prevalent in the oldest age group, there is little difference between the other three.

TABLE IV
AGE DISTRIBUTION OF MEN WITH CORONARY HEART DISEASE

Age (yrs)	Seen at Clinic			Not seen at Clinic			Total		
	Coronary Heart Disease	No. at Risk	Per cent.	Coronary Heart Disease	No. at Risk	Per cent.	Coronary Heart Disease	No. at Risk	Per cent.
65-69	33	82	40	1	10	10	34	92	37
70-74	31	86	36	2	14	14	33	100	33
75-79	12	29	41	2	11	18	14	40	35
80 and Over	12	24	50	2	11	20	14	35	40
Total	88	221	40	7	46	15	95	267	35

It is shown in Table V that the age difference between case and control groups is significant at the 5 per cent. level. Table IV also gives the ages of those who did not attend for medical examination but were entered in the brewery records as having coronary heart disease, and in them the *recorded* prevalence (which is almost certainly an underestimate of the true prevalence) is very much lower in all age groups, though there is a suggestion of increasing prevalence with age. Only those seen at the clinic will be considered further in this paper.

COMPARISON BETWEEN CLINICAL AND ANTHROPO-METRIC CHARACTERISTICS OF MEN WITH CORONARY HEART DISEASE AND THE REMAINDER

In Table V certain clinical and anthropometric characteristics of men with coronary heart disease are compared with those of the remainder. For this analysis "indeterminate" and "healthy" men were combined, because apart from the fact that the "healthy" men were a little younger (see also Acheson and Acheson, 1958, Table IV) they did not differ from the indeterminate group in any of the characteristics studied. A subsequent follow-up showed, however, that they had a better expectation of life (Acheson and Acheson, to be published). Similarly, with the exception of serum lipids (see below) the case group was fairly homogeneous in respect of the variables studied, regardless of the

method of the diagnosis. For instance, in the eight men with myocardial infarction, the mean ponderal index was 12.77 and 12.40 on entry and at survey respectively, and the mean fat index 249.87. These values are closely comparable with those for the whole case group—as indeed were the findings for tobacco consumption and heaviness of work.

It can be seen that the men with coronary heart disease differed significantly from the rest inasmuch as they were slightly older, they were physically stockier at the time of the survey, and they had higher diastolic blood pressures. They also tended to be fatter and to have higher systolic blood pressures. Because all the men with at least 1 mm. depression of the RST segment of the ECG were taken as having coronary heart disease, it is probable that some who were suffering from hypertensive heart disease only were included, since it has been shown that the patterns of left ventricular hypertrophy and myocardial ischaemia cannot be reliably distinguished in this age group (Acheson, 1960b). The difference in arterial blood pressure may be due to them alone, and not to the men with "true" coronary heart disease; in order to investigate this possibility the mean blood pressure of *all* the 38 men with RST segment depression was calculated. The mean systolic pressure proved to be 183.4 mm. Hg (S.E. 5.7) and the mean diastolic pressure 98.6 mm. Hg (S.E. 2.3). Neither of these is significantly higher than the values for the rest of the coronary group, but this contribution does explain most of the

TABLE V
CHARACTERISTICS OF 88 MEN WITH CORONARY HEART DISEASE,
COMPARED WITH THE REMAINING 133 MEN

Characteristic					Coronary Heart Disease Group	Difference from Remainder	<i>t</i>	P
Age (yrs)	...	...	...	...	72.67	+1.33	2.04	0.05
Height (in.)	At entry*	...	...	...	67.91	+0.05	0.16	—
	At survey	...	...	...	66.98	-0.07	0.19	—
Weight (lb.)	At entry*	...	...	...	155.19	+2.12	1.02	0.4
	At survey	...	...	...	160.01	+4.06	1.04	0.4
Ponderal Index	At entry*	...	...	...	12.77	-0.03	0.60	0.6
	At survey	...	...	...	12.37	-0.15	5.25	0.001
Fat	Total of Three Skinfolts (Log scale)†				252.48	+3.81	1.30	0.2
Blood Pressure (mm. Hg)	Systolic	...	...	...	177.23	+6.23	1.50	0.2
	Diastolic	...	...	...	97.27	+3.88	2.15	0.05
Apex Beat (in.)	Distance from Mid-line				4.58	0.00	0.00	—
SerumLipids	Cholesterol (mg.)	...	...	...	213.0	+7.0	1.06	0.3
	Lipoproteins (Ratio β/α)	...	...	...	1.93	+0.11	1.61	0.5
	Frequency of Pre- β -lipoprotein (per cent.)	...	...	...	22.00	+5.00	0.83	0.5

* See footnote * page 53.

† See footnote † page 50.

difference in systolic pressures between case and control groups shown in Table V, although it only accounts for half the difference in diastolic pressure. It is worth adding here that other workers (Brown, Davidson, McKeown, and Whitfield, 1957; Thomas, Cochrane, and Higgins, 1958) have found the diastolic blood pressure to be raised in men aged 55-70 with coronary disease. More important, however, similar tests showed that this sub-group differed little if at all from the rest of the coronary cases in respect of age, ponderal index, or any of the three criteria of serum lipid abnormality. On the other

on entry and such differences as were found in body weight could have occurred by chance in 40 per cent. of samples.

In view of the definite difference in ponderal index, which was first noted when a preliminary analysis was made of the records of the first 129 men to attend the clinic, additional anthropometry was carried out on 91 of the last 92 men (40 with coronary heart disease and 51 controls); the results are shown in Table VI. In the coronary heart disease group the flexed biceps, subcutaneous fat, breadth of femoral condyles, deflated chest circum-

TABLE VI
SOMATOMETRIC COMPARISONS BETWEEN 40 MEN WITH CORONARY HEART DISEASE AND 51 CONTROLS

Measurement		Coronary Heart Disease	Difference from Remainder	<i>t</i>	P
Ponderal Index	At entry*	12.94	-0.02	0.215	—
	At survey	12.47	-0.18	1.302	0.2
Chest (cm.)... ..	Deflated	92.88	+1.06	0.803	0.5
	Inflated	98.25	+0.39	0.298	—
	Expansion	5.37	-0.70	1.667	0.2
Muscle (cm.)	Calf	34.44	+0.46	0.812	0.5
	Biceps	30.50	+1.11	1.891	0.2
Bone (cm.)	Femur	9.75	+0.11	0.937	0.4
	Humerus	8.07	-0.11	1.021	0.4
Fat	Total of Three Skinfolts (Log scale)† ...	250.08	+7.53	1.049	0.3

* See footnote * page 53.

† See footnote † page 50.

hand they do account for some of the extra body fat of the coronary group.

There was no difference in stature or physique*

* The fact that physique differed significantly between the two groups at the time of the survey, but not when the men first joined the brewery merits further comment. There are three possible reasons for this:

- The men who later developed coronary heart disease lost more in stature through the years than the controls. An analysis of the data gave no grounds for believing this—although all the men did “shrink” to some extent, thus lowering the mean ponderal index for the entire sample.
- The coronary heart disease group gained more weight during the years than the controls. Table V shows that there were in fact only 2 lb. more difference between the two groups at the survey than there had been previously. Such weight gain would presumably be due to laying down adipose tissue, and the analysis does not show a significant difference in this respect.
- The two groups differed significantly throughout, but the initial measurements were not sufficiently well standardized to show this. There is reason to believe that this was indeed the case. The purpose of these earlier measurements was simply to ensure that the recruits came up to certain basic requirements in terms of weight for height; they were not designed for research or scientific work. The senior medical attendant at the time of the survey recalled that, whereas his former chief measured the recruits without boots and with few clothes, some of his erstwhile juniors were less careful, and at times the height and weight were recorded of a fully clothed man with footwear. Analysis tended to bear this out, because groups of men who joined the brewery during certain periods tended to lose more height per year between recruitment and the survey than other groups recruited at different times. Furthermore, stature was frequently recorded to the nearest whole inch. Such variation in technique would tend to blur any difference in physique which may have existed between the two groups of men.

ference, and calf all tended to be greater, but the chest expansion and breadth of humeral condyles were less. None of these differences reached the conventional limits of statistical significance in the relatively small numbers examined.

SERUM LIPIDS

The serum cholesterol was only 7 mg./100 ml. higher in the coronary heart disease group than the other 133 men (see Table V) and did not differ at all between the “healthy” and “indeterminate” groups. The β/α lipoprotein ratio and the frequency of pre- β -lipoprotein tended to be higher in the coronary group, but in each case the probability lay outside the conventional limits of statistical significance. For the eight men with myocardial infarction, however, all three measures of the serum lipids were higher than those of the coronary group taken as a whole. When the eight men with infarction were compared with the control group, the difference for serum cholesterol was found to be significant ($P < 0.05$) and

the probabilities for the lipoprotein factors were reduced from 50 to 30 per cent. (Table VII).

TABLE VII

BLOOD LIPIDS OF EIGHT MEN WITH MYOCARDIAL INFARCTION COMPARED WITH 133 CONTROLS

Lipid	Myocardial Infarction Group	Difference from Remainder	<i>t</i>	P
Serum Cholesterol (mg.)	237.37	+31.37	2.06	0.05
Lipoproteins (Ratio $\frac{\beta}{\alpha}$)	2.03	+0.21	1.23	0.3
Frequency of Pre- β -lipoprotein (per cent.)	37.5	+20.5	1.17	0.3

PHYSICAL ACTIVITY AT WORK

Table VIII shows a comparison between the coronary heart disease group and the rest of the sample in terms of the amount of physical exertion involved in the job which they had had the longest. It can be seen that in neither group does the observed distribution deviate to any extent from the expected but such deviation as exists shows that the prevalence is lowest in those whose work was heavy and highest in those whose work was comparatively light, while the intermediate group take an intermediate position. When similar Tables (not shown) were drawn up to compare the "healthy" men with the coronary group and with the indeterminate group, the values for $\chi^2_{(2)}$ were 0.03 and 0.16 respectively ($P > 0.9$).

TOBACCO AND ALCOHOL

Information about the smoking habits of the men at the time of the survey is given in Table IX. In contrast to their alcohol consumption (see below) very few of them were able to recall exactly how much they had smoked when they had been fully employed, although most of them said that when

they went on pension they smoked less than they had previously. There was a very pronounced relationship between age and the type of tobacco used; 62 per cent. of the men aged 75 years and over were pipe smokers and 9 per cent. cigarette smokers, as compared with 28 per cent. pipe smokers and 51 per cent. cigarette smokers in the men aged less than 75 years. It seemed, in fact, that the 1914-1918 war was a critical period as far as the use of tobacco was concerned; those whose smoking habits were established before that time preferred a pipe, but those who started smoking during or after the war chose cigarettes; a similar observation has been made of Englishmen (Edwards, McKeown, and Whitfield, 1959).

TABLE IX

SMOKING HABITS AT TIME OF SURVEY, BY AGE

Type of Tobacco	Age (yrs)				Total
	Under 75		75 and Over		
	No.	Per cent.	No.	Per cent.	
Cigarette	85	51	5	9	90
Pipe	47	28	33	62	80
Cigarette and Pipe	8	5	3	6	11
None	27	16	12	23	39
No Record	1		0		1
Total	168		53		221

In none of the groups of smokers was there any suggestion of a relationship between the use of tobacco and the incidence of coronary heart disease. However, when the three groups of smokers are combined, and their distribution in respect of whether or not they had coronary heart disease is compared with that of the non-smokers, there are five fewer smokers among the coronary group than would be expected were the distribution random.

TABLE VIII

DISTRIBUTION OF SAMPLE BY PHYSICAL ACTIVITY AT WORK IN THE JOB THEY HELD THE LONGEST

Survey Group	Physical Activity at Work						No Record	Total
	Light		Intermediate		Heavy			
	Actual	Expected	Actual	Expected	Actual	Expected		
Coronary Heart Disease ...	18	17.28	28	26.31	40	42.41	2	88
Indeterminate and "Healthy"	26	26.72	39	40.69	68	65.59	—	133
Total	44	44.0	67	67.0	108	110.0	2	221

$$\chi^2_{(2)} = 0.45 \quad (0.8 > P > 0.7).$$

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The probability of this occurring by chance on the basis of χ^2 is between 5 and 10 per cent. (Table X).

TABLE X

COMPARISON BETWEEN ALL SMOKERS AND NON-SMOKERS IN CORONARY GROUP AND REMAINDER

Smoking Habits	Coronary Group		Remainder		Total
	Actual	Expected	Actual	Expected	
Smokers ...	67	71.58	114	109.42	181
Non-Smokers	20	15.42	19	23.58	39
Total ...	87		133		220
No Record	1		—		1

$$\chi^2_{(1)} = 2.73 \quad (0.1 > P > 0.05)$$

Table XI compares the consumption of stout of the two groups, both at the time the men were seen, and when they were at work. Two points about this Table are worthy of comment; first there is little to suggest that there is any relationship between the amount of stout consumed and the presence of coronary heart disease; secondly as a group they reduced their alcohol intake by over 80 per cent. when they retired. The reasons for this were multiple; all of them had been entitled to at least 2 pints* a day free of charge—the draymen had many more than that—but when they retired this allowance stopped. When they became pensioners they had less money to spend on alcohol, and their need for fluids was presumably less than when they were doing hard work. Yet the fact remains that men, some of whom had averaged 20 pints a day for 30 years, were able to reduce this at will without any apparent ill effect; it seems to follow that stout drinking even in extreme quantities does not necessarily lead to addiction.

TABLE XI

CONSUMPTION OF STOUT BY CORONARY GROUP AND REMAINDER

Consumption of Stout (pints/day)	Coronary Heart Disease Group		Remainder	
	Mean	S.E.	Mean	S.E.
Before Retirement ...	6.4	0.65	5.8	0.42
After Retirement ...	1.2	0.14	1.1	0.10

DISCUSSION

Before attempting to evaluate the findings in this analysis, it must be emphasized that it is a retrospective study of survivors only, and that it therefore

* Imperial pint = 0.5682 litres.

differs materially from two of the major surveys of Morris (Morris, Heady, and Barley, 1952; Morris, Heady, Raffle, Roberts, and Parks, 1953) which, although to some extent retrospective in time, were prospective inasmuch as they used comprehensive medical records and so permitted men who died to be included in the analysis. It differs also from the retrospective survey of Gertler and White (1954) because the present data have the advantage that they are divisible into cases and controls, whereas Gertler and White were obliged to try to find matched controls from the population of Boston as well as using a comparison group of 146 unmatched male volunteers. The surveys of Thomas and his collaborators (Thomas and others, 1958; Thomas, Cotes, and Higgins, 1956) are the most closely comparable, in both the viewpoint of sampling and case-finding. Moreover, Thomas and Higgins both co-operated in the study of observer variation on the present ECGs and their level of diagnosis is very similar to that of this study (Acheson, 1960b). These aspects of survey technique are important when the results of each are compared.

PREVALENCE

The prevalence of coronary heart disease in the sample analysed above does not differ materially from that in the sub-sample which was reported previously. The comments and comparisons then made (Acheson and Acheson, 1958) are equally applicable here and need not be repeated. In the earlier study, however, no reference was made to the estimate by Morris and others (1952) that the overall prevalence of coronary disease in doctors aged 65 is 9 per cent. The very wide disparity between their figure and that reached in the present paper is probably largely due to the different methods of case-finding, for Morris had to depend on records of men who had lost time from work because of their illness, whereas each of the Dubliners was carefully examined. Many of those who had incontrovertible signs of coronary heart disease had learned to live with their incapacity so that they had neither lost time before retiring nor consulted a doctor afterwards (see Acheson and Acheson, 1958; Table IX). Two other factors which weigh in opposite directions will influence the present estimate of prevalence: first, it will have been slightly inflated by the inclusion of some men whose RST depression and/or T-wave changes in left ventricular leads was due to hypertension, but were indistinguishable clinically from those with myocardial ischaemia without cardiac pain (Acheson and Acheson, 1958; Acheson, 1960b); secondly, it is certain that seven of the 45 men who did not attend the clinic had coronary heart disease,

and it is highly probable that the prevalence among these absentees was in fact greater than among those who were examined (see Cochrane, 1951), their mortality over a 2-year period being certainly almost twice that of the attenders (Acheson and Acheson, to be published). Thomas and others (1958), who used sampling and diagnostic techniques similar to those used in this research, found the prevalence of coronary disease in miners aged 55 to 64 years to be 38 per cent. and in farm-workers of the same age to be 28 per cent., estimates which accord with those reported here.

PHYSIQUE

The fact that men with coronary heart disease are heavier for their height, *i.e.* stockier, than the controls seems to be the only result of the present study which meets with universal agreement. Gertler and White (1954) found that the ponderal index of American men who had had a coronary thrombosis before the age of 40 years was 0.18 less than that of the controls—a difference which was significant and agreed closely with that reported here. They were also able to somatotype their subjects, using the technique of Sheldon and others (1940), and they classed the coronary group as endomorphic mesomorphs (*i.e.* squarely built muscular men with a tendency to adiposity). In a report on *post mortem* examinations of patients dying of coronary disease before the age of 46 years, Spain, Bradess, and Huss (1953) also concluded that the "predominant" mesomorph was especially at risk. Morris, Heady, and Raffle (1956) did not have enough cases to compare the physique of the busmen who developed coronary disease with that of the remainder, but by comparing the sizes of their uniforms they did show that drivers, who are particularly prone to coronary disease, were burlier at all ages than conductors. Thomas and others (1958) did not use any index of physique and, although they found their coronary group to be significantly heavier than the controls, this must in part be due to the fact that they were significantly taller. Their coronary group did, however, have a greater arm girth without showing any difference in the amount of subcutaneous fat in the arm, a finding which led the authors to the conclusion that the weight difference was more likely to be due to muscularity than to fat. In a longitudinal study, Dawber, Moore, and Mann (1957) showed that excess weight corrected for height carried an extra liability to coronary heart disease but they assumed without justification, that such excess of weight was primarily due to obesity. Forssman and Lindegård

(1958) found their subjects to be fatter but, although they measured physical strength, which did not differ between the groups, they did not assess muscularity somatometrically. These conclusions, taken in association with those shown in Table VI, indicate that *at all ages* the muscular man, who is perhaps a little overweight, is particularly liable to develop coronary heart disease.

SERUM LIPIDS

It has been suggested previously (Thomas and others, 1958; Oliver, 1958) that the part played by serum cholesterol in the pathogenesis of coronary disease may be greater in younger than in older men. Gertler and White (1954) found that the cholesterol was 62 mg./100 ml. higher in their group of patients than in their unmatched controls, and this relationship between coronary heart disease and serum cholesterol in young men has been repeatedly demonstrated by other authors (Oliver and Boyd, 1953; Spain, Bradess, and Greenblatt, 1955; Dawber and others, 1957; Doyle, Heslin, Hilleboe, Formel, and Korn, 1957; Forssman and Lindegård, 1958, etc.). Even subclinical coronary heart disease in apparently healthy young men is associated with a raised serum cholesterol (Rumball and Acheson, 1960). Yet, in parallel with the present group of old men, taken as a whole, Thomas and others (1958) found in their subjects, all aged over 55 years, that the cholesterol level in the coronary group did not differ significantly from that of the controls. An important differentiation in the clinical type of disease which is associated with raised serum lipids was made by Dawber, Kannel, Revotskie, Stokes, Kagan, and Gordon, (1959), who showed that, whereas new cases of coronary thrombosis developing over a 6-year period in Framingham had a raised serum cholesterol, new cases of angina pectoris did not. This also is consistent with the present findings, for the eight men with myocardial infarction—presumably those who had suffered a thrombosis and survived—did have a significantly raised cholesterol level, the difference between them and the controls being 31 mg./100 ml.

The β/α lipoprotein ratio, which is raised in coronary heart disease in younger men (Barr, Russ, and Eder, 1951; Russ, Eder, and Barr, 1951; Oliver and Boyd, 1955), was not significantly raised in these old Dubliners, and the frequency of pre- β -lipoprotein also higher in younger men with fresh infarcts and myocardial ischaemia (Smith, 1957; Weitzman and Smith, 1959)—differed little between the controls and the whole group of old men with coronary disease.

SMOKING AND ALCOHOL

The prospective survey of the relationships between smoking and lung cancer in British medical practitioners by Doll and Hill (1956) showed coincidentally that there was a relationship between the consumption of tobacco and deaths from coronary heart disease, but this was significant in the younger doctors only. They could establish no such relationship in men aged over 65 years, nor could McKeown and his collaborators in a survey of the smoking habits of 1,700 men aged 60 to 69 years (Brown, McKeown, and Whitfield, 1957; Edwards and others, 1959)—both studies thus support the present failure to demonstrate a correlation between smoking and coronary heart disease in old men, whereas Dawber and others (1959) confirm its association with “an increased incidence of non-fatal myocardial infarction and of death from coronary heart disease in men 45–62 [years old]”. Neither Gertler and White (1954) nor Dawber and others (1959) found alcohol consumption to be raised in coronary heart disease, and Reid (1958), having reviewed data from other sources, concluded that, although excessive indulgence in alcohol is associated with a high death rate from circulatory disease in general, it does not appear to cause coronary disease.

HEAVINESS OF WORK

Although Morris (Morris and others, 1953; Morris and Crawford, 1958) concluded that heavy work has definite prophylactic value against developing coronary heart disease early, against dying shortly after the first attack, and to a lesser extent against the disease occurring at all, he did not claim that activity at work prevents coronary heart disease. Subsequent authors who have claimed inability to confirm Morris' findings have not had data which were at all suitable for testing his hypothesis. The failure of the present study or that of Thomas and others (1956) to show any relationship between coronary disease and effort of work are certainly not at variance with Morris' hypothesis, for in both studies the samples were aged over 55, were survivors, and were mostly suffering from the sort of disease that was preponderant in Morris' conductors and postmen. Furthermore, in men aged 55 years and over, the incidence of coronary heart disease that was *not immediately fatal* was almost identical in drivers and conductors, as it was in postmen and telephonists; and in their later analysis of national *post mortem* statistics Morris and Crawford (1958) found that the prophylactic effect of heavy work became progressively less in the older patients. The pathological classification used by Morris in the last mentioned report compares more closely with

that of the present study because, as well as those with angina, there were Dubliners with ECG changes only, a type of patient of which Morris would have been unaware among his London Transport or Post Office employees, who, being symptom-free would not have taken time off work or even consulted a doctor as a result of their coronary heart disease. Like his angina group, however, they were evidently suffering from a chronic form of the disease and over 2 years the prognosis for the angina and “ECG only” group proved to be almost identical (Acheson and Acheson, to be published). The findings in a Birmingham survey also suggest that expenditure of effort is prophylactic in the more acute form of coronary disease only because it was in Social Classes I and II that the light and sedentary workers had a higher incidence of coronary heart disease (Brown, Davidson, and others, 1957), and it was in Class I that “myocardial occlusion” as opposed to “other forms of coronary artery disease” was predominant (Brown, McKeown, and Whitfield, 1958).

AETIOLOGY OF CORONARY HEART DISEASE IN OLD MEN

It would seem that the majority of old men with chronic coronary heart disease who are active enough to attend a medical department for examination differ in many respects from young men who suffer “acute” coronary thrombosis; the older group taken as a whole do not have higher serum lipids, they do not smoke more, and they have not held less energetic jobs. With the important exception of the eight men who had myocardial infarction and whose serum cholesterol levels were raised, the only similarity between the younger and older groups is that both are muscular and perhaps have a tendency to obesity. This raises important questions. Do the greater part of these survivors have the same disease as the acute and dangerous infarct which has become so much more common in younger men? To what extent does a high serum cholesterol contribute to the pathogenesis of coronary atherosclerosis in man? Is the increased incidence of coronary heart disease in such disorders of lipid metabolism as xanthomatosis and diabetes concerned solely with coronary atherosclerosis, or with raised coagulability of the blood, or with both? Does tobacco act only through the known effect of nicotine on the vascular bed (Burn, 1951; Henderson, 1953; etc.), or does it act in other ways? Morris (Morris, 1951; Morris and Crawford, 1958) believes that there has been no increase in the amount of coronary atheroma over the past 50 years, and that some other cause should be sought for the rise in incidence of coronary heart

disease. Presumably, because coronary atherosclerosis is rare or absent when the cholesterol is low (Higginson and Pepler, 1954; Toor, Katchalsky, Agmon, and Allalouf, 1957; Brunner, Manelis, and Loebel, 1959; etc.) and increases in frequency as the cholesterol rises (Oliver and Boyd, 1957), because coronary thrombosis seldom if ever occurs without coronary atherosclerosis, and because there is thought to be a thrombotic element in atheroma formation (Duguid, 1954; Duguid and Robertson, 1955), there has been a tendency among many authors to assume that the cholesterol-atherosclerosis relationship is the most important from the aetiological viewpoint. Such an assumption disregards the cogency of Morris' arguments, for it has now been shown that the coagulability of the blood is increased in hospital patients with coronary heart disease (McDonald and Edgill, 1957) and that such patients become unduly lipaemic after a standard fat meal (Woldow, Chapman, and Evans, 1954; Mitchell and Brontë Stewart, 1959). Evidently coagulability and the lipid content of the blood are closely related (Fullerton, Davie, and Anastasopoulos, 1953; O'Brien, 1956; McDonald and Fullerton, 1958a; MacLagan, Billimoria, and Curtis, 1958) and, while exercise reduces both lipid content and coagulability (McDonald and Fullerton, 1958b; Cohen and Goldberg, 1960), smoking is associated with a raised serum cholesterol (Gofman, Lindgren, Strisower, de Lalla, Glazier, and Tamplin, 1955; Dawber and others, 1959; Karvonen, Keys, Orma, Fidanza, and Brozek, 1959).

All this suggests that coronary heart diseases can be classified in two broad groups which differ in their aetiology as well as their clinical manifestations. The first is angina pectoris (or subclinical ischaemic disease due to coronary sclerosis and detectable on the ECG) which is likely to be found in old men, perhaps in the more active young men and certainly in Social Class V (Brown and others, 1958). The second, which tends to develop in younger men who smoke, are inactive at work, and consume many of their calories in the form of saturated fats (which in the opinion of Sinclair (1958) are deleterious because they have a high ratio of non-essential to essential fatty acids), is coronary thrombosis, the "new" disease commonest in Social Class I (Brown and others, 1958) and a much more sinister entity. Of the 88 cases of coronary heart disease in this study, eighty would seem to fit broadly into the first category, and the eight infarctions into the second. Such a classification is obviously a gross simplification of a very complex problem, however, for both forms can and frequently do occur in the same patient; angina can develop in young men and acute occlusion in old men, although according to Morgan (1956)

the latter may in some cases be due to an atheromatous embolus. Yet such a classification is in line with the suggestions of other authors (Morris, 1951; Elkeles, 1957; Brock, 1958; Morris and Crawford, 1958; Reid, 1958; Acheson, 1958; Robertson, 1959; Gresham and Howard, 1960; etc.) and does help to explain several of the apparent inconsistencies and contradictions in the current literature. It also helps to explain why mortality from cerebral haemorrhage (International List 331), another condition which is associated with atherosclerosis, has not increased in the same way as that classified in the International List as "coronary artery disease" (No. 420).

SUMMARY

221 of a random sample of 267 pensioners, aged 65-85 years, on the books of Messrs. Arthur Guinness Son and Co. Ltd. (Dublin), were interviewed and examined physically by the author between January, 1957, and June, 1958.

In addition to a clinical examination of the heart and lungs, the data included the ECG at rest, and when possible, after exercise; venous blood sample; urine; height, weight, and certain other body measurements; and information about habits. On the basis of a history of angina pectoris and/or ECG changes, 88 men (40 per cent.) were diagnosed as having coronary heart disease; of the 58 men who performed an exercise tolerance test satisfactorily, 22 had a normal ECG immediately afterwards and since they gave no history of angina pectoris were classified as "healthy". When all the 88 men with coronary heart disease were compared with the remaining 133 men they were found to be significantly older ($P<0.05$), to have a higher diastolic blood pressure ($P<0.05$), and to have a lower ponderal index, *i.e.* they were physically stockier ($P<0.001$). The two groups did not differ significantly in respect of total serum cholesterol, β/α lipoprotein ratio, frequency of pre- β -lipoprotein, subcutaneous fat, use of tobacco, alcohol consumption, or physical activity at work. However, eight of the 88 cases in the coronary group had ECG evidence of myocardial infarction and in them the serum cholesterol was significantly higher than in the controls ($P<0.05$). These results are compared with those of other authors and it is concluded that coronary heart disease in old men is due principally to atherosclerosis rather than to thrombosis of the major vessels, and that its aetiology differs from that of the acute thrombotic episodes which are becoming increasingly common in middle-aged men.

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