

EPIDEMIOLOGY

Mortality in participants and non-participants of a multifactorial prevention study of cardiovascular diseases: a 28 year follow up of the Helsinki Businessmen Study

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Abstract

Objective—To investigate pretrial risk factors and long term mortality (1964–1992) in participants and non-participants of a multifactorial primary prevention trial.

Design—A prospective study among 3313 initially healthy businessmen. During the 1960s (1964 onwards), 3490 healthy male business executives born between 1919 and 1934 participated in voluntary health checks at the Institute of Occupational Health in Helsinki. From that period cardiovascular disease (CVD) risk factors were available in 3313 men. In the beginning of the 1970s these men were invited to join a multifactorial primary prevention trial of CVD. Six groups were formed: (I) healthy participants in a high risk intervention group (n = 612), and (II) their randomised control group (n = 610); (III) a non-participant low risk group (n = 593); (IV) an excluded group with signs of CVD (n = 563); (V) a refused group (n = 867); and (VI) dead (n = 68). Groups I and II participated in the five year prevention trial which started in 1974. Other groups were followed up through registers, with no personal contact.

Measurements—Cardiovascular risk factors during the 1960s. Mortality follow up using national registers up to 31 December, 1992.

Main results—Baseline risk factors were lowest in the low risk group, highest in the excluded group, intermediate and comparable in other groups. Eighteen-year (1974–1992) mortality (per 1000) was 79.3, 106.6, 155.2, 179.9, and 259.3 in the low risk, control, intervention, refused, and excluded groups, respectively (P < 0.001). In the whole population of 3313 men, the 28-year (1964–1992) total (n = 577) and coronary deaths (n = 199) were significantly predicted by smoking, blood pressure, and cholesterol; cancer deaths (n = 163) by smoking only; and violent deaths (n = 83) by none of the risk factors. One-hour postload glucose was significantly associated with total mortality in

the intervention group only. When the intervention and control groups were included in the same model, the effect of group on total mortality tended to be dependent on the 1 h blood glucose value (P = 0.06 for the group by 1 h glucose interaction term).

Conclusion—The traditional risk factors (smoking, blood pressure, and cholesterol) are significantly associated with 28-year mortality in this high social class population with previous health education. Conversely, a “clustering” of low risk factors predicted low total, coronary, and cancer mortality. The findings on 1 h blood glucose suggest that factors related to glucose tolerance explain in part the excess mortality in the intervention group compared with the control group.

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Keywords: cardiovascular disease prevention; mortality; mortality in non-participants

Several multifactorial prevention studies aimed at reducing cardiovascular diseases were started during the 1970s.¹ One of these was the Helsinki Businessmen Study which employed a five year treatment period to modify risk factors.² Despite effective lowering of risk factor levels by the intervention methods, the 15 year follow up revealed a significantly higher total, cardiac, and violent mortality in the intervention group than in the control group.³ The reasons for the unexpected results were not readily explained by analyses of risk factors and drug treatments, and therefore explanations have been sought from play of chance or unsuccessful randomisation.^{4–6} Various interpretations of the study results, for example falsely linking increased coronary heart disease and violent deaths to the treatment of hypercholesterolaemia, may even have led to undue pessimism about reducing cardiovascular risk factors.⁷ Because of this discussion we became interested in analysing the results in their epidemiological context, that is, in the whole “background”

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population consisting of over 3300 businessmen. In contrast to most prevention studies, the Helsinki Businessmen Study has the unique possibility of yielding pretrial risk factor levels and reliable 28-year follow up data of participants and non-participants alike, including men who were excluded because of low levels of risk factors and even those who refused to participate in the prevention study.

Methods

Altogether 3490 men, mostly business executives born in 1919–1934, participated in health checks during the 1960s (1964 onwards) at the Institute of Occupational Health, Helsinki. Initially all men were professionally active and without serious disease. The degree of self selection was probably high as the health checks were voluntary and were performed only in Helsinki. The health checks included clinical examination, ergometry, and laboratory tests. According to the results the men were given health education to improve their cardiovascular disease risk factors. The present study includes the 3313 men (95% of all, the “background population”) from whom risk factor levels were available, and who were subsequently divided to six groups in 1974 (fig 1). During 1973–1974 all these men were evaluated in order to find healthy volunteers with cardiovascular disease risk factors for a multifactorial primary prevention trial. Inclusion criteria for the trial have been described in detail earlier.² After the selection procedures, the following six groups were formed. The inclusion criteria were met by 1222 healthy men who were randomised to (I) an intervention group (n = 612) and (II) a control group (n = 610). The risk factor criteria were not fulfilled by (III) 593 volunteers (the “low risk” group). Another excluded group (IV, n = 563) had symptoms suggestive of cardiovascular disease in the Rose questionnaire (51%), were on regular medications

(20%), or fulfilled other exclusion criteria (20%). Only 53 of them (9%) were excluded because of a history of myocardial infarction (35 men) or ischaemic stroke (18 men). The invitation to tests was refused or not responded to by (V) 867 men (the “refused” group). Group VI consisted of the 68 men out of the 3313 who had died by 1974. Between 1974 and 1980 the intervention and control groups participated in the five year multifactorial prevention trial. These groups and the low risk group were re-evaluated in 1979–1980² and in 1985–86.⁸ Risk factors of the excluded group (IV) and the refused group (V) have not been explored after 1974.

Mortality up to December 31, 1992, in the whole population of 3313 men was determined using the countrywide computerised cause of death register of the Central Statistical Office of Finland. Assessment of vital status is thus 100% complete. Because the population was defined in 1974 as those who were born between 1919 and 1934 and attended at least one health check between 1964 and 1974, the follow up is partly retrospective. Thus we have used two follow up times in this report. (1) Although the mean year of first visit was 1968, a few men belonging to the background population died before that. Therefore we chose the year 1964 (all of the population alive) as the formal start of the follow up involving the whole background population of 3313 men. (2) In the analyses concerning the five groups formed in 1974 and described above, we have used the year 1974 as the start of follow up.

Standard BMDP statistical software⁹ was used for analyses. Mortality differences between the groups were compared using Kaplan-Meier survival curves (BMDP program 1L). Relative risks (hazard ratio, RR) with their 95% confidence intervals (CI) for mortality associated with different initial risk factors were calculated using Cox's model (BMDP 2L).

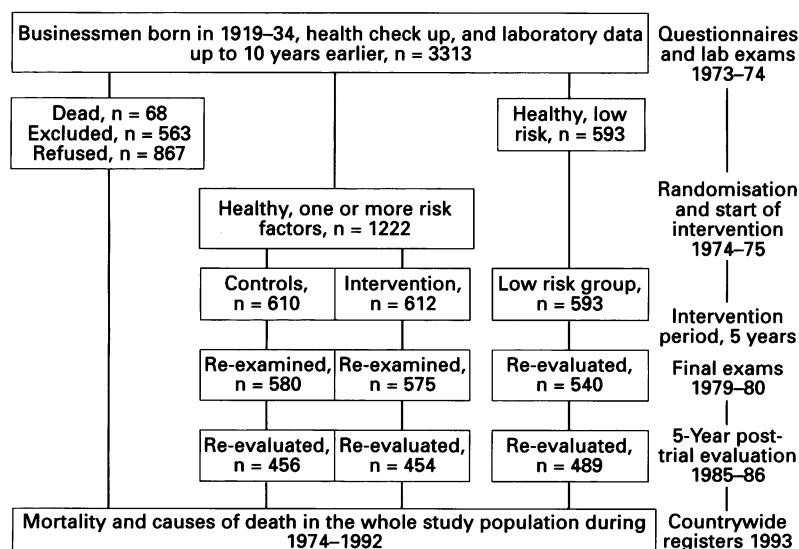


Figure 1 The Helsinki Businessmen Study 1964–1992

Results

RISK FACTOR LEVELS IN THE GROUPS IN THE 1960s

Earlier risk factor levels determined in the 1960s for the different groups defined in 1974 are shown in table 1. The age profiles were roughly comparable. The low risk group—as expected—already had the lowest risk score in the 1960s, whereas the highest and second highest risk scores were observed among the men who had died by 1974 and in the excluded group, respectively. The risk scores were roughly similar in the control, intervention, and refused groups. Smoking tended to be more prevalent in the refused group, which included both low risk individuals and individuals with illnesses.

MORTALITY IN DIFFERENT GROUPS

Among the 68 men who had died by 1974 the most frequent causes were violence (34%), cardiac disease (31%), and malignant disease (18%). During 1974–1992, total, cardiac, and

Table 1 Pretrial risk factor levels in the groups defined in 1974

Risk factor*	Low risk group (n = 593)	Control (n = 610)	Intervention (n = 612)	Excluded (n = 563)	Refused (n = 867)	Dead in 1974 (n = 68)
Age in 1974 (years)	47 (4)	48 (4)	48 (4)	49 (4)	48 (4)	50 (4)
Body mass index (kg/m ²)	25(2)	26 (3)	26 (3)	26 (3)	26 (3)	26 (3)
Blood pressure (mm Hg)						
Systolic	130 (11)	135 (15)	135 (13)	144 (20)	136 (17)	147 (22)
Diastolic	83 (7)	86 (9)	86 (9)	92 (13)	86 (10)	93 (15)
Cholesterol (mmol/l)	6.6 (1.0)	7.4 (1.3)	7.4 (1.2)	7.4 (1.3)	7.2 (1.3)	7.6 (1.4)
Triglycerides (mmol/l)	1.2 (0.6) n = 211†	1.7 (1.0) n = 260	1.6 (0.7) n = 255	1.7 (1.0) n = 399	1.5 (0.8) n = 278	
1 h Glucose (mmol/l)	5.8 (1.5) n = 479†	6.4 (1.8) n = 493	6.3 (1.8) n = 498	6.7 (2.3) n = 524	6.3 (2.0) n = 701	6.4 (2.6) n = 67
Smokers (%)‡	24.8	43.1	44.5	45.7	46.9	52.1
Risk score§	12 (8)	22 (17)	21 (18)	29 (28)	21 (22)	43 (50)

*Data are mean (SD).

†n = number with measurement.

‡Includes also less than 10 cigarettes/day.

§Calculated according to Keys¹⁰ (risk of cardiac death or Q wave infarction per 5 years and 1000 men).

cancer mortality was lowest in the low risk group (fig 2, table 2). Total mortality was highest in the excluded group, even without the 53 men who had had a non-fatal infarction or stroke before 1974 (data not shown); the second highest mortality was observed in the refused group. Not only cardiac but also cancer mortality was highest in these two groups. Between the intervention and control groups significant differences were observed in the 18 year total (RR 1.46, 95% CI 1.08 to 1.96), coronary (RR 2.05, 95% CI 1.20 to 3.50), and violent deaths (RR 15.9, 95% CI 2.12 to 120.0, table 2). We should point out,

however, that the incidence of violent deaths is similar in the low risk and intervention groups, and there tended to be more deaths in the refused group than in the intervention group (RR 1.16, 95% CI 0.92 to 1.46; table 2, fig 2).

FACTORS ASSOCIATED WITH MORTALITY DURING FOLLOW UP

The associations between initial risk factors and mortality were examined in all 3313 men for the 28 year (1964–1992) follow up period. Total deaths were significantly predicted by age (RR 1.48, 95% CI 1.31 to 1.66), systolic blood pressure (RR 1.18, 95% CI 1.13 to 1.24), serum cholesterol (RR 1.11, 95% CI 1.04 to 1.19), and smoking (RR 1.87, 95% CI 1.55 to 2.25); coronary deaths by age (RR 1.44, 95% CI 1.19 to 1.75), systolic blood pressure (RR 1.24, 95% CI 1.15 to 1.34), and cholesterol (RR 1.26, 95% CI 1.13 to 1.41). Cancer deaths were significantly predicted by age (RR 2.20, 95% CI 1.76 to 2.76) and smoking (RR 3.45, 95% CI 2.38 to 4.99). No significant associations were observed between the measured risk factors (including cholesterol) and violent (non-illness) deaths. Since 1 h postload glucose was determined in only 2762 men in the 1960s, relative risks associated with this criterion were assessed separately (but using all the other risk factors

Figure 2 Kaplan-Meier survival curves up to 31 December, 1992, of the groups defined in 1974. 1. Low risk group; 2. Control group; 3. Intervention group; 4. Refused group; 5. Excluded group. Difference between groups: $P < 0.001$ (Wilcoxon).

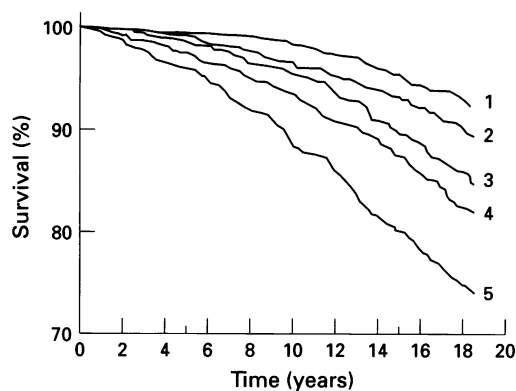


Table 2 Deaths during the 18 year (1974–1992) follow up of the study groups

Death*	Low risk group (n = 593)	Control group (n = 610)	Intervention (n = 612)	Excluded (n = 563)	Refused (n = 867)
Coronary heart disease	15.2 (9)	31.1 (19)	63.7 (39)	119.0 (67)	50.7 (44)
Ischaemic stroke	1.7 (1)	3.2 (2)	0 (0)	12.4 (7)	12.7 (11)
Intracranial haemorrhage	1.7 (1)	6.6 (4)	3.3 (2)	0 (0)	0 (0)
Subarachnoid haemorrhage	1.7 (1)	0 (0)	0 (0)	7.1 (4)	5.8 (5)
Other cardiovascular disease	1.7 (1)	1.6 (1)	1.6 (1)	24.9 (14)	3.5 (3)
Neoplasms	28.7 (17)	47.5 (29)	44.1 (27)	53.3 (30)	55.4 (48)
Violent deaths	25.3 (15)	1.6 (1)	26.1 (16)	21.3 (12)	18.5 (16)
Accidents	16.9 (10)	1.6 (1)	21.2 (13)	16.0 (9)	11.5 (10)
Suicide	6.7 (4)	0 (0)	3.3 (2)	5.3 (3)	5.8 (5)
Homicide	1.7 (1)	0 (0)	1.6 (1)	0 (0)	1.2 (1)
Other	3.4 (2)	13.1 (8)	14.7 (9)	16.0 (9)	30.0 (26)
Unknown	(0)	(1)	(1)	(3)	(3)
All	79.3 (47)	106.6 (65)	155.2 (95)	259.3 (146)	179.9 (156)

*Deaths per 1000 men until 31 December, 1992. Classified according to the Finnish version of the *International classification of diseases* (ICD-9). The numbers in parentheses indicate absolute events.

as covariates). In these analyses 1 h glucose was not significantly associated with the 28 year mortality. Exclusion of the intervention group did not change the results.

Additional age adjusted analyses showed that particularly coronary mortality but also total mortality rose by the cholesterol quintile of the 1960s. RRs for total mortality were 1.00, 1.03, 1.21, 1.18, and 1.51 (95% CI 1.17 to 1.95) from the lowest to the highest cholesterol quintile. No association was observed between cholesterol and cancer deaths or violent deaths. Examinations of suicides ($n = 23$) and other non-illness deaths ($n = 60$) separately gave similar results. Further division of the lowest cholesterol quintile with 92 deaths into tertiles (cut off points 5.2 and 5.9 mmol/l) showed that the lowest cholesterol level was associated with the lowest risk (RRs 1, 1.4, 1.3).

In stratified analyses examining the risk factors for total mortality in the different groups defined in 1974, smoking was consistently significant (RRs 1.5 to 2.8 compared with non-smokers; table 3). In addition, systolic blood pressure predicted mortality in the excluded and refused groups and marginally so in the control group. Interestingly, while age consistently predicted mortality in other groups (45–70% increase in RR per five years) the 19% increase in the intervention group was not statistically significant (table 3). One-hour glucose (logarithmically transformed value) was significantly associated with total mortality in the intervention group (RR 16.0, 95% CI 2.5 to 100.9), but not in the other groups. The result was seemingly different from that in the control group (RR 1.01, 95% CI 0.1 to 10.6), but as the confidence intervals overlapped we also explored the association using an interaction term in the Cox models. These analyses showed that in the combined intervention plus control groups total mortality was significantly associated with log 1 h glucose (RR 5.79, 95% CI 1.39 to 24.17), Keys' risk score (RR 1.09, 95% CI 1.01 to 1.17), and group (control group 0, intervention group 1: RR 1.53, 95% CI 1.07 to 2.18). When the interaction term (log 1 h glucose \times group) was included in the model the relative risks of group and the glucose were no longer significant, whereas the interaction term

approached statistical significance with a P value of 0.06.

Discussion

The unexpected result of the Helsinki Businessmen Study seemed to give a pessimistic impression of multifactorial primary prevention,^{2,3} and the 18 year results still show a higher mortality in the intervention than in the control group (table 2, fig 2). However, the present analysis of the background population of 3313 men gives an important new perspective on this outcome. The initial setting of the study and the data linkage with the national death register offered a unique chance of obtaining information on pretrial risk factors and survival follow up from men who refused to participate in or were excluded from the actual prevention trial. The present results show that the low risk group—as defined by the cardiovascular risk factor status in the 1960s and 1974—continues to have the best prognosis after 18 years. This concerns not only coronary, but cancer and total mortality as well. Furthermore, those who refused the intervention trial fare even worse than the intervention group. On the other hand, smoking, serum cholesterol, and blood pressure also significantly predicted total deaths in this population of high social class. Unexpectedly, baseline smoking (smoker/non-smoker) did not significantly predict coronary mortality (RR 1.22, 95% 0.89 to 1.67), but the effect is probably diluted by smoking cessation over the follow up years. As a whole, the Helsinki Businessmen Study results cannot be interpreted as refuting the current idea of cardiovascular risk factors.

The "cholesterol debate" has particularly involved the issue of associations between low cholesterol and non-cardiovascular mortality.^{11–13} These concerns have been opposed^{14–16}—most recently by the results of the 4S (Scandinavian Simvastatin Survival Study¹⁷)—and they were not supported by the present study which showed increasing total mortality with increasing serum cholesterol. Multivariate analyses suggested that a 1 mmol/litre rise in total cholesterol implies an 11% increase in mortality. The result is in accordance with earlier experience in Finland from

Table 3 Relative risks of total deaths (1974–1992) for initial risk factors in different groups

Risk factor	Group (number of deaths with complete risk factor data)					
	Low risk group (47)	Control (60)	Intervention (95)	Excluded (142)	Refused (95)	All (439)
Age, 5 year*	1.55† (1.08 to 2.23)	1.70 (1.21 to 2.37)	1.19 (0.92 to 1.53)	1.45 (1.07 to 1.74)	1.49 (1.18 to 2.20)	1.47 (1.30 to 1.65)
Body mass index, 5 kg/m ²	1.37 (0.65 to 2.77)	0.82 (0.49 to 1.37)	1.24 (0.85 to 1.18)	1.06 (0.80 to 1.40)	1.08 (0.78 to 1.50)	1.12 (0.94 to 1.32)
Systolic blood pressure, 10 mm Hg	1.18 (0.92 to 1.50)	1.18 (1.00 to 1.40)	1.02 (0.88 to 1.19)	1.14 (1.05 to 1.25)	1.17 (1.05 to 1.31)	1.18 (1.12 to 1.24)
Cholesterol, 1 mmol/l	0.83 (0.62 to 1.11)	0.97 (0.79 to 1.18)	1.08 (0.92 to 1.27)	1.16 (0.97 to 1.28)	1.11 (0.85 to 1.25)	1.10 (1.02 to 1.18)
Smoking, yes/no	2.27 (1.26 to 4.09)	2.78 (1.62 to 4.77)	1.53 (1.02 to 2.30)	1.69 (1.11 to 2.37)	1.56 (0.99 to 2.46)	1.90 (1.57 to 2.30)
1 h Glucose 1 mmol/l‡	0.30 (0.02 to 5.37)	1.01 (0.10 to 10.6)	16.0 (2.53 to 100.9)	3.27 (0.87 to 12.4)	0.55 (0.09 to 3.43)	2.53 (1.10 to 5.81)

*Interval used in the calculation of the relative risk.

†Relative risks were calculated using the Cox proportional hazards model (95% confidence interval in parentheses).

‡Separate model because of missing data on one-hour glucose (measured in 2695 men of these groups). Logarithmic transformed value adjusted for age, body mass index, systolic blood pressure, serum cholesterol and smoking.

the North Karelia Project¹⁸ and the Seven Countries Study.¹⁹ The impact of serum cholesterol on mortality depends on the proportion of coronary deaths in the population. When this proportion is low, the effect of serum cholesterol is weak as well.²⁰ This is demonstrated in table 3, showing the best association in the excluded group which also had the greatest coronary mortality. Several recent studies²¹⁻²³ but not all,²⁴ have failed to show an association between low cholesterol and cancer. In our study cancer deaths were not significantly associated with initial cholesterol in different analyses and the group with low risk for cardiovascular disease also had the lowest cancer mortality.

The rate of non-illness deaths (including accidents, suicide, and homicide) was significantly higher in the intervention than in the control group.³ On the other hand, a high rate of such deaths was observed in the low risk group. The rates of non-fatal violent events were also similar in these three groups.²⁵ The difference between intervention and control groups may thus be due to a chance, that is, an exceptionally low incidence in the control group. It has been suggested that low serum cholesterol or cholesterol lowering is associated with violent death^{11-13, 26} but the mechanisms are speculative, and, for example, a recent study from North Karelia did not find this association.²⁷ In the Helsinki Businessmen Study population, violent events were not associated with initial serum cholesterol, and in the intervention group fatal and non-fatal violent events were not predicted by in-trial hypolipidaemic drug use.²⁵ On the other hand, these events were independently associated with use of alcohol, which is an important possible confounding variable.

It has been suggested that the associations observed in some studies between low cholesterol and total or non-cardiovascular deaths are due to confounding factors.^{28, 29} In the recent analysis by Law *et al*¹⁶ low cholesterol was associated with excess deaths in community based studies, but not in employed cohorts. In accordance with this, no J curve was observed between cholesterol and total mortality of the whole cohort in the present study of businessmen.

Two findings in the present analyses do not support obvious doubts⁴ that the randomisation of the intervention and control groups could have been unsuccessful. First, as presented in table 1, the risk factor levels between these two groups were similar before and after randomisation. Second, unlike in the other groups, age was not a significant predictor of deaths in the intervention group (table 3), implying that there were modifying factors (intervention methods) on mortality. Taking into account that both blood pressure and cholesterol predicted mortality in the background population, the significant decrease of these risk factors during the intervention² should have improved prognosis in the intervention group. As this was not the case, a chance finding—such as the low mortality caused by violence in the control group

—or more likely something in the intervention methods needs to be considered as a possible explanation for the unexpected result.¹ The present findings may offer an additional potential clue. As shown in table 3, 1 h glucose significantly predicted mortality in the intervention group but not in the control group, despite similar baseline glucose concentrations and significant weight reduction in the intervention group during the intervention period.² The fact that the effect of group on total and coronary heart disease mortality was no longer significant when the group by 1 h glucose interaction term was added to the model suggests that factors related to glucose tolerance explain a part of the excess mortality in the intervention group compared with the control group. Aspects of the intervention methods—possibly mental stress induced by intense health education in the dominant executives, or blood pressure medications^{8, 30}—may have made individuals with impaired glucose tolerance especially vulnerable.

In conclusion, this study shows that the traditional cardiovascular risk factors³¹ are also important predictors of mortality among men of the highest social class. Cholesterol was specifically associated with cardiac deaths and its impact on total mortality seemed to be determined by the proportion of coronary deaths to total deaths. In this population, where confounding factors (initial diseases, different life styles, or social class) were minimised, no evidence was found for an association between low cholesterol and non-vascular or non-illness deaths. The value of studying homogeneous populations to enhance internal validity has also recently been discussed in the context of body weight and mortality.³² However, the important questions remain: what is the optimal treatment to lower the risk factors in primary prevention and what are the target levels for intervention? Apparently the intervention methods were not optimal in the Helsinki Businessmen Study. Consequently, the unconventional results of this trial should—rather than calling for pessimism—stimulate more research to find better intervention methods for the primary prevention of cardiovascular diseases.

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