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Work resumption after invasive heart procedures, rehabilitation and ergonomic evaluation: from the hospital to the workplace

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Abstract

Our Institute adopts a multidisciplinary protocol named "CardioWork" for work resumption after invasive cardiac procedures and subsequent rehabilitation: after evaluation of the cardiac functional profile, the occupational physician analyses the work activity prior to the cardiopathological event, identifies the presumed task energy requirement (from specific, published tables), and compares it with the exercise test results. Indications regarding timing and modality of returning to work are formulated accordingly. To verify the reliability of the indications thus provided, we carried out a clinical-functional follow-up study in the workplace, with Holter ECG and Armband measurement of actual energy expenditure. Over the course of two years, we enrolled 36 patients (mostly males, aged between 30 and 70 years), hospitalized after coronary revascularization, valve replacement or cardiac defibrillator implant. After rehabilitation, instrumental diagnostics (Holter ECG, echocardiography, exercise test) showed discrete functional conditions, with better values with regard to cardiac function than exercise capacity and effort tolerance. All subjects were judged fit for the job, in most cases with limitations concerning ergonomic factors, working timetable and/or stress. They returned to work quickly, with good adherence to the indications provided. Workplace Holter ECG did not show appreciable differences compared to the hospital evaluation. In one case, the average energy expenditure measured while working was higher than that inferred from the tables; in the remaining subjects, the actual expenditure coincided with what was expected or was lower. In a minority of cases (39%), the measured average expenditure slightly exceeded the optimal value (35% of the maximal value at the exercise test) recommended at the time of hospital discharge. At the end of the workplace evaluation, it was not necessary to formulate new indications. The study provides further evidence of the effectiveness of the CardioWork protocol in promoting return to work after invasive heart procedures. Though they need continuous updating, the published estimates of presumed task energy requirement remain reliable. In particularly complex cases, it is however advisable to carry out a field check of the ergometric assessments performed at the end of rehabilitation.

Key words: myocardial revascularization, valve replacement, cardiac rehabilitation, energy requirement, job fitness.

Introduction

Cardiovascular diseases are the main cause of death and disability, in Italy and worldwide. Ischemic heart disease alone is responsible for about a fifth of deaths in both sexes [1-3].

In recent decades, mortality from heart disease has decreased, both for the containment of risk factors and for the improvement of diagnostic and therapeutic procedures. However, morbidity rates, as opposed to mortality rates, are increasing. Moreover, although cardiopathies -and especially coronary heart disease- are typical of the elderly, many affected patients are still of working age [4,5].

The involvement of relatively young subjects, and the onset of a condition of chronicity and disability, have exacerbated problems that were little considered in the past, namely that of returning to work after an acute cardiac event, and that of maintaining occupational activity in the event of chronic heart disease. They are complex processes, conditioned by clinical and functional aspects (residual ischemia, left ventricular ejection fraction, effort tolerance, arrhythmic risk), interacting with psychological, socio-demographic and occupational (exposure to noxious agents, work and night shifts, commuting) factors. Therefore, in order to promote a permanent and secure reintegration, return to work should take place after a multidimensional assessment that analyses the possible interference of these factors [6-8].

Our group adopts a multidisciplinary protocol named “CardioWork”, aimed at job resumption after invasive cardiac procedures and subsequent rehabilitation. The protocol applies to workers who have undergone surgery for myocardial revascularization (coronary angioplasty or by-pass) or valvular disease, and are subsequently sent to our Institute for rehabilitation. During the rehabilitative treatment, the heart functional profile is defined. After that, the occupational physician analyses the work activity preceding the cardiopathological event, identifies the presumed energy requirement of the job, and compares it with the results of the ergometric test. Indications regarding timing and modality of returning to work are formulated accordingly. The subjects are re-evaluated over time, providing them with new indications when appropriate. Workers who follow the protocol show high survival with maintenance of satisfactory clinical conditions (good left ventricular function, exercise tolerance, rare cardiologic relapses, and few sick leave days), adherence to prescriptions, high employment rate, and high degree of subjective satisfaction. All this confirms the importance of appropriate rehabilitation after an acute cardiac event, and the need for an interdisciplinary approach involving the occupational physician. By following this strategy, patients not only return to work quickly, effectively and with minimal risk, but also tend to maintain it and reach retirement age in good health [9,10].

The energy requirement of the task, contemplated in the CardioWork protocol, is obtained from published estimates [11-13]. In the workplace, however, several factors (such as microclimate and work-related stress) can influence the residual functional capacities with modalities that are unpredictable during the evaluation in a hospital environment. Furthermore, the work activity is often dynamic, especially in jobs that require an alternation of tasks, thus energy requests during the work shift may fluctuate significantly. To overcome these possible interferences, a valid strategy could be that of an objective ergonomic assessment directly in the workplace. We therefore decided to measure the actual energy expenditure in the field, and to compare the results with the indications provided at the time of hospital discharge, in order to verify their reliability.

The primary endpoint of the study was to verify the correspondence between the estimated task energy requirement (based on literature data) and the real energy profusion on the job. An additional purpose was the further validation of the CardioWork protocol to support return to work after invasive cardiac procedures.

Materials and Methods

Hospital evaluation

The study enrolled occupationally active patients of both sexes, with a recent history of heart disease and related invasive treatment, hospitalized over the course of two years at the Rehabilitation Cardiology Unit of our Institute. Inclusion criteria were the willingness of the subject and his/her employer to participate in the study, and the practical feasibility of the evaluation phase in the workplace (see below).

Each subject followed the CardioWork protocol, including instrumental diagnostics (echocardiography, 24-hour Holter electrocardiography, treadmill exercise test), personalized physiokinesitherapy, and interviews with psychologists and dieticians, aimed at alimentary education and control of cardiovascular risk factors (in particular, smoking habits and sedentary lifestyle) [9,10]. This part does not substantially differ from an ordinary cardiac rehabilitation program [14]. As an additional stage, the hospitalization ended with an occupational medicine evaluation, to provide indications on return to work and job limitations. Recommendations were tailored to each single case, relating the patient's psychophysical conditions to the physical and mental requirements of his or her job. Particularly, we formulated limitations regarding one or more of the following work aspects: physical energy requirements, psychological stress, timetable, night shifts, transfers, thermal discomfort.

To standardize data collection, an anamnestic form was utilized, specifying: personal data; cardiac event (date, type, previous treatment, residual symptoms, current drug therapy); job typology (employee or self-employed); working timetable (full time, part time, shifts); daily work-related travel (less than or greater than 50 km, adding the home-workplace roundtrip to the transfers during working time); workplace climate (thermal comfort or discomfort); exposure to noise or chemicals; injury rate index, calculated using the INAIL (National Workers' Compensation Authority) data for the last 3 years; and (most important to estimate the residual working capability) task energy requirement, expressed as multiples of basal metabolic rate (metabolic equivalent of the task [MET]).

The average energy requirement was estimated from published tables, classifying the various tasks in four groups: sedentary (< 2 METs), light (2 to 4 METs), moderate (4 to 6 METs), and heavy (> 6 METs) (12). For each patient, the data were compared with the maximum working capability achieved during the exercise stress test: a healthy subject is able to carry out the exercise for 6 to 8 hours, amounting to 30% to 35% of maximum aerobic capacity, with peak values that must not exceed two thirds of the maximal effort.

Workplace evaluation

After resuming work, the subjects underwent a Holter ECG during a work shift (to reveal any differences from what emerged at the end of rehabilitation, and to verify whether the performance of the tasks led to arrhythmias or ischemic signs), and an ergonomic monitoring with SenseWear® Armband (SWA) for a week, to measure the average energy expenditure and the maximal effort of the job. The SWA, metabolic band, is a multi-sensor tool which, worn on the triceps of the right arm for a continuous period of time, provides the calculation of energy expenditure and the quantification of physical activity during daily activities. In short, physiological signals from the body (skin temperature, temperature proximal to the body, body heat dissipation, galvanic skin resistance) are used, in combination with activity identification formulas, to calculate the energy consumption based on predetermined algorithms. Individual data were downloaded, analysed and stored with the SenseWere® base software.

Another anamnestic form was utilized, to collect the time (in months) elapsed between hospital discharge and return to work; periods of absence from work due to illness or injury; task changes or variations in working conditions in terms of timetable (reduction or modification of shifts), travel due to work, and energy requirement; compliance with the limitations suggested at the of the hospital evaluation (total, partial or absent).

After this second assessment, the occupational physician once again expressed an opinion on the adequacy of the reintegration into work, formulating new indications if necessary.

Statistical analysis

Descriptive statistical analysis was performed, calculating means and standard deviations (SD) for the quantitative variables; medians, minimum and maximum values for ordinal variables; frequencies and percentages for qualitative variables.

Comparisons between two groups (subjects returning to work within/after 3 months) were carried out with the Student's *t* test for unpaired data on quantitative variables, and with the chi-square test on qualitative or categorical variables.

Results

During the enrolment period (two years), 36 patients (mainly males, aged between 30 and 70 years) were recruited (Table 1). In 16 of them (44.4%) cardiac rehabilitation was due to a coronary event, treated with percutaneous angioplasty (PTCA) or (more rarely) coronary artery bypass graft (CABG), alone or associated with valve heart surgery (CABG + VS). In two patients, a cardiac defibrillator had been implanted (ICD). In the other half of the sample (18 cases) the rehabilitative hospitalization was consequent to valve replacement surgery (VS). Holter electrocardiography revealed an arrhythmic profile (≥10 ventricular extrasystoles per hour and/or episodes of non-sustained ventricular tachycardia and/or episodes of atrial fibrillation) in nine subjects (25.7%), and residual ischemia (ST segment and/or T wave alterations) in three subjects (8.6%). Echocardiography showed an average left ventricular ejection fraction (LVEF) of 51.5 ± 7.2%. VS patients had worse cardiac function (LVEF < 50% in 30.6% of subjects) than patients hospitalized for coronary artery disease (LVEF < 40% in 19.4% of subjects). Both ICD subjects had a LVEF value around 35%. At the exercise test, 13 patients (36.1%) reached a value higher than 6 METs, 15 (41.7%) reached a value between 4 and 6 METs, and 8 (22.2%) were unable to reach 4 METs. Contrary to echocardiographic results, there was no statistical difference between subjects who had undergone valve replacement surgery compared to those hospitalized for coronary artery disease. Within the latter group, BPAC subjects performed worse than those treated with PTCA.Regarding occupational data, 26 patients (72.2%) worked full-time during the day, 8 (22.2%) worked day/night shifts, and 2 (5.6%) had a part-time job. With regard to traveling, 10 subjects (27.8%) made work-related trips greater than 50 km per day. As regards physical-chemical risk factors, 18 (50.0%) reported thermal discomfort, 11 (30.6%) were exposed to noise, 9 (25.0%) to chemical risk. Fifteen subjects (41.7%) carried out a job with an INAIL injury rate index > 4. Regarding energy requirement, light tasks (presumed requirement: 2-4 METs) were the most represented, followed by sedentary tasks (Table 1). At the end of hospital rehabilitation, all the patients were judged fit to return to their jobs, in two cases without any restrictions. One or more limitations were recommended to the remaining 34 subjects, as illustrated in Table 2, from which it can be seen that most limitations concerned the energy requirement of the job (for heavy tasks) or (especially for sedentary tasks) working timetable and stress. It was possible to retrieve reliable information on the actual return to work for 32 patients: all had started working again (in three cases with a change of job). Half of them (n = 16) had returned to work within three months of the cardiac invasive procedure, 12 subjects (37.5%) within six months and 4 (12.5%) within a year (average resumption time: 122 ± 12.5 days). The mean age (54.1 ± 4.8 years) of those who had returned to work within three months was higher than that (48.4 ± 5.9 years) of those who had returned later ($p < 0.01$; Student t test). There was no significant difference between the two groups (work resumption before and after three months) with regard to the type of cardiac event, LVEF values, presumed task energy requirement, and exercise test results. Information on compliance with the recommended limitations was provided by 35 subjects: 9 of them (25.7%) declared to have completely respected the recommendations, 24 (67.7%) reported partial compliance. Three subjects (8.6%) reported no compliance. Holter ECG during a work shift did not show appreciable differences in any subject compared to the hospital evaluation. In particular, the work activity did not induce arrhythmias or signs of ischemia. Armband measurement of the average energy expenditure in the workplace (carried out between two months and one year after returning to work) showed a value higher than that estimated in the literature [11-13] in one case: the tables indicated a requirement of less than 2 METs while the measured value was 2.2 METs. In 13 cases (36%) the tables reflected what was measured at work, while in 22 cases (61%) they overestimated the real expenditure. Most of the overestimations (19 of 22 cases) were observed among subjects with presumed energy requirement between 2 and 4 METs. In this group, the mean measured expenditure was 1.54 ± 0.23 METs. Compared to the calculation carried out in the hospital phase, regarding the optimal average energy expenditure during the working day (35% of the maximum value achieved during the exercise test), the expenditure measured with the Armband was below the limit in 22 cases (61% of the sample; mean deviation: 1.08 ± 0.87 METs). In the remaining 14 subjects (39%), the actual expenditure exceeded the limit set at the time of hospital discharge (mean deviation: 0.53 ± 0.45 METs). Regarding the maximal effort, 23 subjects (64%) exceeded the peak value (80% of the maximum exercise test value) suggested at the end of the hospital evaluation (mean deviation: 3.21 ± 2.33 METs). At the end of the workplace evaluation, job resumption was considered adequate for all subjects, without the need to formulate new indications.

Discussion

During the enrolment period (two years), it was possible to recruit a relatively limited number (36) of patients. This was due to the difficulty of harmonizing practical problems of the patients themselves, of the companies where the post-hospital phase of the research was to take place, and of the healthcare and technical support staff for the study. Even with this limitation, the data collected provide further confirmation of the usefulness of the CardioWork protocol in promoting job resumption after invasive cardiac procedures. As in previous studies [9,10], the subjects returned to work quickly while maintaining good health conditions, with discrete adherence to the limitations recommended at the end of the cardiologic rehabilitation process.

Work resumption was also confirmed to be optimal for the less young and for jobs with moderate or heavy energy demands. Surprisingly, those who returned to work early (within three months of the cardiac event that had led to hospitalization) were slightly older than those who returned later. The tendency in older people to resume earlier could be due to greater family responsibilities, or a greater fear of not being able to relocate in the event of job loss.

Our previous observations had indicated that return to work is faster for those performing sedentary or light tasks, and that patients undergoing thoracotomy surgery take longer to resume than those undergoing angioplasty [9,10]. It was not possible to confirm these data in the present study, probably due to the small sample size.

In the investigated patients, instrumental diagnostics (Holter ECG, echocardiography, exercise test) showed discrete functional conditions, with better values with regard to cardiac function than those relating to exercise capacity and effort tolerance. In particular, for almost all types of cardiac event, we measured a mean value of left ventricular ejection fraction (LVEF) greater than 50%. The only exception were the two subjects who had received a cardiac defibrillator (ICD), as can be expected since international guidelines set an LVEF value $\leq$ 35% as an indication for ICD implantation [15]. Predictably, patients with valve replacement had worse cardiac function than those hospitalized after coronary revascularization.

Regarding the exercise test, most of the subjects presented a reduced working capacity: about two thirds failed to reach 6 METs and eight patients achieved a value of less than 4. Contrary to echocardiographic findings, there were no differences between subjects with valve replacement versus those treated for coronary artery disease. Among the latter, however, bypass patients obtained worse results than those treated with angioplasty. In any case, at the end of the rehabilitation process, and after careful evaluation by the occupational physician, it was possible for everyone to return to work (with appropriate precautions; in three cases with a change of job). In particular, ergonomic limitations were necessary for those performing more energy-consuming tasks, while lighter tasks (e.g., office work) required measures aimed at reducing work-related stress and modulating working timetable.

The percentage of patients who returned to work (total in the present study, slightly below 90% in our previous experiences [9,10]) is higher than reported in other studies [16,17]. The short time in which the return to work takes place (a few months), and the high percentage of subjects who (at least partially) comply with the limitations, are other noteworthy results. Our research follows the pioneering observations of Mompere *et al*. [18], who had reported, as early as the 1980s, a more frequent return to work in coronary bypass patients, when the occupational physician intervenes during rehabilitation. In more recent times, the usefulness of this approach in promoting the return to work of the cardiologic patient has also been highlighted by Italian authors [19,20].

The main purpose of the present study was the ergonomic evaluation of the job in the field, to verify the correspondence between presumed energy requirement (based on specific, published tables) and real expenditure, and to remodulate the indications provided at the end of cardiological rehabilitation. In only one subject the requirement foreseen by the tables resulted underestimated. In 13 cases the tables reflected reality and in the remaining 22 (more than half) they overestimated it, especially for light tasks. What was found is not surprising since the tables need continuous updating to reflect the changes (in particular the improvement of ergonomic conditions) that occur over time [13,21]. Furthermore, the tables estimate the average energy requirement considering all the foreseen activities of the single task. In our sample, on the other hand, most of the subjects had received a judgment of job fitness with limitations, and therefore they complied, at least partially, with the recommendations, with a predictable reduction in the actual energy expenditure. All this considered, the tables can be considered reliable.

In a minority of subjects (39%) the average energy expenditure of the task measured at work turned out to be higher than the optimal value recommended at the end of the hospital evaluation. This deviation was modest (on average about 0.5 METs), was not reflected in subjective disturbances and/or electrocardiographic alterations (excluded by Holter ECG during work activity), and therefore did not require the remodulation of the job fitness judgment. All this is not easy to interpret: the value recommended on the basis of the ergometric test takes into account only the subject's functional capacity, while on the job there are confounding factors such as load handling, unfavourable microclimate and work-related stress which can affect the real energy expenditure. Furthermore, between the two evaluations (exercise test in the hospital and workplace measurement with Armband) there was a period of time of a few months during which the clinical-functional conditions could have improved, as generally happens after the acute cardiac event and consequent rehabilitation.

Conclusions

Overall, the comparison between the hospital evaluations and those carried out in the workplace is reassuring regarding the reliability of the indications provided by the CardioWork protocol to facilitate work resumption. However, in particularly complex cases (e.g., “difficult fitness judgment” with the need for second-level assessment [22]), it is advisable (for an optimal return to work) to carry out a field check of the ergometric assessments performed at the end of hospital rehabilitation.

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Table 1. Main sample characteristics (n = 36).

Characteristics	**% (*n*) or Mean (± SD)**
Age (years)	51.1 (± 6.1)
Sex	
Male	80.6 (29)
Female	19.4 (7)
Education	
Primary/secondary school	58.3 (21)
High school	30.6 (11)
University	11.1 (4)
Presumed task energy requirement (METs)	
< 2 (sedentary)	22.2 (8)
2-4 (light)	69.4 (25)
4-6 (moderate)	5.6 (2)
> 6 (heavy)	2.8 (1)
Type of intervention	
Percutaneous Transluminal Coronary Angioplasty (PTCA)	30.6 (11)
Coronary Artery Bypass Graft (CABG)	11.1 (4)
Valvular substitution (VS)	50.0 (18)
CABG + VS	2.8 (1)
Implantable Cardioverter Defibrillator (ICD)	5.6 (2)

Table 2. Suggested work limitations (n = 65).

Limitation field	**% *(n)***
Energy requirement	77.8 (28)
Working timetable	33.3 (12)
Stress	27.8 (10)
Shifts	16.7 (6)
Thermal discomfort	13.9 (5)
Transfers	11.1 (4)