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Death Rates among the Italian Railroad Employees, with Special Reference to Coronary Heart Disease and Physical Activity at Work[1]

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All the male employees of the Italian railroad system at work on April 1, 1963, were classified by age, occupation, level of physical activity, and other relevant social and working characteristics. This group cohort, for a total of 172,459 subjects, was followed for 5 years, and all deaths occurring in that period of time were recorded and analyzed in relation to some of the entry characteristics. The analysis, mainly focused on the question of physical activity at work, showed that the overall corrected death rates are somewhat higher in men with heavy work, as compared with moderate and sedentary workers. The same applies to several other causes of death, individually considered, like "other degenerative heart disease" (excluding true coronary), "chronic bronchitis," and "violence." No substantial differences were found between occupations for death rates due to "cancer" and "strokes." The only cause of death which definitely prevails in sedentary and moderate workers, as compared to the heavy ones, is coronary heart disease, defined by "myocardial infarction and sudden death of probable coronary origin," differences being statistically highly significant.

Coronary heart disease (CHD) is the major cause of death in Western societies. Much investigation has been made on the questions of diet, emotional stress, and habitual physical activity level as basic patterns related to some coronary risk factors, like serum cholesterol, arterial blood pressure, body fatness, and body weight.

Many attempts to investigate the role of physical activity, as connected with work, have been made over the last 20 years; some of them having indicated a higher risk of developing CHD in sedentary people, other studies having not confirmed or having contradicted such findings (1–22, 24–27, 29, 32).

Epidemiological field studies, conducted in relatively small populations, even though intensively studied, seem to be inadequate for solving the question. It became readily evident that different approaches were needed. An ideal way for solving the problem would be that of inducing sedentary people to change their habits and to see whether a long-term follow-up would show a lower incidence of CHD, as compared with control groups. But most feasibility studies and theoretical estimates conducted along this line have also shown the difficulties encountered in obtaining a long-term participation in training programs (23, 26, 28, 30).

A different approach was that of investigating large groups, such as a consistent sample of physically active and sedentary employees of the railroad industry of the U.S.A., classifying them as more or less active, and to following retirements and deaths for 2 years. The results were consistent with the hypothesis that a higher

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level of physical activity may have a protective role against the development and particularly against mortality from CHD (27).

The idea of setting up a similar, even though not necessarily parallel, study of the Italian railroad people, arose from the facilities offered by the Ministry of Transportation, to which the Italian State Railroad system belongs. The knowledge that CHD is less frequent in Italy than in the U.S.A. and the greater differences in physical activity levels of so called "sedentary" vs "active" people in Italy than in the U.S.A. would have added interest to the study.

MATERIAL AND METHODS

In 1963, a census was made of all the male employees at work on March 31, of the Italian railroad system. Each of the 172,459 men was classified by age, occupation, type of work, habitual physical activity related to work, social class, geographical location, salary class, and other characteristics.

The classification of jobs in relation to physical activity could be made by different criteria and in different ways. That presented here is one of the many possible ones, and it was originally suggested by our consultant Dr. H. Taylor, of the University of Minnesota, in 1963. Such classification was constructed before the beginning of the study, and without knowing anything of the subsequent mortality data. The main categories of jobs included in each of the three activity classes are those indicated in Table 1. They have been allocated after a careful study of the characteristics of each job, mainly in relation to the physical activity involved.

During the following 5 years, that is from April 1, 1963, to March 31, 1968, all deaths were recorded that occurred either in people still at work or who had retired in the meanwhile.

The basic information was collected through the Board of Pensions of the railroad, the central files of the Medical Service of the railroad and its peripheral offices. Death causes were obtained from the Board of Pensions and, for men who died after retirement, from the General Register Office of the place where the man lived and/or died.

TABLE 1

LIST OF THE MAIN TYPES OF JOBS REQUIRING DIFFERENT LEVELS OF PHYSICAL ACTIVITY IN THE STUDIED POPULATION

Sedentary
Higher degree of stationmaster, directors of factories and hangars, higher degree of technicians, secretaries, clerks, telegraphers, interpreters, train conductors, file clerks, doormen, etc.
Moderate
Lower degree of stationmasters, some types of switchmen, train driver, engine and wagons supervisors, factory workers, brakemen, skilled technicians, some types of station general helpers.
Heavy
Switchmen, section men, maintenance of rail men, unskilled manual workers, some types of driver helpers.

Non-medical "events" (like retirements) were coded by trained clerks; while medical "events" were coded by an experienced epidemiologist, using as a basis the VIII Revision of the International List of Diseases and Causes of Death of W.H.O. (1967) (31) (three digits classification). Death causes were not classified as indicated on the official certificates, but by searching for the "best" or most "reasonable" cause elicited from all the possible medical information on the health and disease history of each man as recorded on the personal file at the railroad. Cases indicated as sudden and unexpected death (occurring within 24 hours from the onset of symptoms; this information could always be obtained for men still at work) were associated with the code of myocardial infarction (410), when the death was typical for a cardiac mechanism and other possible causes could be excluded.

In Table 2 a detailed list of terms used for describing mortality by causes is presented together with the corresponding International Codes. All the subsequent tables will refer to such terms. The main aim of breaking down the cardiovascular mortality, in the way presented there, is connected with the intention to keep the cases of degenerative heart diseases where the coronary involvement is surely or almost surely in a different category from those where there are some doubts about a true coronary participation to the disease. On the other hand, cases of death classifiable in the class defined "other degenerative heart diseases" are relatively rare before the age of 60.

Rates were computed per 1,000 men exposed to risk. The age breakdown was made by 5-year classes, whereas the occupational classification was limited to the three large groups of sedentary, moderate, and heavy workers.

In connection with the different age distribution of the three occupational groups, the direct standardization of rates was therefore performed using the overall railroad population age distribution as standard population.

The term "corrected cases" indicates the number of men with a given "event" who would have been found in the same occupational group on the basis of the "age-corrected rates." Such theoretical numbers have been used for the analysis of the χ^2 statistics in order to test the significance of difference in rates. No Yates continuity–correction has been applied.

TABLE 2

MEANING, IN TERMS OF INTERNATIONAL CODING,[a] OF THE CAUSES OF DEATH AS INDICATED IN THE SUBSEQUENT TABLES

Myocardial infarction and sudden death of probable coronary origin: 410, 411, 413, cases of 412 indicated as healed myocardial infarction, and sudden death as defined in the text.
Other degenerative heart diseases including hypertensive heart disease: cases of 412 (when not included in the previous point), 414, 400–404, 427, 428.
Strokes: 430–438.
Cancer all sites: 140–239.
Lung cancer: 162.
Stomach cancer: 151.
Violence: E800–E999.
Chronic bronchitis and similar conditions: 490–493.

[a] Based on VIII Revision ICD, W.H.O., 1967, three digits classification.

TABLE 3
POPULATION AT RISK CLASSIFIED BY AGE AND PHYSICAL ACTIVITY AT WORK[a]

Age	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60+	Total
S	1728	3528	3150	9013	9454	7683	8287	2707	1866	47,416
M	656	2660	4346	14,821	12,984	10,866	13,242	4228	1090	64,893
H	1590	7563	8482	12,306	10,684	7369	8603	2922	630	60,150
Total	3974	13,751	15,979	36,140	33,122	25,918	30,132	9,857	3,586	172,459

[a] S = sedentary workers; M = moderate workers; H = heavy workers.

RESULTS

Description of the Population at Risk

The age and occupation distribution of men exposed to risk is given in Table 3. As compared with any free-living population, there is a relative shortage of men in the lower and upper age groups. The highest age class is open, but nobody was aged more than 65 and most of men in this group were between 60 and 62.

The age distribution within the three occupational groups seems to be indirectly related to the level of physical activity. This reflects the tendency of men in heavier jobs towards earlier retirement.

Overall Death Rate, Main Causes of Death and Death due to All Causes

Such data are summarized in Table 4. Deaths occurring within 5 years were 3428 (including those of men who died after retirement), the overall crude death rate per thousand in 5 years being 19.87 per thousand. Because of the irregular age distribution of this population, it is difficult to judge about this rate, but for the middle-aged men it is somewhat lower than that of the Italian male population of the same age and sex. This is probably connected with selection of men when they enter the railroad. In terms of death causes, cardiovascular diseases as defined here (and not

TABLE 4
OVERALL CRUDE DEATH RATE AND MAIN CAUSES OF DEATH[a]

	Main causes of death and their percentages related to all causes			
	N	%		
Myocardial infarction and sudden death of probable coronary origin	792	23.10	29.81	36.84
Other degenerative heart diseases	230	6.71		
Strokes	241	7.03		
Cancer all sites	1047	30.54		
Violence	405	11.81		
Liver cirrhosis	179	5.22		
Chronic bronchitis and similar conditions	60	1.75		
All other causes	474	13.82		
All causes (grand total)	3,428	100.00		

[a] Deaths in 5 years: 3428. Crude overall death rate per thousand in 5 years: 19.87.

TABLE 5
DEATH RATES DUE TO "ALL CAUSES" IN 5 YEARS, DISTRIBUTED BY AGE AND OCCUPATION. "TOTAL" RATES ARE NOT AGE-CORRECTED. RATES PER THOUSAND[a]

Age	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60+	Total
S	2.31	3.40	5.39	4.88	11.74	17.31	31.61	75.72	92.17	20.24
M	1.52	4.13	3.45	4.79	15.09	18.03	30.35	92.47	115.59	21.71
H	5.03	2.77	3.53	6.66	13.19	18.86	32.89	80.87	169.84	17.60
All	3.27	3.19	3.88	5.45	13.52	18.05	31.42	85.62	112.93	19.87

[a] S = sedentary; M = moderate; H = heavy.

including some of the cardiovascular codes of the international classification) rank first (36.84%), with cancer second. However if cardiovascular diseases are broken down into several more homogeneous categories, none of them has a rate higher than cancer. Anyhow, myocardial infarction and sudden death of probable coronary origin make up 23.10% which is the expected level in Italy for a male population of that age. Another relevant item is the high rate of deaths ascribed to "violence" (11.81%) which is only partly due to an excess risk at work of these men.

Death rates per thousand for all causes are broken down by age and occupation in Table 5. An increasing age trend of exponential type, as expected, is evident. Some irregularities in such trend can be explained by the small numbers involved in some age–occupation classes.

The overall excess of mortality of heavy and moderate workers, as compared to sedentary workers, is statistically significant when corrected rates and cases are considered (Table 6). The possible role of violent deaths is suspected as explanation of such finding.

Deaths due to "myocardial infarction (MI) and sudden death (SD) of probable coronary origin" and to "other degenerative heart diseases," as related to physical activity.

The interest of this study was mainly focused on the question of physical activity as possibly related to the development of coronary heart disease and, therefore, a more extensive analysis has been made on this item.

Death rates due to MI and SD show a regular increasing trend with age in all three occupational groups, apart from some irregularities clearly due to the small numbers involved in the extreme ages. When comparing rates between the three occupational groups and at specific age groups, no or minimal differences exist between sedentary and moderate workers; whereas definitely lower rates occur in heavy workers (Table 7).

A more synthetic view of the facts is reported in Table 6. The χ^2 statistics on "corrected cases" give nonsignificant P values when comparing sedentary with moderate workers: on the other hand, the chance explanation for the differences between sedentary and heavy, and between moderate and heavy workers, are always much less than 0.001.

Apart from possible bias in classification of jobs and of causes of death, the risk of

TABLE 6
AGE CORRECTED DEATH RATES IN THE THREE PHYSICAL ACTIVITY CLASSES FOR SOME MAJOR CAUSES[a,b,c]

Cause of death	Rates			Comparisons		
	S	M	H	S vs M	S vs H	M vs H
All causes	18.46	20.28	21.31	<0.005	<0.001	n.s.
Myocardial infarction and sudden death	5.15	5.19	3.15	n.s.	<0.001	<0.001
Other degenerative heart diseases	1.05	1.28	1.79	n.s.	<0.01	<0.02
Strokes	1.57	1.10	1.71	<0.01	n.s.	<0.001
Cancer all sites	5.70	6.36	6.23	n.s.	n.s.	n.s.
Cancer of lung	1.52	1.32	1.44	n.s.	n.s.	n.s.
Cancer of stomach	0.83	1.08	1.36	n.s.	<0.01	<0.01
Chronic bronchitis and related conditions	0.11	0.38	0.68	<0.001	<0.001	<0.02
Violence	1.24	2.35	3.46	<0.001	<0.001	<0.001
All causes minus violence	17.22	17.93	18.9	n.s.	n.s.	n.s.
Myocardial infarction and sudden death *plus* other degenerative heart diseases	6.19	6.48	4.95	n.s.	<0.01	<0.001

[a] Rates per thousand in 5 years.
[b] The comparison between activity classes are based on the "corrected cases," employing the χ^2 test.
[c] S = sedentary; M = moderate; H = heavy.

dying in 5 years of MI or SD seems to be definitely higher for sedentary and moderate workers as compared to heavy workers, while sedentary and moderate people are substantially at the same risk.

As previously pointed out, "Other degenerative heart diseases" is a category which includes miscellaneous types of heart diseases of chronic degenerative type, including hypertensive heart disease, without clear connection with a coronary disease, according to the common meaning of such term. They account for lower death rates in all three occupational groups, but the situation is reversed as compared with that of MI and SD, since heavy workers are more frequently affected by these diseases than the other two groups.

TABLE 7
DEATH RATES DUE TO "MYOCARDIAL INFARCTION AND SUDDEN DEATH OF PROBABLE CORONARY ORIGIN," IN 5 YEARS, DISTRIBUTED BY AGE AND OCCUPATION[a,b]

Age	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60+
S	—	—	0.65	0.77	3.70	4.68	9.89	22.90	23.04
M	—	0.37	0.69	0.87	4.15	4.41	7.92	26.72	26.60
H	—	0.26	0.35	0.65	1.40	3.25	5.92	17.11	9.52

[a] Rates per thousand.
[b] S = sedentary; M = moderate; H = heavy workers.

No significant differences do exist between sedentary and moderate workers, while the χ^2 statistics is significant when comparing sedentary and moderate with heavy workers. The reasons for this reverse behavior are of difficult search. The question of possible misclassification of cardiac deaths has been tackled by pooling cases of MI + SD with those of "other degenerative heart diseases," starting from the assumption that the latter may have the same etiological meaning as the other purer coronary-type heart diseases; assuming that possible interexchange of diagnosis may have occurred; and considering that heavy workers are more affected by the so-called "other degenerative heart diseases." As a result of this analysis, the last line of Table 6 shows that differences between occupations maintain the same directions as for MI + SD alone and that the chance explanation of such differences is very small, although the values of χ^2 are lower than those found in line 2 of Table 6.

Other possible doubts about this kind of conclusion may arise in relation with eventual misclassification of physical activity connected with the job. In fact, some categories of jobs could be moved from one activity class to the nearest one, on the basis of different points of view. Furthermore, the sedentary group includes a small, but not indifferent, subgroup of so-called doormen, file clerks, attendants, etc., made up, in a large proportion, of men who moved from a more active job to a sedentary one, because of some kind of disease. It has been shown that this group has an excess mortality, at least for overall causes taken together. In order to test the amount of influence of this subgroup on the overall picture, a purer comparison was set up. Limiting the analysis to deaths due to MI and SD and to middle-aged men, two subgroups of men, who are at the extremes of the activity scale, were compared. They are the clerks and the high ranking stationmasters as representative of the sedentary men on one hand, and the maintenance of rail men and unskilled manual workers on the other hand, as representative of the heavy workers. In both cases, men cannot move from one career to the other; they are appointed for that work only, and no confusion can arise whatsoever. Table 8 shows the results of such analysis and a further confirmation is given to the hypothesis that sedentary people are more prone to die from MI and SD than their colleagues engaged in heavy physical work. The corresponding death rates for some other occupational subgroups are reported, as an example of the general situations, in Table 9; the chosen subgroups cover about 75% of men aged 40–59.

Deaths Rates Due to Other Causes as Related to Physical Activity (Table 6)

Deaths due to strokes occurred most frequently in heavy workers; sedentary people came second in this respect, but the significance of differences has no statistical meaning. A lower mortality rate for strokes occurred in moderate workers, the differences with the other two categories being statistically significant. No valid explanation to these findings is apparent.

The death rates due to cancer were considered for all sites, and then separately for the two main locations of this disease, that is, lung and stomach. For all sites, no statistical differences between occupations were found. The same applies to the death rates for lung cancer alone. On the other hand, highly statistically differences have been found for stomach cancer, with a clear predominance of cases in heavy as

TABLE 8

DEATH RATES DUE TO "MYOCARDIAL INFARCTION AND SUDDEN DEATH OF PROBABLE CORONARY ORIGIN." COMPARISON BETWEEN TWO SPECIFIC AND "PURE" OCCUPATIONAL GROUPS, AGED 40–59 [a,b,c]

	Crude rates	Corrected rates	Corrected cases
Sedentary			
Clerks and high rank station masters: 12,090 men at risk	7.27	7.84	95
Heavy			
Maintenance of rail men and unskilled manual workers: 23,318 men at risk	4.74	4.58	102

[a] χ^2 17.46.
[b] $P < 0.001$
[c] Rates per thousand in 5 years.

compared to moderate and sedentary workers. An explanation for this finding does not exist at the moment.

The death rate due to chronic bronchitis and similar conditions is relatively low in this population, but it is of great interest for the marked differences between occupations. Heavy workers are the most prone to the disease; with moderate coming second, and sedentary third. In all comparisons, differences reach statistically significant levels.

Also in the group of violent death heavy workers are the mostly affected, while the sedentary ones are the least, with the moderate in an intermediate position. In all the possible comparisons the differences are highly significant. A preliminary deeper analysis of this group of deaths would indicate that the excess mortality of heavy workers is not entirely explained by the work accidents.

As already pointed out we found a slight excess mortality in heavy workers, when considering all causes together. On the other hand, as clearly shown, the violent deaths can account for all the differences between occupations. In fact, no statistical differences arise anymore when all causes minus violent causes are considered (Table 6). This means then, apart from violence, which is a non-natural cause of death, there is a substantial equality of overall mortality risk for these three occupational groups, although, at the level of single death causes, great differences can be found.

Comparisons with the U.S. Study.

A brief comparison with the results obtained by a similar study in the railroad industry in the U.S.A. is due (27). There are, of course, certain difficulties in comparing jobs, but the classification of both the U.S. and the Italian physical

TABLE 9

DEATH RATES DUE TO "MYOCARDIAL INFARCTION AND SUDDEN DEATH OF PROBABLE CORONARY ORIGIN" IN SOME OCCUPATIONAL SUBGROUPS OF MEN AGED 40–59 INCLUDING THOSE PRESENTED IN TABLE 8. AGE-CORRECTED RATES PER THOUSAND IN 5 YEARS[a]

Occupational subgroup	Physical activity	N^b	Rate
Directors of factories and hangars and station administrators	S	934	28.70
Train chiefs and similar	S	943	19.29
Station masters and station assistant	M	1976	15.02
Switchmen, higher degree	M	4818	9.42
Clerks, including directors and inspectors, and high rank stationmasters	S	12090	7.87
Factory workers	M	20324	7.32
Drivers	M	5499	6.60
Maintenance of rail men and unskilled manual workers	H	23318	4.58
Switchmen, lower degree	H	3583	4.51

[a] S = sedentary; M = moderate; H = heavy workers.
[b] N = men exposed to risk.

activity classes has been made by the same person and basically with the same criteria.

The overall picture is not completely similar when the three activity classes are compared in the U.S.A. and Italy for their death experience.

In the U.S. group, the picture is absolutely uniform: the death rates are decreasing from sedentary to moderate to heavy workers for all causes—all causes minus violence, arteriosclerotic heart diseases, and cancer.

The same does not apply to the Italian group, where such a trend is clear only for arteriosclerotic heart disease (anyhow defined), whereas no occupational differences exist for cancer; and an inverse situation occurs for overall deaths, for chronic bronchitis, and for violence. Finally, no difference can be found for all causes minus violence.

An explanation of such different behavior is difficult. There should not be a question of numbers since the American group was slightly greater, even though followed for only 2 instead of 5 years; on the other hand, at least for some causes, as for instance heart diseases, the annual rates are definitely higher in the U.S. than in Italy, as expected. Unfortunately, a direct comparison of rates has been difficult because of the different duration of the two studies, and, partly, the different age distribution.

DISCUSSION

The mortality data presented here seem to answer in a positive way the main objective of the study: that is, whether physical activity connected with occupation may protect men against coronary heart disease mortality. It is important to note that this has been the only finding in full agreement with the parallel U.S. study.

We are perfectly aware that we deal with an observational study, and that possible bias may still exist. A problem which frequently arises in the interpretation of this kind of data is the possible interference of the so-called "vocational tendency into the job choice," which is, within certain limits, linked to socio-economical and educational situations and might be the major factor responsible for the distribution of men in different occupational groups. If this vocational tendency could fully govern any finding concerning the positive relationship of habitual physical activity vs the protection against coronary heart disease, it might be biased by the simple existence of an association, e.g., of tendency to sedentary work and tendency to the disease. A solution of this aspect of the question is hard to devise.

Within the further analysis already planned, there is the question of correlating the salary levels and the socio-economical status, and the level of job-responsibility to overall and coronary mortality. Partial analysis made on the 4-year data showed the expected trend: that is, higher salary, higher socio-economic status, and higher job-responsibility correspond to higher coronary mortality. But since these three variables are highly inversely correlated with physical activity, the meaning of the association with coronary heart disease seems difficult to interpret. A possible hypothesis may be the concurrence of all those characteristics with the development of coronary heart disease (or the protection against it, when considering the opposite level). It is also known that some of the above characteristics might contribute to determine different levels and distribution of other risk factors like blood pressure, serum cholesterol, and smoking habits which could not be measured in this study. A multivariate analysis of those working–social characteristics might help towards a better interpretation of facts.

On the other hand, it is felt that a further follow-up of these occupational groups for several more years, may help to answer other questions. In particular, we would be highly interested to see whether the decrease of physical activity related to retirement of already large subgroups, may induce a decreasing protection against coronary heart disease in men who for their lifetimes have been active and apparently protected. This might be a indirect way of estimating the long term benefit, if any, of physical activity performed for many years.

SUMMARY

All the male employees of the Italian railroad system at work on April 1, 1963, were classified by age, occupation, level of physical activity, and other relevant social and working characteristics. Such a group for a total of 172,459 subjects was followed for 5 years and all deaths occurring in that period of time were recorded and analyzed in relation to some of the entry characteristics.

The analysis mainly focused on the question of physical activity at work and showed that the overall corrected death rates are somewhat higher in men who perform heavy work, as compared with moderate and sedentary workers. The same applies to several other causes of death, individually considered, like "other degenerative heart disease" (excluding true coronary), "chronic bronchitis," and "violence." No substantial differences were found between occupations for death rates due to "cancer" and "strokes". The only cause of death which definitely prevails in sedentary and moderate workers, as compared to the heavy ones, is

coronary heart disease, defined by "Myocardial infarction and sudden death of probable coronary origin," differences being statistically highly significant.

Such results are somewhat contrasting with those of a similar study conducted in the U.S. railroad people, where for all causes and for most individual causes of death, sedentary people showed higher rates than moderate, and these showed higher rates than heavy workers.

The possible influence of job classification and death coding, does not seem to introduce substantial bias in the present Italian study.

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