Absence from work and physical fitness

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Lindén, V. (1969). *Brit. J. industr. Med.*, 26, 47-53. **Absence from work and physical fitness.** The distribution of sickness absence in a given population is not one of chance but is governed by the nature of the individuals making up the group. Earlier studies strongly suggested that an individual factor was operating. The present paper is concerned with the possible influence of a physical factor. Are those who repeatedly absent themselves from work less physically fit than those who do not, and are the former, in carrying out their work, overtaxing their respiratory and circulatory systems? Pilot studies were carried out on 203 employees from different occupations. Physical fitness was determined by measurement of the maximal oxygen uptake during performance of dynamic work. A bicycle ergometer of the mechanical braking type was used.

For 51 customs officers, an inverse relationship between maximal oxygen uptake and number of absences from work was found. No such relationship was found for 56 firemen, which might have been expected because they form a selective group. So far as male and female office workers were concerned, no relationship was found between the maximal oxygen uptake and number of absences. Some morphological recordings were also made. No relationship was found between the data for height, weight or skinfold thickness and the maximal oxygen uptake or number of absences.

Continuous, telemetric heart rate recording, which roughly indicates the level of oxygen uptake, was performed in 10 employees from different occupations during whole working days. Five were 'repeaters', *i.e.*, persons with many sickness absences for different and unrelated conditions, occupied with non-sedentary work. They were found to have much higher heart rate recordings than some of their fellow-workers used as controls. The former thus made higher demands on their vital systems than the latter, and they were physically overtaxed by their daily work. No investigation was made in this study with regard to the extent these men may be trained physically. Three were postmen who had been following that occupation for more than 20 years; they did not seem to benefit from the physical training apparently involved in their work. Repeaters having subnormal physical fitness will probably never be able to cope with strenuous physical work. Preventive measures such as physical training programmes should be taken early in their lives. Vocational guidance at the start of their working careers is also necessary.

Earlier studies have revealed many facts about the incidence of absence from work. The distribution of sickness absence in a given population is not one of chance but is governed by the nature of the individuals making up the group (Hinkle and Plummer, 1952; Fulton, 1952; Sopp, 1958, 1960; Lokander, 1962). The findings strongly suggest that

an individual factor is operating. What about the influence of a physical factor? Does the frequency of sickness absence tend to be related to physical fitness? Are 'repeaters', *i.e.*, persons with many sickness absences for different and unrelated conditions, less physically fit than individuals who rarely absent themselves from work? The present

paper describes a pilot study of 203 healthy adults concerning the relationship between absence from work and physical fitness.

Method

The American Medical Association Committee on Exercise and Physical Fitness defines physical fitness as the general capacity to adapt and respond favourably to physical effort. Physical fitness is a complex quality which is influenced by psychological and social factors. Also, the functional conditions are very complicated, but the measurement of the physical basis of working ability must be based on the technique that is available.

The biological substratum for physical fitness is linked to energy metabolism. Energy metabolism is based on aerobic and anaerobic processes. The most important is the aerobic process which is dependent on complete oxidative assimilation of food. This process is the basis for our daily muscular activity and, therefore, is the basis of the evaluation of physical fitness. The capacity of aerobic energy metabolism is very great; in principle it is unlimited and linked to the intake of food. However, power, *i.e.*, the energy which can be set free per unit of time, is limited and depends on the transmission of oxygen to the working muscle. A measure for the energy set free per unit of time can be obtained by determining the maximal oxygen uptake. Maximal oxygen uptake is the highest obtainable rate of oxygen uptake which can be recorded during the performance of rhythmic muscular exercise. The relationship between maximal oxygen uptake and the work load is established by measurements at several submaximal intensities. Those work loads are found, above which a further increase in work output does not bring about any higher oxygen consumption.

FIG. 1. Estimation of maximal oxygen uptake by means of linear relationship between heart rate and submaximal work (bicycle riding), extrapolated to maximal heart rate, which is the empirically established mean figure for the population to which the subject belongs, age difference taken into account.

This levelling off of oxygen uptake is used as an indication that the true maximal value has been reached. Types of exercise should be used which activate the larger muscles of the body. The method is very reliable. The variation from test to test, on the same individual, is from 2 to 5 % (Hermansen, 1964). In this study the indirect method of measuring maximal oxygen uptake was used. It is based on the linear relationship between 'steady state' values for heart rate and oxygen uptake. This relationship is established by using three or four exercises of submaximal intensities, and the maximal work rate can be estimated by extrapolation to the 'maximal' heart rate (Fig. 1). Values for 'maximal' heart rate are those averages worked out by Andersen (1966a) based on studies of healthy sedentary adults. The 'maximal' work is converted to maximal oxygen uptake by using the tables of Andersen (1966b). Maximal oxygen uptake is expressed as millilitres per minute per kilogramme body weight. Correction for age is made by using the tables of Hermansen and Andersen (1965), the maximal oxygen uptake being expressed as per cent of normal.

Procedure

A bicycle ergometer of the mechanical braking type was used (von Döbeln, 1954). The rate of pedalling was kept constant at 50 rotations per minute. The rate of work was increased by adding to the friction load. The duration of pedalling was five minutes, the heart rate being recorded just before the end of this period. The heart rate was recorded by means of an electrocardiograph. Room air humidity was always low, ranging from 40 to 60%. Air temperature was mostly between 16° and 18°C., although occasionally it rose to 24°C. The subjects had not eaten for the two hours immediately preceding the examination. They arrived in the laboratory at different times of the day. They undressed except for trousers and shoes. Height and weight were recorded as well as skinfold thickness, which was measured at 10 different locations of the body by means of a skinfold calliper (Best, 1954). The 10 locations were the cheek, the chin, the chest in the middle of a line between the major tubercle of the humerus and the angle of the sternum, the back of the upper part of the left arm, the back just below the angle of the scapula, the flank in the middle of a line between the axillary fossa and the iliac crest, the hip just above the iliac crest, the abdominal wall just to the left of the umbilicus, the knee just above the patella, and the leg in the middle of a line between the popliteal fossa and the calcaneus. The sum of these measurements enables the lean body mass to be determined, knowing the total body weight, as suggested by Allen, Peng, Chen, Huang, Chang, and Fang (1956).

Vital capacity and forced expiratory volume were measured to assess lung function. Following these examinations the subject rested on a couch for about half an hour. During this period the electrocardiogram and blood pressure were recorded. A medical examination, including sedimentation rate, haemoglobin percentage, and a urine test for protein, blood, and bacteria, had been carried out the previous day. Chest radiographs of all the subjects were taken. Those people in whom a physical abnormality was discovered were omitted from the experiments.

After resting, the subject mounted the bicycle and the seat was adjusted to allow a slight bend of the knee while the pedal was at its lowest position. Electrodes for the E.C.G. were fixed on the chest and on the left arm. A third neutral electrode was fixed on the back. All the subjects started at a low rate (about 300 kp.m./min.) which was maintained for five minutes. The rate is calculated as follows: friction load in kilogrammes by number of rotations of the ergometer wheel (r) divided by the number of minutes during which the experiment was maintained. Example:

$$\frac{2 \text{ kg.} \times 858 \text{ r}}{5} = 343, \text{ metres per minute.}$$

The load was then increased to about 600 kp.m./min. and this rate was also maintained for five minutes. A third period of five minutes' duration at a rate of about 1,000 kp.m./min. terminated the experiment (Fig. 1). The number of rotations of the ergometer wheel was recorded by means of an electrical counter placed in a panel and connected to a timer so that the exact time and number of rotations could be recorded for each test. These data were used for calculation of the work rate. At the end of each of the three periods, the heart rate was recorded by the electrocardiogram. Ten individuals were submitted to both the indirect and the direct methods for assessing maximal oxygen uptake. The two sets of figures varied within narrow limits (Table 1).

TABLE 1
PAIRED MEASUREMENTS OF MAXIMAL OXYGEN UPTAKE: COMPARISON OF RESULTS ACHIEVED BY DIRECT AND INDIRECT METHODS

Subject	Max. O_2 (l./min.)		Max. O_2 (ml./min./kg.)	
	Direct	Indirect	Direct	Indirect
P.E.	4.580	4.50	59	59
O.F.	2.080	2.05	34	34
J.J.	2.008	2.10	29	30
J.L.	2.036	1.90	30	30
R.L.	4.000	3.80	44	44
A.M.	3.000	2.90	34	33
I.M.	2.174	2.60	26	29
A.S.	2.635	2.60	34	33
R.Ä.	2.470	2.60	41	44
H.B.	3.268	3.10	54	54

The subjects

Recruitment was not without difficulties. At first it was planned to divide the subjects into repeaters and stable workers, but they felt this categorization to be discriminating and rejected it. It was then decided to use all workers in a few different places of employment. A fire brigade was chosen because a high standard of medical fitness is required before entry. Before being engaged, the men must have qualified for an athletic badge and physical training is compulsory. In this group a high capacity for physical work and few absences due to minor ailments were anticipated. All the men from one fire-station were called up for examination. There was

TABLE 2
PHYSICAL CHARACTERISTICS OF INDIVIDUALS STUDIED (AVERAGE FIGURES $\pm$ STANDARD ERROR AND STANDARD DEVIATION)

Age groups	No.	Age (years)	Weight (kg.)	Height (cm.)	Skinfold (mm.)
<i>Firemen</i>					
20-29	8	24.5 $\pm$ 0.9 2.5	80.1 $\pm$ 2.5 7.1	180.8 $\pm$ 1.2 3.4	101 $\pm$ 14.2 39.7
30-39	17	34.9 $\pm$ 0.5 2.2	78.1 $\pm$ 2.2 8.8	177.9 $\pm$ 1.0 4.2	99 $\pm$ 6.7 27.4
40-49	22	43.9 $\pm$ 0.6 2.6	75.9 $\pm$ 1.5 6.9	177.5 $\pm$ 1.0 4.5	95 $\pm$ 5.2 24.5
50-59	9	51.6 $\pm$ 0.3 1.0	73.6 $\pm$ 2.8 8.3	174.6 $\pm$ 1.3 3.8	91 $\pm$ 8.7 26.0
<i>Customs officers</i>					
20-29	1	26	60	174	105
30-39	18	36.4 $\pm$ 0.6 2.7	70.6 $\pm$ 1.6 6.9	175.8 $\pm$ 3.3 13.9	114 $\pm$ 7.7 32.9
40-49	32	40.4 $\pm$ 0.4 2.1	73.5 $\pm$ 1.2 6.6	175.7 $\pm$ 1.0 5.4	114 $\pm$ 4.3 24.3
50-59	0				
<i>Male office workers</i>					
20-29	10	24.5 $\pm$ 0.8 2.6	71.4 $\pm$ 1.9 6.0	178.5 $\pm$ 1.8 5.8	88 $\pm$ 13.5 42.9
30-39	27	35.1 $\pm$ 0.7 3.4	74.0 $\pm$ 1.5 7.7	176.3 $\pm$ 1.1 5.5	116 $\pm$ 7.6 39.5
40-49	22	42.9 $\pm$ 0.6 2.7	75.5 $\pm$ 1.6 7.5	177.8 $\pm$ 1.5 6.9	129 $\pm$ 8.3 39.0
50-59	3	51.7 $\pm$ 0.4 0.6	81.3 $\pm$ 1.3 2.3	180.3 $\pm$ 2.0 3.5	106 $\pm$ 12.8 22.1
<i>Female office workers</i>					
20-29	8	22.2 $\pm$ 0.8 2.3	55.7 $\pm$ 1.6 4.9	165.0 $\pm$ 1.4 4.3	92 $\pm$ 6.5 19.6
30-39	4	31.8 $\pm$ 1.0 2.1	66.3 $\pm$ 2.9 5.9	164.8 $\pm$ 1.5 3.0	116 $\pm$ 29.5 59.0
40-49	1	40.0	67.0	173.0	105
<i>Men from different occupations</i>					
20-29	4	23.8 $\pm$ 1.2 2.4	73.8 $\pm$ 2.7 5.3	177.8 $\pm$ 2.4 4.8	106 $\pm$ 5.2 10.4
30-39	7	36.3 $\pm$ 1.0 2.7	75.3 $\pm$ 4.2 11.2	179.7 $\pm$ 2.7 7.3	103 $\pm$ 5.3 14.0
40-49	6	43.8 $\pm$ 0.9 2.3	78.8 $\pm$ 6.6 16.1	179.2 $\pm$ 3.7 9.0	113 $\pm$ 15.0 36.8
50-59	3	52.0 $\pm$ 0.9 1.6	78.3 $\pm$ 7.1 12.3	178.6 $\pm$ 3.3 5.7	165 $\pm$ 3.3 5.7
60-69	1	60.0	87.0	186.0	170.0

full co-operation. One man was omitted because of heart disease discovered at medical examination.

Customs officers were chosen because no definite physical standards are laid down at the start of employment. According to the hypothesis in this study, a tendency towards an inverse relationship between physical capacity and number of absences from work for

small ailments was anticipated. All the men from one customs office were asked to participate; four refused. It was found later that the unco-operative group consisted of repeaters. Two men were omitted because of disease. Sedentary work was represented by male and female clerks from local government offices. There was complete co-operation; one woman was omitted because of disease.

When the investigation had been completed, the author visited the personnel managers of the work-places involved as well as the company doctors and treating practitioners. Information about spells and days of incapacity for work during the previous five years for each of the subjects was provided. Twenty-nine men were omitted from the study, eight because the information with regard to absence was incomplete and 21 because of prolonged spells of absence due to serious or chronic disease which might be claimed to have influenced their physical capacity. Thus the study covers 203 individuals - 51 customs officers, 56 firemen, 62 male and 13 female office workers, and 21 male employees from different non-sedentary occupations. All the subjects were entitled to full wages during absence because of illness and injuries. Different sick pay schemes, therefore, have not influenced the findings.

During the years 1961-65 the 203 individuals concerned had a total of 1,036 absences of one day or more from work. The 51 customs officers had most absences and the highest figures for short spells (less than four days), being 343 and 248 respectively. The corresponding figures for the 56 firemen were 187 and 13 respectively.

Table 2 shows the physical characteristics of the individuals studied. No relationship is found between these characteristics and either the maximal oxygen uptake per cent of normal or the number of absences.

Results

Maximal oxygen uptake in relation to age, sex, and occupation

Irrespective of occupation and sex the maximal oxygen uptake tended to decline with increasing age. The figures varied widely from one occupation to another. The firemen had higher figures than the male office workers, who in their turn produced higher figures than the customs officers.

Maximal oxygen uptake in relation to absence from work

Firemen For the 56 firemen, it was found that the maximal oxygen uptake per cent of normal and number of absences from work were not related. The correlation coefficient was -0.16 and standard error 0.13 . The averages (max. O_2 (litre/min.) and max. O_2 (ml./min./kg.)) are given in Table 3. It appears that three firemen had more than eight absences from work during the years 1961-65 and that their figures for maximal oxygen uptake were lower than those for their fellow workers.

Customs officers For the 51 customs officers, an inverse relationship was found between the maximal

TABLE 3
DISTRIBUTION OF 56 FIREMEN ACCORDING TO NUMBER OF SPELLS OF INCAPACITY FOR WORK AND PHYSICAL WORKING CAPACITY. 179 SPELLS OF ONE DAY OR MORE DURING 1960-65

	Spells			
	0	1-3	4-8	9+
No. of men	4	30	19	3
Average figures				
Age	44	39	40	40
Max. O_2 (l./min.)	3.0	3.1	3.2	2.5
Max. O_2 (ml./min./kg.)	38	42	41	30
% working capacity	97	103	104	76

oxygen uptake and the number of absences (Fig. 2). Rank correlation gave -0.47 , i.e., 22% of the variation is explained by the correlation. The 16 customs officers who had more than eight absences had lower average figures for maximal oxygen uptake than the men who had fewer spells of absence. The average figures tended to decrease as the number of absences increased (Table 4). None of the 16 men with more than eight absences had any chronic disease which could be said to influence the figures by causing frequent relapses and repeated absences. Most of the absences were caused by upper respiratory infections, headache, back-pain, etc.

FIG. 2. Number of spells of incapacity for work 1961-65 in relation to physical work capacity. Male customs officers. $r = -0.43$; standard error 0.14 .

TABLE 4

DISTRIBUTION OF 51 CUSTOMS OFFICERS ACCORDING TO NUMBER OF SPELLS OF INCAPACITY FOR WORK AND PHYSICAL WORKING CAPACITY. 390 SPELLS OF ONE DAY OR MORE DURING 1960-65

	Spells			
	0	1-3	4-8	9+
No. of men	4	16	15	16
<i>Average figures</i>				
Age	40	40	43	39
Max. O ₂ (l./min.)	2.9	2.9	2.5	2.2
Max. O ₂ (ml./min./kg.)	38	40	33	31
% work capacity	96	99	83	76

The number of days lost in absences was not likely to influence the observed pattern. Nineteen spells lasting more than 20 days were equally distributed among the men and thus not especially linked to those with many absences or with low physical fitness.

For each man a record was kept of how he occupied his time outside normal working hours. This included the method of travel to work. It also included recreational activities such as sport, gardening, and housebuilding. In the first group (men who had had no absence from work) all had some physical leisure time activity. In group 2 (men having had one to three absences (average figures for performance were the same as in group 1)), four were inactive during leisure time, occupying themselves mainly with reading, television, etc. In the last two groups, few of the men undertook any physical activity during leisure time. They numbered 6 out of 16 and 3 out of 15 respectively.

Office workers For male and female office workers no relationship was found between the maximal oxygen uptake per cent of normal and number of absences, the correlation coefficient being -0.21 for the men and -0.12 for the women, and the standard error being 0.13 and 0.22 respectively. It will, however, be seen from Tables 5 and 6 that the highest figures for maximal oxygen uptake were recorded in the groups of men and women who had had no spell of absence. Information was collected about the men's leisure time activity. The men who were more active during leisure time generally had higher figures for maximal oxygen uptake.

A comparison was made between two selected groups of individuals. One group covered seven repeaters who were selected by study of absence registers. Men having had more than 15 absences from work for minor and unrelated conditions during the years 1961-65 were chosen. The other

TABLE 5

DISTRIBUTION OF 62 MALE OFFICE WORKERS ACCORDING TO SPELLS OF INCAPACITY FOR WORK AND PHYSICAL WORKING CAPACITY. 290 SPELLS OF ONE DAY OR MORE DURING 1960-65

	Spells			
	0	1-3	4-8	9+
No. of men	12	20	17	13
<i>Average figures</i>				
Age	34	36	39	39
Max. O ₂ (l./min.)	2.9	2.7	2.7	2.7
Max. O ₂ (ml./min./kg.)	41	37	36	35
% work capacity	97	90	87	89

TABLE 6

DISTRIBUTION OF 13 FEMALE OFFICE WORKERS ACCORDING TO NUMBER OF SPELLS OF INCAPACITY FOR WORK AND PHYSICAL WORKING CAPACITY. 60 SPELLS DURING 1960-65

	Spells			
	0	1-3	4-8	9+
No. of women	6	3	3	1
<i>Average figures</i>				
Age	25	21	33	34
Max. O ₂ (l./min.)	2.3	2.5	2.1	1.9
Max. O ₂ (ml./min./kg.)	38	44	33	30
% work capacity	91	120	94	88

group covered men from the same occupations at similar ages, who had had no or very few absences from work during the same period of time. All the men had been employed by the same employer for most of their working lives. All were occupied in semi-sedentary work. The group of repeaters accounted for 120 absences. The other group accounted for seven absences. The figures for max. O₂ litres/min. and max. O₂ ml./min./kg. and maximal oxygen uptake per cent of normal were significantly lower for the first group.

Discussion

Karpovich (1959) stresses the fact that men and women with higher vital capacity are more physically fit than those with lower vital capacity. This is also related to body weight and skin surface area. On the other hand, says Karpovich, 'a large vital capacity does not make a champion'. In the present study no relationship was found between lung function (vital capacity and forced expiratory volume), maximal oxygen uptake or number of

absences. The capacity of the lungs will usually not limit the physical fitness because the respiratory system is not normally used to its full extent.

The morphological recordings made in this study are rough. No relationship was found between the findings for height, weight or skinfold thickness and maximal oxygen uptake or number of absences. Repeaters do not differ from other workers so far as morphological characteristics are concerned.

It is not possible to ascertain whether the differences with regard to physical fitness are due to constitutional or environmental factors. The individuals concerned do not differ so far as morphological characteristics are concerned, which might suggest that environmental factors are of greater importance than inborn characteristics. Psychological factors are likely to be operating. Repeaters do not feel comfortable under the rules of the group; frustrated, they react by withdrawal, which may weaken their motivation for physical activity.

The repeaters studied here came from families of low social standing, offering little or no incentive for physical activity. Four out of seven of these families had been supported by poor relief throughout the whole of the subjects' childhoods. Will insufficient nourishment throughout childhood reduce an individual's adaptability so as to reduce his capacity for physical work in later life? It is known that early protein deficiency may cause permanent brain damage. Height and weight do not go unharmed (Randal, 1966; Khan, 1966).

In the course of their daily work, are repeaters exposed to physical efforts which are beyond their inferior physical fitness? How much of their energy do they dissipate in the course of their daily work? These questions have been approached by means of studies on 10 employees in non-sedentary occupations. They were chosen at random through absence registers. Five were repeaters and five stable workers. Maximal oxygen uptake was measured for all by both the direct and the indirect methods. The repeaters were found to have subnormal figures for maximal oxygen uptake; the latter group had normal or high ratings for physical fitness. Each of the 10 men carried, during a whole working day, a miniature radio transmitter connected to electrodes which were fixed to the chest. They were accompanied during the whole day, and, by means of a portable radio, continuous telemetric heart rate recordings were made. When thermal factors are not interfering, continuous heart rate recordings indicate roughly the level of oxygen uptake.

The heart rate recordings for the repeaters were much higher than for the non-repeaters. The first thus make higher demands on their vital systems than the latter. These recordings confirm that the repeaters have poor physical fitness and that they are liable to be physically overtaxed by their daily

work. No investigation has been made in this study regarding the extent to which these men may be trained physically. They are so stressed in the course of their daily work and have so little motivation that they probably will benefit very little from medical physical training. Three of the repeaters studied here were postmen who have been following that occupation for more than 20 years. They carry about 30 lb. (13.6 kg.) of mail and walk about 2 km. twice a day, but the repeaters involved did not seem to benefit from the physical training apparently involved in this sort of work.

The results of the heart rate recordings for four postmen are shown in Figure 3.

Figure 3 (bottom left) relates to a postman who had a working capacity of 118% of normal (max. O_2 ml./min./kg. measured by direct and indirect methods 54). He was followed throughout a whole working day and he showed no difficulties in performing his work. The peaks up to 130 were caused by his running up two steep hills; he obviously demonstrated that effort did not affect his breath. The graph has an open space because the man delivered the mail so quickly that his lunch-break lasted nearly two hours. He, therefore, went home for lunch as was his custom. He showed no signs of fatigue at the end of the working day.

Figure 3 (top left) is concerned with a postman with 74% working capacity (max. O_2 ml./min./kg. 34), who was found to have heart-rates between 115 and 125 during mail delivery; he had a much easier route with no hills to climb. He used much more time in delivering the mail and got a shorter lunch-break than normal. He hardly had time to sit down for his meal and a rest; the heart rate did not decrease during this period of time. At the end of his working day he complained of fatigue. He was pale and looked exhausted.

A similar pattern was found for two other postmen (Fig. 3, top right, bottom right) with low figures (max. O_2 ml./min./kg. 34 and 26 respectively). The heart rate recordings showed even higher figures (for one of them mostly between 120 and 140) and they appeared to be highly strained at the end of the working day.

The first of these four men had only few absences throughout his 20 years of service. The three others were repeaters having had more than 30 absences each during an equal number of years, and all for minor ailments.

Repeaters having subnormal physical fitness will probably never be able to cope with strenuous physical work. They make, in the course of their daily work, higher demands on their vital systems than non-repeaters. People with normal or high physical fitness will, in the course of their daily work, draw on their energy to a smaller extent, and will generally not overtax their respiratory and circulatory systems. The many absences, year in and year out, of the repeaters frustrate them, and impair their motivation and capacity for group affiliation. They do not feel comfortable under the rules of their groups. Preventive measures such as

FIG. 3. See text.

physical training programmes could be taken early in their lives. Vocational guidance at the start of their working career is also necessary.

In occupational medicine the evaluation of physical working capacity is of great importance. This study should be looked upon as a pilot study pointing to a method in which physiology plays an important part.

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