logist, but only because he discovered abnormalities in the thymus in patients already labelled as suffering from myasthenia by the clinician. From this sprang thymectomy and the observations of pharmacologists and physiologists on a possible relationship between the thymus gland and the myoneural junction. Essential though the contributions of the non-clinical scientists are to the solution of the problem, I do not believe that the work of the clinical neurologist is therefore finished. Looking broadly at the clinical picture he may well ask himself whether myasthenia is a single entity—whether in fact it is a disease or a symptom; whether there is such a thing as thyrotoxic myasthenia as well as an association between thyrotoxicosis and myasthenia gravis, and where in the picture are to be placed the myasthenic syndromes associated with avitaminosis and with carcinoma of the lung. In other words the contributions which the pathologist and the biochemist are making to the building up of the hypothesis about myasthenia should stimulate the clinician to discriminate further in his own field.

And so one might multiply instances: the various forms of polyneuritis, motor-neurone disease, disseminated sclerosis, parkinsonism of the degenerative type, even epilepsy itself, at once suggest themselves as fields of research where the clinical neurologist with a knowledge of the possibilities of biochemistry may have a contribution which he alone has the power to make.

The relationship between the metabolism of the nervous system and that of the rest of the body is still almost uncharted territory. How rich it is in possibilities is shown by recent research on the metabolism of copper and the amino-acids in Wilson's disease, and this also shows how important are the links between neurology and internal medicine.

A Challenge

I have but touched the fringe of a vast subject, but I hope I have said enough to convince you that the prospects for clinical neurology were never brighter than they are today. Let me conclude with some words of Cajal which are both an encouragement and a challenge to us, his successors:

"Great men are at times geniuses, occasionally children, but always incomplete. Even granting that the genius subjected to the test of critical inspection emerges free from all error, we should consider that everything that he has discovered in a given domain is almost nothing in comparison with what is left to be discovered. Nature offers to all of us inexhaustible wealth, and we have no cause to envy those who preceded us, nor to exclaim as did Alexander in consequence of the victories of Philip: 'My father is going to leave me nothing to conquer!'"

". . . The long words of science are justified because they are unfamiliar. This seems to be a doubtful recommendation, and one which suggests that the scientist takes a pride in writing pages that are deliberately obscure. This is not so . . . the apparent unfamiliarity of scientific words, the air they have of belonging to a specialised type of thought and language, sets them apart, in some way, from the speech of everyday life. This is an advantage to the users of both languages. Shapeless and amorphous are literally the same, sleeplessness does not seem to be very different from insomnia, yet in each case both words have their appropriate uses, and the English language is the richer because both are available. It is not true to say that either language can be translated into, or replaced by, the other without loss. The loss may be small, if hypogeal is replaced by underground; it is much greater if hypostatic is translated into understanding. It may even be complete. Kipling once told us that,

> The Colonel's Lady an' Judy O'Grady
> Are sisters under their skins.

His meaning is lost if a scientist describes them as subcutaneous siblings."—T. H. SAVORY. *The Language of Science*. London, 1953; p. 184.

CORONARY HEART-DISEASE AND PHYSICAL ACTIVITY OF WORK

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(*Concluded from p. 1057*)

II. STATEMENT AND TESTING OF PROVISIONAL HYPOTHESIS

The suggestion emerged from part I of this paper that physical activity in work is associated with a lower incidence and severity of coronary (ischæmic) heart-disease in middle-aged men. This proposition is interesting in view of the present dearth of useful theories on the causes of coronary heart-disease and of its probable increase. The possibility that the association may be a causal one, and that factors of *low* incidence and mortality may be identified in occupation, is worth pursuing in the hope of eventually discovering clues to the prevention of the disease. As has so often happened in epidemiology, clues may be discovered before the intimate processes of the disease are fully understood. We therefore adopted the suggestion as a working hypothesis, and proceeded to test it as best we could. The provisional hypothesis may be stated, as an association between variables, thus:

> Men in physically active jobs have a lower incidence of coronary heart-disease in middle age than have men in physically inactive jobs. More important, the disease is not so severe in physically active workers, tending to present first in them as angina pectoris and other relatively benign forms, and to have a smaller early case-fatality and a lower early mortality-rate.

Since there was no indication that the greater incidence and severity of coronary heart-disease in the physically less active workers was associated particularly with mental factors in their work, and for other reasons, no alternative hypotheses were framed for the present in psychological terms, and the observations were confined as far as possible to the dimension of physical activity and inactivity of work. The hypothesis, thus, is not advanced in any exclusive sense: it was necessary, however, to try to isolate it if any progress was to be made.

Methods Adopted in Testing the Hypothesis

In this type of research, dealing as it often must with material impossible to "control," of less accuracy than might be wished, and from which it is difficult to isolate variables, special precautions need to be taken by the investigator. In the present instance reliance was placed on the power of simultaneous attack on the problem from different directions; and independent bodies of material were used so that the cumulative effect (as well as individual findings that may by themselves lack conviction) can be considered.

Attempts have been made to test the provisional hypothesis by observing its capacity to predict in a variety of situations. The following tests were carried out:

First test.—Enlarging the evidence by a further period of observation of the experience from which the original observation was made (London Transport and the Post Office).

Second test.—Extending the hypothesis from "early" to all coronary mortality and observing the national experience

TABLE VII—MORTALITY IN FIRST 3 MONTHS OF FIRST CLINICAL EPISODE OF CORONARY HEART-DISEASE: DRIVERS AND MALE CONDUCTORS (AGED 35–64 INCLUSIVE) OF CENTRAL BUSES OF LONDON TRANSPORT EXECUTIVE, 1949–52

Average Annual Rates per 1000

Ages (years)	Early mortality (first 3 months)		Ages (years)	Man-years observed	Immediate mortality (first 3 days)	Mortality at 4 days to 3 months	Early mortality (first 3 months)		Ages (years)	Man-years observed	Immediate mortality (first 3 days)	Mortality at 4 days to 3 months	Early mortality (first 3 months)	
	Drivers	Conductors					No. of deaths	*Rate per 1000 p.a.*					No. of deaths	*Rate per 1000 p.a.*
	TABLE VII(A) 1951–52		Drivers				TABLE VII(B) 1949–52		Conductors					
35–44	*0·5*	..	35–44	15,878	*0·3*	..	6	*0·4*	35–44	13,510	..	..	2	..
45–54	*1·0*	..	45–54	17,188	*0·8*	*0·4*	20	*1·2*	45–54	7606	*0·5*	..	4	*0·5*
55–64	*4·0*	*2·3*	55–64	9814	*2·6*	*1·2*	37	*3·8*	55–64	5300	*1·1*	*1·1*	12	*2·3*
Total no. of deaths	32	9	Total no. of deaths		44	19	63		Total no. of deaths		12	6	18	
Standardised rate at ages 35–64 incl.	*1·5*	*0·8*	*Standardised rate* at ages 35–64 incl.		*1·1*	*0·5*		*1·5*	*Standardised rate* at ages 35–64 incl.		*0·5*	*0·3*		*0·8*

Definitions as in tables I and IV.

Further population counts were made as on Jan. 1, 1952 and 1953.
$0{\cdot}001 < P < 0{\cdot}01$ testing the difference in table VII(B) between drivers and conductors both in immediate mortality and early mortality, using the t test.

of twenty years ago, described in the Registrar-General's Occupational Mortality Supplement.

Third test.—Making deductions from the hypothesis in terms of the course of coronary heart-disease as well as its incidence and mode of presentation, and trying to verify these on yet another set of data—a current sample of death certificates.

First Test (Direct Confirmation): Further Observation of Transport and Postal Workers

The information in part I covers the years 1949–50, and it was mostly collected by the middle of 1951. The analysis, however, could not be undertaken until 1952, and by this time it was impracticable to collect detailed morbidity data for 1951 and 1952, highly desirable though this was now seen to be. The deaths, however, that occurred during those years were recorded in the Central Record of Staff Statistics of London Transport Executive; and the Post Office has for many years kept records of the mortality of its staff. Since the lower death-rates of the conductors and postmen during the first days and weeks of clinical coronary heart-disease were the main findings in 1949–50 it was clearly important to know whether these workers maintained their advantage in 1951–52, particularly since wide variations in mortality-rates from year to year are commonly found in this type of study even when dealing with substantially larger numbers of cases than we have been able to do.

Table VII(A) gives the early mortality-rates from coronary heart-disease among the drivers and conductors of the central ("red") buses in 1951–52. (The figures for tram and trolleybus drivers and conductors are not shown in table VII because the trams were being withdrawn during 1951.) The drivers have a higher mortality in each ten-year age-group during 1951–52 (in each five-year group also) and the standardised rate summarises the excess as 90%. This was little different from the findings in 1949–50, the greater excess shown in the middle columns of table IV being mainly due to the particularly low mortality among the tram and trolleybus conductors.

Table VII(B) amalgamates the experience of the central bus workers for the four years by adding and averaging the deaths and population figures over 1949–52. The "immediate mortality" of the drivers is seen to be about twice that of the conductors, and mortality in the rest of the first three months is about two-thirds higher; total early mortality is over 80% as much again in the drivers as in the conductors.

Table VIII(A) describes the early mortality among the five postal grades during 1951–52. The Civil Service executives and clerks were not studied in 1951–52; so, unfortunately, only one truly sedentary grade remains—the telephonists. In 1951–52, as in 1949–50, the postmen had a substantially lower early mortality than the telephonists; comparisons with the three "intermediate" grades are again of little interest. The combined rate for 1949–52 in table VIII(B) shows the by now expected trend (fig. 2).

Summing up: in 1951–52 the physically more active workers (conductors and postmen) had lower early mortality-rates than the physically less active workers (drivers and telephonists, respectively). Enlargement of the evidence by two further years' experience therefore, supports the hypothesis.

The next test should be to repeat these special observations in different groups of workers; but this would mean

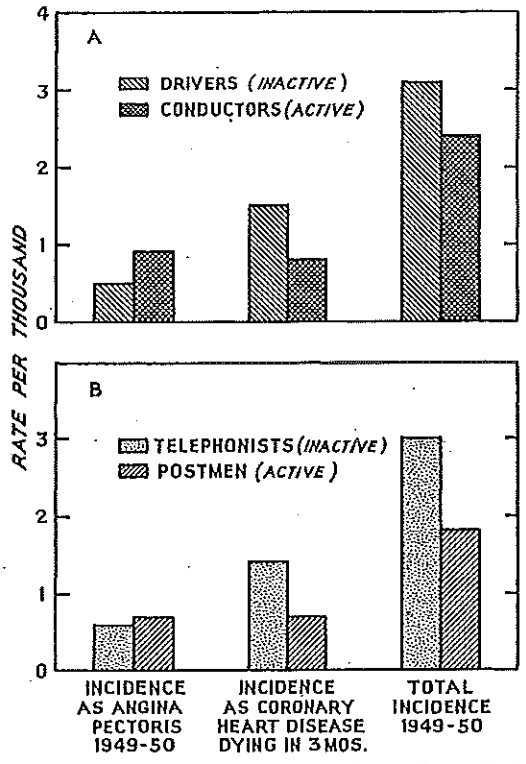

Fig. 2.—First clinical episodes of coronary heart-disease in 1949–52: A, drivers and male conductors, aged 35–64, of Central London Buses; B, G.P.O. male telephonists and postmen, aged 35–59.

a delay of some years before results could be available. We therefore turned to data already available, such data having the merits and drawbacks of being collected for quite other purposes.(b)

Second Test: Physical Activity of Work, and the Death-rate from Coronary Heart-disease

It has been postulated, as the most important part of the hypothesis to be tested, that the "early mortality" from coronary heart-disease—death in the first three months of the clinical disease—is lower in middle-aged men in physically active jobs than in men doing physically inactive work. But it has previously been suggested in this series [12] that this early mortality is responsible for about three-quarters of the coronary deaths *in middle age*.(c) The present postulate may thus be extended to include *all* coronary deaths:

> That men doing physically active work have a lower mortality from coronary heart-disease in middle age than men in less active work.

A test of this extended hypothesis will be a test, though perhaps not a rigorous one, of the original hypothesis.

It was decided therefore to make a special analysis of the mortality from coronary heart-disease in the various occupations for which data are available in the Registrar-General's Occupational Mortality Volume of the Decennial Supplement for 1930–32 [17] the latest (and only) years that could be studied. "Coronary thrombosis" was beginning to be commonly diagnosed in this country late in the 1920s,[15] so the analysis is worth making.

TABLE VIII—MORTALITY IN FIRST 3 MONTHS OF FIRST CLINICAL EPISODE OF CORONARY HEART-DISEASE IN MALE POSTAL WORKERS (AGED 35–59 INCLUSIVE), 1949–52

Standardised Rates per 1000 per Annum

Occupation	TABLE VIII(A) 1951–52: Early mortality (first 3 months) No. of deaths	TABLE VIII(A) 1951–52: Early mortality (first 3 months) *Rate per 1000 p.a.*	TABLE VIII(B) 1949–52: Man-years observed	TABLE VIII(B) 1949–52: Early mortality (first 3 months) No. of deaths	TABLE VIII(B) 1949–52: Early mortality (first 3 months) *Rate per 1000 p.a.*
Postmen	68	*0·7*	160,986	125	*0·7*
Postal and telegraph officers Supervisors .. Postmen higher grade	51	*0·8*	57,440	104	*0·8*
Telephonists	16	*1·5*	25,144	29	*1·4*

Definitions as in tables I, IV, and VI.
Further population counts were made as on Jan. 1, 1953.

METHOD

It is very difficult to differentiate between the occupational groups of social class I (the leading professions, managers, owners, &c.), or of social class II ("lesser" professions, &c.) in terms of the physical work they involve. We therefore examined social classes III (skilled workers), IV (semi-skilled workers), and V (unskilled workers) which include a wide variety of heavy and light jobs. There are mortality data for 70 occupational "groups" in these three classes (excluding the Armed Forces) and they contain over $2^1/_2$ million men aged 45–64 years—the great majority of all the men in these classes.

They used three categories:

	Categories	Groups	No. of men
A	Physically heavy jobs	16	670,465
B	Physically light jobs	23	540,012
C	Intermediate and doubtful jobs—i.e., jobs which were both heavy and light; or neither; about which the referees disagreed; or which they were unable to to classify	31	1,406,549
	Total	70	2,617,026

(The contents of the categories are detailed elsewhere.[13]) We then sorted the groups into their social classes, and calculated death-rates for coronary heart-disease.

We do not in our unit have the necessary knowledge to make an informed grading of these occupation groups to heavy and light work, especially for as long ago as 1930–32. And for a different reason, also, we invited others to make the classification for us. It is important in this kind of inquiry to take precautions against any recognisable source of "bias": in the present instance the grading of jobs should obviously be "blind," so that in cases of doubt the decision whether a job is heavy or light in respect of physical activity cannot be affected by knowledge of what is happening to the other variable being studied—coronary mortality. We therefore requested two colleagues, experts in industrial medicine, to classify the occupation groups—without telling them our hypothesis or, indeed, what problem we were investigating. They kindly agreed; and, in addition, they did the grading independently, consulting together only at the end over a few doubtful groups.

TABLE IX—MORTALITY FROM CORONARY HEART-DISEASE IN HEAVY AND LIGHT WORKERS (MEN AGED 45–54): ENGLAND AND WALES, 1930–32

Average Annual Death-rates per 1,000,000

Social class	Physical demands of work: Heavy	Intermediate and doubtful	Light
III	*172*	*225*	*341*
IV	*166*	*155*	*327*
V	*97*	*236*	*323*
Mixed	*78*	..	*265*
Total classes III, IV, and V	*139*	*229*	*337*
Total no. of deaths (3 years)	154	531	321
1931 Census population ×3	1,110,390	2,363,772	951,732
Men Aged 55–64			
III	*597*	*608*	*916*
IV	*353*	*463*	*556*
V	*363*	*490*	*728*
Mixed	*259*	..	*561*
Total classes III, IV, and V	*396*	*530*	*866*
Total no. of deaths (3 years)	357	983	579
1931 Census population ×3	901,005	1,855,875	668,304

Death-rates calculated from information given in table 4A of the Registrar-General's Decennial Supplement, part IIA (1938).[17]
Deaths are those certified to no. 94 of the Fourth Revision of the *International List of Causes of Death*, 1929.
The classification of occupation groups was specially made.

The rates for classes III, IV, and V combined at other ages were:

Ages (years)	Heavy	Intermediate and doubtful	Light
35–44	*46*	*61*	*61*
65–69	*859*	*1137*	*1745*
70–74	*1227*	*1501*	*2307*

(b) The first two authors alone are responsible for the remainder of this paper.
(c) This study [12] showed that 70% of all coronary *deaths* during the years 1940–50 among a group of medical practitioners, aged 40–64, took place in the first month of the first clinical attack of the disease; the majority of these being deaths in the first few days (here called "immediate").

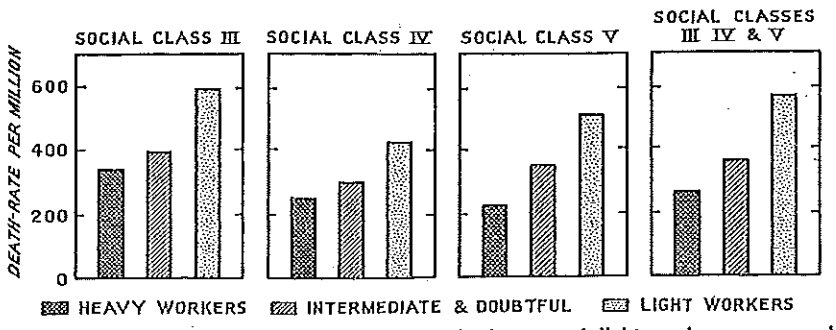

Fig. 3—Mortality from coronary heart-disease in heavy and light workers, men aged 45–64, in England and Wales in 1930–32.

RESULTS

The results are shown in table IX and summarised in fig. 3. In brief, the coronary mortality of the groups doing physically heavy work is rather less than half that of the light groups. The advantage of the heavy workers is seen at ages 45–54 and 55–64 separately, and in the social classes individually. As satisfactory (technically speaking!) as this finding, which supports the hypothesis, is the central placing of the intermediate and doubtful groups, and the strong "trend" shown in the figures. Moreover, the fact that the excess mortality of the light-occupation groups is no more evident among the skilled men of social class III than in the semi-skilled workers of social class IV and the unskilled workers of class V does not suggest that there is an important psychological strain involved in the light occupations which might be responsible for *their* excess mortality. These jobs in classes IV and V—skilled workers in gas works service, metal machinists, metal glazers, &c.; barmen, printing-machine minders, printers, &c.; messengers and porters (excluding railway, &c., porters)—do not obviously involve "responsibility" or special "brainwork," however much some light jobs of social class III may or may not be saturated with psychological stress factors. Fig. 4 plots the mortality-rates of occupation groups with an average of 10 or more deaths per year, and shows almost no overlap of heavy and light groups. If there is a major psychological influence operating to produce the mortality gradient of table IX, the scatter of fig. 4 suggests that it is so intimately associated with the physical factor as not to be readily distinguishable from it.

DISCUSSION

The validity of this test depends on several things, including the classification of the occupations. We cannot at the moment do anything about that. Of another order is the difficulty which arises because men may change their jobs on account of illness. They may be advised, for instance, to transfer from heavy work to light for the sake of their health, and the mortality-rates in light jobs may thus be exaggerated. (Certain low-skilled light jobs indeed are often reserved for the infirm.) This is one disadvantage of having to accept the last occupation before death as a sufficient indicator of a man's main occupation during his life. As already indicated, however, this problem is unlikely to be critical in the present instance, because a majority of all deaths from coronary disease in middle-aged men probably occurs in the first clinical episode of the disease—i.e., *before* there is opportunity to change jobs on account of it. The distribution of deaths in the doctors has already been mentioned. The standard of diagnosis in these doctors is likely to be particularly high, and premonitory clinical manifestations of coronary heart-disease, mild or atypical as well as typical, are far likelier to have been diagnosed among them in 1940–50 than in the general population in 1930–32. Yet, as has been said, in almost three-quarters of the coronary deaths among the doctors there was no record of illness (lasting as much as a week) due to coronary heart-disease before the first reported and fatal attack.

Two further pieces of evidence may be mentioned in support of this proposition:

(1) In a representative sample of death certificates obtained for another inquiry and referring to March, 1952, there were, in men aged 45–74 years, 118 deaths from coronary heart-disease about which some clinical information was available. From this information it appeared that 83 (70%) of these deaths had probably occurred in first clinical episodes of the disease, and 35 probably in second or later episodes. This material will be discussed more fully in the next test of the hypothesis.

(2) A group of light occupations which are highly specialised and require considerable skill and training was isolated from social class III in the Registrar-General's occupational mortality data. Such occupations are potter, compositor, french polisher, railway-engine driver, railway signalman, and the police. It is very unlikely that middle-aged men will transfer to these occupations because they are suffering from coronary heart-disease, or one of its precursors (or even from ill health not considered at the time to be related to coronary heart-

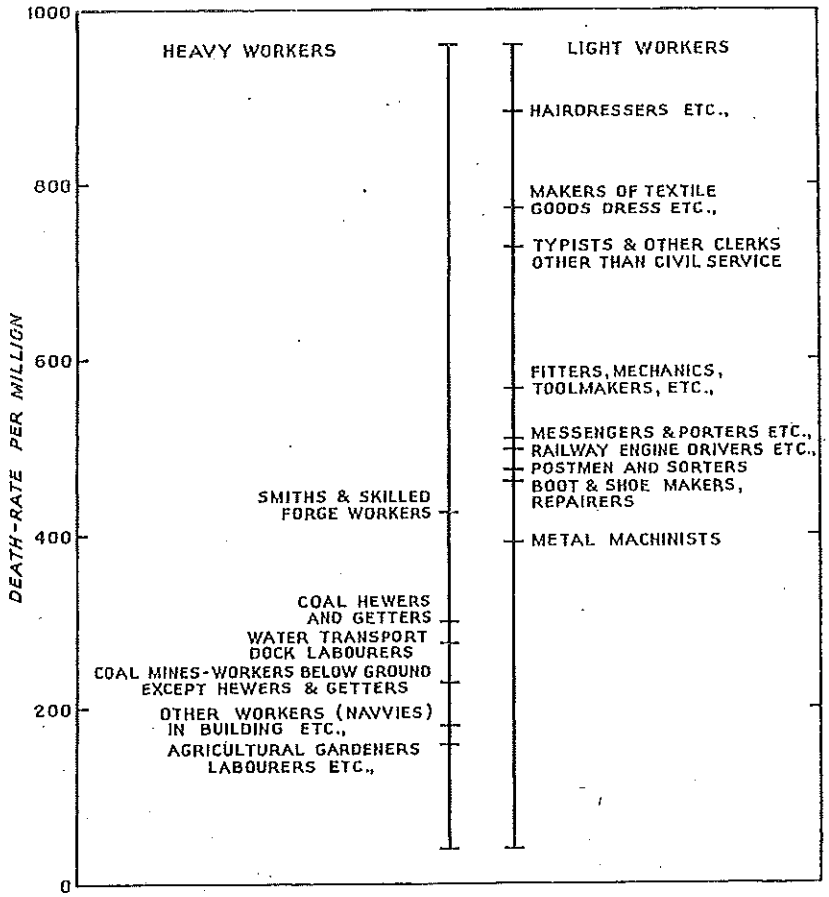

Fig. 4—Mortality from coronary heart-disease in heavy and light workers, men aged 45–64, in England and Wales in 1930–32. Rates for occupation groups in social classes III, IV, and V having 10 or more deaths per year.

disease). Moreover, certain of these occupations will require a pre-employment medical examination. The mortality from coronary heart-disease in this special group of light occupations was found to be substantially greater than in the heavy workers of social class III, and this excess was apparent from 45–54 through 70–74 years of age. This is evidence of course only about one side of the problem—that light workers have a high mortality.

The only alternative explanation we can think of which might account for the trend of table IX is that since heavy workers live often in villages and small towns, and light workers in cities where medical facilities may have been better, the diagnosis of coronary heart-disease—still a relatively "new" condition in 1930–32—might have been more readily made in light workers. However, in the years under consideration, mortality was as commonly ascribed to so-called "myocardial" disease in light workers as in heavy workers, and this renders unlikely an explanation depending mainly on the quality of diagnosis and certification. It will be interesting to observe the trends of occupational mortality between 1930–32 and 1949–53 when figures for these latter years become available; and this may provide another test of the hypothesis. (The suggestion from the preliminary figures for 1949[18] is that the difference between heavy and light workers will be less than in 1930–32.)

Summing up, therefore, it appears that coronary mortality as a whole in each of social classes III, IV, and V was lower during middle age among heavy than light workers, and the hypothesis has been supported and extended. This test has one considerable advantage over the first, for it provides information about categories of work—heavy and light—and not merely about individual jobs. It may also be added that the excess of mortality with light work is more striking in coronary heart-disease than in any of the other causes of death for which the Registrar-General provides data.(d)

Third Test: Physical Activity of Work, and the Natural History of Coronary Heart-disease

So far, these investigations have begun with *occupational groups* involving various degrees of physical activity and have observed the rate of occurrence of cases of coronary heart-disease in them. We next tried to test the hypothesis from the opposite direction by collecting *cases* of coronary heart-disease and observing their distribution among men with various degrees of physical activity in their jobs.

TABLE X—MORTALITY OF HEAVY AND LIGHT WORKERS (MEN AGED 45–64 INCLUSIVE) ENGLAND AND WALES, 1930–32. SOCIAL CLASSES III, IV, AND V COMBINED

Average Annual Death-rates per 1,000,000

Cause of death	Physical demands of work		
	Heavy	Intermediate and doubtful	Light
Coronary heart-disease ..	*254*	*359*	*556*
Myocardial diseases	*1375*	*1706*	*1393*
Valvular diseases, &c.	*1048*	*1179*	*993*
Arteriosclerosis without cerebral lesion	*147*	*186*	*149*
Cerebral vascular lesions ..	*995*	*1203*	*1169*
Nephritis	*574*	*731*	*754*
Diabetes	*119*	*145*	*190*
Bronchitis	*633*	*851*	*522*

See footnotes to table IX and ref. 13.

Coronary heart-disease of middle-aged men may be regarded clinically as a "spectrum." Cases first presenting as angina pectoris belong to the benign and chronic end of the spectrum; those dying in the first clinical episode of "coronary thrombosis" represent the other extreme of malignancy and acuteness; and between these two, which may be regarded at this level of abstraction as "minimal" and "maximal" modes of first attack, there are various grades and stages. (The justification for such an approach lies in the unitary pathology, structural and functional, of ischæmic heart-disease; and in the varying prognosis in different clinical types of it.) Similarly, with deaths from coronary heart-disease: deaths in *later* clinical episodes represent a more benign and chronic type of disease than do deaths in *first* clinical episodes. Regarding the spectrum in terms of the present hypothesis, it may be postulated that the physical component of their work affects the chances that middle-aged men will suffer from coronary heart-disease—i.e., will get on to the "spectrum" (the "incidence"); and also how they will fare, what type of disease they will suffer, and when they will die, if they do get on to it.

We may be able later to test the hypothesis in hospital outpatient departments and wards on patients with coronary heart-disease; but this will be difficult for many technical reasons connected with the characteristic unrepresentativeness of hospital data. Meanwhile we are limiting ourselves to a preliminary consideration of *deaths* from coronary heart-disease, and to quite simple approaches to the natural history of the disease in terms of the mode of first presentation and the subsequent course.

HYPOTHESIS AND DEDUCTION

In heavy workers, it is postulated, the first clinical episode of coronary heart-disease is particularly likely to take the form of angina (or other relatively benign manifestation); and heavy workers are therefore less likely than light workers to die in their first episode. Now coronary heart-disease is a chronic, relapsing condition, and men who have recovered from a *first* episode of it are liable to have later attacks in one of which they will die. If the heavier workers have a more benign form of onset and a lower case-fatality in their first episode than light workers, as the hypothesis affirms,

(d) Analysis in these terms of heavy occupation groups and light is not particularly rewarding with other cardiovascular and related conditions. Table X summarises the findings.

There is a heavy/light trend in mortality from "nephritis"—probably much of it hypertension,[16] and a much stronger one in diabetes; but it is impossible to be as sure in these conditions as with coronary disease that the greater mortalities in the light occupations are not due in substantial part to inflation of the rates by transfer of sick men from heavier jobs. "Nephritis" fails on the trial of the special group of light occupations, though diabetes mortality passes this trial. Many of the diabetes deaths which, because of the coding rules then in force, are best regarded as deaths in diabetic men rather than deaths from diabetes, may well have been due to coronary disease, and the gradient of mortality with physical activity in diabetes, may, therefore, be a further support of the main hypothesis (see also Joslin [3]).

In the other conditions included in the table, the excess mortality in the Intermediate and Doubtful column suggests that the approach is wrong, that the material has been cut, so to speak, against the grain. This may be because physical activity in work is not relevant to the ætiology, whatever it may be, of these conditions; or because these conditions have led to much job-changing—from heavy work to less heavy, for example, or from more skilled lighter jobs to less skilled heavier ones.

We thought of another test of the hypothesis along these lines—that the incidence of coronary heart-disease should be *inversely* correlated with conditions which are commoner in heavy workers. That this test might be useful is indicated by the Registrar-General's occupational mortality data, which show an inverse relation between deaths from coronary heart-disease and deaths from accidents.[13]

they are thus more likely to have the disease in a chronic form—to suffer later episodes, and to die in a later episode. It may therefore be predicted that analysis of a *representative* series of deaths from coronary heart-disease and of the occupations of the men dying (provided these have not been changed to any important extent on account of the disease) will show that

> Heavy workers have a smaller proportion of their coronary deaths in first clinical episodes of the disease, and a bigger proportion in later episodes, than light workers (Deduction A).

This deduction may be restated, that the ratio

$$\frac{\text{Deaths occurring in first clinical episodes}}{\text{Deaths occurring in later episodes}}$$

will be smaller among heavy workers than light workers. It is, of course, an inference drawn from the more important part of the provisional hypothesis—that physical activity in work is associated with less severe coronary heart-disease.

METHOD

We were much interested in the idea of testing the hypothesis in this way, but the only sample of death certificates available, though representative, was not really large enough for a thorough treatment of the method. What follows must therefore be regarded as a trial run, a "pilot" of the proper test.

TABLE XI—NATURE OF WORK OF MEN (AGED 45–74 INCLUSIVE) DYING OF CORONARY HEART-DISEASE, LONDON AND HOME COUNTIES, MARCH, 1952

Number of Deaths in Various Categories

Clinical stage of disease at which it was considered men died	Physical demands of their work				Total
	"Heavy" work		"Light" work		
	Heavy	Moderately heavy	Moderately light	Light	
Row 1 Deaths in first episode (ordinary certificates)	2	3	20	20	45
Row 2 Deaths in first episode (coroners' certificates)	5	3	16	14	38
Row 3 Sum of rows 1 and 2	13 (7 + 6)		70 (36 + 34)		83
Row 4 Deaths in later episodes (ordinary certificates)	11 (5 + 6)		24 (13 + 11)		35
					118
Row 5 Deaths that could not be classified (ordinary and coroners' certificates)	5	8	14	11	38
Total	17	20	63	56	156

The table includes all deaths registered in the sample period in London and the Home Counties (population approx. 11½ million) except for the following:

In 4 deaths the men had no occupation, or the occupation was not stated on the certificate.

In 3 deaths the occupation could not be graded.

In 21 deaths the certifying practitioner did not provide further clinical information.

The true total is, therefore, 184.

Row 5 is made up of 19 ordinary certificates and 19 coroners' certificates.

Statistical significance.—The distribution of deaths in row 1—where we are most certain that the episodes were "first"—is significantly different (at the 5% level) from that of row 4, but the addition of row 2 makes the difference insignificant. Tests of significance based on such small numbers lose most of their value, however, in the presence of a failure-rate of 36% (we are dealing mainly with 118 deaths out of a possible total of 184). On the other hand, of the 66 deaths not included in the 118, there were 59 (38 from row 5 plus the 21 cases about which the practitioners did not provide further clinical information) where occupation data were available. 22 of these deaths were in "heavy" workers and 37 in "light." It can be shown that only a very bizarre distribution of these deaths to first or later episodes (of which there is no evidence) could falsify the general support given by these data to the hypothesis.

We have copies in our unit, as said, of a representative though small sample of death certificates (kindly supplied to us by the Registrar-General for another and related study [7]). The sample included all deaths from cardiovascular (and some other) conditions that were registered during the first week of March, 1952, in London and the Home Counties and a one-in-three sample of those registered in the second week. The certificates for Coronary Heart Disease, coded by the General Register Office to no. 420 in the Sixth Revision of the *International List of Causes of Death*,[8] were extracted. In nearly all cases the certifying practitioner had provided the unit with clinical information additional to that already on the certificate. It was therefore possible to classify the deaths as follows:

ORDINARY DEATH CERTIFICATES

Deaths that, judging from the information which was provided by the patients' medical attendant seemed to have occurred in the *first* clinical episode of coronary heart-disease.

Deaths that seemed to have occurred in *later* episodes.

"Unclassifiable" deaths.

CORONERS' CERTIFICATES

Coroners' certificates, after necropsy without inquest, were classified into:

Deaths that occurred in hospitals (the minority).

Deaths that occurred elsewhere—mainly at home (the majority).

The latter were regarded as deaths which more probably had occurred in first clinical attacks of the disease than in later attacks, though this can only be a guess; the former, since extraneous factors enter into the decision whether deaths in hospital are notified to the coroner or no, were allotted to "Unclassifiable."

This classification was done independently by two physicians, and only cases on which they agreed were allocated to "first" or "later" categories. In the great majority of certificates there was no doubt about the appropriate categorisation; where there was doubt certificates were regarded as "unclassifiable."

We thus had the following groups of deaths:

(1) Deaths in first clinical episode (ordinary certificates).
(2) Deaths in first clinical episode (coroners' certificates).
(3) The sum of these—all deaths regarded as having occurred in the first clinical episode of coronary heart-disease.
(4) Deaths in later episodes (ordinary certificates).
(5) Deaths that could not be classified (ordinary and coroners' certificates).

Meanwhile, we also copied the occupation from each certificate and approached two more colleagues, specialists in industrial hygiene, with the request that they grade the various jobs in terms of the physical demands of the work; and, as in the previous test, we did not tell them our hypothesis. The new occupational grading used a 4-point scale: heavy physical demands—moderately heavy—moderately light—light physical demands. The experts we consulted had each independently selected this scale; they separately agreed on the allocation of nearly all the jobs; in a few, so they informed us, they agreed after discussion; in three they were unable to suggest any grading.(e)

RESULTS

Table XI presents the results of this classification of deaths and jobs, the horizontal rows corresponding to the categories of deaths listed above. Row 1 gives the occupational distribution of the men whose death certificates were signed in the ordinary way, and which were judged to be deaths that had occurred in the *first* clinical episode of coronary heart-disease on the basis of the special information supplied by the attending practitioner. 2 of the 45 men who so died were heavy workers, and 20 were light workers. Row 4 makes the same analysis for men considered to have died in *later* episodes; 5 of the 35 were heavy workers and 11 were light workers. Reading down the *heavy* column it can be seen that of the 17 heavy workers who died of coronary heart-disease, 2 on ordinary certificates were regarded as having died in their first attack, a further 5 were coroner's cases also classified as deaths in the first episode making 7 deaths during the first attack in

(e) Examples of the grading are:

Heavy	*Moderately heavy*	*Moderately light*	*Light*
Builder's labourer	Bricklayer	Tailor and cutter	Clerk
Platelayer	Sheetmetal worker	Maintenance engineer	Compositor
Agricultural worker	Stoker	Medical practitioner	Telegraphist

TABLE XI(A)—DEATHS FROM CORONARY HEART-DISEASE IN "HEAVY" AND "LIGHT" WORKERS

(Data of table XI)

NUMBER OF DEATHS

Work group	All classes		Social class III		Social classes IV and V	
	Episode of disease in which death occurred					
	First	Later				
"Heavy"	13	11	1	4	11	7
"Light"	70	24	41	14	4	0

RATIOS

Ratios of deaths in first episodes to deaths in later episodes

	First : Later		
"Heavy"	1·2 : 1	0·25 : 1	1·6 : 1
"Light"	2·9 : 1	2·9 : 1	>1·6 : 1

Numbers are taken from row 3—all deaths in first episode—and row 4—deaths in later episodes—of table XI, amalgamating the heavy and moderately heavy workers as "heavy," and the moderately light and light workers as "light."

all (row 3 in the *heavy* column). The *light* column shows that 34 of the 56 light workers were judged to have died in their first attack (20 on ordinary certificates and 14 on coroners' certificates), as against 11 in row 4 which were considered to be deaths in later episodes. And so on.

Table XI (A) orders the data of table XI in a form suitable for testing the Deduction stated previously.(f) The Deduction, on the whole, seems to be borne out. Among the "heavy" workers in all social classes combined, the ratio of deaths in first attacks to deaths in later attacks is less than half what it is in the "light" workers—13 to 11, or 1·2 : 1, compared with 70 to 24, or 2·9 : 1. If, as discussed in the Second Test, "heavy" workers have transferred in any numbers to "light" on account of the disease, and then died, it would mean that the number 24 is inflated and the ratio of 2·9 : 1 among the "light" workers, compared with 1·2 : 1 in the "heavy," underestimates the true difference in the distribution of deaths between these two groups.

Table XI(A) also breaks down the information by social class, and indicates why this has to be done. In brief, there is only one moderately heavy worker (a farmer) among the 36 men in social classes I and II; so it is not possible to test the deductions on our present data for these classes. Social class III includes 5 moderately heavy workers (engineering craftsmen) among the 60 cases, but none of the really heavy workers. Social classes IV and V, on the other hand, have all the really heavy workers of table XI (they were mostly labourers of various kinds) and only 4 light and moderately light workers among the 22 deaths being considered. Since the physical demands of work are thus strongly associated with social class, we had to try to make sure that under guise of heaviness and lightness of work we were not merely dealing with an aspect of social class. The analysis of table XI(A) was therefore repeated *within* social class III, and *within* social classes IV and V taken together. It can be seen that the deduction is also borne out within these classes so far as the numbers permit (fig. 5).

The possibility that the trends of table XI are the product of social-class factors is so interesting that we examined it in another way, by making a similar analysis of the 67 deaths of married women from coronary heart-disease in the present sample of certificates. (The occupation given on the death certificate of a married woman is that of her husband.) The data referring to the married women showed *no* such trends as table XI(A), and Deduction A is refuted in them. There was no evidence, that is to say, that the *wives* of "heavy" workers in social classes III, IV, and V had a different pattern of mortality from the *wives* of "light" workers. The nature of the physical demands of their jobs, it may therefore be proposed, affects the coronary experience of men as a direct *occupational* influence: if physical activity in work was only a reflection of *class* (or social-economic) influences the natural history of the disease in their wives might well also have been affected.(g)

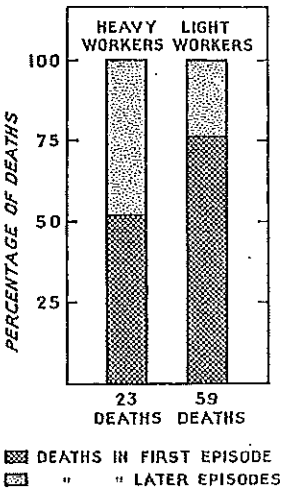

Fig. 5—Nature of work of men, aged 45–74, dying of coronary heart-disease in London and home counties in March, 1952.

Summing up, this death certificate material, which deals with current experience, thus also provides some support to the provisional hypothesis by bearing out deductions drawn from it. Heavy workers, there is some evidence, tend to have coronary heart-disease in a more benign and chronic form than light workers, and to die more commonly than light workers in second or later episodes of the disease. That is to say, using independent data, an association has been demonstrated or (at least, there is promise of it when adequate numbers are available) between physical activity at work and the *course* of the established disease. This association is complementary to that already demonstrated with incidence, mode of first clinical presentation, initial severity of the disease, and early mortality-rate.

III. COMMENT

The present study began with observation of transport workers and the finding that one group of them, the conductors, whose job obviously involved considerable physical activity, had a different experience of coronary heart-disease from the drivers, whose job

(f) We had not intended to extend the present study beyond 65 years of age, because the other parts of it are limited to middle age. But available numbers were too small, especially when it became essential to break them down by social class. The tables therefore include the deaths occurring at 45–74 years of age. For the same reason it was also necessary to amalgamate the moderately heavy workers with the heavy, and the moderately light with the light; and these groups will henceforth be termed "heavy" and "light," for short. Again, to ensure sufficient numbers, the cases of row 1 could not be considered separately from the coroners' cases of row 2, so that in effect rows 3 and 4 can alone be used in testing the deductions. (As the distribution of deaths at 65–74 years is very similar to that at 45–64 years, the introduction of another decade does not introduce a new element into the discussion in so far as the present problem is concerned. The other amalgamations were equally undesirable; but since they made the tests more rigorous—blurring the contrast between row 1 and row 4 for instance—we thought them justifiable.)

(g) Another deduction involves a slightly different treatment of the data. It may be postulated that the *duration* of the disease before death, in a representative series of deaths, will be longer in heavy workers than in light workers. Using only the "ordinary" certificates with adequate information, such an analysis shows that the deduction is borne out. Of 16 heavy workers who died of coronary heart-disease aged 45–74 years, 12 died at three months or more, and 4 died in less than three months, after the clinical onset of the disease. In 59 light workers the duration before death was three months or more in 25 men, and under three months in 34.

(There were 57 deaths ascribed to "myocardial" diseases in men aged 45–74 years in the sample of death certificates. It has been suggested that these deaths should be amalgamated with those certified to coronary disease in analysis of cardiovascular mortality; but scrutiny of the information now available to us indicates that such a procedure would be quite unwarranted.[6 11])

obviously involved less physical activity. The conductors had a lower incidence of coronary heart-disease. More important, the disease they had was less severe, and was less often rapidly fatal. Analysis of the experience of postal workers and Civil Servants showed a similar trend when the postmen were compared with sedentary workers.

A provisional hypothesis was then made about the relations of physical activity in work to the incidence, severity, and mortality of coronary heart-disease in middle-aged men. This hypothesis (briefly, that physical activity in work is associated with a more favourable experience of coronary heart-disease) has now been tested in three different ways—on four independent bodies of evidence; on data from the same source as the original hypothesis and on other data remote from it; basing predictions on deductions and extensions from the hypothesis as well as on parts of the hypothesis itself.

None of the tests we have applied (they are all reported in part II) falsify the hypothesis; some support it strongly, some weakly. The protection against coronary heart-disease associated with physical activity in work has now been demonstrated, in some measure, in national, regional, and group statistics; in the mortality of three social classes separately, and of the larger occupation groups in them individually; in the morbidity from coronary heart-disease of several grades of workers, as well as in their mortality; over the range of middle age and within it; when the standard of diagnosis was held constant and was probably high, and when it may have varied widely; currently and twenty years ago; before the disease was commonly diagnosed and since; on two separate gradings of physical activity; and approaching the problem through the study of "populations" as well as by the collection of cases. Reliance may be placed on the cumulative effect of the regularities that have been demonstrated, however inadequate some individual pieces of evidence by themselves so obviously are. Moreover, the constancy of the association in such varying circumstances encourages the hope that we are dealing with a causal relationship—the most likely origin of such a constancy. The hypothesis, therefore, may be regarded as a useful one which has so far survived. Several questions that arise will now be briefly discussed.

PHYSICAL AND PSYCHOLOGICAL FACTORS

The most important question is about the difficulties, in this type of study, of separating observations of the physical aspects of work from observations of other aspects such as the mental and socio-economic. In the present instance it is quite impossible to be sure how far we have succeeded in isolating physical activity from, for example, confounding psychological factors. Special pains were taken to focus on this physical dimension of work: physical activity and inactivity were identified and examined in a variety of situations, and in each of them they seemed to be important variables. If in fact we have been studying only, or mainly, psychological factors operating under cover of the physical, the association of these psychological factors with physical activity must be extraordinarily close; so close that no matter how the data are analysed from the physical point of view, the unknown psychological factors turn up instead or as well. It is possible that psychological variables, such as work satisfaction and frustration, the presence or absence of anxiety, emotional equilibrium, or personality integration, are correlated with physical activity at work; and they may be in part produced by it. But it seems unlikely that the relation between such psychological aspects and physical activity can be close and regular enough to explain in psychological terms the association with coronary heart-disease that was found (*a*) in such a variety of occupations, and (*b*) in such a diversity of psychological situations. The problem, it must be remembered, is not merely one of coincidence or complementarity in any particular job, but of intimate functional association of emotional equilibrium, for example, with a general physical attribute of work—its physical activity. Another consideration is important. There are, of course, differences in the psychological strains involved in different jobs and in the emotional support they afford, and these may apply generally to the men working in them. However, compared with such general environmental factors, the relative importance of the immediate personal situation (and what it means to the individual) is so much greater in the psychological field than in the physical that an intimate functional association of the psychological with a general physical factor, such as activity, again seems unlikely. At any rate, it has yet to be demonstrated. Nevertheless, it is quite conceivable that at the biological level, physical activity in work performs a stabilising function (for example in channelling so-called aggressive drives) and this may be important in highly civilised societies and, for all we know, may be particularly relevant to conditions such as coronary heart-disease. However applicable these considerations may or may not be, it seems reasonable to postulate that physical activity of work is a relevant factor in coronary heart-disease, whether or no there also are significant psychological aspects, and whether or no these are closely associated with physical activity.[h]

POSSIBLE EFFECT OF PHYSICAL ACTIVITY ON CORONARY CIRCULATION

The next matter of interest is the possible mechanisms whereby physical activity could influence coronary heart-disease if the relationship is causal. One relevant observation at least has been made—that men engaged in more active work do not appear merely to have a lesser total incidence of the disease but also, within this feature, *more* angina. This is easy to understand—that with greater effort a symptom, angina, induced by effort is commoner; and the outdoor nature of much heavy work may also be contributory. Is it possible that this is all that is happening, and that everything else in the coronary circulations of the contrasting occupational groups is equal? . . . that with more physical activity there is more angina; and that this is sufficient (by acting as an early warning signal) to produce the other and beneficial phenomenon of a substantially lower mortality?

It is unlikely from the evidence (and from general experience of coronary heart-disease also) that this can be the whole story. If physical activity in work is effective solely by evoking the symptom of angina, certain corollaries should follow—which do not. The total incidence of the disease should be *higher* in the more active men (whatever the partition of cases between fatal and non-fatal), and it should be appearing at earlier ages because their greater exertion will be inducing symptoms and making manifest in them coronary heart-

(*h*) Rough and ready psychological classifications of most of the Registrar-General's occupation groups of 1930–32 were attempted by two psychologist colleagues. They place little reliance on them, among other reasons, because of the variety of jobs included in single occupation groups, and because of gaps in their own experience. It is interesting, therefore, that in spite of these reservations some suggestive findings emerged. In social classes III, IV, and V, taken together, occupation groups involving (*a*) "team-work"; (*b*) "little or moderate responsibility for things"; and (*c*) "banging, bashing and cutting" (i.e., expression of aggression in action upon materials or physical objects), had less mortality from coronary heart-disease than their relevant contrast groups. These differences are not accounted for simply by the heaviness/lightness of the occupation groups concerned.

disease which in sedentary workers will be quiescent and undetected. Neither in the transport workers nor in the postal workers, however, is there any evidence of greater incidence among the physically more active. Indeed the total incidence is somewhat lower in the conductors and postmen despite its probable inflation with the cases brought to light by greater exertion. Nor is there any suggestion that the disease is appearing in the physically more active at younger ages.

The proposition then that their different rate of symptom formation and manifestation (highly important influences of occupation on health), together with the consequences of these, alone distinguish the physically more active group from the physically less active, would appear to be an inadequate explanation of the present observations. We need, therefore, to consider the possibility that physical activity acts upon the coronary circulation itself, as well as influencing the demands made upon it; that greater physical activity benefits the coronary circulation, or lesser activity damages it, or both. What mechanisms may be involved can only be guessed: whether, for example, there is protection (a greater ability to "cope" with thrombosis/occlusion) because of hypertrophy of arteries and small vessels with activity (an increased coronary capacity with the increased blood-flow of exercise;) or, contrariwise, whether there is a greater liability to thrombosis or atheroma with inactivity.

Satisfactory evidence is not available on the possible contribution of sunlight and outdoor life (the last of these, at least, strongly associated with physically active work), or the sedentary posture (not easily separated from lightness of work), or the effects of particularly violent or sudden physical efforts which may introduce other and harmful factors.[1 9 22] Nor are there any facts on the occupational distribution of influences that may mediate the final results—dietary habits, and obesity; or hypertension, for instance. Meanwhile, as a first step in the investigation of possible mechanisms, we hope to define the prevalence of advanced coronary atheroma in men who were engaged in different types of work, bringing together the necropsy material at the London Hospital[10] with the present hypothesis, though special studies will be needed of the architecture of the main and collateral coronary circulation, and of the blood lipids.(i)

OTHER OCCUPATIONAL AND SOCIAL FACTORS

There seem to be occupational factors in coronary heart-disease other than the physical effort of the job. During the present inquiries quite substantial differences in their experience of coronary heart-disease have been encountered between occupational groups where no question of a substantial difference in physical activity arises. The group of general practitioners studied, for example, appeared to have twice the incidence in 1947–50 of the other doctors.[12] (j) The nature of these other occupational factors is unknown. A highly tentative attempt at psychological analysis of the occupational mortality data has already been mentioned. The other scraps of evidence which we have do not suggest that the problem is simply one of responsibility—the executive officers, for instance, do not have a higher incidence or mortality than the clerks. Nor does it appear that mental work as such is sufficient to transform the incidence: schoolmasters, whose experience was observed in much the same way, have the same rates as the "intermediate" group of postal workers, the postal and telegraph officers, supervisors, and postmen higher grade. In physical activity these four occupations are similar, though scarcely in mental. (The total incidence in the schoolmasters in 1949 at 35–59 years of age was 2·0—41 cases—with an early mortality of 0·8; in these postal grades taken together the figures were 2·0 and 0·9 respectively.)

Osler[14] commented on the "remarkable fact with which we are all familiar—that angina pectoris is an affection of the better classes, and not often seen except in private practice." Allbutt[1] disagreed, and of course the greater prevalence of aortic syphilis before the first world war has to be remembered in connection with such discussions. The Occupational Mortality Supplement for 1930–32 recorded a considerable excess of coronary mortality in the men of social classes I and II, and in the course of an interesting discussion suggested that sedentariness of work, and nervous and dietary factors may be involved.[17 20 21] (The standard—and fashion—in diagnosis may also be important in these class differences.) Differences in nutrition (so likely to be proved important in atheroma, the basis of the disease) may provide another link between the contrasting coronary experience of Western and undeveloped countries[4 5]; and between war-time and normal prevalence.[10]

We are thus seeking at least three sets of factors in this field:

(1) Physical activity/inactivity.
(2) Other occupational factors (possibly including psychological ones).

These may operate *within* the same social class as well as contributing to the differences *between* the social classes. In addition, however, there may well be:

(3) Other social factors (possibly including nutritional ones)

also tending to produce differences between the social classes. There is every reason to suppose that various physical, psychological, and social factors operate together, and it is quite possible that unfavourable factors cluster in certain occupational groups.

CONSTITUTIONAL FACTORS

No evidence is available from the present study on the rôle of constitutional influences, traditionally so

(i) An incidental finding may be mentioned here. Analysing the deaths from coronary heart-disease in married women for the purpose of the Third Test it was noticed that, compared with the men, they had far more of their coronary mortality in episodes of the disease later than the first. Among the men there were 83 deaths that had occurred, probably, in first episodes, and 35, probably, in later episodes—a ratio of 2·4 : 1. In the married women, using the same methods and information, the numbers were 35 and 32 respectively, or a ratio of 1·1 : 1. As discussed previously, there is a substantial difference in this ratio between male "heavy" workers (1·2 : 1) and "light" workers (2·9 : 1)—though not among their wives. That is to say, the ratio among all married women is the same as in male "heavy" workers. There are several possible explanations for this phenomenon besides the obvious one.

(j) This excess, it is interesting to notice, was *over-all*, in all three main modes of first presentation of the clinical disease: in angina pectoris as well as in "coronary thrombosis"—myocardial infarction and "immediate mortality." Such a uniform excess is unlike the pattern of the occupational differences in the disease that is the main concern of the present paper. It is possible, therefore, that a high incidence of angina in the presence of a low total incidence, as in the conductors, (or, more generally, the frequency of angina pectoris as first clinical manifestation relative to that of rapidly fatal "coronary thrombosis") may be an indicator that the coronary experience of different occupational groups is being affected by differences in the physical activity of these groups. When this is happening—the hypothesis might be advanced—men in the physically more active group who have a low total incidence and mortality for which their physical activity is materially responsible will nevertheless have, as a discriminant feature, a high absolute incidence of angina (or high, at any rate, relative to the incidence of "immediate" death.) There are many possibilities in industrial medicine for testing such a hypothesis.

important, and of increasing interest in chemical and physical terms.[2] What we are really concerned with, in a disease that certainly has many "causes," is heredity *in* environment. The bus-drivers, for instance, had been driving London buses twenty-three years on average before their first clinical attack of coronary heart-disease, the conductors had "conducted" for twenty-seven. (Many of the drivers had been conductors for a time before they became drivers; but there is no evidence as yet that their experience was different from that of the men who had been drivers from the start.) There are many ways in which constitution and early experience may affect the incidence and natural history of disease. For example, they may influence initial and later choice of job—and also be related to susceptibility to particular diseases. Or, personalities of certain types, and men with certain physiques, may find what they want in light rather than heavy jobs—and develop the diseases associated with their type of personality and physique, as well as the diseases associated with light work. It is premature, however, when so little is known about either constitutional or environmental factors, to attempt any assessment of the contribution of each kind of factor to the production of coronary disease. The problem is similar to the psychological one in that choice of a physical *category* of work, not any particular job, would need to be highly correlated with constitutional factors which increase proneness to coronary heart-disease.

* * *

Since we consider that we are dealing with what is still hypothesis rather than established fact—at most an association has been established rather than a causal connection—we do not propose now to discuss the social implications of the findings. It can, however, be pointed out that they may be relevant to the suggestion that there has been a real increase of coronary heart-disease in recent years—i.e., during a period in which heaviness and hours of work have declined; during the second Industrial Revolution with its new sources of power, its increasing specialisation and mechanisation; in a time of growth in the scale of enterprise, with increasing numbers of men engaged in management, administration, and the bureaucracy. Thus observations such as now reported may indicate future possible approaches to the prevention of coronary heart-disease; though at what stages in the natural history of the disease intervention will become possible is not apparent. However important the constitutional factors may be in coronary disease there is mounting evidence of variation of its incidence with environment in time, place, and society. Meanwhile, we need evidence as to whether physical activity *outside* work (this may well also have diminished in recent years) in exercise and games, for example, can compensate for lack of physical activity *in* work. If exercise is taken up late in a chairborne life it may conceivably even be harmful.

IV. SUMMARY

This report continues the epidemiological study of coronary disease and deals particularly with the relations of physical activity and inactivity in work to coronary heart-disease among middle-aged men.

Transport workers, postal workers, and Civil Service executive officers and clerks were observed during 1949–50. Bus conductors (on double-decker vehicles) were found to have less coronary heart-disease than bus drivers, and postmen less than telephonists, executive officers, and clerks. Moreover, what disease the conductors and postmen had was less severe.

On the basis of these observations, the hypothesis was advanced that

> Men in physically active jobs have a lower incidence of coronary heart-disease in middle age than have men in physically inactive jobs. More important, the disease is not so severe in physically active workers, tending to present first in them as angina pectoris and other relatively benign forms, and to have a smaller early case-fatality and a lower early mortality-rate.

This hypothesis was tested in three ways.

The early mortality-rate of conductors and postmen in 1951–52 was again found to be lower than that of the drivers and telephonists. Since this "early mortality" (i.e., death in the first weeks of the first clinical attack) seems to be the greater part of the *total* coronary mortality in middle-aged men, an analysis was made of the Registrar-General's occupational mortality data for 1930–32; this showed that at 45–64 years of age heavy workers had half the mortality from coronary heart-disease of light workers. Examination of a sample of death certificates of coronary heart-disease in London and the Home Counties during March, 1952, suggested that heavy workers died less often than light workers in their first clinical attack, and tended more often than light workers to have the disease in chronic form.

Reference is made to possible mechanisms whereby physical activity and inactivity might affect the processes of coronary heart-disease.

Other possible occupational and social-class factors in coronary heart-disease are considered. At least three possible sets of factors in this field need to be investigated: (1) physical activity/inactivity; (2) other occupational factors, including possible psychological factors; (3) factors in social class, including possible nutritional factors. There may be a cluster of unfavourable factors among certain occupations, particularly in the upper social classes.

We are grateful to a large number of people for helping us in this inquiry: the many hundreds of practitioners and hospital staff who provided us with information; the General Register Office for the certificates in the Third Test and other information; Dr. R. S. F. Schilling, Nuffield Department of Occupational Health, University of Manchester, and Dr. R. Murray, H.M. Medical Inspector of Factories, for the classification of occupation groups used in the Second Test; Dr. P. H. Nash and Mr. R. J. Sherwood of the Occupational Health Sub-Unit, London School of Hygiene and Tropical Medicine, for the classification of jobs used in the Third Test; the National Union of Teachers, the Teachers' Provident Society, and Mr. A. J. Eedle; and our medical and lay colleagues in the Treasury, in other branches of the Civil Service, in the Post Office, in London Transport Executive (particularly Mr. F. H. Spratling, Mr. F. J. Lloyd, and Dr. L. G. Norman), and in the Social Medicine Research Unit (particularly Dr. J. I. E. Hoffman for reading the manuscript and helping to classify the deaths in the Third Test, Dr. E. M. Backett, who also helped to classify these deaths, and Mr. V. B. Kanter who did the psychological ratings of the occupation groups with him, Mrs. I. R. Murray and the secretarial and computing staff).

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