# CHAPTER XI
# CARDIAC REHABILITATION IN SOUTH AFRICA - REVIEW OF RESEARCH AND IDENTIFICATION OF ESSENTIAL HEALTH RESEARCH PRIORITIES

Dr WE Derman, Ms KL Derman, Prof TD Noakes

## CARDIAC REHABILITATION - CURRENT STATUS

### Background

Coronary artery disease (CAD) contributes much to the burden of morbidity and mortality from chronic diseases in industrialised countries, including South Africa.[1] Many countries have adopted prevention policies designed to reduce the prevalence of risk factors for CAD and in turn alleviate the burden of CAD in their populations.

Although the mortality rate for CAD for white South Africans is presently decreasing, the incidence of CAD for all South African population groups other than blacks remains extremely high.[2] The true incidence of CAD in the South African black population is presently unknown. It is however generally accepted that as the incidence of hypertension in the black South African population is increasing, it is expected that the incidence of CAD in this population will similarly increase over the next few years.

There is now sufficient evidence to show a relationship between physical inactivity and cardiovascular mortality, and physical inactivity has been firmly established as a risk factor for the development of CAD.[3-5] Furthermore, middle-aged men and women who work in physically demanding jobs or perform moderate to strenuous recreational activities have fewer manifestations of CAD compared to their less active peers.[3,4]

Meta-analysis studies of clinical trials reveal that medically prescribed and supervised exercise can reduce both morbidity and mortality rates of patients with coronary artery disease.[6-9] Therefore regular physical exercise is important in the primary, and indeed secondary prevention of CAD.

Demand for cardiac rehabilitation services is therefore likely to increase in the future due i) to the expected increase in hypertension in the black South African community; ii) the increased age of the general population and iii) interventions such as thrombolysis, stents, laser ablation and other revascularisation procedures which allow more patients to participate in structured exercise programmes.

### Definition

Cardiac rehabilitation can be considered the process of restoring psychological, physical and social functions to optimal levels in those individuals who have had prior manifestations of CAD.

---

*Dr Wayne E Derman (M.B.Ch.B., Ph.D., F.A.C.S.M.) is Senior Lecturer in Sport Science at the MRC/UCT Bioenergetics of Exercise Research Unit. He is also Medical Director of the Cardiac Rehabilitation and Chronic Disease Rehabilitation Programme at the Sport Science Institute of South Africa.*

*Kirsten Louis Derman completed her B.Sc. (Med)(Hons) in Sport Science at the University of Cape Town in 1990. She has recently completed her M.Sc. (Med) degree in the rehabilitation of patients in chronic heart failure.*

*Prof TD Noakes (see Chapter VI).*

## Patients

A cardiac rehabilitation programme may include patients who have had coronary artery bypass surgery, myocardial infarction, pacemaker implantation, cardiac transplantation, valve replacement, coronary angioplasty, or who have other evidence of cardiovascular disease such as a positive stress test, angina pectoris or other evidence of disease from a radionuclide study or coronary catheterisation. If rehabilitation takes place once CAD has been diagnosed, this is termed secondary cardiac rehabilitation. If a patient with documented risk factors for CAD participates in a cardiac rehabilitation programme, this is termed primary cardiac rehabilitation.

## Cardiac Rehabilitation Programmes

Whilst exercise training forms the mainstay of cardiac rehabilitation, programs may include the services of a dietitian, psychologist, biokineticist and/or physiotherapist. Patient counselling and spouse education forms an important part of cardiac rehabilitation programs.[10] Some programs also have religious counselling as part of the program.

## Staff

The importance of a multi-disciplinary team approach to cardiac rehabilitation has recently been stressed.[11] The staff of a cardiac rehabilitation programme usually include a medical doctor/physician/cardiologist trained in cardiac rehabilitation, exercise physiologist/biokineticist, dietitian, psychologist, and a cardiac trained sister. It is obviously not always possible to have the above mentioned staff at all programs throughout South Africa and it is indeed possible to run an effective programme with the minimum of staff.

## The benefits of cardiac rehabilitation

The physiological benefits of cardiac rehabilitation have recently been reviewed.[12-15]

Physiological benefits of cardiac rehabilitation can be divided into a) benefits of early rehabilitation and b) benefits of ongoing rehabilitation.

### *Benefits of early rehabilitation*

- Prevention of the detrimental effects of prolonged bed rest. Strict bed rest has been shown to have a significant effect on physiological function. After a few days the patient has:

  significantly decreased cardiorespiratory fitness
  decreased blood volume
  decreased red blood cell count
  a negative nitrogen and protein balance
  decreased strength and flexibility
  increased orthostatic hypotension
  increased risk of thromboembolism

Early physical activity decreases post-surgical stiffness and prevents complications of post-surgical atelectasis in patients who have undergone coronary artery bypass grafting.

- Prevention of general deconditioning.

- Promotion of psychological well being. Decrease in incidence and severity of depression and anxiety.

- Provision of spiritual comfort.
- Decrease in length of hospital stay.
- Increased awareness of cardiac disease information and modes available for life-style alteration.

***Benefits of ongoing rehabilitation***

- Regular physical exercise reduces the myocardial oxygen requirement at a given level of exercise and raises the angina threshold.[16] Myocardial oxygen requirement is directly related to the cardiac rate-pressure product (heart rate X systolic blood pressure). Exercise training reduces the rate-pressure product at any given level of exercise, thus reducing the overall myocardial oxygen demand. Therefore, angina pectoris will occur at a higher workload after exercise training than before exercise training.
- Regular physical exercise improves myocardial oxygen supply. This is possibly due to formation of collateral vessel formation. This has been shown in animal models but no evidence exists in humans.[17]
- Regular physical activity decreases blood platelet aggregability.[18]
- Regular physical activity enhances the body's natural thrombolytic capacity. Exercise has been shown to be an important stimulus for release of endothelial tissue-plasminogen activator into the blood.[19]
- Regular physical activity reduces the chance of developing ventricular fibrillation. This has been shown in the rat model.[20] It has also been shown from the physically active subjects in Paffenberger's[21] study and from the civil servants in Morris's[4] study that this group (of physically active subjects) had less chance of dying suddenly from heart disease.
- Regular physical exercise has a positive influence on the other CAD risk factors. Recent studies have shown that regular exercise:

  increases high density lipoprotein (HDL) concentrations.
  decreases the total cholesterol:HDL ratio
  decreases serum triglyceride concentrations
  lowers systolic and diastolic blood pressure in hypertensive patients
  decreases the risk of developing hypertension
  enhances carbohydrate metabolism therefore helps to prevent and control diabetes mellitus
  reduces stress

- Regular physical exercise in the form of a formal cardiac rehabilitation programme enhances the psychological well-being in these patients[22] and enhances the patient's quality of life.[23-25]

***The cost-benefit relationship of cardiac rehabilitation***

In the past cardiac rehabilitation programmes have been criticised for not being cost-effective, however little data are available. Ades, *et al.*[26] studied hospitalisation and medical costs in patients who participated in a structured cardiac rehabilitation programme and compared the costs to those patients who did not participate in regular cardiac rehabilitation. Medical charges for patients participating in cardiac rehabilitation were on average $739 lower than charges for patients not participating in cardiac rehabilitation. This was due to both a lower incidence of hospitalisation and lower charges per hospitalisation. Results of this and other studies indicate an association between participation in cardiac rehabilitation programmes and lower cardiac rehospitalisation costs in the

years after an acute coronary event.[24,26-28] Shephard[29] argues that patients who develop chronic disease will require some form of treatment, exercise offers an attractive option for both secondary and tertiary prevention, particularly if programmes have low facility and opportunity costs, and attention is directed to high-risk patients.

## CARDIAC REHABILITATION IN SOUTH AFRICA

Existing cardiac rehabilitation programmes in South Africa are listed in Table I.

**Table I. Cardiac rehabilitation programmes in South Africa**

| CARDIAC REHABILITATION CENTRE | AREA | TELEPHONE NUMBER | CONTACT NAME |
|---|---|---|---|
| Addington Hospital Dept Physiotherapy | Durban | 031-2111 X288 | Mrs Moodliar |
| Bloemfontein Rehabilitation Clinic | Bloemfontein | 051-461078 | Dr F Retief |
| Cavendish Square Cardiac Rehabilitation | Claremont, Cape Town | 021-4066265 | Dr W Derman |
| East London Cardiac Rehabilitation Centre | East London | 0431-20801 | Meryl Johnson |
| Ferncrest Hospital Cardiac Rehabilitation | Rustenburg | 01466-56060 | Sr Y Haig |
| Flora Clinic | Weltevreden Park, Gauteng | 011-475-3190 | Esme Richards |
| Foreshore Cardiac Rehabilitation Centre | Cape Town | 021-615292 | Dr P Macfarlane |
| Groote Schuur Cardiac Rehabilitation | Cape Town | 021-4049111 X1714 | Sr Veronica Francis |
| Johannesburg Cardiac Rehabilitation Centre | Gauteng | 011-4077155 | Dr AG Digenio |
| Lenasia Cardiac Rehabilitation Centre | Lenasia, Gauteng | 011-8543496 | Dr AG Digenio |
| Milpark Hospital Rehabilitation | Johannesburg, Gauteng | 011-7268236 | Dr F Hitchcock |
| Natal Cardiac Rehabilitation Centre | Congela, Natal | 031-2604218 | Dr M Mars |
| N1-City Cardiac Rehabilitation Centre | Goodwood, Cape Town | 021-587194/5 | Dr C Capnias |
| Port Elizabeth Cardiac Rehabilitation Centre | Port Elizabeth | 041-338113 | Sr L Seaman |
| Pretoria Heart Hospital | Pretoria, Gauteng | Box 1104, Pretoria | Sr A Van Zyl |
| Pretoria Sports Centre Cardiac Rehabilitation | Pretoria, Gauteng | 012-437711 | Prof J Loots |

Cardiac rehabilitation programmes in South Africa (continued)

| CARDIAC REHABILITATION CENTRE | AREA | TELEPHONE NUMBER | CONTACT NAME |
|---|---|---|---|
| RK Khan Hospital Cardiac Rehabilitation | Chatsworth, Natal | 031-433223 | Dr Ronjith |
| Roodepoort Stadsraad Biokinetics | Roodepoort, Gauteng | 011-7642837 | R Bezuidenhout |
| Tygerberg Cardiac Rehabilitation Centre | Tygerberg, Cape | 021-9385426 | Prof H Weich |
| Tygervalley Cardiac Rehabilitation Centre | Tygervalley, Cape | 021-5512917 | Dr J Koenig |
| UCT/Heart Foundation Cardiac Rehabilitation | Rondebosch, Cape Town | 021-235110 | Mr S Burden |
| UCT/Point Cardiac Rehabilitation | Sea Point, Cape Town | 021-4066265 | Dr W Derman |
| Wentworth Hospital Cardiac Rehabilitation | Wentworth, Natal | 031-484311 | Ms T Sibeya |
| Witbank Hospital Cardiac Rehabilitation | Witbank | 0135-656111 | |

## REVIEW OF RESEARCH CONDUCTED IN CARDIAC REHABILITATION PROGRAMMES IN SOUTH AFRICA

Research in the field of cardiac rehabilitation in South Africa began only in the mid-1980's. Gordon, *et al.*[30,31] described the cardiac rehabilitation programme at the 1 Military Hospital and stressed the importance of the pre-discharge exercise stress-test. This group also studied the exercise ventilatory responses after training in patients with coronary artery disease ingesting ß-blockers. The results of this study showed that patients who participated in prolonged exercise training showed physiological adaptations to the training despite simultaneous ingestion of ß-blockers.[30]

In 1987 this group of researchers studied the effects of ß-blockade on thermoregulation during exercise in patients with CAD. The authors reported that patients ingesting ß-blockers were at increased risk of hyperthermia during exercise. These findings led to the recommendation that climatic conditions be carefully controlled in cardiac rehabilitation programmes.[32]

Since this time, research conducted in the field of cardiac rehabilitation has only taken place in those programmes allied to large academic hospitals. Most of the research has therefore been conducted at the UCT/Heart Foundation & UCT/Point cardiac rehabilitation programmes which are allied to the MRC/UCT Bioenergetics of Exercise Research Unit, and at the Johannesburg Cardiac Rehabilitation Programme which is allied to the University of the Witswatersrand.

Research at the University of Cape Town conducted on the effects of cardiac rehabilitation began in 1983 when Schomer, *et al.*[22] studied the effects of a cardiac rehabilitation programme on the psychological well-being of the patients. Schomer, *et al.*[22] found that regular physical exercise in the form of a formal cardiac rehabilitation programme enhanced the psychological well-being of patients participating in that programme.

More recently, the group of researchers at UCT have performed studies to determine the cause of exercise intolerance in patients with heart failure. Derman, *et al.*[33] performed skeletal muscle biopsies on thirteen patients with chronic heart failure, and found that the skeletal muscle was

profoundly abnormal. The myopathy of cardiac failure has since been described in detail.[34] Together with the Department of Pathology at Red Cross Children's Hospital. These researchers have described a scoring system to determine the severity of the skeletal muscle pathology.[35] It is of interest to note that it is the severity of the skeletal muscle pathology and not the ejection fraction which predicts exercise performance in patients with heart failure.[35]

Recent work has been undertaken to determine the effects of various interventions on the myopathy of chronic cardiac failure. Derman, *et al.*[36] determined the effects of cardiac transplantation on exercise tolerance, skeletal muscle function and skeletal muscle pathology. These variables were measured before and six weeks after orthotopic cardiac transplantation. At six weeks after cardiac transplantation, exercise performance was only slightly improved but the skeletal muscle pathology was unchanged. This finding indicates that the histological changes are more a marker, rather than the cause of impaired skeletal muscle function before and after cardiac transplantation. Both the myopathic changes and skeletal muscle function improve substantially after 6 months of formal cardiac rehabilitation.[37]

Other work at UCT has aimed to determine training methods to increase functional capacity in patients participating in cardiac rehabilitation programmes. Derman, *et al.*[38] examined the effects of the addition of circuit weight training to a conventional cardiac rehabilitation programme. Skeletal muscle strength and functional capacity increased after circuit weight training without increasing left ventricular mass. The authors conclude that circuit weight training is a safe and effective method to increase functional capacity without causing left ventricular hypertrophy.

Researchers at the University of Cape Town have also sought to determine the effects of ß-blocking agents on exercise performance and exercise training adaptations in hypertensive patients participating in cardiac rehabilitation programmes. Derman, *et al.*[39] reported that patients ingesting ß-blocking agents do not enjoy the full adaptation to exercise training programmes. This alteration to the expected adaptation might be because of altered skeletal muscle function due to chronic ingestion of ß-blocking agents.

Current research in the field of cardiac rehabilitation at the MRC/UCT Bioenergetics of Exercise Research Unit is aimed at further study of the cause and rehabilitation of the myopathy of chronic cardiac failure and the effects of high intensity interval training in patients participating in cardiac rehabilitation programmes.

The research group at the Johannesburg Cardiac Rehabilitation Center aligned to the University of the Witswatersrand, have over the past ten years, been particularly active in research of the effects of cardiac rehabilitation. Digenio, *et al.*[40] reported that patients who complied well with a six month programme at the Johannesburg Civic Center Cardiac Rehabilitation Center achieved a significant reduction in certain coronary risk factors. Body weight, skinfold thickness and triglyceride concentrations were significantly reduced. The total cholesterol/HDL ratio was also favorably altered after training in this group of patients.

A study by Morris, *et al.*[41] of these same patients, described changes in apoprotein A1, B and lipoprotein a. The authors report significant positive changes in apo A1, apo A/apo B ration and Lp(a) after exercise training. Multiple regression analyses showed that alterations in the lipid fractions were not related to changes in physical fitness. Changes in Lp(a) showed a positive correlation with changes in the Broca index and the use of fibrates.

Digenio, *et al.*[42] also documented the rate of exercise-related cardiac arrest in the Johannesburg Cardiac Rehabilitation Programme. The incidence of fatal cardiac arrest in this programme was 1/160 000 patient hours. This low rate of cardiac arrest is similar to that reported in two large studies conducted in the USA and reinforces the safety of the practice of cardiac rehabilitation.[43]

Researchers at this same programme report good compliance with the exercise programme. Digenio, *et al.*[44] reported that 36% of patients dropped out of the rehabilitation programme by 12 months and 50% had dropped out by 18 months. Dropouts complied less than compliers in terms of attendance and intensity of exercise before dropping out of the programme. High age, cigarette smoking, low peak oxygen uptake and patient's feelings of hostility were identified as factors predicting patient dropout.

Recent work by the Johannesburg group concerns patients in cardiac rehabilitation programmes with left ventricular systolic dysfunction.[45] Digenio, *et al.*[45] studied adaptations to 6 months of exercise training in cardiac rehabilitation patients with normal systolic function and compared these adaptations with those in patients with impaired systolic function. Similar significant improvements were seen with respect to peak $VO_2$, exercise time and ventilatory threshold in all patients independent of their resting ejection fraction after exercise training. These findings indicate that adaptations to exercise training occur in patients with severely impaired left ventricular systolic function.

## THE CHALLENGES FACING CARDIAC REHABILITATION IN SOUTH AFRICA

It is somewhat surprising that although South Africa has a high incidence of CAD, we are many years behind in the development of cardiac rehabilitation services for our population with heart disease. This is probably due to the fact that until very recently, the efficacy of formalised cardiac rehabilitation had not been established, and clear guidelines for the practice of cardiac rehabilitation had not been clearly defined. Furthermore, as the data concerning the benefits of cardiac rehabilitation have only emerged in recent years, many cardiologists, physicians and general medical practitioners (and therefore patients) are unaware of the benefits that cardiac rehabilitation programmes offer.

At present the cardiac rehabilitation programs in South Africa vary. There are programmes which offer a full multi-disciplinary approach to cardiac rehabilitation including full dietary assessment and prescription, psychological support, exercise testing and prescription, blood pressure monitoring and continuous heart rate and telemetry monitoring. On the other hand there are programmes which offer exercise only. The exercise performed by the patients varies from being structured, individually prescribed, and monitored, to exercise that is unstructured and unmonitored. Some cardiac rehabilitation programmes are directed by medically qualified directors skilled in the theories and application of modern cardiac rehabilitation and exercise prescription. Other programmes are run solely by nursing staff or in some cases, the local minister.

Guidelines for cardiac rehabilitation in South Africa do not exist. These are urgently required and it is important that they are compiled with all of South Africa's population groups, economic stratification and diversity of programme structures in mind. This will enable both the patient with greater economic means and the patient with no means at all, to enjoy the benefits of effective cardiac rehabilitation.

Although the statistics show that CAD in the white and coloured communities in South Africa is not increasing, the incidence of hypertension in the South African black community is increasing, and as the incidence of CAD and hypertension is linked, it is likely that the need for cardiac rehabilitation programmes in the South African black community will increase in the future.

At present there are no/few cardiac rehabilitation programmes in the black community. It is of importance to note that cardiac rehabilitation programmes are either funded by the local authorities or funded by charging the patients for cardiac rehabilitation services (private programmes). The current feeling is that local authorities wish to privatise the rehabilitation programmes so that the cost of rehabilitation will be borne by the patient or the patient's medical aid. This presents a problem as most patients requiring cardiac rehabilitation will not be able to afford these services unless i) cardiac rehabilitation is provided (continues to be provided) as a community service to the

public, funded by the local authorities or ii) sponsorship or subsidy for rehabilitation programmes should be actively sought from the private sector.

At present there is no Medical Association/RAMS code for the charging of cardiac rehabilitation services. Practitioners billing patients for cardiac rehabilitation services must therefore use code numbers 0101 and 0108 for cardiac rehabilitation. This is the same code for a general practitioner's visit. As most medical aid schemes function on a set maximum of general practitioners visits, a problem is encountered when a patient participating in cardiac rehabilitation rapidly exceeds the maximum number of permitted medical aid funded visits. We therefore recommend that the practice of cardiac rehabilitation be allocated a separate code as a matter of urgency.

## FUTURE DIRECTIONS AND RESEARCH PRIORITIES IN THE FIELD OF CARDIAC REHABILITATION IN SOUTH AFRICA

### Community-based research

At present the true incidence of CAD in the black South African population is unknown. It is therefore important that research be initiated to determine the incidence of CAD in an 'urbanising' population. A study similar to the 'Framingham' study should be conducted on a small but representative sample of an urbanising community e.g. Guguletu where it would be possible to follow up families recruited into the study.

Identification of risk factors for CAD in **young** black and coloured populations. Although there are data to describe certain risk factors in the coloured and black South African communities, there are at present no data describing patterns of physical activity in these populations.[46-49] As the incidence of CAD is expected to increase in these populations it would be important that epidemiologically-based studies be conducted in the underprivileged communities to identify **all** the modifiable risk factors for CAD.

If the expected increase in CAD occurs in the black South African population, it is feasible to expect an increase in the number of clinicians/physicians referring patients for cardiac rehabilitation. This in turn would increase the need for qualified health professionals to work in the area of cardiac rehabilitation. It is also possible that cardiac rehabilitation services may become linked with family practitioners and health professionals within the community and indeed, in outlying areas away from the large cities.[50] It is also likely that there will be an increase in more home-based less formalised cardiac rehabilitation programmes, particularly for lower risk groups.

Research should therefore be directed to determine the needs for i) establishment of cardiac rehabilitation programmes in poor socio-economic environments; ii) training programmes available for education/training of staff and training of appropriate personnel to conduct cardiac rehabilitation with the minimum of equipment; iii) cost-benefit studies for the creation of such programmes

There are few data available on methods of training cardiac rehabilitation patients at a distance from the rehabilitation programme. Most of the studies to date have used advanced technology to prescribe exercise at a distance.[51] Research should also therefore be aimed at determining methods to prescribing exercise at a distance and using the minimal amount of costly equipment.[50] As standard methods of prescribing exercise are not available in underprivileged communities, alternative methods of safe exercise prescription should be investigated.

### Research of exercise performance in cardiac rehabilitation programmes

South Africa has the skills and technology which has produced research in the field of cardiac rehabilitation, at least on a par with research being conducted at other major international cardiac rehabilitation centers. We feel that it is important that good quality research is maintained so that a complete understanding of exercise intolerance in the patient with cardiac disease can be

achieved, so that suitable rehabilitation programmes can be designed for these patients. To this end we feel that the following areas of research should be of priority.

*Prolonged effects of circuit weight training*

Studies at both the UCT Cardiac Rehabilitation programmes and at the Johannesburg Cardiac Rehabilitation programmes have shown beneficial short term adaptations to circuit weight training. However the long term effects of circuit weight training are still unknown.

*Safety and benefits of high-intensity exercise in cardiac rehabilitation populations*

Recent studies indicate that the exercise capacity of patients in cardiac rehabilitation programmes can be increased through high-intensity exercise training.[52] Further studies should be conducted to determine if the increased exercise performance after high-intensity training translates into an increased functional capacity in activities of daily living and to determine the long-term effects and safety of high-intensity exercise training in cardiac rehabilitation patients.

*Effects of carbohydrate supplementation in cardiac rehabilitation patients*

There are currently no data available of the effects of carbohydrate/anti-oxidant supplementation on exercise tolerance and functional capacity in patients with cardiac disease. As some beneficial effects have been documented in healthy populations, it would be of important to determine if these effects occur in patients with cardiac disease.

*Effects of cardiac rehabilitation in special groups*

There is little information available on the effects of exercise training and cardiac rehabilitation in special groups including paediatric, aged populations and female patients. Research should therefore be conducted to determine the effects of exercise training on these patient groups.

**REFERENCES**


1. Steyn K, Fourie J, Bradshaw D. The impact of chronic diseases of lifestyle and their major risk factors on mortality in South Africa. *SAMJ* 1992;**82**:227-231.
2. Walker AR, Adam A, Kustner HG. Changes in total death rate and in ischaemic heart disease death rate in interethnic South African populations, 1978-1989. *SAMJ* 1993;**83**:602-605.
3. Powell KE, Thompson PD, Caspersen CJ, Kendick JS. Physical activity and the incidence of coronary heart disease. *Ann Rev Public Health* 1987;**8**:253-287.
4. Morris JN, Clayton DG, Everitt MG, Semmence AM, Burgess EH. Exercise in leisure time: Coronary attack and death rates. *Br Heart J* 1990;**63**:325-334.
5. Blair SN, Kohl HW 3rd, Paffenberger RS Jr, Clark DG, Cooper KH, Gibbons LW. Physical fitness and all-cause mortality: A prospective study of healthy men and women. *JAMA* 1989;**262**:2395-2401.
6. O'Connor GT, Buring JE, Yusuf S, Goldberg SZ, Olmstead EM, Paffenberger RS Jr, Hennekens CH. An overview of randomized trials of rehabilitation with exercise after myocardial infarction. *Circulation* 1989;**80**:234-244.
7. Oldridge NB, Guyatt GH, Fischer ME, Rimm AA. Cardiac rehabilitation after myocardial infarction: Combined experience of randomized clinical trials. *JAMA* 1988;**260**:945-950.
8. Berlin JA, Colditz GA. A meta-analysis of physical activity in the prevention of coronary heart disease. *Am J Epidemiology* 1990;**132**:612-628.
9. Hedback B, Perk J, Wodlin P. Long-term reduction of cardiac mortality after myocardial infarction: 10-year results of a comprehensive rehabilitation programme. *Eur Heart J* 1993;**14**:831-835.
10. Levy JK. Standard and alternative adjunctive treatment in cardiac rehabilitation (Review). *Texas Heart Inst J* 1993;**20**:198-212.
11. Kellerman JJ. Long-term comprehensive cardiac care - the perspectives and tasks of cardiac rehabilitation. *Eur Heart J* (Ed) 1993;**14**:1441-1444.
12. Squires RW, Gau GT, Miller TD, Allison TG, Lavie CJ. Cardiac rehabilitation: status 1990. *Mayo Clinic Proceedings* 1990;**65**:731-755.
13. Naughton J. Exercise training for patients with coronary artery disease. Cardiac rehabilitation revisited. (Review). *Sports Med* 1992;**14**:304-319.
14. Pashkow FJ. Issues in contemporary cardiac rehabilitation: a historical perspective. (Review). *J Am Coll Cardiol* 1993;**21**:822-834.
15. Bittner V, Oberman A. Efficacy studies in coronary rehabilitation. (Review). *Cardiol Clin* 1993;**11**:333-347.

16. Trap-Jensen J, Clausen JP. Effect of training on the relation of heart rate and blood pressure to the onset of pain in effort angina pectoris. In: Larsen OA, Malmborg RO, eds. *Coronary Heart Disease and Physical fitness: Symposium on Physical Fitness and Coronary Heart Disease*. Baltimore, MD: University Park Press, 1971:111-114.
17. Franklin BA. Exercise training and coronary collateral circulation. *Med Sci Sports Exerc* 1991;**23**:648-653.
18. Rauramaa R, Salonen JT, *et al.* Inhibition of platelet aggregability by moderate-intensity physical exercise. *Circulation* 1986;**74**:939-944.
19. Eichner ER. Coaguability and Rheology: Haematologic Benefits fron Exercise, Fish and Aspirin. *The Physician and Sports Medicine* 1986;**14**:102-110.
20. Noakes TD, Higginson L, Opie L. Physical training increases ventricular fibrillation threshold of isolated rat hearts during normoxia, hypoxia and regional ischaemia. *Circulation* 1983;**67**:24-30.
21. Paffenberger RS Jr, Hyde RT, Wing AL, Hsieh CC. Physical activity, all-cause mortality, and longevity of college alumni. *N Engl J Med* 1986;**314**:605-613.
22. Schomer H, Noakes TD. Exercise training after a heart attack: a psychological study. *SAMJ* 1983;**64**:473-475.
23. Sparks KE, Shaw DK, Eddy D, Hanigosky P, Vantrese J. Alternatives for cardiac rehabilitation patients unable to return to a hospital-based programme. *Heart and Lung* 1993;**22(4)**:298-303.
24. Oldridge NB, Guyatt G, Jones N, Crowe J, Singer J, Feeny D, McKelvie R, Runions J, Streiner D, Torrance G. Effects of quality of life with comprehensive rehabilitation after acute myocardial infarction. *Am J Cardiol* 1991;**67**:1084-1089.
25. Blumenthal JA, Wei J. Psychobehavioral treatment in cardiac rehabilitation. (Review). *Cardiol Clin* 1993;**11(2)**:323-31.
26. Ades PA, Huang D, Weaver SO. Cardiac rehabilitation participation predicts lower rehospitalization costs. *Am Heart J* 1992;**123**:916-921.
27. Levin LA, Perk J, Hedback B. Cardiac rehabilitation - a cost analysis. *J Int Med* 1991;**230**:427-434.
28. Oldridge NB, Streiner DL. The health belief model: predicting compliance and dropout in cardiac rehabilitation. *Med Sci Sports Exerc* 1990;**22**:678-683.
29. Shephard RJ. Economic benefits of secondary and tertiary cardiac rehabilitation: a critical study. (Review). *Ann Acad Med Singapore* 1992;**21**:57-62.
30. Gordon NF, Kruger PE, Cilliers JF. Improved exercise ventilatory responses after training in coronary heart disease during long term beta-adrenergic blockade. *Am J Cardiol* 1983;**51**:755-758.
31. Gordon NF. Inpatient cardiac rehabilitation. *SAMJ* 1984; **65**:78-82.
32. Gordon NF, Myburgh DP, Schwellnus MP, Van Rensburgh JP. Effect of Beta-blockade on exercise core temperature in coronary artery disease patients. *Med Sci Sports Exerc* 1987;**19**:591-596.
33. Derman EW, Selley KL, Emms M, Brink J, Noakes TD. Structural and functional abnormalities of skeletal muscle before and after orthotopic cardiac transplantation. *Cardiovasc J of Southern Africa* 1992;**3(Suppl 4)**:22.
34. Derman EW, Derman KL, Emms M, Sinclair-Smith C, Brink J, Noakes TD. The Myopathy of chronic cardiac failure: relationship to exercise performance. *J Molecular and Cellular Cardiology* 1994; (In Press).
35. Derman EW, Derman KL, Emms M, Sinclair-Smith C, Brink J, Noakes TD. Abnormal skeletal muscle histology, and not the ejection fraction, predicts exercise tolerance in patients with chronic heart failure. In: Monduzzi Editore. Published Proceedings of the European Section Meeting. Bologna, Italy: International Society for Heart Research, 1994:183-188.
36. Derman EW, Selley KL, Emms M, Sinclair-Smith C, Brink J, Noakes TD. The improvement in skeletal muscle function antedates histological improvement following cardiac transplantation. *Med Sci Sports Exerc* 1993a;**25**:**(Suppl 5)**S4-24.
37. Derman EW, Selley KL, Emms M, Sinclair-Smith C, Brink J, Noakes TD. Exercise performance and skeletal muscle pathology improve after cardiac transplantation and exercise training. (Abstract). *Eur Heart J* 1993;**14**:118.
38. Derman EW, Scales N, Clark DR, Mabin T, Noakes TD. Circuit weight training improves exercise tolerance of cardiac rehabilitation patients without causing left ventricular hypertrophy. *Med Sci Sports Exerc* 1994b; **26(5)**: S142.
39. Derman EW, Clark DR, Noakes TD. ß1-selective blockade impairs training adaptations & the expected reduction of perceived exertion during exercise in hypertensive adults. (Abstract) *Eur Heart J* 1993c; **14**:1328.
40. Digenio AG, Sim JG, Krige K, Stewart A, Morris R, Dowdeswell RJ, Padayachee GN. The Johannesburg cardiac rehabilitation programme. *SAMJ* 1991;**79(4)**:183-187.
41. Morris R, Digenio AG, Padayachee GN, Kinnear B. The effect of a 6-month cardiac rehabilitation programme on serum lipoproteins and apoproteins A1 and B and lipoprotein a. *SAMJ* 1993;**83(5)**:315-318.
42. Digenio AG, Sim JG, Dowdeswell RJ, Morris R. Exercise-related cardiac arrest in cardiac rehabilitation. The Johannesburg experience. *SAMJ* 1991;**79(4)**:188-191.
43. Haskell WL. Cardiovascular complications during exercise training of cardiac patients. *Circulation* 1978;**57**:920-924.
44. Digenio AG, Padayachee N, Groeneveld H. Multivariate models for compliance with phase 3 cardiac rehabilitation services in Johannesburg. *Ann Acad Med Singapore* 1992;**21**:121-127.
45. Digenio AG. The role of exercise conditioning in cardiac rehabilitation. *CME* 1993;**11(2)**:231-239.
46. Steyn K, Jooste FL, Bourne L, Fourie J, Badenhorst CJ, Bourne DE, Langenhoven ML, Lombard CJ, Truter H, Katzenellenbogen J, *et al.* Risk factors for coronary heart disease in the black population of the Cape Peninsula. The BRISK study. *SAMJ* 1991;**79**:480-485.
47. Steyn K, Fourie J. Requirements of a coronary heart disease risk factor intervention programme for the coloured population of the Cape Peninsula. *SAMJ* 1990;**78**:78-81.
48. Steyn K, Steyn M, Langenhoven ML, Rossouw JE, Fourie J. Health actions and disease patterns related to coronary heart disease in the coloured population of the Cape Peninsula. *SAMJ* 1990;**78**:73-77.
49. Steyn K, Rossouw JE, Joubert G. The coexistence of major coronary heart disease risk factors in the coloured population of the Cape Peninsula (CRISIC study). *SAMJ* 1990;**78**:61-63.
50. Pye J, D'Loughlin C, Dodson R, Pye L. Improving rural health: Heart Smart - an opportunity for family physician community involvement. *Family Medicine* 1993;**25(9)**:585-588.
51. Lavie CJ, Milani RV, Littman AB. Benefits of cardiac rehabilitation and exercise training in secondary coronary prevention in the elderly. *J Am Coll Cardiol* 1993;**22**:678-683.
52. Hagberg JM, Montain SJ, Martin WH 3rd, Ehsani AA. Effects of exercise training in 60-to 69-year-old persons with essential hypertension. *Am J Cardiol* 1989;**64**:348-353.