Ambulatory electrocardiography in car workers

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ABSTRACT A previous study in a car assembly plant showed that production-line workers had a lower incidence rate of heart attacks than executive staff. In the present study some major coronary risk factors and 24-hour ambulatory electrocardiograms were investigated in two age-matched samples of 30 middle-aged men drawn from these occupations. Men with a known history of heart disease were excluded. Compared with production-line workers, executive staff on average had a higher diastolic blood pressure ($P < 0.05$) and fewer took heavy exercise during their leisure time ($P < 0.05$). Ventricular premature beats (VPB) occurred in similar numbers of men in both groups (35%) and the frequency of VPB was also similar for each of the periods of work, leisure and sleep. Apart from isolated ectopic beats, disturbances of rhythm were uncommon, and neither VPB nor other arrhythmias appeared to be induced by occupational factors.

In a study of men employed in an Oxford car factory (Baxter *et al.*, 1976), production-line workers were found to have a significantly lower age-adjusted incidence of heart attacks compared with other workers in the factory and with the rates derived by Kinlen (1973) for men in the Oxford community. Staff workers with executive responsibilities had the highest incidence, almost three times higher than the community. The study described here compared some major coronary risk factors and the frequency of ventricular premature beats (VPB) and other arrhythmias in the ambulatory electrocardiogram (ECG) of samples of middle-aged men drawn from these two occupations. Employees with a history of heart disease were excluded, as one of the aims of this study was to explore the value of ambulatory ECG monitoring in fit workers.

Subjects and methods

Thirty staff men were randomly selected from a computer printout of employees aged 40-59 years. Each of these men was paired with a production-line worker randomly chosen from male production workers of the same age (within one year) as the staff men. The mean age of the participants was 51 years. The employees' medical records from the medical centre were examined in order to exclude

anyone with a known history of heart disease from any cause. The selected men were also required to be on day shift when the study took place during the winter months November 1975-March 1976.

At a preliminary interview a doctor explained the study to each prospective subject and invited him to take part. Although optional arrangements were available to ensure confidentiality, in the event all the participants agreed to have their results disclosed to their factory and family physicians, and there were no refusals on these grounds. The overall response rate was 86%, six production-line and four staff workers being unwilling to take part. Their medical records were reviewed: one production worker had a history of polycythaemia and another was suffering from depression, but the records for the other eight men were unremarkable. Unsuitable subjects and non-participants were replaced by randomly choosing another staff or production worker as described above.

The pairs of men in turn attended the medical centre early in the morning on a weekday, each man completing the self-administered version of the London School of Hygiene chest pain questionnaire (Rose and Blackburn, 1968) extended to include questions on tea and coffee consumption, and leisure-time physical activity, such as sports, regular heavy work about the home, and other exercise. Height in cm (without shoes) and weight in kg (without jacket or overalls) were recorded, these variables being used to calculate an index of relative weight

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(weight/height²). The blood pressure was measured twice in the left arm with a standard mercury sphygmomanometer while the subject was seated, the same physician taking the blood pressure of each pair. The diastolic pressure was recorded at the disappearance of the arterial sounds (Phase 5). The Medilog cassette recorder (Oxford Instruments Co.) was fitted with the electrodes applied in the V₁ and V₅ position, and the ECG signal was checked with a monitoring device. The men then returned to their work to follow their usual activities for the 24 hours of recording. Two recorders with calibrated recording speeds were used and, in order to reduce possible bias, were alternated between the occupations.

Twenty-four hours later the pair of men returned to the medical centre to have blood taken for estimation of plasma cholesterol (non-fasting) by routine Auto Analyser at the Radcliffe Infirmary. The men were also asked about their tea, coffee and tobacco consumption over the previous 24 hours, their leisure activities, and the times at which they stopped work, went to bed, awoke, and started work again.

The tapes were analysed by one of us (P.M.M.C.) who did not know the identity or occupation of the subjects concerned. Ventricular premature beats (VPB) were stated to be present if at least two were seen over the 24 hours of recording. The analysis was carried out on a purpose-built system (Cashman and Stott, 1974) which automatically detected and wrote out arrhythmic events, such as VPB, while statistical data on heart rate were simultaneously gathered using a computer program. This stage of processing yielded values every hour for the mean and variance of the R-R interval and the mean heart rate, as well as revealing the presence of any significant disturbance of cardiac rhythm.

Recordings containing more than five premature beats in the 24 hours were further analysed using another special-purpose computer program (Cashman, 1976). This classified and counted ECG complexes according to their morphology, and was thus able to distinguish supraventricular premature beats from VPB and to separate VPB arising from different foci. Counts of premature beats and total heart beats were carried out over the periods of work, leisure and sleep for each subject, but excluding the time after awakening towards the end of the 24 hours when the quality of some of the recordings fell because of deterioration in the electrode-skin contact.

Results

According to the replies to the standard questionnaire, none of the men had a history of myocardial infarction, angina or other heart disease, but two staff workers were being treated for hypertension

with diuretics. One other staff worker was taking allopurinol for gout and one production-line worker was taking a tranquilliser, but none of the other men was regularly taking drugs. The numbers of smokers in both samples were similar (47%) as were the numbers of ex-smokers, though the production-line men smoked fewer cigarettes on average (17 compared with 22 per day). Ventricular premature beats are stated to be brought on by excessive tea and coffee drinking as well as by smoking (Beeson and McDermott, 1975); all the men drank tea regularly, but only 18 production-line men drank coffee compared with 25 staff men, although the average quantities of the two beverages consumed by these men were similar. There was little difference in the numbers taking part in sports (43%), keep-fit exercises or similar activities (20%), but more production-line men, 23 compared to 13, reported doing heavy work about the house or garden at least once a week ($\chi^2 = 5.62$; $P < 0.05$).

CLINICAL VARIABLES

The staff men had a mean diastolic blood pressure of 86.9 mmHg which was significantly higher than the 81.6 mmHg found in the production-line men (Table 1; $P < 0.05$). This difference cannot be attributed to obesity as the relative weights of the two groups were nearly the same, as were the mean values of the plasma cholesterol. The staff men were taller by 4.6 cm (1.8 inches).

Table 1 Means ($\pm$ SEM) of clinical variables in car workers

Variables	Workers			
	Production-line		Staff	
Number examined	30		30	
Blood pressure (mmHg):				
Systolic	138.8	(± 3.1)	140.1	(± 3.0)
Diastolic	81.6	(± 1.5)	86.9	(± 1.8)*
Plasma cholesterol (mmol/l)	6.40	(± 0.24)	6.51	(± 0.22)
Height (cm)	171.0	(± 1.3)	175.6	(± 1.0)**
Weight (kg)	74.3	(± 2.0)	78.3	(± 1.9)
Weight/height* (kg/m ²)	25.4	(± 0.5)	25.3	(± 0.5)

*Difference between production-line and staff significant at 5% level.

**Difference between production-line and staff significant at 1% level.

HEART RATES

Mean heart rates for the periods at work, leisure and sleep were obtained for the two groups by averaging the individual hourly rates according to the times given by each man for these activities. The heart rates for the two groups were not very different, although the production-line men had a higher rate at work, and a lower rate at sleep, than the staff men (Table 2). The difference between the work and sleep rates

Table 2 Mean heart rates ($\pm$ SEM) according to activity

Workers	Heart rate (per min)					
	Work		Leisure		Sleep	Work minus sleep
Production-line	85.1	(± 1.6)	74.9	(± 1.8)	60.7	(± 1.7)
Staff	83.9	(± 1.8)	76.9	(± 1.7)	64.1	(± 1.7)
						24.4 (± 1.3)*
						19.8 (± 1.5)*

*Difference between production-line and staff significant at 5% level.

was 23% greater for the production-line men, a result which was statistically significant ($t = 2.28$; $P < 0.05$).

VENTRICULAR PREMATURE BEATS

Twenty-one men (35%), ten production-line and eleven staff workers, had at least two VPB on their ambulatory ECG (Table 3). One or more episodes of VPB occurred in six production-line and nine staff men during work, in six production-line and seven staff men during leisure, and in six production-line and eight staff men during sleep. Four of the production-line men and five staff had at least one episode in all three periods of activity.

Table 3 Age distribution of all workers, and of those with one or more episodes of ventricular premature beats

Age (yr)	Total number of workers (and % with VPB)	Number of workers with VPB	
		Production-line	Staff
40-4	12 (17%)	1	1
45-9	10 (60%)	2	4
50-4	22 (41%)	4	5
55-9	16 (25%)	3	1
All ages	60 (35%)	10	11

Full counts of the numbers of VPB for the three periods were obtained on those tapes with more than five VPB in the recording period, and tapes from 12 men (20%), six from each of the two groups, came into this category. The VPB rates for these men are given in the Figure, which shows that the type of activity had little effect on the rates for the production-line men. Two staff men had higher rates at work and one of these men also had a high rate during leisure, but for all six staff men the mean VPB rates for the three periods were not significantly different either from each other or from the mean rates for the six production-line men. In addition, multifocal VPB were present in four staff and two production-line men. An isolated VPB couplet was observed in two staff and one of the production-line men, and another staff man had coupled VPB for a short time at work. During the day of recording these six men from each occupation drank about the same amount of tea and coffee, and five out of six in both groups were non-smokers.

Figure Mean VPB rates per 100 000 cycles (square root transformation) in six production-line and six staff men with frequent VPB.

For all 60 men there were no significant differences between the men with VPB and those without in the levels of any of the variables under study, including cigarette smoking, blood pressure, plasma cholesterol and leisure physical activity.

OTHER ARRHYTHMIAS

Ten production-line and six staff men had at least one episode of supraventricular ectopic beats in the 24 hours. Single brief episodes of supraventricular tachycardia were observed in two subjects during leisure and in another two subjects during sleep; three of these men were production-line workers. Another production-line man had transient ventricular bigeminy during sleep.

Discussion

The main differences we have found in the two

samples, which may have contributed to the contrasting incidence of heart attacks in the two occupations, were that, in addition to their mostly sedentary jobs, the staff workers had on average a higher diastolic blood pressure and fewer of them tackled heavy jobs about the house or garden during their leisure time. Raised blood pressure and lack of physical activity are well known to contribute to coronary heart disease. Although the long-term effects of occupational factors on blood pressure remain speculative, in a recent study of two cohorts of Belgian bank clerks a lower blood pressure was found in the cohort with the more monotonous and less responsible jobs (Kornitzer *et al.*, 1975), a result similar to our own. Work about the home was noted by Kornhauser (1965) to be a popular hobby among Detroit car workers, probably because it was more satisfying to the semi-skilled person than his monotonous occupation. As well as leisure activity, other away-from-work factors are likely to be involved. However, the mean plasma cholesterol levels were similar, suggesting that the basic susceptibility of the two occupations to coronary heart disease was not very different.

Heart rate may affect the frequency of VPB but the heart rates for our two groups (Table 2) were similar. The recordings were taken during the weekdays in winter, and the leisure rates especially might well show differences at weekends or at other times of the year. The difference found between the work minus sleep rates was chiefly attributable to a lower sleeping rate among the production-line workers, which may be a reflection of a higher level of physical fitness among these men. Heart rate at work may be influenced by various psychological, physical and environmental stresses which we did not attempt to measure in this study.

The significance of VPB is considered to depend upon their frequency and pattern as well as the circumstances in which they arise (Lown and Wolf, 1971). Frequent VPB on the resting or ambulatory ECG of patients in the post-infarction period are widely accepted to be associated with an increased risk of coronary death (Blackburn, 1973; Kotler *et al.*, 1973), but it is not clear if they are important *per se* or merely reflect the severity of the previous infarct. In people without prior clinical coronary heart disease, however, the prognostic value of VPB as an independent risk factor is unresolved, although VPB have been shown to occur with the psychological stress of speaking in public (Taggart *et al.*, 1973), to be less frequent during sleep than during the day (Lown *et al.*, 1973), and to be controllable by meditation (Lown *et al.*, 1976). Certainly in patients with coronary heart disease psychological factors are believed to influence the incidence of VPB and may

be at least as potent in precipitating arrhythmias as exercise stress (Ryan *et al.*, 1975). However, in the present study the number of men in the two occupations with one or more episodes of VPB in the 24 hours was similar, and these episodes were not significantly more frequent during work than at other times of the day in either group. Comparisons of the VPB rates in the men with frequent VPB gave a similar result. A higher prevalence of disturbances of rhythm has been reported in a previous ambulatory study (Clarke *et al.*, 1976) of an apparently normal population, including R-on-T VPB, disturbances of conduction and ventricular tachyarrhythmias. The possibility that some ECG findings were missed in our analysis cannot be excluded, but these are likely to be few as the tapes were analysed in a unit which reports regularly on large numbers of clinical recordings.

A larger study might reveal more differences in coronary risk factors to account for the higher risk of heart attack previously found in the staff workers. Despite the differences observed, the findings on the ambulatory ECG were similar between the two occupations. It is unlikely that, with the size of the present study, a greater than two-fold difference in the true overall prevalence of VPB would have been missed. Our results suggest that, in men with no previous history of heart disease, disturbances of rhythm are uncommon and do not appear to be induced by occupational factors.

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