CARDIAC REHABILITATION RESEARCH LEYDEN

Progress Report 1966 - 1967

CRRL

University Hospital
Netherlands Institute for Preventive Medicine TNO
Leyden

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C O N T E N T S

Introduction

Cardiac rehabilitation, especially rehabilitation of patients after a myocardial infarction, becomes internationally more and more a matter of concern. This applies for our country as well.

A special stimulus comes from a change in the social security legislation. Nowadays the residual working capacity of the disabled worker has to be estimated within rather narrow limits. We concentrated upon male myocardial infarction patients.

Research, for instance concerning the validity of the extrapolation from exercise tests to the work situation, concerning the possibilities of reconditioning, concerning the value of the different psychological and social factors, etc., is going on.

An integrated multidisciplinary approach is needed to make the research fruitful.

We started a year ago and we are now able to present to you our first progress-report.

H.W.H. Weeda

1 General considerations and medical aspects. H.W.H. Weeda

Generally speaking one may state that suitable work is good for everybody. This applies even more so to the worker stricken by a myocardial infarction.

The working capacity is lowered by the infarction. By chance we are able to show you an example of the foregoing in the next figure.

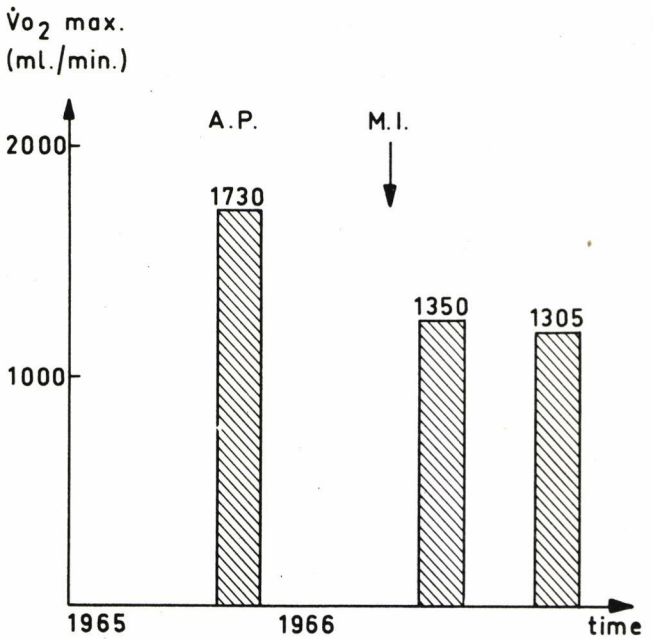

Figure 1
$\dot{V}o_2$ max. before and after myocardial infarction. This figure shows the physical working capacity represented by the maximum oxygen uptake of a man, 56 years of age, before and after a myocardial infarction. Eight months before the infarction the maximum oxygen uptake amounted to 1730 ml per minute. At that moment the patient had rather vague anginal complaints. Six weeks and three months after the infarction the maximum oxygen uptake was decreased to respectively 1350 and 1305 ml per minute. This decrease amounted to about 24 percent.

In this context I have to stress the fact that a myocardial infarction is a milestone in a long history of coronary artery disease, it is the outburst of a long standing disease. It is a disease which affects a rather large group of workers. In Holland one estimates that each year about 5400 male workers between the ages of 30 and 60 are stricken by a myocardial infarction. Accord-

ing to an article by PELL and D'ALONZO the five-year survival rate of a large group of employed men with a first myocardial infarction amounted to 74%. That is the reason why it is worthwhile to strive for vocational rehabilitation.

Our work classification unit has started its activities about a year ago. Only male patients below the age of 60 are accepted after a thorough medical examination by one of the members of the team. The assessment of the employability can be roughly divided into a physical aspect and a psycho-social aspect. Of course there exists an interrelation between both aspects.

The physical aspect includes the determination of the working capacity and the estimation of the work load of the worker concerned at his workshop. The maximum oxygen uptake is taken as a measure for the working capacity and is measured during an exercise test with gradually increasing load on a bicycle-ergometer. The work load is estimated by means of an interview-method. If possible the calculation of the work load is verified by measuring the oxygen consumption during the actual work. There is made a reasonable assumption that the permissible energy expenditure at a working time of 9 hours a day may not surpass one-third of the equivalent energy derived from the maximum oxygen consumption measured at the end of the maximum exercise test. In a number of cases it is decided to recondition the patients in view of the loss of condition, which occurs in most cases. This improves the physical working capacity and in doing so it betters the employability.

The psycho-social aspect of the assessment of the employability can be separated into three parts. First the man is considered in relation to his family. Second the man is considered in relation to the work, taking in account his personality structure. Third the responses of the patient to his illness, disability, unemployment and his former job, etc. are registered and carefully regarded. The advise concerning employability, or selective job placement is given by a team, which weighs all these medical, energetic and psycho-social aspects in close cooperation with the attending and industrial physician of the patient. All cases are followed up, because the best test and the ultimate proof of proper placement is the work itself. In a small number of cases this is done by

measuring the energy expenditure at the job and by registering the telemeter ECG during the work.

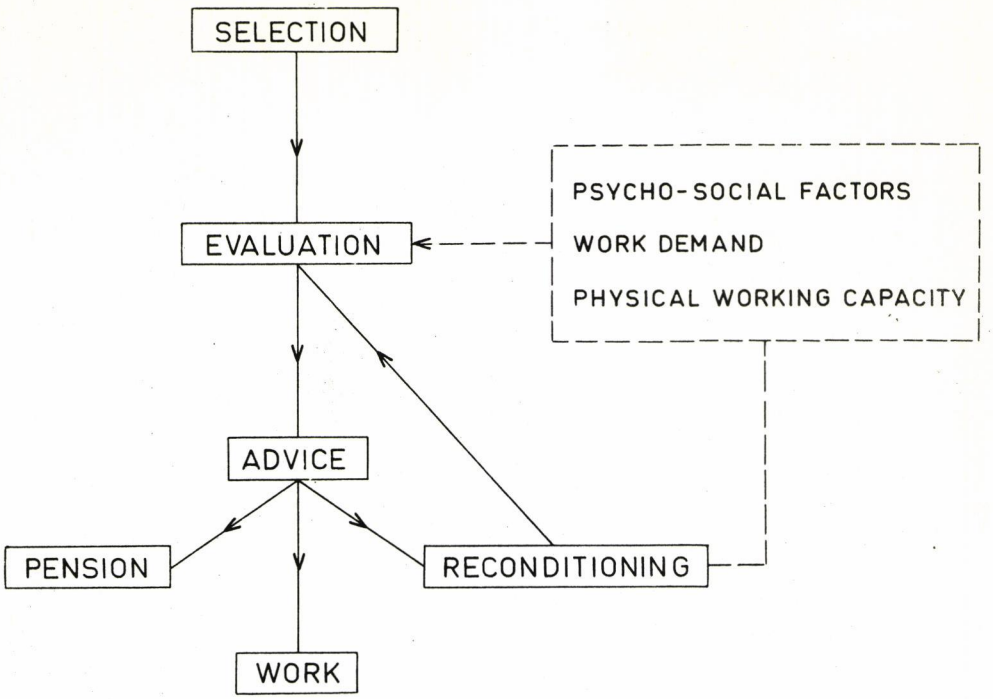

Figure 2

This figure summarizes the foregoing in a working scheme entitled: Rehabilitation Coronary Heart Disease. There exists a certain Selection. Not every patient with a myocardial infarction is send to us by his attending physician within our area. On the other hand we do not accept every patient, for medical and for other reasons. After this selection there will be an Evaluation. This evaluation comprises in the main the estimation of the physical working capacity, of the work demand and of a number of psycho-social factors. All these factors are discussed within the team and this discussion leads to an Advice. From this advice you can take three roads. The left road leads to Pension because the patient is not employable. The right road leads to a Reconditioning program and thereafter to re-evaluation. This physical reconditioning betters not only the physical working capacity but also some motivational factors of the patient. The middle road leads to Work, thus to re-employment, if necessary after reconditioning.

Although the total number of patients was 42, it was not possible for all of us to study this whole group. Not always the proc-

edure was carried out completely in every case.

After these introductory remarks I will confine my self to the medical aspects. Forty patients underwent a total of 73 maximal exercise tests with a gradually increasing load. The patients were activated to carry on the exercise test as far as possible. The supervising physician was prepared to terminate the test abruptly whenever hazardous changes developed. Only once we had to stop the exercise test because in that particular case the patient got a short paroxysm of ventricular tachycardia, which disappeared spontaneously. We had no accidents in this group of patients with coronary heart disease, which is in accordance with the literature. Although we requested the patients earnestly to continue the exercise test as far as possible we accepted on the other hand the desires of the patient to stop the exertion, even though the objective evidence of distress might not be impressive.

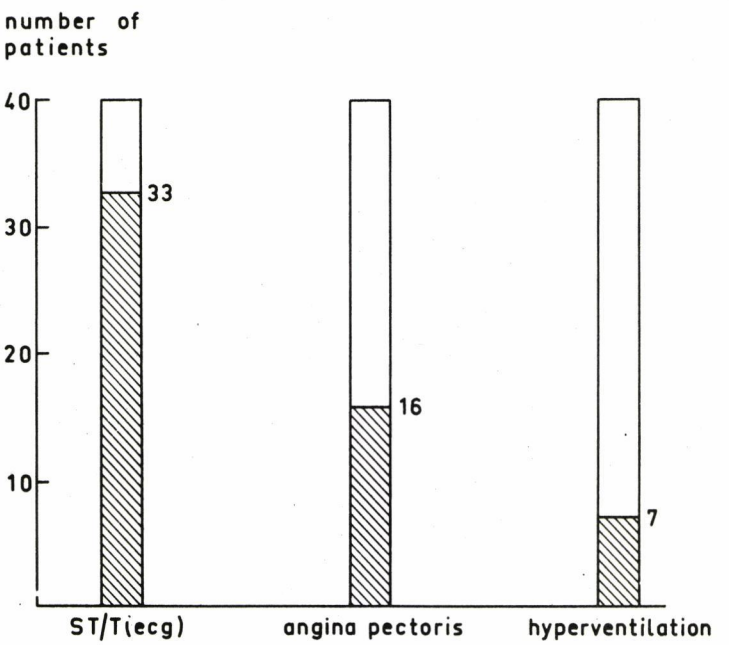

Figure 3

This figure shows the symptoms and signs during maximal exercise in patients with a myocardial infarction. At the left hand you can see that 33 out of 40 patients got ST/T changes, which were taken as an ECG sign of coronary ischemia. This means that 7 out of 40 post infarction patients had no ECG signs of coronary ischemia during maximal exercise. In the middle you can see that less than half of the patients got anginal complaints.

So the ECG is far more sensitive to coronary ischemia than the subjective feelings of the patient, a well known fact. At the right hand you find 7 patients who had a marked alveolar hyperventilation, which contributed at least in a part of these patients to the feeling of dyspnea, they experienced during and outside the exercise situation.

Although we had no unfavourable experiences concerning the safety of the procedure I have to remark that every maximal exercise test in these patients requires close observation of the patient and of the ECG upon an oscilloscope by a physician trained in cardiology and in exercise-physiology.

2 Physical working capacity and work demands. B. Bink

The physical working capacity is determined by imposing a gradually increasing load up to the breaking point upon a patient seated on a bicycle-ergometer. Figure 1 shows the method.

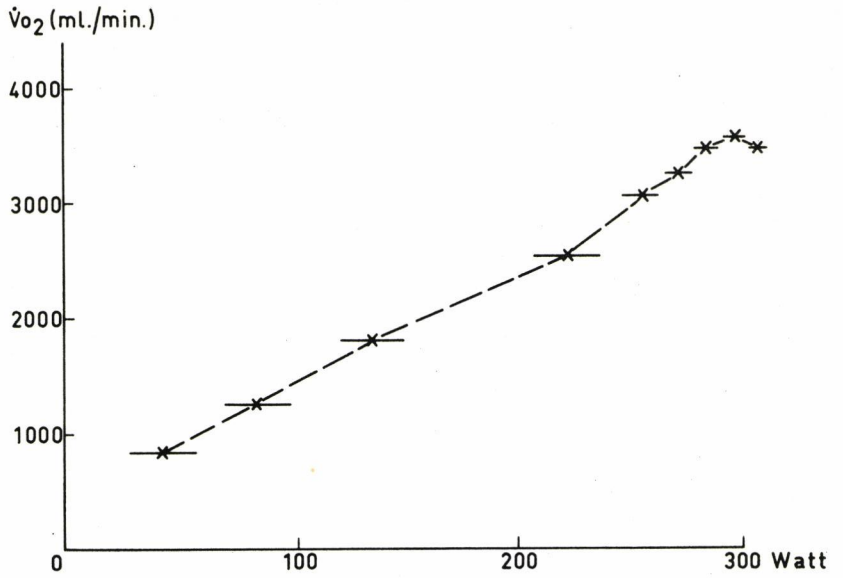

Figure 1
Determination of maximum oxygen uptake.

To assess the aerobic capacity of our subjects we use an increasing load on a bicycle-ergometer. On the abscissa the load in watts ranges from 0 to 300 watt. The increase of the load is by 10 watts per minute. On the ordinate the oxygen uptake is in ml/minute. There is an increase of oxygen uptake with the increase of the load. In this case a leveling-off and thereafter a decrease of oxygen uptake is shown.

Normally in exercise physiology it is not so difficult to apply criteria, which indicate that the exercise has been maximal. For instance the point at which the oxygen uptake levels off can be used, or the height of the pulse rate is used as a measure, and also in use is the attaining of a certain rather high value of the lactic acid within the blood. All these criteria are of very doubtful value in the exercise studies in cardiacs. In spite of all we have the strong impression that our exercise studies have been max-

imal in most cases. This impression is based on the observation that in a number of cases the pulse rate attained the standard maximal value, and that the p_H drop was considerable, also the ECG showed considerable changes in a great number of cases at the end of the exercise, which must be interpreted as a myocardial ischemia. Important in this connection is that in all those cases wherein a second exercise study was done the results were very good comparable.

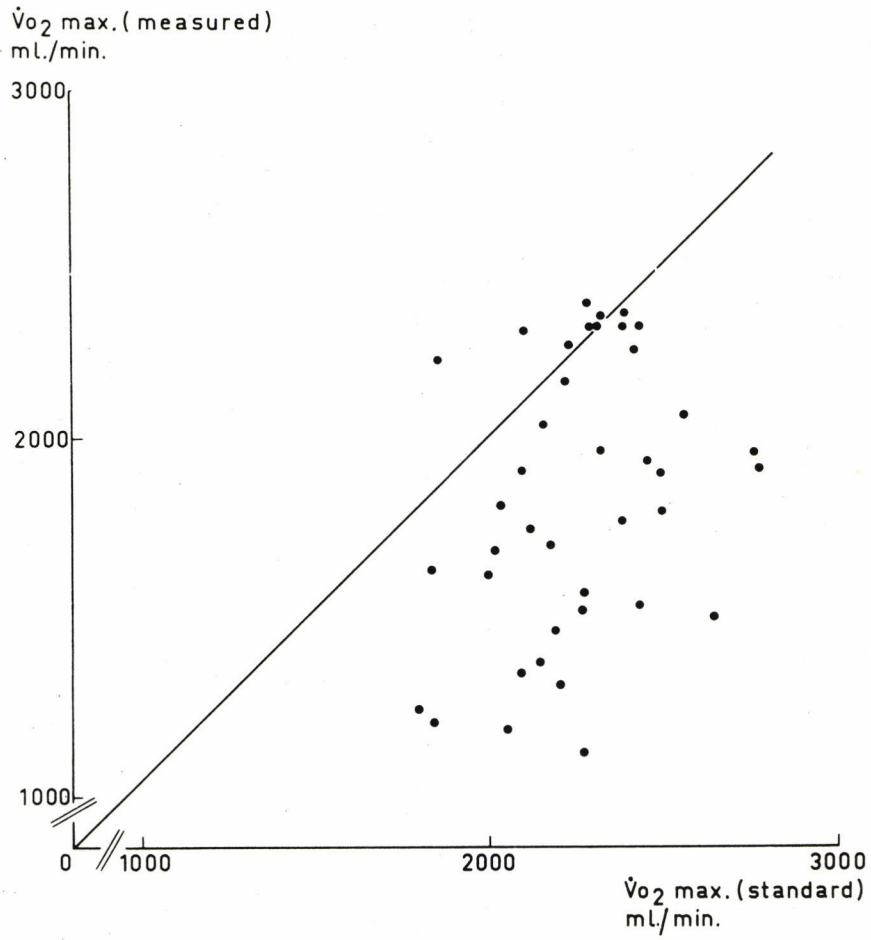

Figure 2
Relative maximum oxygen uptake in patients with coronary heart disease.

In figure 2 the relation between maximum oxygen uptake as calculated from a regression formula and measured maximum oxygen uptake is given. On the abscissa the norm in these 41 patients for maximum oxygen uptake as calculated from the regression formula found in 170 normal subjects, who performed a maximum exercise, is plotted. In the regression formula age, length and weight are used.

On the ordinate the maximum oxygen uptake, as measured in these 41 patients, is plotted. In patients a lower maximum oxygen uptake is found as could be normally expected, except in seven subjects. The mean in these patients is about 80% of normal maximum oxygen uptake.

We all know the level of physical activity is lower the longer it lasts. At the second congress of this Society in Dortmund we showed a linear relationship of the endurance time in minutes and the load in watts (or the oxygen uptake in l/minute). For healthy subjects we have empirically found the relation

$$\dot{V}o_2 t = \frac{\log 5700 - \log t}{\log 5700 - \log 4} \dot{V}o_2 \text{ max}$$

$\dot{V}o_2 t$ is the allowable working capacity in ml O_2/minute for time t in minutes and $\dot{V}o_2$ max is the maximum oxygen uptake in ml/minute. Assumed is that the maximum oxygen uptake can be sustained during four minutes.

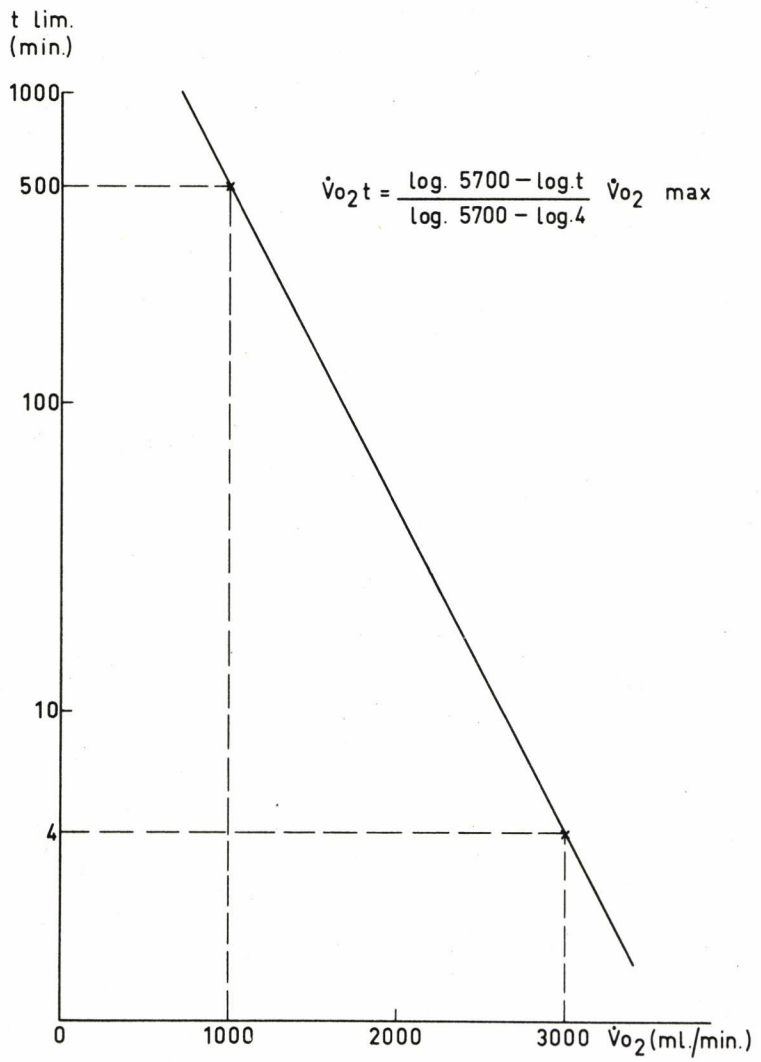

Figure 3
Relation between endurance oxygen uptake and maximum oxygen uptake.

The relation is given for a subject with a maximum oxygen uptake of 3 l/minute. The allowable oxygen uptake at 500 minutes working time is 1 l/minute, so one-third of maximum oxygen uptake.

This empirical relation between the energy expenditure determined during a short exercise test and the energy expenditure for a whole workday found in normal men had to be verified in cardiacs.

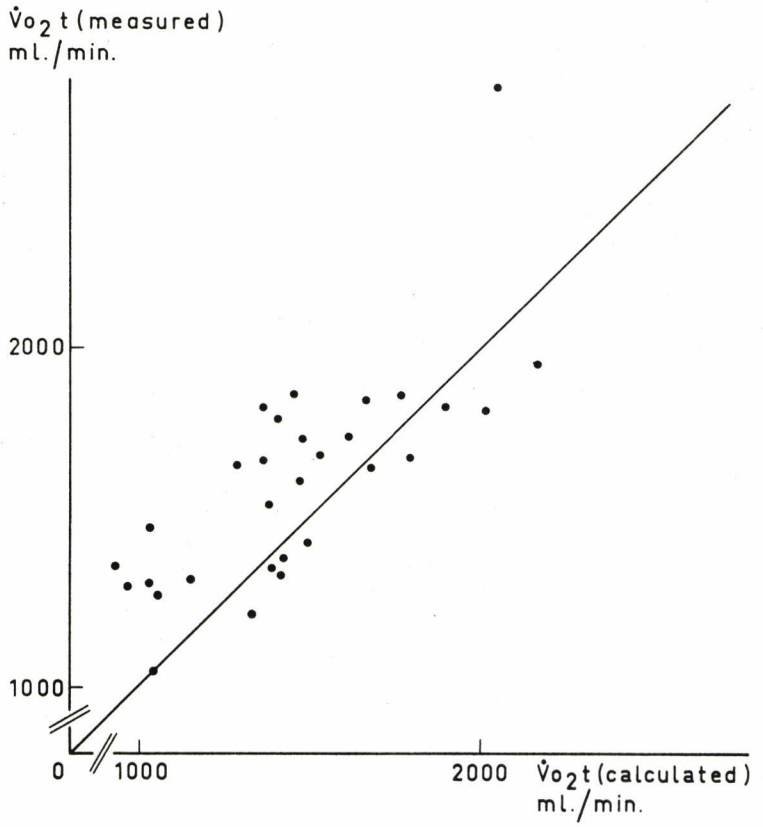

Figure 4
Relative endurance oxygen uptake in patients with coronary heart disease.

From this formula we calculated the endurance oxygen uptake during the last minutes belonging to the endurance time the patient has maintained a steady exercise.(These figures are given on the abscissa.) We measured the oxygen uptake, the patient actually had at this moment. (These figures are given on the ordinate.) We find endurance oxygen uptake in patients somewhat higher than found by the formula. Since the formula takes into account energetic needs during leasure time as well, the same is found in normal subjects during exercise studies. In other words the formula holds for pat-

tients with coronary heart disease.

The decision whether a patient is allowed to return to his original work depends on the energy requirements of his job. So the energy expenditure during actual work should be estimated. The mean level of metabolism throughout the working day can be found from the duration and work intensity of all forthcoming activities.

3 Assessment of energy expenditure. H. van der Sluys

When a patient with a myocardial infarction is healed there is the question whether he can do his original work full time or part time or it will be better to advise him to look for an other job. To give an answer to this question we have to know his working capacity and his work load.

From the maximum oxygen uptake can be calculated the working capacity for the total working time of this patient. For knowing the work load of the job a method is developed by which an indirect time and motion study is used. In general, the energy expenditure for each activity in kilocalories can be calculated by multiplication of the time spent in minutes and the number of kilocalories expended per minute. In this approach not only the time spent on each activity is determined, but also the kind of each activity. In order to obtain the caloric costs each activity is analysed in terms of posture and movements. Combination of these factors with body weight, the weight of loads to be carried, and the speed provides the nett energy expenditure for each activity. Basal metabolism is derived from standard tables. A description of this method is added to this report. We used this method the first time in 1965 during an epidemiological study of coronary heart disease, undertaken in an a-select population of 629 male inhabitants between 46 and 66 years of age in a provincial town.

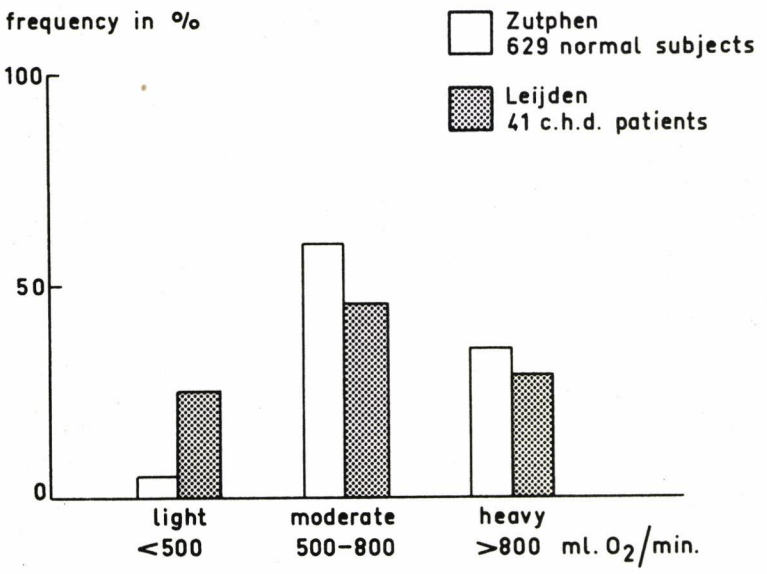

Figure 1
Comparison of daily work load between patients with coronary heart disease and normal subjects.

The provincial town group from Zutphen and our group of heart patients were divided into three grades of daily work load, light, till 500 ml oxygen uptake, moderate, from 500 till 800 ml and heavy, more than 800 ml oxygen uptake per minute. These grades were arbitrarily chosen. Generally speaking the two groups are the same, but perhaps there is a slight preponderance of the more light occupations in our group of heart patients.

The mean value of the caloric expenditure on work was 2073 with a minimum value of 1028 and a maximum value of 4368 kilocalories. In the group of coronary patients in the age between 45 and 65 years of age we studied the workload, the mean value amounted to 1879 kilocalories with a minimum value of 934 and a maximum value of 3548 kilocalories. If we have the data concerning the working capacity and the workload of the patient we can advise reemployment. The case of a shoe-repairer may illustrate the foregoing. He had a working capacity of 2.99 kcal/minute. After the assessment of his energy expenditure, his workload amounted to 2.56 kcal/minute. However, in the structure of his work there was a part demanding such a high number of kilocalories and such an endurance-time that we had to advise to discontinue his original work. After studying the situation on the spot it seemed to be possible to change things in such a way that this particular work could be done sitting down instead of in standing position, so less energy was used. After this change it was possible for him to resume his original job. The metabolism was measured and the ECG registered to make sure that assessment and proposals were correct. Before the change was made this part of work had an energy expenditure of 4 kcal/minute. After changing we calculated an energy expenditure of 2.54 kcal/minute, and the corresponding measure amounted to 2.68 kcal/minute. (See figure 2)

ECG monitoring during work should not be forgotten as a part of the follow-up of patients with coronary artery disease. For that we used telemetric ECG apparatus. As an example I present you the case of a weaver, who could not return to his former job because of unavoidable peak loads. Therefore the patient is employed as an aide in the storage for light work. Though this work was energetically permitted, the ECG recording showed a tachycardia caused by an untreated arrhythmia. Among others this light work consisted of sweeping a 50 m^2 floor and was done at a low speed. (See figure 3)

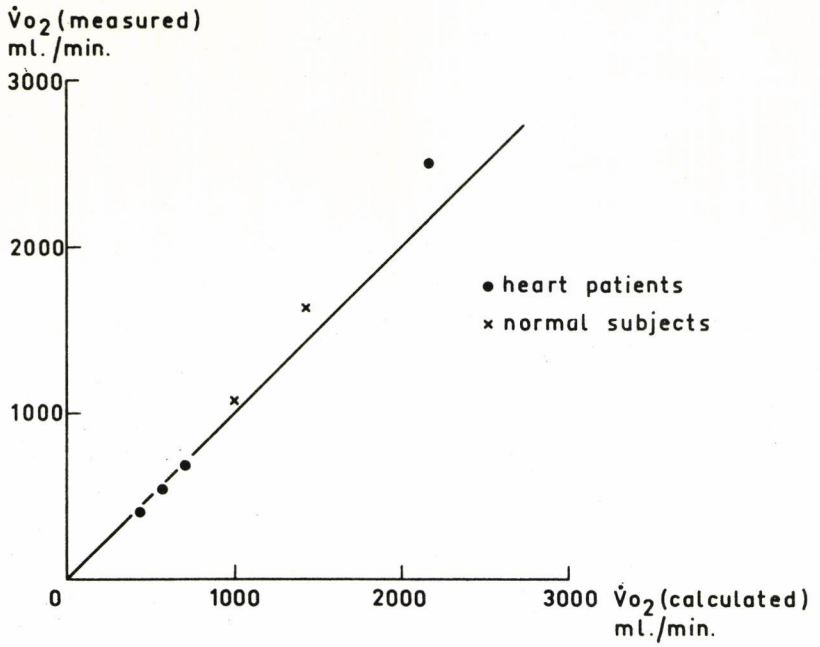

Figure 2
The results of the control measurements versus the calculation. Although there are not so many points you can see that there exists a rather good correspondence between the measurement and the calculation.

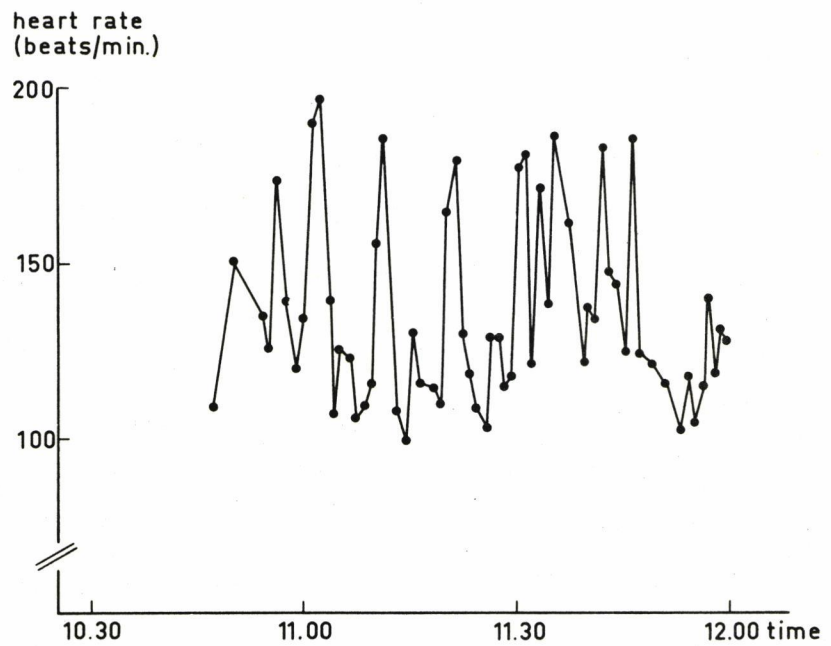

Figure 3
Heart rate during work in a patient with arrhythmia. Sweeping a floor a normal subject should have a frequency of about 100 beats per minute. Here you can see the influence of the disease on a patient, for his heart-rate went up to 190 beats per minute, which is not acceptable from the cardiological point of view.

The preliminary conclusions of our study are:

1. The accuracy of this assessment of the energy expenditure by indirect time and motion study is satisfactory for individual cases.
2. Figure 4.
3. Figure 5.

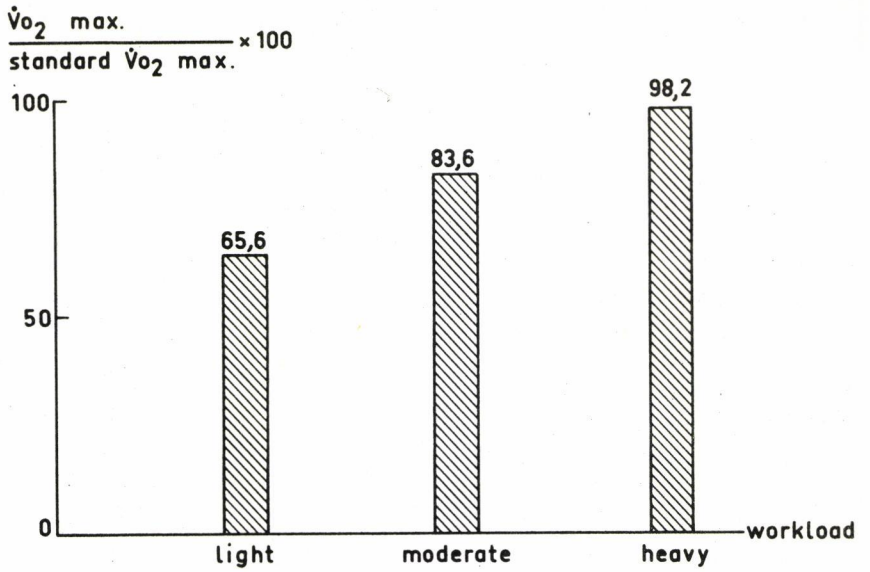

Figure 4
Daily work load versus effort tolerance. The first figure shows you in respect to the occupations, that generally there seems to be no difference between heart patients and normal subjects. However, in this figure you can see that as the pre-infarction occupations were heavier the relative effort tolerance after the infarction is higher.

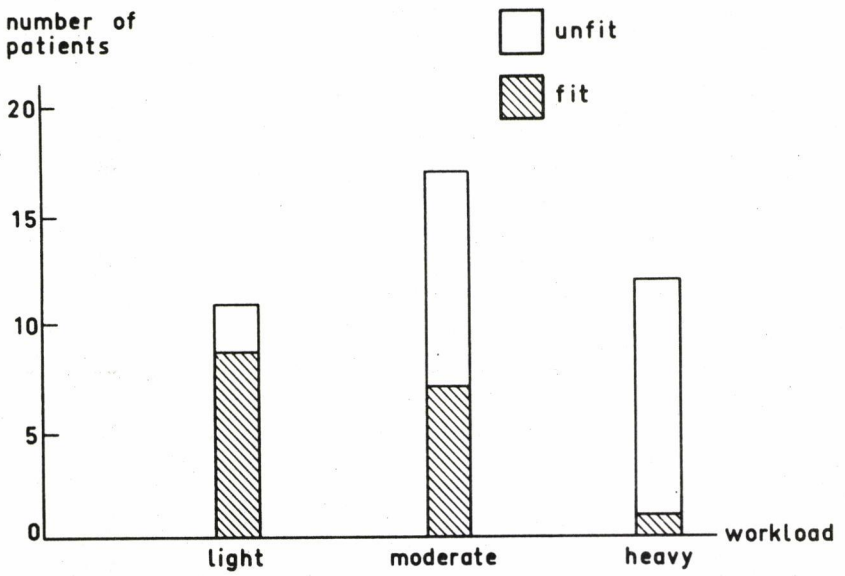

Figure 5
Energetic capacity for daily work. The social aspects

of the patients with a heavier occupation are worse. It is usually not possible to resettle them in their former job: there are at least two reasons for that. In the first place can be stated that, although they appear to have an almost normal effort tolerance, this special group of laborers has lost a substantial part of their relatively supernormal working capacity. In the second place can be stated that the energy expenditure of these particular jobs is often to high in proportion to the physical working capacity of normal elder workers.

Given this rather unfavourable outcome we can raise the question whether it is possible to improve the working capacity of this type of patients with a coronary artery disease. For instance the problem posed by the rehabilitation of a police-officer. This man held a clerical position which was suitable in energetic aspect. He was considered for promotion but his new job was energetically just above his capacity. That was the reason why we advised a training program in the case concerned.

4 Training of patients with coronary heart disease. J. Pool

The maximum oxygen uptake of patients with a myocardial infarction, is below normal. For this phenomenon there are two explanations. 1. By a lesion of the heartmuscle the capacity of the heart as a pump is decreased. 2. The bedrestperiod, following the acute infarction, diminishes the working capacity of the individual. We ourselves examined the influence of bedrest on the maximum oxygen uptake. In 4 cardiopulmonary healthy subjects we found a decrease of 10 to 30% after a bedrestperiod of 6 weeks.

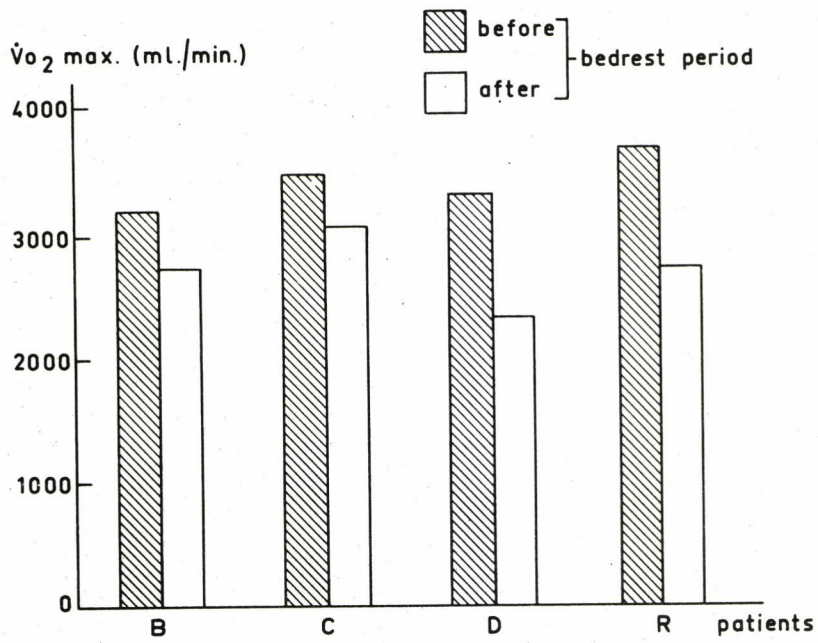

Figure 1
Influence of bedrest on the maximum oxygen uptake of four healthy subjects.

So a trial is indicated to improve the maximum oxygen uptake by physical reconditioning. In the paper of Mr. van der Sluys is already mentioned that the amount of this uptake is of great importance for the return to work. An increase improves the possibility of reemployment. Besides we consider the training of cardiacs to be important from a psychological point of view. The patients note that they are fit for regular physical exercise, and their selfconfidence increases.

On basis of the experiences of BARRY et al. from Philadelphia

and VARNAUSKAS et al. in Gothenburg we decided to a training in the outpatient department. Five days a week the patients came to the cardiological outpatient department during a period of 6 to 8 weeks. A bicycle-ergometer was used for training, permitting a simple control of the workload and a continuous ECG monitoring. Besides, cycling is an important part of Dutch life, though there never was a Dutch "Tour de France" winner.

Bicycle-ergometers in use at the moment are rather expensive. It will be expected that in the near future reconditioning will occur on a large scale. Therefore we developed a cheap bicycle-ergometer of a limited capacity, but suitable for trainingswork of heartpatients.

Figure 2
A simple bicycle-ergometer with a mechanical brake for training of heartpatients.

The mechanical rim-brake is fixed to a bow, that is rotating free on the axis of the wheel. The brakepressure is adjustable. During cycling the bow is pressed in the direction of the rotation of the wheel, but the force of a spring pulls this bow in the opposite direction. The bow reaches an equilibrium and the angle between the rest- and equilibrium-position is a measure for the brake-

force.

The training started with a workload depending on the maximum oxygen uptake measured in the previous ergometer test. During the training the exercise load was increased gradually giving attention to ECG changes, heart rate and complaints. Directly after the training period the maximum oxygen uptake was measured again to determine the training result. Up to this moment we trained eleven patients. In three cases the training was discontinued prematurely because of non-cardiac complications.

The result of training in patients with a myocardial infarction		
Patients	$\dot{V}o_2$ max. ml. O_2/min.	Result of training ml. O_2/min.
A	730	+460
B	1040	+475
C	1080	+200
D	1650	+ 70
E	2060	+520
F	2250	+215
G	2260	+450
H	2305	- 80
mean	1670	+290

Figure 3
Effect of physical training on the maximum oxygen uptake of 8 patients with coronary heart disease.

Figure 3 shows the results of the remaining eight patients, who finished the training program. The increase of the maximum oxygen uptake amounts up to 520 ml oxygen per minute, with a mean improvement of 280 ml. One patient did not improve.

In Figure 4 the training results of a patient with coronary heart disease are presented.

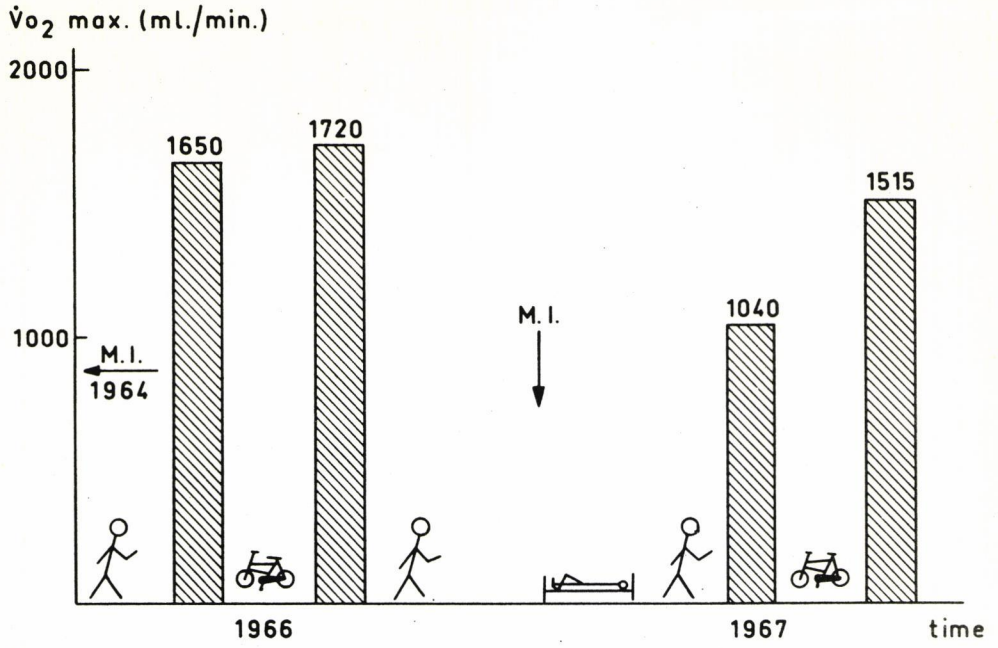

Figure 4
Training results of a patient with coronary heart disease before and after a myocardial infarction.

In 1964 he had an infarction. In 1966 he trained for two months with a moderate result. After the training period he did his normal daily work in a record-office. In 1967 he got a new infarction and kept bedrest for six weeks. After that he was slowly mobilised. Than we measured again his maximum oxygen uptake, which was very low. After a new training program he improved considerably, but his maximum oxygen uptake was not as high as before the infarction.

I hope it is clear that the maximum oxygen uptake may considerably increase by a period of systematic physical exercise. An example of the practical consequences is already mentioned in the preceding paper; it pertains to the police officer. A problem rose because he was considered for promotion. The new job connected with a higher rank demanded a better physical condition. After reconditioning he was physically fit enough for the new job. However, this job was not only physically but also emotionally more stressing.

5 The psychological assessment of employability and workload.

J.G.J.E. Josten

Apart from the comparison between working capacity and the physical demands made by the job, there is a psycho-social barrier which has to be accounted for in the decision that the worker may or may not resume work.

The subject of myocardial infarction was considered to be one of the strongholds of orthodox psychosomatics. An example of psychosomatic theory is the clear cut picture of the "cardiac personality", drawn by FRIEDMAN and ROSENMAN in their "Behavior Pattern A".

The concept of the "cardiac personality" received its fatal blow in two recent articles by KEITH and by MORDKOFF and PARSONS. After summarizing extensive research in this field, they conclude that evidence in support of something like a "cardiac personality" is very thin indeed.

In a majority of males in our culture above a certain age there are degenerative changes in the arteries of the heart. If there exists a correlation between personality and changes in the condition of heart arteries, which are wide spread, then the significant personality structure would be very common. If this is true, personality structure has no predictive value in this direction.

Taking these considerations as a starting point, the rule of parsimony requires us to return to the notion that cardiac patients are (average) people with a stroke of bad luck. However, bad luck leads to critical situations and psychology is very much interested in behavior elicited by critical conditions.

In the study of personality, two dimensions of behavior are of great importance: neuroticism, or personal balance and introversion/extraversion, a measure of orientation toward the social environment. Cardiac patients tend to be more neurotic than the general population, but this tendency is present in people with all kinds of physical disability and is probably true for everyone in stressful circumstances.

Since it is our opinion that personality changes are not related to the phenomenon of infarction as such, changes are necessarily related to situational and/or functional changes. The functional changes are derived from the physiological measurements, mentioned

in the preceding papers:

1. The ratio between maximum oxygen uptake and the standard value. This ratio indicates the effort tolerance, relative to the performance of individuals with correponding age and height.
2. The ratio between permissible work load and work load of the former job, as established by questionnaire method. This ratio indicates the capacity for work.

As a matter of convenience, both ratios are multiplied by one hundred.

The fact that an individual is not able to resume his former job is a situational defined fact. The finding that there is a significant correlation between neuroticism and degree of incapacity for work strengthens the opinion that differences in personality make-up of cardiac patients are related to situational changes.

This is only a first step. Other, still unreported research evidence shows that a combination of neuroticism and extraversion scores can be very useful.

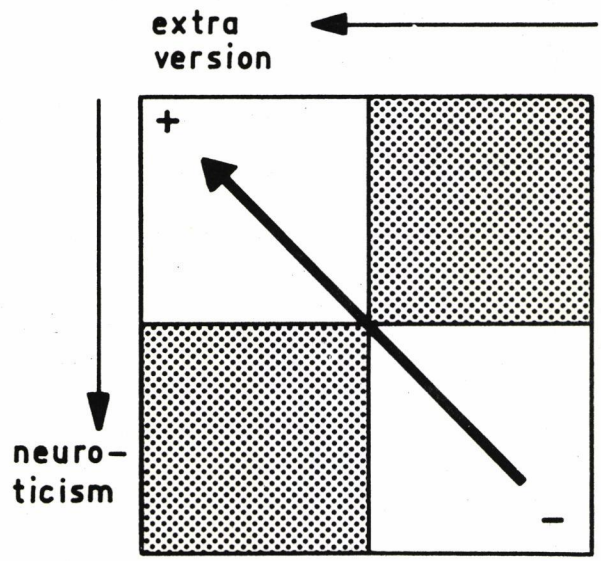

Figure 1
Personality categories derived by dividing the neuroticism and extraversion scores along the median of the norm population.

The sample is spit up into four categories by dividing the two scales along the median value of the norm population. There are reasons to believe that individuals in the categories along the

diagonal are those who have arrived at a more stable mode of disability-related behavior. The direction of the arrow points from a negative to a positive mode of adjustment. In the shaded categories are the individuals who lack stability in their handicap-related behavior. Lack of stability in behavior often results from frustrating circumstances.

What is the origin of frustrations experienced by the unstable categories in this sample? To find an answer to this question, the two "stable" categories are combined and, as such compared with the unstable categories on the following variables:

- effort tolerance (ratio I)
- workload of the former job
- capacity for work (ratio II)

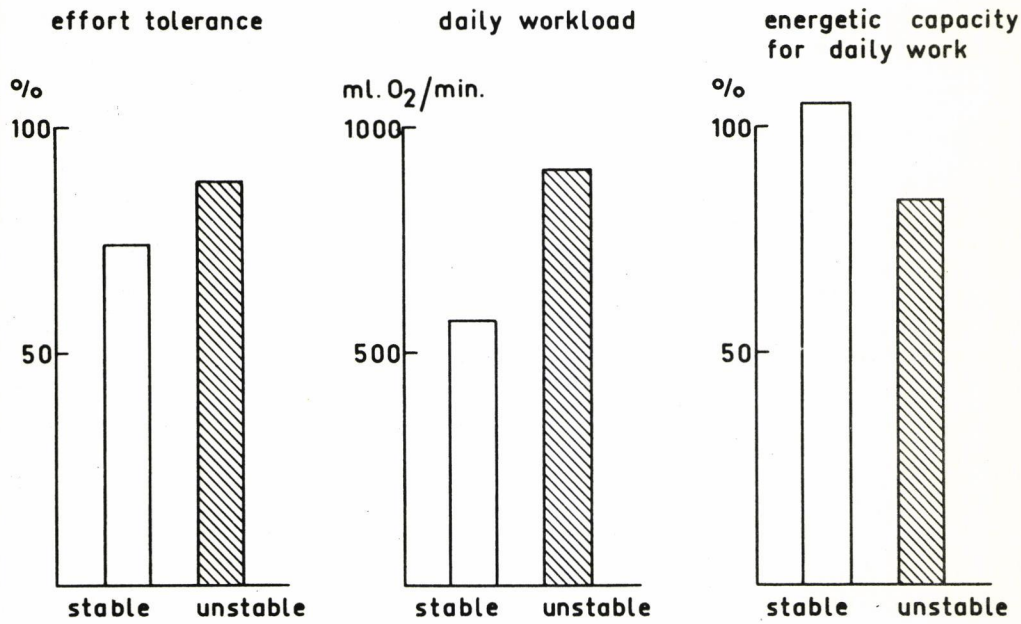

Figure 2
Differences in effort tolerance, work load and capacity for work between the "stable" and the "unstable" categories.

The higher scores are the more favourable. All differences are statistically significant at a 5% level. The unstable workers are less disabled, but have a higher workload. As a result they are more incapacitated for work. So they experience the frustrating situation of being incapacitated for work, although being only slightly disabled. The situation is especially frustrating because

of the fact that myocardial infarction as a handicap is not visible to the social environment of the worker.

If we compare the categories along the arrow pointing from a negative to a positive mode of adjustment then we arrive at the following conclusions:

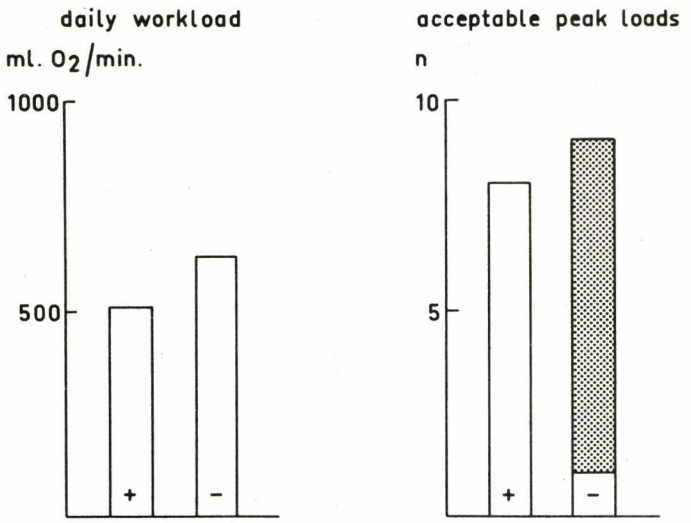

Figure 3
Differences in workload and number of patients with unacceptable peakloads of the former job between the categories with a positive and a negative mode of adjustment.

- the mean value of the work load of the positive category is significantly lower.
- workers in the positive category hardly ever meet working conditions with peak loads, which they are unable to cope with.

The conclusion is, that the positive category is in the more favourable position as to the resumption of work. These results lead again to the conclusion that personality measurements are sensitive to changes in the relations with the environment.

These frustrations which were present in the unstable group are to be seen as a rather diffuse emotional stress. It is generally accepted that more direct emotional stresses often occur in the work situation and that, in the case of the cardiac patient exposition to these stresses should be avoided as much as possible. It would be of the greatest importance if sensitivity to emotional stress could be measured or at least demonstrated, to include this

information in advice pertaining to the resumption of working activities.

A second part of this investigation was devoted to gaining foothold in this subject matter. Patients were given tasks, asking for precision movements, with performance depending on speed. At the same time ECG recordings were made.

In the case of the police officer, mentioned in preceding papers, promotion to higher rank was dependent on his capacity to digest unavoidable emotional stresses. A very significant change in the ECG pattern was registered during the performance of the frustrating tasks.

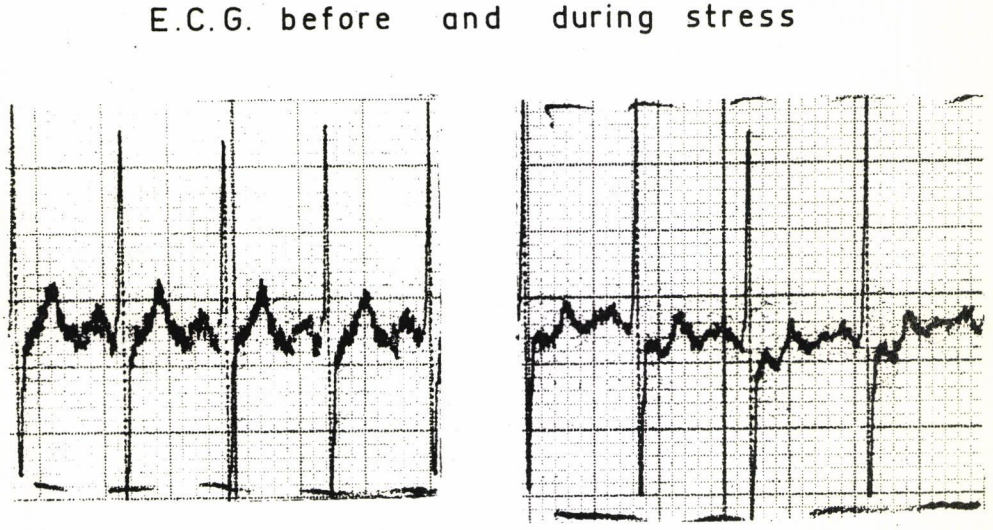

Figure 4
ECG recordings before and during the execution of precision movement tasks.

With this result we feel that some progress, though very small indeed, is made in getting a grip on this problem. As for the police officer, in spite of his evident reactions to emotional stress, it was advised that he should be promoted anyhow. After all, the advice was a choice between two unfavourable conditions: stress by non-promotion or by working conditions.

To bring this series of papers to a conclusion, let me present to you a general impression of the result of the activities of the unit.

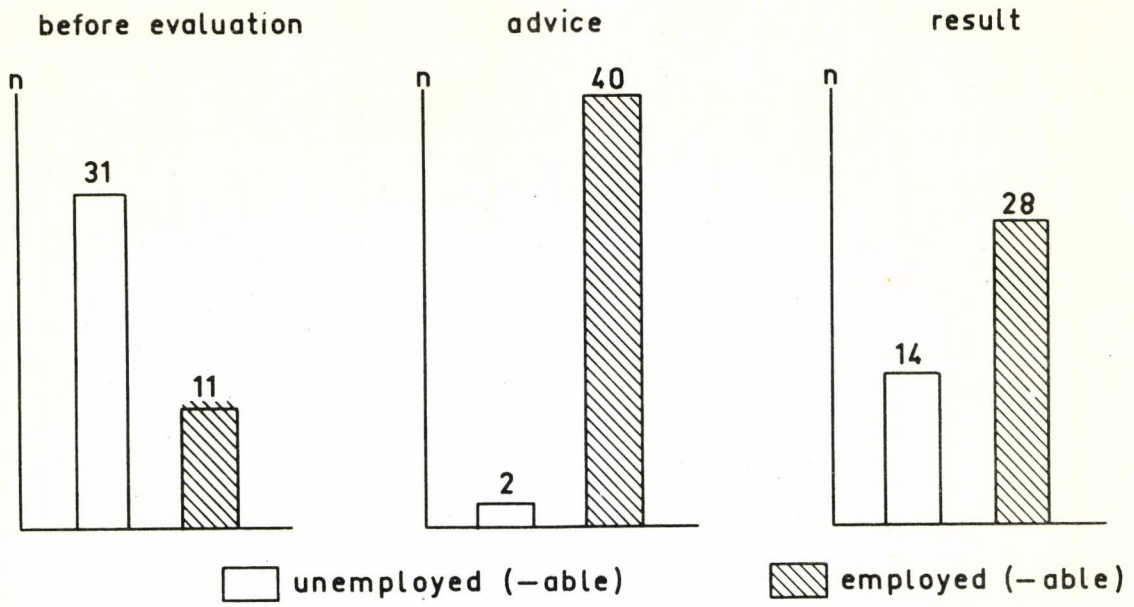

Figure 5
Result of placement procedure based on the units advice. The short period of activity of the unit makes it impossible to allow for different time intervals between advice and result.

Comparing "Before evaluation" with "Result" you will see that there is a marked improvement in the number of employed.

Comparing "Advice" with "Result" makes it clear that other factors, for instance the situation on the labour market, influence the employability of the worker.

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