Kardiovaskuläre Medizin 2007;10:317–325

Original article

Mattia Arrigo, Thomas F. Lüscher

Cardiology,
Cardiovascular Center,
University Hospital Zurich,
Switzerland

Physical activity in patients with coronary artery disease before and after cardiac catheterisation: lack of improvement at 3 months follow-up without cardiac rehabilitation

Abstract

Background: Ischaemic heart disease is still the leading cause of death worldwide. Physical activity of at least moderate intensity appears to improve outcome of coronary artery disease via different cellular mechanisms. For these reason it appears mandatory that patients are informed about the importance of exercise in the secondary prevention of coronary artery disease. We therefore studied the amount of physical activity of patients with coronary artery disease before and 3 months after hospitalisation for cardiac catheterisation considering (1.) the degree of information about the role of physical activity in the management of their disease, (2.) the general health status before and after cardiac catheterisation, and (3.) the participation in a cardiac rehabilitation program after hospitalisation.
Methods: We analysed 126 patients with coronary artery disease who underwent cardiac catheterisation at the University Hospital of Zurich. We collected information about their general health status and their physical activity before and after the intervention. The amount of physical activity for each patient was classified in one of five categories.
Results: About 95% of the patients were informed about the importance of exercise for cardiovascular health. Three months after hospitalisation, most of the patients assessed their health status as good or satisfying and their feeling of energy increased compared to before the intervention. However, in the entire population, most of the patients did not follow the minimal recommendation for health enhancing physical activity and the amount of physical activity was not different before and after the hospitalisation. On the other hand, patients who underwent cardiac rehabilitation were much more active than those who did not.
Conclusions: Even though most of the patients are aware of the importance of regular exercise in the secondary prevention of coronary artery disease, and for their health status, only a few of them comply with the recommendation to perform regular physical exercise. New strategies to increase the number of physically active patients should be developed in the future to improve the outcome in patients with documented coronary artery disease, especially considering the effectiveness of cardiac rehabilitation for that purpose.

Key words: conronary artery disease; physical activity; cardiac rehabilitation

Zusammenfassung

Hintergrund: Ischämische Herzerkrankungen sind nach wie vor weltweit die Hauptursache für Infarkt und Tod. Körperliche Aktivität mittlerer Intensität scheint die Prognose der koronaren Herzkrankheit über verschiedene zelluläre Mechanismen zu verbessern. Aus diesem Grund sollten diese Patienten über die Bedeutung der körperlichen Aktivität in der Sekundärprävention der koronaren Herzkrankheit ausführlich informiert werden. Wir untersuchten daher den Umfang der körperlichen Aktivität von Patienten mit koronarer Herzkrankheit vor und nach einer Herzkatheteruntersuchung. Dokumentiert wurden (1.) der Stand der Kenntnisse der Patienten über die Rolle von körperlicher Aktivität in der Behandlung ihrer Krankheit, (2.) der allgemeine Gesundheitszustand vor und nach Herzkatheteruntersuchung und (3.) die Teilnahme an einer kardialen Rehabilitation nach dem Krankenhausaufenthalt.
Methoden: In der Studie wurden 126 Patienten mit koronarer Herzkrankheit, die am Universitätsspital Zürich untersucht wurden, er-

There is no conflict of interest.

Correspondence:
Prof. Thomas F. Lüscher
Klinikdirektor Kardiologie
HerzKreislaufzentrum
UniversitätsSpital
CH-8091 Zürich
E-Mail: cardiotfl@gmx.ch

Kardiovaskuläre Medizin 2007;10: Nr 10

fasst. Daten über den allgemeinen Gesundheitszustand sowie über die körperliche Aktivität vor und 3 Monate nach dem Eingriff wurden gesammelt. Der Umfang an körperlicher Aktivität wurde in fünf Kategorien unterteilt. *Ergebnisse:* Etwa 95% der Patienten waren über die Wichtigkeit körperlicher Aktivität in der Prävention von kardiovaskulären Erkrankungen informiert. Drei Monate nach der Intervention schätzten die Mehrheit der Patienten ihren Gesundheitszustand als gut oder befriedigend ein, und fühlten sich energievoller im Vergleich zu der Zeit vor dem Eingriff. Trotzdem folgte in der Gesamtpopulation die Mehrheit der Patienten nicht den minimalen Empfehlungen für eine gesundheitswirksame Bewegung und der Umfang der körperlichen Aktivität vor und nach dem Krankenhausaufenthalt unterschied sich nicht signifikant. Dagegen zeigte sich, dass Patienten, die an einer kardialen Rehabilitation teilgenommen hatten, deutlich aktiver waren im Vergleich zu denjenigen, die sich keiner Rehabilitation unterzogen hatten.
Schlussfolgerungen: Auch wenn die Mehrheit der Patienten sich der Wichtigkeit einer regelmässigen körperlichen Aktivität für die Sekundärprävention der koronaren Herzkrankheit als auch für ihren Wohlbefinden bewusst ist, folgen nur Wenige den entsprechenden Empfehlungen. In Zukunft sollten neue Strategien entwickelt werden, um die Anzahl an körperlich aktiven Patienten mit dokumentierter koronarer Herzkrankheit zu steigern. Insbesondere sollte dafür die Rolle der kardiologischen Rehabilitation berücksichtigt werden.

Schlüsselwörter: koronare Herzkrankheit; körperliche Aktivität; kardiale Rehabilitation

Table 1
Possible biological mechanisms for exercise-induced reduction in cardiac mortality.

Cardiovascular influences
Reduction of heart rate and blood pressure [9, 13, 18]
Reduction of myocardial oxygen demand [9, 13]
Increase in myocardial contractility [13]
Increase in peripheral venous tone [13]
Expansion of plasma volume [9, 13]
Favorable changes in platelet aggregation and fibrinolytic system [9, 13, 20–23]
Increased endothelium-dependent vasodilatation [9, 13, 18, 23–27]
Enhanced synthesis, release and duration of action of nitric oxide [9, 13, 23, 25]
Increases in blood flow, collateral vessels, and capillary density [9, 13, 18]
Enhanced parasympathetic tone [9, 13, 28, 29]
Reduction of chronic inflammation [9, 13, 23]
Metabolic influences
Reduction of overweight and obesity [9, 13]
Enhanced glucose tolerance [9, 13, 30]
Improved lipid profile [9, 13, 18, 31–33]
Lifestyle influences
Decreased likelihood of smoking [13, 34]
Possible reduction of stress [13, 35]
Short-term reduction of appetite [13, 36]

Introduction

Despite progress in the diagnosis and therapy, ischaemic heart diseases are still the leading cause of death worldwide [1]. Data of the American Heart Association show that cardiovascular disease as the underlying cause of death accounted for 37.3 percent of all deaths in the United States [2]. Increasing age, male sex and heredity are the most important non-modifiable risk factors. Hypercholesterolaemia, hypertension, diabetes mellitus, physical inactivity, obesity and overweight, tobacco smoke and over-consumption of alcohol, stress and depression, are the most important modifiable factors. These factors account for most of the risk of myocardial infarction. Other parameters are currently being investigated as to their role in cardiovascular disease [3–5].

The effect of physical activity of at least moderate intensity in reducing the risk of coronary artery disease has been shown in numerous studies [6–13]. Exercise and lifestyle changes favorably alter the clinical course of coronary artery disease [11, 14–18]. Numerous trials of exercise interventions after myocardial infarction have demonstrated a reduction in overall mortality and in mortality from cardiovascular causes [11, 16], as well as decreased rates of subsequent coronary events and hospitalisation [9, 14, 17]. The mechanism of the exercise-related decreases in mortality from cardiovascular disease is probably multi-factorial (table 1) [19].

In spite of these favorable cardiovascular effects of exercise, the risk of cardiac events may actually increase during a physical effort. Indeed, complications of physical training in patients with coronary artery disease include acute myocardial infarction or cardiac arrest, but rates of coronary events in rehabilitation settings are extremely low [37, 38]. Therefore, the Swiss Federal Office of Sport (BASPO), the Swiss Federal Office of Public Health (BAG) and the Network HEPA Switzerland, elaborating the guidelines of the World Health Organization (WHO), published in 2002 a document with recommendations for improving pu-

Table 2
Leisure-time physical activity in Switzerland [41] (n = 18719).

Category	weekly amount of physical activity	
Trained	At least 3 sessions of cardio-respiratory training (sweating episode).	27.0%
Regular active	At least 5 sessions of at least 30 minutes each one of moderate intensity physical activity (getting out of breath).	8.9%
Irregular active	At least 150 minutes of moderate intensity physical activity or 2 sessions of cardio-respiratory training.	25.6%
Partial active	At least 30 minutes of moderate intensity physical activity or 1 session of cardio-respiratory training.	19.1%
Inactive	Less than 30 minutes of moderate intensity physical activity.	19.4%

blic health through physical activity [39]. Women and men of all ages are recommended to perform at least half an hour a day of moderate intensity physical activity [7, 9, 39], characterised by getting somewhat out of breath but not necessarily sweating. The half hour of daily exercise can be broken down into sequences of at least 10 minutes duration [7, 39]. The most important step to improve cardiovascular health is to change from being inactive to an activity level of half an hour daily. People who already attain this level can further improve their health by taking up a training program for cardio-respiratory fitness, strength and flexibility. A training program for cardio-respiratory fitness should consist of at least 3 training session per week of at least 20 minutes duration. In terms of intensity it should cause slight sweating and accelerated breathing yet still allow for talking while exercising. Strength and flexibility training can improve well-being further [39].

Despite these documented benefits, in Switzerland (as in most of Western countries) a substantial part of the population is inactive or does not reach an appropriate level of daily physical activity [40, 41]. The "Observatorium Sport und Bewegung Schweiz", analysed in 2002 the behavior of the Swiss population regarding leisure-time physical activity and the participants were classified in 5 categories of activity (table 2) [41]. Nearly two-third of the population (64.1%) are inactive or not-enough active, only 8.9% are active and 27% are trained.

It is estimated that in Switzerland only physical inactivity causes 2900 deaths and contributes to 2.1 millions diseases of various sorts, which generates costs estimated at 2.4 billions CHF per year [39]. In the last years the Swiss population has been more and more sensitised about the importance of physical activity and a lot of projects were started to increase the number of active citizens. Particularly, patients with coronary artery disease are regularly informed by physicians, media and the heart foundations about the importance of regular physical activity in the secondary prevention (risk reduction in patients with established coronary artery disease who are at high risk for recurrent cardiac events and death from cardiac causes [7]) and are recommended to change lifestyle enhancing, among others, the weekly amount of physical activity. In patients with myocardial infarction, and at least part of those who have undergone coronary revascularisation due to chronic stable angina, cardiac rehabilitation is indicated [7, 9]. Despite the efforts of all partners of the Swiss public health system, there have been no studies on the effectiveness of information campaigns on the awareness of patients about the importance of regular physical activity in the secondary prevention of coronary artery disease and its impact of lifestyle.

We therefore studied the amount of physical activity of patients with coronary artery disease before and 3 months after hospitalisation for cardiac catheterisation considering (1.) the degree of information about the role of physical activity in the management of their disease, (2.) the general health status before and after cardiac catheterisation, and (3.) the participation in a cardiac rehabilitation program after hospitalisation.

Patients and methods

Study Population

The study was conducted in the University Hospital of Zürich (Switzerland). A total of 150 patients with coronary artery disease were interviewed between January and June 2005 during their hospitalisation for a cardiac catheterisation. We identified eligible patients by reviewing the admission logs of the Andreas Grüntzig

Kardiovaskuläre Medizin 2007;10: Nr 10

Table 3
Classification of the amount of physical activity.

Category	weekly amount of physical activity
Trained	At least 3 sessions of "vigorous" activities.
Regular active	At least 5 sessions of at least 30 minutes each one of "moderate" activities.
Irregular active	At least 150 minutes of "moderate" or 2 sessions of "vigorous" activities.
Partial active	At least 30 minutes of "moderate" activities or 1 session of "vigorous" activities.
Inactive	Less than 30 minutes of "moderate" activities, or only "light" activities.

cardiac catheterisation laboratory and patient's charts. For inclusion, patients were required to have established or new detected coronary artery disease, and the ability to complete the whole interview and questionnaires program. Informed consent was obtained from each patient.

Interview

Patients received the questionnaire 2 times, during the hospitalisation and 3 months later at home. During the first interview, informed consent was obtained and the participants were informed about the aims of our study, and educated about how to fill in the questionnaire. The first questionnaire was devoted to the situation in the 3 months before the hospitalisation, the second form involved questions about the situation after cardiac catheterisation and the received education during hospitalisation.

Collected data

We created a form of 20 questions organised in 2 sections. The first part focused on the general health status of the patient. We collected data about self-perceived health status, limitations in the activities of daily living, amount of energy and pain, psychosocial status, using a questionnaire. The second part collected data about the amount of physical activity performed by the patients, the motives for being active or inactive respectively, and the degree of information about the role of physical activity in the prevention of cardiovascular disease. Patients were requested to indicate the kind of activity with a brief description, subjective intensity, duration of every session and number of sessions per week. We collected data about leisure-time physical activity only as physical activity during work is difficult to quantify and was omitted. The interviewer also collected personal and biometrical data (age, height, weight, BMI, social and martial status, cardiovascular risk status, presentation of coronary artery disease, including a cardiac rehabilitation program) by direct interviews with the patients and reviewing patients charts. To assess how much these factors might change after the hospitalisation and how much these might be influenced by the amount of physical activity the questionnaire was completed at baseline and at 3 months follow-up.

Data analysis

Physical activity was quantified using the metabolic equivalents (MET) according to the Compendium of Physical Activity [42]. One MET is defined as the energy expended per minute by a subject sitting quietly and is equivalent to 3.5 ml of oxygen uptake per kilogram of body weight per minute by a 70-kg-adult. Through the description of the activity given by the patients, we could estimate the intensity of the activity. Intensities of greater than 6 MET were classified as "vigorous", intensities between 3 and 6 MET were classified as "moderate", intensities under 3 MET were classified as "light" [12, 19, 43] For example bicycling at 20 km/h (8 MET) is classified as "vigorous", walking at 6.5 km/h (5 MET) is classified as "moderate", and playing darts (2.5 MET) is classified as "light".

The amount of physical activity of the patients was classified in 5 categories, adopting the same criteria used by the study of the "Observatorium Sport und Bewegung Schweiz" [41] (table 3).

Results

Patient sample

Of the 150 subjects who were interviewed during the hospitalisation for cardiac catheterisation, 126 (84%) completed the study and were included for statistical analysis. Reasons to loss of follow-up were mainly poor compliance of the patients in answering the form.

Characteristics of the population

The main characteristics of the 126 patients who were included in the statistical analysis are shown in table 4.

Clinical presentation

Of the 126 patients who were included in the statistical analysis, 20 (15.9%) had typical stable angina symptoms [6], 63 (50.0%) had unstable angina (angina at rest, new onset angina or increasing angina) [44], 3 had ST-segment elevation myocardial infarction

Table 4
Characteristics of the patients included in the statistics.

Age	64.4 ± 11.6
<45	5
45–54	23
55–64	30
65–74	43
75–84	23
>85	2
Sex	
Males	84
Females	42
Formation	
Required schooling	31
Apprenticeship	76
High school	2
University or college	16
Other	1
Activity	
Self-employed	12
Employed	32
Homemaker	6
Unemployed	2
Disability-assurance annuitant	5
Retired	69
BMI (Body Mass Index)	**27.2 ± 4.85**
<20	7
20–24	38
25–29	53
>30	28
Risk factors	
Overweight (BMI >25)	81
Adiposity (BMI >30)	28
Hypertension	81
Dyslipidaemia	62
Diabetes mellitus	20
Nicotine	38
Family history	45
Others	7
Total risk factors	
0	18
1	25
2	25
3	35
4 or more	23

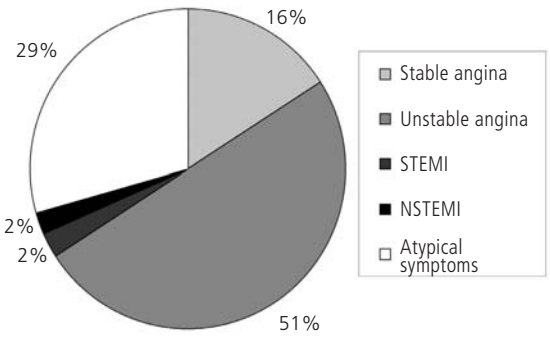

Figure 1
Clinical presentation at the time of hospitalisation for cardiac catheterisation.

(2.4%) [45], 3 had non-ST segment myocardial infarction (2.4%) [44] and 37 (29.4%) had asymptomatic coronary artery disease or atypical symptoms (fig. 1)

Rehabilitation Program

Of the 126 patients, 21 underwent a rehabilitation program (16.7%). 16 of these patients (12.7% of the total) were hospitalised at one of the specialised clinics in Switzerland and 5 patients (4% of the total) underwent an outpatient rehabilitation program. Of the 21 patients who underwent a rehabilitation program, 28.6% had stable angina, 47.6% had acute coronary syndrome at admission, and 23.8% had atypical clinical presentation. 105 patients (83.3%) did not undergo a rehabilitation program.

30% of the patients with stable coronary disease, 14.5 % of those with an acute coronary syndrome and 13.5% of those with atypical clinical presentation underwent a rehabilitation program.

Information about importance of physical activity

Patients were asked about the importance of physical activity in the primary and secondary prevention of cardiovascular disease.

During the first interview 119 (94.4%) and during the second interview 121 (96.0%) knew about the important role of physical activity for cardiovascular health.

General health

Subjective health status, effective disability in moderate and intensive activities, amount of pain and feeling full of energy are, among others, factors who can influence the amount of physical activity. We analysed the prevalence of these factors before and after catheterisation (table 5, fig. 2 and 3)

Physical activity

Ten of the 126 patients (7.9%) were trained patients at the time of the first interview. Their number stayed constant over time. Forty-three (34.1%) of the patients were regularly active at the time of the first interview, and their number decreased to 35 (27.8%) in the second interview. During the first interview 73 patients (58%) did not follow the minimal recommendations for health enhancing physical activity: 21 (16.7%) were classified as irregularly active, 14 (11.1%) as partially active and 38 (30.2%) as inactive. During the second interview the number of patients who did not follow the minimal recommendations increased to

Kardiovaskuläre Medizin 2007;10: Nr 10

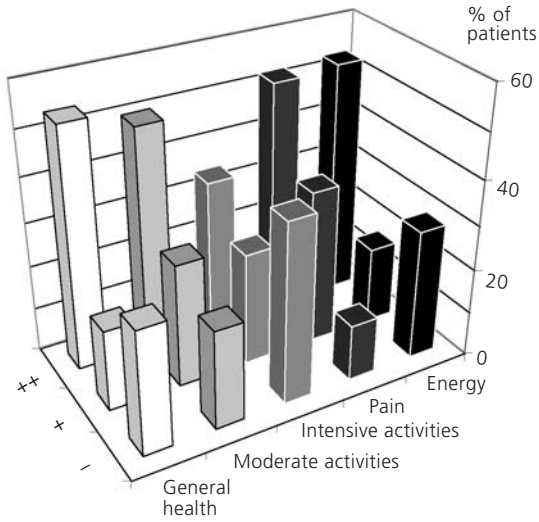

Figure 2
Distribution of physical factors at admission.

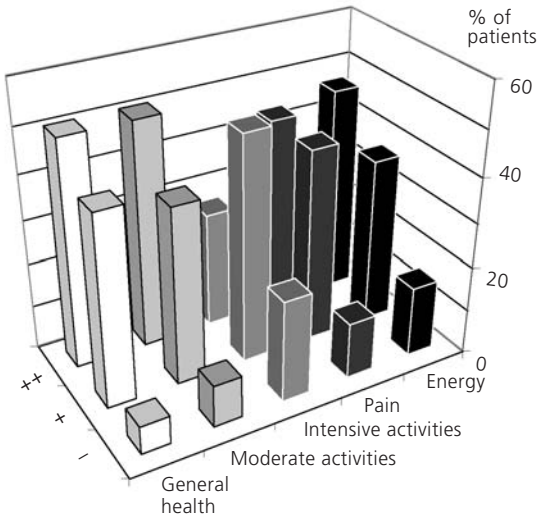

Figure 3
Distribution of physical factors 3 months after catheterisation.

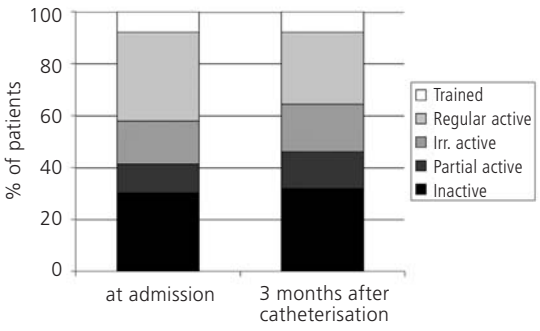

Figure 4
Amount of physical activity at admission and 3 months after catheterisation.

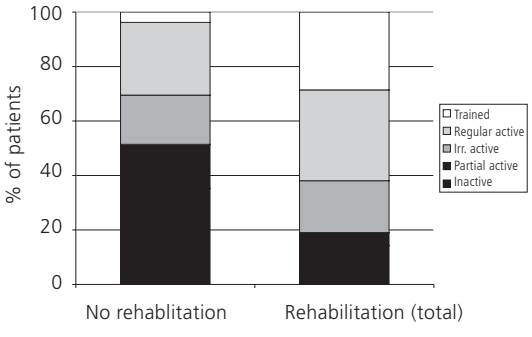

Figure 5
Physical activity 3 months after catheterisation.

from 73 to 81 (64.3%): 23 (18.3%) were classified as irregular active, 18 (14.3%) as partial active, and 40 (31.7%) as inactive (fig. 4).

We also analysed the trend of activity of every single patient. Most of them, 65 (51.6%) did not change category of activity. Thus, the reported increase or decrease in the amount of physical activity was too small to be detectable and too small to affect their physical fitness. Some patients however changed their category of physical activity: 27 (21.4%) raised their category and 34 (27%) lowered their category.

Physical activity and cardiac rehabilitation

We analysed the amount of physical activity 3 months after catheterisation comparing the distribution in the 5 categories of activity (see above) of patients who underwent a rehabilitation program after the hospitalisation versus patients who did not.

Only 3.8% of patients who did not undergo rehabilitation were trained compared to 28.6% of patients who underwent rehabilitation. 35.2% of patients who did not undergo rehabilitation were completely inactive 3 months after catheterisation, compared to only 14.3% of patients who underwent rehabilitation (table 6, fig. 5)

Reasons for being active or inactive

Active people have been asked about the factors that motivated them in pursuing a regular physical activity. Positive effects of physical activity on health was the most frequently mentioned reason, followed by fun during the activity. Medical counseling and social contacts were less effective to motivate the patients (table 7)

Inactive people have been asked about the reasons that hindered them in pursuing regular physical activities as recommended. During the first interview, the main reason was heart disease, followed by lack of motivation, other diseases and lack of time. In the second interview the main reason was the lack of motivation, followed by heart disease, other diseases, and lack of time (table 8).

Discussion

This study attempted to assess the amount of physical activity of cardiac patients undergoing catheterisation with or without a percutaneous intervention at a University center before and 3 months after hospitalisation, con-

sidering 3 factors who could influence the activity of the patients (information about the role of physical activity in the management of coronary artery disease, general health status, participation in a cardiac rehabilitation program).

We first assessed whether patients were informed about the role of physical activity in the secondary prevention of coronary artery disease. As expected, nearly 95% of the patients knew about the health benefits of exercise already before the index hospitalisation. Thus, it seems that information campaigns developed by all partners of the Swiss public health system (physicians, associations) and media, have been effective at this level.

We also assessed the general health status of the individual patients. Subjective health status was judged as insufficient by 27.8% of the patients before hospitalisation, but only by 6.3% after the hospitalisation, accounting for a relative reduction of 77%. A similar trend could be observed for other factors such as disability in moderate activities (22.2%; 9.5%; –57%), in intensive activities (40.5%; 23.0%; –43%) and "feeling full of energy" (29.3%; 15.9%; –46%). The influence of pain on the activities during daily living stayed constant (12.7%; 12.7%; –0%). This may be related to the fact that the reported pains were not only of cardiac origin. Nevertheless, these data show an important improvement of some pa-

Table 5
Physical factors at admission and 3 months after catheterisation.

	at admission (%)	3 months after catheterisation (%)	difference (%)	p-value
General health status				
Excellent / very good (++)	54.0	50.8		
Satisfying / sufficient (+)	18.2	42.9		
Insufficient (–)	27.8	6.3	–77	0.000
Disability (moderate)				
Not at all (++)	50.0	50.8		
A little (+)	27.8	39.7		
A lot (–)	22.2	9.5	–57	0.006
Disability (intensive)				
Not at all (++)	34.1	26.2		
A little (+)	25.4	50.8		
A lot (–)	40.5	23.0	–43	0.002
Influence of pain				
Not at all / a little bit (++)	52.4	43.7		
Moderately / quite a bit (+)	34.9	43.7		
Extremely (–)	12.7	12.7	0	
Feeling full of energy				
All / most of the time (++)	53.2	46.8		
Some of the time (+)	17.5	37.3		
A little / none of the time (–)	29.3	15.9	–46	0.010

Table 6
Physical activity and cardiac rehabilitation.

	at admission	3 months after catheterisation		
	Total	Total	no rehabilitation	with rehabilitation
	%	%	%	%
Trained	7.9	7.9	3.8	28.6
Regular active	34.1	27.8	26.7	33.3
Irregular active	16.7	18.3	18.1	19.0
Partial active	11.1	14.3	16.2	4.8
Inactive	30.2	31.7	35.2	14.3

Table 7
Reasons for being active at admission and 3 months after catheterisation.

	at admission (%)	3 months after catheterisation (%)
Health	74.7	76.7
Fun	62.1	47.8
Medical counseling	20.7	27.8
Social contacts	19.5	15.6

Table 8
Reasons for being inactive at admission and 3 months after catheterisation.

	at admission (%)	3 months after catheterisation (%)
Heart disease	43.6	33.3
Lack of motivation	35.9	44.4
Other disease	28.2	33.3
Lack of time	20.5	22.2

rameters that could influence the amount of physical activity after hospitalisation. This is probably the result of the applied therapies such as percutaneous coronary interventions, cardiovascular drugs, and cardiac rehabilitation.

Simultaneously we analysed the actual amount of physical activity. Before hospitalisation 58% of the patients did not follow the recommendations for health-enhancing physical activity. After hospitalisation their number increased to 64.3% and the number of regularly active patients decreased from 34.1% to 27.8%, while the number of trained patients stayed constant at 7.9%. These data are surprising and should give rise to concern. In fact, despite the fact that nearly 95% of the patients were informed about the importance of physical activity for cardiovascular health, only a minority pursued regular exercise. As only 6.3% judged their general health status as insufficient after hospitalisation, and only 9.5% felt disabled in moderate intensity activities, this was not related to their inability to exercise. As nearly a third of the patients was completely inactive and nearly two third were not sufficiently active, it appears that patients although well informed were not motivated to increase their amount of physical activity. In fact, although before hospitalisation heart disease was the leading reason for not being active (43.6%) followed by lack of motivation (35.9%) and other reasons, after the three month follow-up the leading reason was lack of motivation (44.4%), followed by heart disease (33.3%) and other reasons.

Rapid access to optimal cardiac care, fast improvement of symptoms with minimal invasive procedures are positives factors in the health system, but their long-term effects may be limited by the lack of engagement of these patients in the active management of their disease. This is a very concerning behavior demonstrating the ineffectiveness of counseling and of the experience of a hospital stay for cardiac causes to change lifestyle. Thus, other interventions must be considered to implement a change in physical activity in cardiac patients. Cardiac rehabilitation has been advocated to that purpose [46].

Furthermore we also determined whether the involvement in a cardiac rehabilitation program might have influenced the future physical activity of these patients. It seems that patients who were included in a rehabilitation program were much more active up to 3 months after catheterisation than patients who did not. Because of the small number of patients who underwent rehabilitation, this observation should be interpreted with caution and tested in larger studies in the future. Also it might be important to develop new information campaigns, with a specific focus on the motivation of the patients for the active management of their disease.

References

1 Murray CJ, Lopez AD. Mortality by cause for eight regions of the world: Global Burden of Disease Study. Lancet. 1997; 349:1269–76.
2 American Heart Association. Heart disease and stroke statistics – 2006 Update. Available from website: www.americanheart.org/presenter.jhtml?identifier=3000090.
3 Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associates with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364:937–52.
4 Frasure-Smith N, Lesperance F, Gravel G, et al. Social support, depression, and mortality during the first year after myocardial infarction. Circulation. 2000;101:1919–24.
5 Linden W, Stossel C, Maurice J. Psychosocial interventions for patients with coronary artery disease: a meta-analysis. Arch Intern Med. 1996;156:745–52. Erratum, Arch Intern Med. 1996;156:2302.
6 Abrams J. Chronic stable angina. N Engl J Med. 2005;352: 2524–33.
7 Ades PA. Cardiac rehabilitation and secondary prevention of coronary heart disease. N Engl J Med. 2001;345:892–902.
8 Kavanagh T. Exercise in the primary prevention of coronary artery disease. Can J Cardiol. 2001;17(2):155–61.
9 Leon AS, Franklin BA, Costa F, Balady GJ, Berra KA, Stewart KJ, et al. Cardiac rehabilitation and secondary prevention of coronary heart disease: an American Heart Association scientific statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity), in collaboration with the American association of Cardiovascular and Pulmonary Rehabilitation. Circulation. 2005;111 (3):369–76. Erratum, Circulation. 2005;111(3):1717.
10 Miller TD, Fletcher GF. Exercise and coronary artery disease prevention. Cardiologia. 1998;43(1):43–51.
11 O'Connor GT, Buring JE, Yusuf S, et al. An overview of randomized trials of rehabilitation with exercise after myocardial infarction. Circulation. 1989;80:234–44.
12 Schmermund A. Kardiorespiratorische Fitness. Die Bedeutung des Sports für die Gesundheit. Herz. 2004;29:365–72.

13. Shephard RJ, Balady GJ. Exercise as cardiovascular therapy. Circulation. 1999;99:963–72.
14. Haskell WL, Alderman EL, Fair JM, et al. Effects of intensive multiple risk factor reduction on coronary atherosclerosis and clinical cardiac events in men and women with coronary artery disease: the Stanford Coronary Risk Intervention Project (SCRIP). Circulation. 1994;89:975–90.
15. Niebauer J, Hambrecht R, Velich T, et al. Attenuated progression of coronary artery disease after 6 years of multifactorial risk intervention: role of physical exercise. Circulation. 1997;96:2534–41.
16 Oldridge NB, Guyatt GH, Fischer ME, Rimm AA. Cardiac rehabilitation after myocardial infarction: combined experience of randomized clinical trials. JAMA. 1988;260:945–50.
17 Ornish D, Scherwitz LW, Billings JH, et al. Intensive lifestyle changes for reversal of coronary heart disease. JAMA. 1998;280:2001–7. Erratum, JAMA. 1999;281:1380.
18 Schuler G. Primary and secondary prevention: physical activity. Z Kardiol. 2002;91(Suppl 2):30–9.
19 Graf C, Predel HG, Bjarnason-Wehrens B. Körperliche Aktivität in der Primärprävention der koronaren Herzkrankheit. Kardiovaskuläre Medizin. 2004;4:119–25.
20 Rauramaa R, Salonen JT, Seppanen K, Salonen R, Venalainen JM, Ihanainen M, et al. Inhibition of platelet aggregability by moderate-intensity physical exercise: a randomized clinical trial in overweight men. Circulation. 1986;74(5): 939–44.
21 Stratton J, Chandler WL, Schwartz RS, et al. Effects of physical conditioning on fibrinolytic variables and fibrinogen in young and old healthy adults. Circulation 1991;83:1692–7.
22 Suzuki T, Yamauchi K, Yamada Y, et al. Blood coagulability and fibrinolytic activity before and after physical training during the recovery phase of acute myocardial infarction. Clin Cardiol. 1992;15:358–64.
23 Verma S, Anderson TJ. Fundamentals of endothelial function for the clinical cardiologist. Circulation. 2002;105: 546–9.
24 Hambrecht R, Wolf A, Gielen S, et al. Effect of exercise on coronary endothelial function in patients with coronary artery disease. N Engl J Med. 2000;342:454–60.
25 Miller VM, Vanhoutte PM. Enhanced release of endothelium-derived factor(s) by chronic increases in blood flow. Am J Physiol. 1988;255(3 Pt 2):H446–51.
26 Schachinger V, Britten MB, Zeiher AM. Prognostic impact of coronary vasodilator dysfunction on adverse long-term outcome of coronary heart disease. Circulation. 2000;101:1899–906.
27 Windecker S, Allemann Y, Billinger M, Pohl T, Hutter D, Orsucci T, et al. Effect of endurance training on coronary artery size and function in healthy men: an invasive followup study. Am J Physiol Heart Circ Physiol. 2002;282:2216–23.
28 Goldsmith RL, Bigger JT Jr, Steinman RC, Fleiss JL. Comparison of 24-hour parasympathetic activity in endurance-trained and untrained young men. J Am Coll Cardiol. 1992; 20(3):552–8.
29 Malfatto G, Facchini M, Sala L, Branzi G, Bragato R, Leonetti G. Effects of cardiac rehabilitation and beta-blocker therapy on heart rate variability after first acute myocardial infarction. Am J Cardiol. 1998;81:834–40.
30 Dylewicz P, Bienkowska S, Szczesniak L, Rychlewski T, Przywarska I, Wilk M, et al. Beneficial effect of short-term endurance training on glucose metabolism during rehabilitation after coronary bypass surgery. Chest. 2000;177(1): 5–7.
31 Schuler G, Hambrecht R, Schlierf G, et al. Regular physical exercise and low-fat diet: effects on progression of coronary artery disease. Circulation. 1992;86:1–11.
32 Warner JG Jr, Brubaker PH, Zhu Y, et al. Long-term (5-year) changes in HDL cholesterol in cardiac rehabilitation patients. Do sex differences exist? Circulation. 1995;92:773–7.
33 Wood PD, Stefanick ML, Williams PT, Haskell WL. The effects on plasma lipoproteins of a prudent weight-reducing diet, with or without exercise, in overweight men and women. N Engl J Med. 1991;325(7):461–6.
34 Shephard RJ, Kavanagh T, Mertens DJ, Qureshi S, Clark M. Personal health benefits of Masters athletics competition. Br J Sports Med. 1995;29(1):35–40.
35 Shephard RJ. Exercise and relaxation in health promotion. Sports Med. 1997;23(4):211–7.
36 King NA, Tremblay A, Blundell JE. Effects of exercise on appetite control: implications for energy balance. Med Sci Sports Exerc. 1997;29(8):1076–89.
37 Franklin BA, Bonzheim K, Gordon S, Timmis GC. Safety of medically supervised outpatient cardiac rehabilitation exercise therapy: a 16-year follow-up. Chest. 1998;114:902–6.
38 Van Camp SP, Peterson RA. Cardiovascular complications of outpatient cardiac rehabilitation programs. JAMA. 1986; 256:1160–3.
39 Bundesamt für Sport Magglingen (BASPO), Bundesamt für Gesundheit (BAG). Gesundheitswirksame Bewegung, ein Grundsatzdokument, 2002. Corrected and republished on 2004. Available from website: www.hepa.ch.
40 US Department of Health and Human Services, Public Health Service, Center for Disease Control and Prevention. Adult participation in recommended levels of physical activity – United States 2001 and 2003. Morbidity and Mortality Weekly Report. 2005;54 (47):1208–12. Available from website: www.cdc.gov/mmwr/mmwrpvol.html.
41 Lamprecht M, Stamm HP. Jahresbericht 2004. Observatorium Sport und Bewegung Schweiz. Available from website: www.sportobs.ch.
42 Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc. 2000;32(9 Suppl):498–504.
43 US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention. Measuring Physical Activity Intensity: Metabolic Equivalent (MET) Level. Available from website: www.cdc.gov/nccdphp/dnpa/physical/measuring/met.htm.
44 Grech ED, Ramsdale DR. Acute coronary syndrome: unstable angina and non-ST segment elevation myocardial infarction. BMJ. 2003;326:1259–61.
45 Grech ED, Ramsdale DR. Acute coronary syndrome: ST segment elevation myocardial infarction. BMJ. 2003;326: 1379–81.
46 Williams MA, Ades PA. Clinical evidente for a health benefit from cardiac rehabilitation: An update. Am Heart J. 2006; 152(5):835–41.