ORIGINAL ARTICLE

Physical activity levels during phase IV cardiac rehabilitation in a group of male myocardial infarction patients

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Objective: To determine physical activity levels during phase IV cardiac rehabilitation in 31 male myocardial infarction patients (median age 62, range 53–77 years).
Methods: Patients recorded daily physical activity over 16 weeks in a diary. Diaries were analysed for total general physical activity (TGPA), leisure time physical activity (LTPA), and ''active for life'' exercise classes (AFL). Pre- and post-observation period (OP) subjects underwent a 10 m shuttle walking test (SWT) to determine changes in aerobic fitness. Rate of perceived exertion (RPE) determined exercise intensity. Estimated gross energy expenditure (EEE) was determined by a regression equation between RPE and Vo_2 (l min^{-1}) during SWT. A total of 97% of subjects were on lipid lowering medication.
Results: There were no correlations between Vo_2 (l min^{-1}) and body mass, therefore kcal min^{-1} indicated activity intensity. There were no significant changes in physical activity patterns or in aerobic fitness. Estimated total LTPA (median 1376, range 128–3380 kcal $week^{-1}$) was less than that recommended to improve aerobic fitness and/or slow progression of coronary artery disease. Sixteen subjects attended a median of 29 (range 1–46) AFL during LTPA; one way ANOVA showed these subjects worked at greater EEE (AFL, $n = 16$, 6.6 (standard deviation 1.4) *v* no-AFL, $n = 15$, 5.1 (1.8) EEE kcal min^{-1}, $p = 0.017$).
Conclusion: Physical activity was stable, but patients' EEE appeared insufficient to improve aerobic fitness or slow progression of coronary artery disease. It was suggested that the promotion of LTPA and the availability of AFL classes should be reconsidered.

In the UK suitable cardiac patients undergo a four phased programme of cardiac rehabilitation (fig 1). By the time patients reach phase IV they are considered stable enough to carry out unsupervised physical activity and to exercise out in the community. After phase III cardiac rehabilitation patients are encouraged to carry out physical activity and participate in phase IV ''active for life'' (AFL) exercise classes, which are supervised circuit based classes provided within the community. There has however been concern that those who do not attend these classes may not carry out sufficient exercise. Although the barriers to participation in cardiac rehabilitation have been identified,[1 2] there are few data to determine whether patients attend these classes or the extent of the patients' physical activity levels during phase IV cardiac rehabilitation.

There is considerable epidemiological evidence to support the relationship between increased levels of physical activity, in terms of energy expenditure, and reduced coronary heart disease morbidity.[3–5] For patients with coronary artery disease, not taking lipid lowering medication, leisure time energy expenditure of around 1600 kcal $week^{-1}$ has been shown to slow the progression of coronary artery disease, and energy expenditure in excess of 2200 kcal $week^{-1}$ to actually result in some regression in the disease.[6] Therefore, this study aimed to determine the types and levels of physical activity that a group of male myocardial infarction patients carry out during phase IV of their cardiac rehabilitation.

METHODS

The study observed the types and levels of physical activity during the first 16 weeks of phase IV cardiac rehabilitation. Approval to carry out the study was given by the local research ethics committee and was funded by the NHS Executive.

Study subjects

Recruitment

Volunteers were recruited from the phase III cardiac rehabilitation programmes run by the local Health Promotion Department within south east Kent, UK. Health Promotion identified potential subjects. The target population were uncomplicated male myocardial infarction patients, non-smokers and taking aspirin. Volunteers were screened for their suitability by their performance during phase III and their cardiac rehabilitation patient notes. Potential subjects were given information sheets. If they wished to participate they were asked to complete medical screening and activity questionnaires, an informed consent, and give their permission for the researchers to contact their general practitioner for his/her approval. Volunteers were excluded if their general practitioner was unable to provide health clearance to allow their participation and/or if the volunteer was unable to understand the nature of the study.

Of the 36 subjects (median age 63, range 53–77 years) who underwent pre-observation period (OP) tests, only 31 subjects (median age 62, range 53–77 years) were available for testing after the 16 week period (table 1). This was because two subjects did not sufficiently complete their activity diaries, two did not wish to continue participation, and the partner of one became unwell. All data reported below refer to those patients who completed the study.

Abbreviations: AFL, ''active for life'' exercise classes; EEE, estimated gross energy expenditure; LTPA, leisure time physical activity; OP, observation period; RPE, rate of perceived exertion; SWT, shuttle walking test; TGPA, total general physical activity

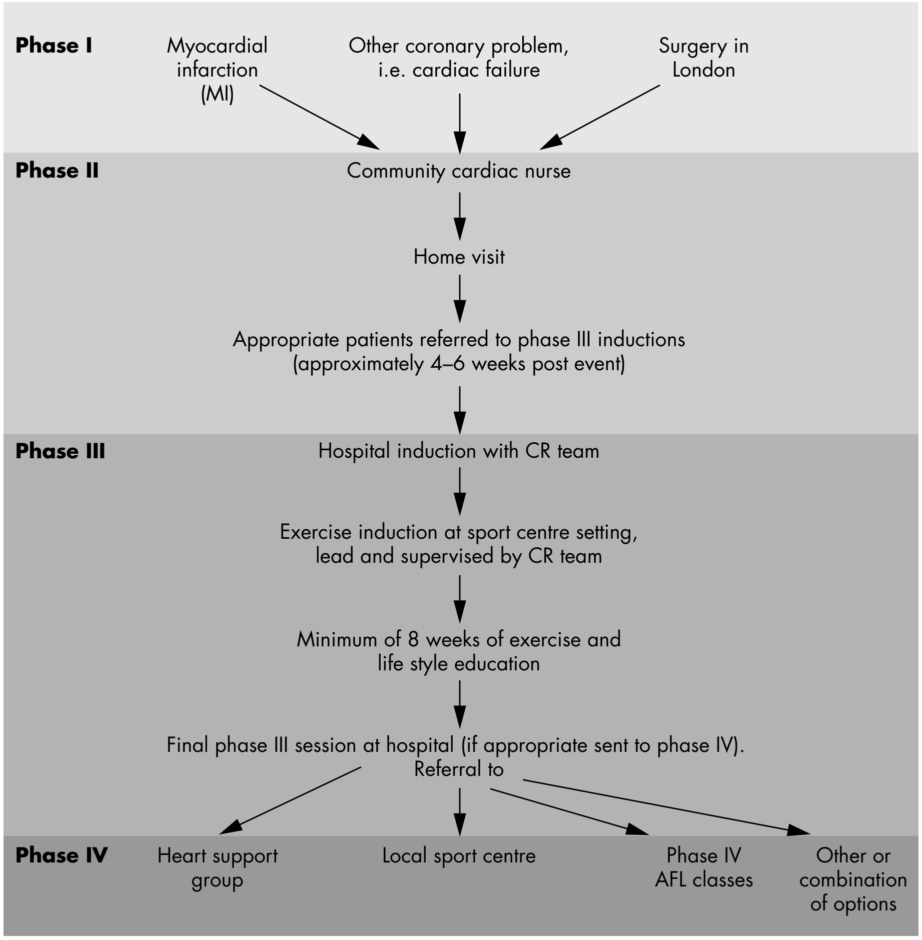

Figure 1 The process of cardiac rehabilitation in south east Kent, UK.

Observation period

Once the subjects had been accepted onto the study they all underwent a pre-OP 10 m shuttle walking test (SWT), which was carried out in the same location and under similar conditions pre- and post-OP. The pre-OP SWT was undertaken a maximum of 2 weeks after subjects completed their phase III programme, so that measures reflected the subjects' status at the end of phase III and beginning of phase IV. After the SWT each subject started to record his daily physical activities in a diary.

Activity diaries

Each day, the subjects recorded the date and duration (minutes) and intensity (rate of perceived exertion (RPE) 6 to 20 chart[7]) of any physical activity for the first 16 weeks of phase IV cardiac rehabilitation. All subjects were extremely familiar with RPE as it was regularly used within the phase III cardiac rehabilitation sessions and during the SWT. At the end of the OP, diaries were submitted for analysis and patterns of physical activity were classified into total general physical activity (TGPA) (inclusive of all reported physical activity and exercise), leisure time physical activity (LTPA) (structured exercise including AFL exercise classes), and physical activity exclusively during phase IV AFL exercise classes (AFL).

10 m shuttle walking test (SWT)

Prior to and after the OP the subjects undertook the SWT, which was carried out in the Physiotherapy Department at Kent and Canterbury Hospital, UK. Before the test, each subject was seated and asked a set of pre-test screening questions, which took around 5 min. After screening the subject's blood pressure, height (only taken pre-OP), and body mass were determined using a stethoscope and sphygmomanometer (Accoson, AC Cossor & Son (Surgical) Ltd, London, UK), a stadiometer, and clinical scales (Seca 052466, Hamburg, Germany), respectively, with the subject wearing similar clothing pre- and post-OP. The subject then lay in a supine position, with their head and shoulders slightly raised for a 12 lead electrocardiogram (P80, Esaotebiomedica, Firenze, Italy), using Q-trace electrodes (Tyco Healthcare, Chicopee, MA, USA). If no additional or acute abnormalities were observed the subject was then instructed on how to carry out the SWT.

The SWT,[8] in this instance, consisted of a maximum of nine stages. The test was terminated when the subject reached stage 9, on two consecutive occasions could no longer reach the end marker by the time of the bleep, showed signs of distress and/or angina, or no longer wished to continue.

Table 1 Subject characteristics for those who completed the study (n = 31)

Age, years	Median 62, range 53–77
Height, cm	Median 172, range 164–190
Pre-OP body mass, kg	Median 83, range 62–117
Post-OP body mass, kg	Median 83, range 66–119

There was no statistical difference in body mass pre- versus post-OP as determined by paired *t* test.

Throughout the test the subject's heart rate (Polar Electro, Kempele, Finland) and oxygen uptake (K4 b^2, Cosmed, Rome, Italy) were monitored, breath by breath. The information was transmitted via short wave telemetry to a lap top computer. RPE[7] was recorded at the end of each stage. Immediately post-exercise and at every subsequent minute for the next 5 min a capillary blood sample was collected from a fingertip using an autolet lance (Owen Mumford, Woodstock, UK) and was assessed for blood lactate concentration (Biosen 5030, EKF Industrie, Elektronik, Germany).

Post-OP each subject was not permitted to exceed the stage that they had achieved during their pre-OP SWT. This was to ensure that any potential post-OP changes in the measured variables could be determined.

Estimate of energy expenditure

In order to estimate each subject's gross energy expenditure (EEE) (kcal) at a particular RPE value, an individual regression equation was established between RPE and the corresponding caloric value of Vo_2 ($l\ min^{-1}$) during SWT. Since there was no Spearman's rank coefficient relationship ($p>0.1$) between pre-exercise and exercise Vo_2 ($l\ min^{-1}$) and body mass, the estimated kcal min^{-1} was seen as an indicator of physical activity or exercise intensity. Hence from the RPE values given in the diaries it was possible to estimate the subjects' EEE (kcal min^{-1}) and intensity for the various physical activities.

Patterns of physical activity and energy expenditure

Diary data were analysed for total time (minutes), mean min $week^{-1}$, mean estimated kcal min^{-1}, total EEE (kcal), and mean EEE $week^{-1}$ (kcal) during TGPA, LTPA, and AFL. To determine changes in levels and/or patterns of physical activity over the OP, the data were divided into 4 week quartiles. The pre-OP equation for estimated kcal min^{-1} was used for the EEE (kcal) for the first quartile, the post-OP equation for the last quartile, and the mean equation of the pre- and post-OP equations for quartiles 2 and 3. AFL data were also analysed for total number of classes and mean number of classes attended over the OP and during each quartile.

Statistical analysis

Statistical analysis was carried out employing the Minitab statistical package (version 13.32) where a 5% significance level was used. Variability of data within a distribution was given as one standard deviation (mean (SD)) for parametric data and median plus range for non-parametric. Differences between groups were determined using one way analysis of variance (ANOVA) or Kruskal-Wallis for non-parametric data. Pre- and post-OP differences were determined using paired *t* tests. Regression analysis for the comparison of two parallel lines was employed to determine differences pre- and post-OP from the SWT data. Spearman's rank coefficient was used to determine the relationship between the levels of physical activity and the measured factors, and relationships between these factors.

RESULTS

Table 2 shows the descriptive data for TGPA, LTPA, and the AFL classes. No statistically significant differences between the quartiles were found for any of the measured variables during TGPA, LTPA, or AFL, indicating physical activity stability over the OP.

AFL classes versus no AFL classes

It was of interest to determine any differences between those who attended the AFL and those who did not. Over the whole OP, the subjects were classified into four categories: subjects who attended no AFL exercise classes at all ($n = 15$), and those who attended 1–10 classes ($n = 7$), 27–46 classes ($n = 9$), or $\geqslant 1$ class ($n = 16$). Analysis was carried out looking at the characteristics and differences between these groups.

Subject characteristics

All subjects were taking aspirin. In addition, 28 were taking statins, 23 ACE inhibitors, 22 β blockers, five calcium channel blockers, two fibrates, two angiotensin II antagonists, two diuretics, and one amioderone; four subjects were diabetic. Medication did not appear to have any significant effect upon any of the measured physical activity parameters or subject characteristics. Only one subject's medication changed over the OP when the dose of their ACE inhibitor was increased.

Subjects who attended $\geqslant 1$ AFL classes (median 29, range 1–46 AFL classes) over the OP ($n = 15$, median age 65, range 57–75 years) compared to those who did not attend any classes ($n = 16$, median age 60, range 53–77 years) showed no significant differences in subject characteristics; nor did those who attended 27–46 AFL classes (median 40, range 27–47 AFL classes; $n = 9$, median age 67, range 57–75 years) compared to those who did not attend any AFL classes ($n = 15$, median age 65, range 57–75 years); or those subjects who attended no AFL classes ($n = 15$, median age 65, range 57–75 years) compared to those who attended 1–10 classes (median 9, range 1–10 AFL classes; $n = 7$, median age 61, range 57–71 years) and 27–46 classes.

Exercise intensity

During LTPA subjects who attended $\geqslant 1$ AFL classes showed a greater EEE kcal min^{-1} exercise intensity than those who did not attend any classes at all (AFL, $n = 16$, 6.6 (SD 1.4) EEE kcal min^{-1} *v* no-AFL, $n = 15$, 5.1 (SD 1.8) EEE kcal min^{-1}, $F = 6.53$, $p = 0.017$). However, the LTPA (which did not include the AFL data) of those who attended $\geqslant 1$ AFL classes over the OP was not significantly different from the LTPA of those who did not attend any classes. Similarly there were no significant differences in LTPA independent of AFL classes between those who attended 1–10 AFL classes, 27–49 AFL classes, or no classes at all.

No other differences in gross EEE kcal min^{-1} were observed in any of the other physical activity measured factors.

Time and energy expenditure

Analysis carried out between those who attended no AFL classes, 1–10 classes, and 27–46 classes over the OP showed no significant difference in the amount of time spent in physical activity or exercise between the groups, although those who attended 26–46 classes over the OP spent approximately 24% more time in LTPA. Furthermore, those who attended 27–46 classes compared to those who attended no AFL classes expended a greater total EEE during LTPA (no-AFL, $n = 15$, median 16 796, range 2184–51 516 EEE kcal *v* 1–10 AFL, $n = 7$, median 19 542, range 4719–67 892 EEE kcal *v* 27–46 AFL, $n = 9$, median 28 837, range 22 615–35 323 EEE kcal, $p = 0.021$) and a greater mean weekly EEE (no-AFL, $n = 15$, median 978, range 128–2944 EEE kcal $week^{-1}$ *v* 1–10 AFL, $n = 7$, median 1286, range 308–3880 EEE kcal $week^{-1}$ *v* 27–46 AFL, $n = 9$, median 1747, range 1413–2048 EEE kcal $week^{-1}$, $p = 0.019$). There were no other statistical differences between these three groups in any of the other measured factors.

Table 2 Descriptive statistics for TGPA, LTPA, and AFL classes over the OP (median and range)

Variable	TGPA n		LTPA n		AFL classes n	
Weeks of observation	31	16 (15–20)	As TGPA		As TGPA	
Mean kcal min^{-1}	30	6.0 (3.7–8.2)	30	6.1 (3.4–9.7)	14	7.2 (5.5–10.7)
Total minutes	31	11 462 (1820–220 225)	31	3728 (489–9850)	16	1740 (60–2760)
Mean min $week^{-1}$	31	683 (164–3015)	31	223 (32–563)	16	120 (60–173)
Total gross EEE (kcal)	30	54 537 (14 633– 379 755)	30	22 615 (2184– 67 892)	14	14 388 (532–19 846)
Mean weekly gross EEE (kcal)	30	3534 (966–21 700)	30	1376 (128–3380)	14	869 (27–1280)
Total number of AFL classes attended					16	29 (1–46)
Mean number of classes attended per week					16	1.7 (0.1–2.9)

Subject numbers vary when it was not always possible to attain reliable measures of energy expenditure.

The 10 m SWT

All subjects finished the SWT when they could no longer reach the end marker by the time the bleep sounded, and although four of the subjects failed, post-OP, to reach the same number of pre-OP shuttles, there were no statistically significant differences between pre- versus post-OP number of shuttles achieved (n = 30, pre-OP 43.0 (SD 10.9) *v* post-OP 42.3 (SD 11.6) shuttles, p = 0.068). From the data collected during the SWT, analysis showed no significant change pre- versus post-OP for heart rate (beats min^{-1}) ($p>0.2$), Vo_2 ml kg^{-1} min^{-1} ($p>0.9$), Vo_2 l min^{-1} ($p>0.2$), or RPE ($p>0.9$), or for the indices of heart rate (beats min^{-1})/ Vo_2 ml kg^{-1} min^{-1} ($p>0.5$), heart rate (beats min^{-1})/ Vo_2 l min^{-1} ($p>0.7$), or for end of test and recovery blood lactate levels (mmol l^{-1}) ($p>0.8$). Nonetheless, pre-OP 96% of subjects reached the 2 mmol l^{-1} level compared to 86% post-OP, and pre- and post-OP 25% of subjects reached the 4 mmol l^{-1} level (pre-OP, n = 28, 3.2 (SD 1.0), range 1.3–5.9 mmol l^{-1}; post-OP n = 28, 3.3 (SD 1.2), range 1.8–6.9).

There were no significant differences in aerobic fitness between any of the AFL or no AFL groups.

β Blockers

Analysis between subjects taking (n = 22, median age 62, range 55–77 years) and not taking β blockers (n = 9, median age 62, range 53–75 years) showed no significant differences in their subject characteristics. Pre-OP, at the end of the SWT, those on β blockers had significantly lower end heart rate (β blockers, n = 22, median 101, range 75–124 beats min^{-1} *v* non-β blockers, n = 9, median 130, range 99–140 beats min^{-1}, p = 0.003). However, there were no significant differences in any of the other measured variables. Similarly post-OP those on β blockers had significantly lower end heart rate (β blockers, n = 22, median 102, range 88–140 beats min^{-1} *v* non-β blockers, n = 9, median 127, range 91–144 beats min^{-1}, p = 0.006). There were no other significant differences. Analysis indicated that none of the other medications significantly affected any of the measured SWT variables.

DISCUSSION

It was evident from the findings of this study that the subjects in general did not expend sufficient amounts of weekly gross LTPA energy (n = 30, median 1376, range 128–3380 kcal $week^{-1}$) to improve their aerobic capacity (1400 kcal $week^{-1}$), slow the progression of coronary artery disease (1600 kcal $week^{-1}$), or show some regression in the disease ($\geqslant$2200 kcal $week^{-1}$), as suggested for cardiac patients not taking lipid lowering medication.[6] However, since 97% of the subjects of this study were taking some form of lipid lowering medication, the fact that they did not reach the suggested amounts of LTPA might not be so significant. Nonetheless, lowering of lipid levels as a result of physical activity is not the only important factor in the regression of coronary artery disease. It is known, for example, that increased levels of physical activity have an antiatherogenic effect by enhancing vascular endothelium activity[9] and producing greater improvements in blood pressure.[10 11] Additionally, when the data were further broken down, the findings revealed that during LTPA the group who attended between 27 and 46 AFL classes (~6 AFL classes per month) over the OP expended the amounts of weekly EEE (median 1747, range 1413–2048 kcal $week^{-1}$) suggested to slow progression of, but not sufficient to show regression in, coronary artery disease. Since the energy expenditure required to show changes in atherosclerotic lesions still needs to be determined for patients taking lipid lowering medication, it is only possible to speculate the effect this level of LTPA might have. Nonetheless, subjects still did not carry out enough LTPA to enhance their aerobic fitness, despite the fact that some of the subjects reached the suggested weekly EEE. This is important, as there is a powerful connection between enhanced aerobic fitness and reduction in coronary heart disease mortality.[12 13] Furthermore, exercise capacity and oxygen uptake during exercise were not significantly affected by β blocking medication despite lower resting and exercise heart rates.

Although some subjects attended the AFL exercise classes and others did not, the amount of time they spent in TGPA and LTPA was not significantly different; those who attended around six AFL classes a month spent ~24% more time in LTPA, although this did not appear to have any additional effect on their aerobic fitness. However, it was evident from the analysis that those who attended one or more AFL classes worked at greater exercise intensity during their LTPA compared to those who did not attend any AFL classes. However, this was the result of participation in the AFL, since their LTPA activity independent of AFL classes was not significantly different from that of those who did not attend any AFL classes during LTPA.

It was of further interest that there appeared to be a difference between subjects who attended 1–10 classes over the OP and subjects who attended $\geqslant$27. Why this occurred still requires clarification.

The findings of this study show that the subjects' activity levels were stable over the 16 weeks, indicating that patients' activity patterns appear to be established upon completion of phase III cardiac rehabilitation. Whether or not this was an artefact due to the way that physical activity was promoted during cardiac rehabilitation or the availability of AFL classes has still to be determined. Nevertheless, a contributing factor to the LTPA of subjects may have been influenced by the fact that currently in south east Kent AFL classes are not offered at weekends or during the evenings, so patients who return to work are unable to attend.

The information contained in the subjects' diaries was the basis for the findings of this study. However, one of the constraints was in estimating the subject's EEE from this

What is already known on this topic

Epidemiological research shows a powerful connection between enhanced aerobic fitness and reduction in coronary heart disease mortality. Furthermore, sufficient amounts of leisure time energy expenditure have been shown to improve aerobic fitness, and slow the progression of and show some regression in coronary artery disease.

What this study adds

This study demonstrated that male myocardial infarction patients' levels and patterns of physical activity appear stable during the first 16 weeks of phase IV cardiac rehabilitation. However, in general their levels of gross energy expenditure, through physical exertion, were not sufficient to enhance their aerobic fitness or meet the required amounts found to reduce coronary artery disease.

information. In view of the fact that heart rate is not a reliable indication of a cardiac patient's exercise intensity, RPE was used instead, and a regression equation was established between RPE and the corresponding caloric value of V_{O_2} (l min^{-1}) during the SWT. This provided an individual corresponding EEE in kcal min^{-1} to RPE value for each subject. However, the perception of effort during physical activity is complex and not totally understood[14] and for cardiac patients RPE values may not always correlate with the intensities of the Borg scale.[15] Nonetheless, intra-subject RPE is a fairly reliable indicator of a subject's exercise intensity for patients both taking and not taking β blockers,[16] and as the subjects were extremely familiar with the use of the RPE scale, it was seen as a reasonable gauge of the subjects' exercise intensity. Furthermore, a regression based on RPE from one type of activity might not totally relate to that of another.[17] For instance, RPE from the SWT might not relate to activities other than walking. Nevertheless, this type of discrepancy generally occurs when subjects exercise above the lactate threshold.[18] Since the subjects of this study rarely, if at all, reached this intensity of physical activity the extent of this discrepancy was considered to be minimal and the methodology employed was felt, in this situation, to be the best estimation of each individual's EEE and exercise intensity during physical activity.

In summary, taking into consideration currently available research, it would appear that although members of the phase III cardiac rehabilitation team were successful at promoting certain levels of LTPA, they were not effective at getting patients to achieve the levels suggested to enhance aerobic fitness. Furthermore, attendance at the AFL classes made little difference to time or EEE spent during LTPA, unless subjects (29% of the subject cohort) attended ~6 or more AFL classes per month, when their LTPA reached the level suggested to slow the progression of coronary artery disease. However, despite these same subjects reaching the suggested amount of LTPA to improve their aerobic fitness, they failed to show any change in this factor. This was also apparent even for those patients who attended the AFL classes and worked at higher exercise intensity during LTPA compared to those who did not attend any classes. Nonetheless, the findings of this study do indicate the physical activity patterns of male myocardial infarction patients during phase IV cardiac rehabilitation and highlight issues regarding the promotion of LTPA by the cardiac rehabilitation team and the availability of AFL classes. Further research is required to fully determine the influences on these patients' activity levels.

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COMMENTARY

Patients undergoing cardiac rehabilitation following a myocardial infarction (MI) achieve major lifestyle changes and improved physical fitness. However, these positive behaviour changes are not well maintained in the long term with a significant rate of relapse observed in many follow up studies. The prognostic significance of improving and maintaining aerobic fitness (V_{O_2} max) is well established in cardiac patients. Improved endothelial function is emerging as a possible direct mechanism for the cardioprotective benefits of exercise. This paper studies the adherence to physical activity in phase IV cardiac rehabilitation after completion of phase III in male post MI patients. It shows that short term maintenance of physical activity is achievable and considers the importance of structured exercise classes. However, the study does not address gender differences or study other clinical populations attending cardiac rehabilitation classes.

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