

Supplementary material

Table S1| Missing Data. ‡ indicates that this variable was a significant predictor of all-cause mortality in a single-variable model.

Variable	description	Missing	%
id	Unique identifier	1	0.04
Illness date	Date of the index event	0	0
Entry date	Date entered the programme	0	0
Graduate date	Date graduated from the programme	0	0
Death date	Date of death	0	0
Diagnosis ‡	A number from 1 to 8 where 1 is myocardial infarction (MI), 2 is coronary artery bypass grafting (CABG), 3 is percutaneous transluminal coronary with or without stenting, 4 is angina pectoris(AP), 5 is valve surgery (VS), 6 is other cardiac conditions e.g. cardiomyopathy, ischaemic and non-ischaemic heart failure (OC), 7 is non-cardiac conditions(NC) and 8 is myocardial infarction with percutaneous transluminal coronary angioplasty as a single episode of care,(MI+PCI).	0	0
Family History ‡	Family history, yes / no	0	0
Age ‡	Age in years	0	0
age category ‡	Age in categories: 1 is under 50, 2 is 50 to 59, 3 is 60 to 69 and 4 is 70	0	0
Sex ‡	Gender	0	0
Cholesterol	Cholesterol measurement at recruitment	537	19.8
Triglycerides	Triglycerides measurement at recruitment	787	29.0
Diabetes ‡	patient has diabetes, yes / no	0	0
Comorbidity	List of comorbidities in free text	0	0
Height	Height in Metres	1161	42.8
Weight ‡	Weight in kilogrammes at recruitment	20	0.7
Weight after ‡	Weight in kilogrammes at completion	799	29.4
weight category before ‡	A is defined as under 75kg, 75-90kg as overweight, and over 90kg as C.	20	0.7
sbp before ‡	Systolic blood pressure at recruitment	15	0.6
dbp before	Diastolic blood pressure at recruitment	26	1.0
sbp after ‡	Systolic blood pressure at completion	742	27.3
dbp after	Diastolic blood pressure at recruitment	763	28.1
vo2 before ‡	Fitness at recruitment in VO2 max	0	0
vo2 after ‡	Fitness at completion in VO2 max	1316	48.5
vo2 category before ‡	Fitness category at entry	0	0
vo2 category after ‡	Fitness category at exit	1316	48.5
anxiety before	Anxiety measured at recruitment using the hospital anxiety and depression scale (HADS). A score between 8 and 10 indicates borderline anxiety, whilst over 10 suggests clinical anxiety.	89	3.3
anxiety after ‡	Categorisation by HADS at completion	748	27.6
depression before ‡	Categorisation by HADS at recruitment	89	3.3
depression after ‡	Categorisation by HADS at completion	749	27.6
overall health before	Patient's perception of overall health at entry - one of six domains from the Dartmouth Coop / wonca charts used to assess functional health and quality of life. Only patients joining after April 1996 were assessed in this way	773	28.5
over all health after	1 (excellent) to 5(poor) patient's perception of overall health at completion	1275	47.0
life before	patient perception of life in general at recruitment	773	28.5

Table S1| Missing Data. ‡ indicates that this variable was a significant predictor of all-cause mortality in a single-variable model.

Variable	description	Missing	%
life after	patient perception of life in general at completion	1275	47.0
feelings before	patient perception of feelings at recruitment	773	28.5
feelings after	patient perception of feelings at completion	1275	47.0
painful tension before	patient perception of painful tension at recruitment	775	28.6
painful tension after	patient perception of painful tension at completion	1276	47.0
physical fitness before	patient perception of physical fitness at recruitment	775	28.6
physical fitness after	patient perception of physical fitness at completion	1274	46.9
social support before	patient perception of social support available to them at recruitment	775	28.6
social support after	patient perception of social support at completion	1274	46.9
risk category before ‡	Risk category (high, medium, low) at recruitment	101	3.7
risk category after ‡	Risk category at exit	730	26.9
Smoking history ‡	coded 0 to 4 where 0 is never smoked, 1 is not smoked for 10 years or more, 2 is not smoked for between 1 and 10 years, 3 is recent quitter, and 4 is current smoker.	3	0.1
aspirin before ‡	Prescription for aspirin at recruitment, yes/no	1	0.04
aspirin after ‡	Prescription for aspirin at completion	671	24.7
ace before ‡	Prescription for ACE inhibitor at recruitment	1	0.04
statin before ‡	Prescription for statins at recruitment	9	0.3
statin after ‡	Prescription for statins at completion	678	25.0
full secondary prevention before	Prescription for aspirin and ACE inhibitors and beta blockers and statins at recruitment	1	0.04
full secondary prevention after ‡	Prescription for aspirin and ACE inhibitors		
resting heart rate ‡	resting heart rate at entry	7	0.3
hrateafter ‡	Heart rate after exercise	681	25.1
exercise sessions	number of exercise sessions attended to completion or drop-out	105	3.9
imd2004score ‡	Index of multiple deprivation derived from post code	114	4.2
combined total comorbidity ‡	D'Hoore comorbidity score	0	0
occupation code ‡	Occupational Code 1-9: Managers & senior officials, Professional occupations, Associate professional, Administrative & secretarial, Skilled trade, Personal service, Sales & customer, Process, plant & machines, Elementary occupations	293	10.8
completer category ‡	1 is completed the programme, 2 is started but did not complete, 3 is never started.	0	0

Risk stratification

All patients who are recruited to exercise-based CR undergo risk stratification during initial assessment. Exercise testing is a part of this process. Risk stratification enables an appropriate and individualised exercise prescription to be planned for patients that reflects the severity of cardiac illness, co-morbidity and current medical state. The American Association of Cardiovascular and Pulmonary Rehabilitation [AACVPR] was the first to lay down criteria for risk stratification.

Risk stratification criteria for cardiac patients (AACVPR 1999) **LOW RISK**

- Uncomplicated MI, CABG, angioplasty or atherectomy
- Functional capacity equal to or greater than 6 METS 3 or more weeks after clinical event
- No resting or exercise induced myocardial ischaemia manifested as angina and/or ST segment displacement
- No resting or exercise-induced complex arrhythmias
- No significant left ventricular dysfunction (Ejection fraction equal to or greater than 50

MODERATE RISK

- Functional capacity less than 5- 6 METS 3 or more weeks after clinical event
- Mild to moderately depressed left ventricular function (Ejection fraction 31-49
- Failure to comply with exercise prescription
- Exercise induced ST-segment depression of 1-2mm or reversible ischaemia defects (echocardiography or nuclear radiography)

HIGH RISK

- Severely depressed left ventricular function (Ejection fraction equal to or less than 30
- Complex ventricular arrhythmias at rest or appearing or increasing with exercise
- Decrease in systolic blood pressure of >15mmHg during exercise or failure to rise consistent with exercise workloads
- MI complicated by Congestive Heart Failure, cardiogenic shock and/or complex arrhythmias
- Patients with severe CHD and marked (>2mm) exercise induced ST-segment depression
- Survivor of a cardiac arrest

Co-morbidity

Table S2| Co-morbidity Score

Weight	Condition
1	Myocardial infarct*
	Congestive heart failure*
	Peripheral vascular disease
	Dementia
	Cerebrovascular disease †
	Chronic pulmonary disease
	Connective tissue disease
	Ulcer disease
	Mild liver disease ‡
2	Hemiplegia
	Moderate/severe renal disease (end stage)
	Diabetes
	Any tumour ♣
	Leukaemia ♣
3	Moderate or severe liver disease
6	Metastatic solid tumour

*Myocardial infarct and congestive heart failure were omitted from the index because they are included in the AACVPR risk stratification for events.

†includes patients with history of stroke or history of cerebrovascular disease.

‡Mild liver disease and hemiplegia were omitted from index because it could not be quantified in Zoghbi database

§Includes patients with end stage renal disease

♣ Labelled as one category (malignancy)

Table S3 | Model B All-cause survival model using fitness change Optimised all-cause survival model ordered by importance of variables to the Model. Pooled hazard ratios are from multiple imputation of missing data

Model Term		complete cases model			Imputed data model
		Hazard Ratio	Confidence Interval		Pooled Hazard Ratio
			lower .95	upper .95	
Age category	under 50	1	-	-	1
	50-59	1.68	0.87	3.26	2.23
	60-69	2.42	1.27	4.58	3.65
	70+	5.42	2.82	10.41	7.77
Fitness:	High baseline, no change	1	-	-	1
	Mid baseline, improve	1.16	0.77	1.74	0.51
	Mid baseline, no change	2.31	1.60	3.35	0.85
	Low baseline, improve	2.63	1.75	3.98	0.95
	Low baseline, no change	3.77	2.42	5.85	1.33
Aspirin	Yes	0.35	0.23	0.55	0.61
	No	1	-	-	1
ACE inhibitor	Yes	1.48	1.14	1.93	1.29
	No	1	-	-	1
Statins	Yes	0.74	0.57	0.96	0.69
	No	1	-	-	1
Gender	MALE	1	-	-	1
	FEMALE	0.71	0.50	1.02	0.70

Table S4 | Model B Cardiovascular survival model using fitness change Optimised Cardiovascular survival model ordered by importance of variables to the Model. Pooled hazard ratios are from multiple imputation of missing data

Model Term		complete cases model			Imputed data model
		Hazard Ratio	Confidence Interval		Pooled Hazard Ratio
			lower .95	upper .95	
Fitness:	High baseline, no change	1	-	-	1
	Mid baseline, improve	1.08	0.59	2.00	0.46
	Mid baseline, no change	2.18	1.25	3.80	0.69
	Low baseline, improve	3.37	1.86	6.15	0.95
	Low baseline, no change	5.10	2.66	9.76	1.49
Statin	Yes	0.43	0.29	0.63	0.52
	No	1	-	-	1
Age category	under 50	1	-	-	1
	50-59	1.16	0.52	2.64	1.70
	60-69	1.83	0.84	4.01	3.01
	70+	3.35	1.50	7.52	5.35
Aspirin	Yes	0.36	0.20	0.65	0.57
	No	1	-	-	1
Gender:	MALE	1	-	-	1
	FEMALE	0.50	0.29	0.86	0.62
ACE inhibitor	Yes	1.59	1.08	2.33	1.41
	No	1	-	-	1
Diagnostic Category	Myocardial Infarction (MI)	1	-	-	1
	Coronary Artery Bypass Graft (CABG)	0.64	0.41	0.98	0.67
	Percutaneous Coronary Intervention (PCI)	0.20	0.05	0.84	0.42
	MI + PCI	1.1	0.37	3.88	0.68
	Angina	0.95	0.48	1.88	0.68
	Other cardiac	1.00	0.24	4.15	0.90

Table S5| Model B Baseline values for patients at recruitment to cardiac rehabilitation programme

	Male		Female		Total	
	Number	(%)	Number	(%)	Number	(%)
Number	895	(86.9%)	134	(13.1%)	1029	(100%)
Mean years of follow-up (sd)	11.6	(3.9)	11.2	(3.8)	11.5	(3.9)
Mean age in years (sd)	61.1	(9.3)	63.1	(9.0)	61.3	(9.3)
	N	%	N	%	N	%
Age group under 50 years	104	11.6	14	10.5	118	11.5
Age group 50-59 years	275	30.7	29	21.6	304	29.5
Age group 60-69 years	336	37.6	52	38.8	388	37.7
Age group 70 years and over	180	20.1	39	29.1	219	21.3
Diagnostic Category						
Myocardial Infarction (MI)	456	50.9	73	54.5	529	51.4
Coronary Artery Bypass Graft (CABG)	269	30.1	34	25.4	303	29.4
Percutaneous Coronary Intervention (PCI)	81	9.1	12	9.0	93	9.0
MI + PCI	36	4.0	3	2.2	52	5.1
Angina	41	4.6	11	8.2	13	1.3
Other cardiac	12	1.3	1	0.7	39	3.8

Table S5| Model B Baseline values for patients at recruitment to cardiac rehabilitation programme

	Male		Female		Total	
	N	%	N	%	N	%
Smoking history						
Never smoked	249	27.8	63	47.0	312	30.3
Not for 10 years+	285	31.9	19	14.2	304	29.6
Not for 1-10 years	34	3.8	4	2.9	38	3.7
Recent quitter	273	30.5	40	29.9	313	30.4
Current smoker	54	6.0	8	6.0	62	6.0
D'Hoore Co-morbidity score						
None	663	74.1	89	66.4	752	73.1
1 (least)	111	12.4	14	10.5	125	12.1
2	102	11.4	27	20.2	129	12.5
3	12	1.3	3	2.2	15	1.5
4 (most)	7	0.8	1	0.7	8	0.8
Diagnosis of diabetes	92	10.3	22	16.4	114	11.1
Family history of CHD	424	47.4	67	50.0	491	47.7
Weight at baseline						
I	402	44.9	35	26.2	440	42.8
II	354	39.67	43	32.2	397	38.6
III	139	15.53	53	39.611.	192	18.6
ACE inhibitor No	479	53.5	54	40.3	533	51.8
ACE inhibitor Yes	416	46.5	80	59.7	496	48.2
Aspirin No	31	3.5	10	7.5	41	4.0
Aspirin Yes	864	96.5	124	92.5	988	96.0
Statin No	338	37.8	43	32.1	381	37.0
Statin Yes	557	62.2	91	67.9	649	63.0
Beta blockers No	573	64.0	80	59.7	653	63.5
Beta blockers Yes	322	36.0	54	40.3	376	36.5
Occupation						
Managers & senior officials	152	17.0	11	8.2	163	15.8
Professional Occupations	98	10.9	7	5.2	105	10.2
Associate Professional	105	11.7	17	12.7	122	11.8
Administrative & secretarial	75	8.4	41	30.6	116	11.3
Skilled trade	250	27.9	7	5.2	257	25.0
Personal service	14	1.6	16	11.9	30	2.9
Sales and customer	18	2.0	10	7.5	28	2.7
Process, plant & machines	110	12.3	10	7.5	120	11.7
Elementary occupations	73	8.2	15	11.2	88	8.6

Table S6| Model B Change from baseline at completion of the programme

	Male		Female		Total	
	N	%	N	%	N	%
Fitness						
High baseline, no change	397	44.3	18	13.4	415	40.3
High baseline, deteriorate	5	0.6	0	0	5	0.5
Mid baseline, improve	203	22.7	28	20.9	231	22.5
Mid baseline, no change	151	16.9	25	18.7	176	17.1
Mid baseline, deteriorate	0	0	0	0	0	0
Low baseline, improve	86	9.6	20	14.9	106	10.3
Low baseline, no change	53	5.9	43	32.1	96	9.3
Depression						
Not depressed, no change	780	87.2	107	79.9	887	86.2

Table S6| **Model B Change from baseline at completion of the programme**

	Male		Female		Total	
Not depressed, deteriorate	14	1.6	2	1.5	16	1.5
Borderline, improve	62	6.9	15	11.2	77	7.5
Borderline, no change	8	0.9	2	1.5	9	0.9
Borderline, deteriorate	2	0.2	0	0	3	0.3
Depressed, improve	26	2.9	7	5.2	33	3.2
Depressed, no change	3	0.3	1	0.7	4	0.4
Anxiety						
Not anxious, no change	607	67.8	73	54.4	887	86.2
Not anxious, deteriorate	40	4.5	10	7.5	16	1.5
Borderline, improve	99	11.1	17	12.7	77	7.5
Borderline, no change	45	5.0	10	7.5	9	0.9
Borderline, deteriorate	9	1.0	0	0	3	0.3
Anxious, improve	68	7.6	11	8.2	33	3.2
Anxious, no change	27	3.0	13	9.7	4	0.4
Change VO_2 ml/kg/min Mean(sd)	3.86	(3.39)	3.51	(3.33)	3.81*	(3.38)
Median final estimated						
VO_2 ml/kg / min						
(10th, 90th)	25.3	(16.3, 35.0)	18.1	(10.4, 26.8)	24.5	(15.2, 35.0)
Median change from baseline						
in						
VO_2 ml/kg / min	3.3	(0.5, 8.1)	2.6	(0.0, 7.95)	3.2	(0.3, 8.1)
(10th, 90th						
Percentiles)						

*Change in VO_2 ml/kg/min $t = 36.16$, $df = 1028$, p -value < 0.001

Model C a subset of Model A of those who also had a BMI measurement.

Table S7| **Model C, a subset of Model A of those who also had a BMI measurement. Baseline values for patients at recruitment to cardiac rehabilitation programme**

	Male		Female		Total	
Number	753		136		889	
Mean years of follow-up (sd)	9.8	(2.5)	9.7	(2.7)	9.8	(2.5)
Mean age in years (sd)	62.1	(9.4)	63.5	(9.1)	62.3	(9.3)
	N	%	N	%	N	%
Age group under 50 years	71	9.4	10	7.3	81	9.1
Age group 50-59 years	214	28.4	33	24.3	247	27.8
Age group 60-69 years	297	39.5	51	37.5	348	39.1
Age group 70 years and over	171	22.7	42	30.9	213	24.0
Diagnostic Category						
Myocardial Infarction (MI)	302	40.1	60	44.1	362	40.7
Coronary Artery Bypass						
Graft (CABG)	256	34.0	37	27.2	293	33.0
Percutaneous Coronary						
Intervention (PCI)	98	13.0	19	14.0	117	13.2
MI + PCI	49	6.5	7	5.1	56	6.3
Angina	26	3.5	11	8.1	47	4.2
Other cardiac	22	2.9	2	1.5	24	2.6
Smoking history						
Never smoked	197	26.2	60	44.1	257	28.9
Not for 10 years+	287	38.1	20	14.7	307	34.5
Not for 1-10 years	49	6.5	7	5.1	56	6.3
Recent quitter	181	24.0	41	30.2	222	25.0
Current smoker	39	5.2	8	5.9	47	5.3

Table S7| Model C, a subset of Model A of those who also had a BMI measurement. Baseline values for patients at recruitment to cardiac rehabilitation programme

	Male		Female		Total	
D'Hoore Co-morbidity score						
None	536	71.2	86	63.2	622	70.0
1 (least)	84	11.2	18	13.2	102	11.6
2	107	14.2	29	23.0	136	15.3
3	16	2.1	2	1.4	18	1.9
4 (most)	10	1.3	1	0.1	11	1.2
Diagnosis of diabetes	105	13.9	18	13.2	123	13.8
Family history of CHD	335	44.5	76	55.9	411	46.2
BMI at baseline						
BMI Normal	220	29.2	36	26.5	256	28.8
BMI Overweight	363	48.2	60	44.1	423	47.6
BMI Obese	170	22.6	40	29.4	210	23.6
ACE inhibitor No	295	39.2	49	36.0	344	38.7
ACE inhibitor Yes	458	60.8	87	64.0	545	61.3
Aspirin No	26	3.5	6	4.4	32	3.6
Aspirin Yes	727	96.5	130	95.6	857	96.4
Statin No	120	15.9	18	13.2	138	15.5
Statin Yes	633	84.1	118	86.8	751	84.5
Beta blockers No	329	43.7	57	41.9	386	43.4
Beta blockers Yes	424	56.3	79	58.1	503	56.6
Occupation						
Managers & senior officials	128	17.0	9	6.6	137	15.5
Professional Occupations	93	12.4	7	5.2	100	11.2
Associate Professional	81	10.8	16	11.8	97	10.9
Administrative & secretarial	65	8.6	43	31.6	108	12.1
Skilled trade	212	28.2	8	5.9	220	24.8
Personal service	13	1.7	18	13.2	31	3.5
Sales and customer	15	2.0	11	8.1	26	2.9
Process, plant & machines	87	11.5	7	5.1	94	10.6
Elementary occupations	59	7.8	17	12.5	76	8.5

Table S8 | Model C, a subset of Model A of those who also had a BMI measurement. Optimised all-cause survival model ordered by importance of variables to the Model. Pooled hazard ratios are from multiple imputation of missing data

Model Term		complete cases model		Imputed data model		
		Hazard Ratio	Confidence Interval		Pooled Hazard Ratio	
			lower .95	upper .95		
Age category	under 50	1.00	-	-	1.00	
	50-59	3.05	2.96	0.92	10.03	1.99
	60-69	4.17		1.28	13.56	3.05
	70+	10.64		3.24	35.00	6.31
Fitness:	High baseline	1.00		-	-	1.00
	Mid baseline	1.49		1.00	2.20	1.80
	Low baseline	2.12		1.41	3.21	2.92
Smoking history	Never smoked	1.00		-	-	1.00
	Not for 10 years+	1.22		0.83	1.80	1.18
	Not for 1-10 years	1.42		0.74	2.74	1.23
	Recent quitter	1.98		1.28	3.05	1.45
	Current smoker	1.71		0.78	3.80	1.66

Table S8 | Model C, a subset of Model A of those who also had a BMI measurement. Optimised all-cause survival model ordered by importance of variables to the Model. Pooled hazard ratios are from multiple imputation of missing data

Model Term		complete cases model		Imputed data model	
		Hazard Ratio	Confidence Interval		Pooled Hazard Ratio
			lower .95	upper .95	
Statins	Yes	0.65	0.45	0.94	0.69
	No	1.00	-	-	1.00
D'Hoore Co-morbidity score	None	1.32	0.86	2.05	1.20
	1 (least)	1.52	1.04	2.22	1.49
	2	1.68	0.76	3.71	1.90
	3	3.38	1.32	8.65	2.43
Depression at baseline	Not depressed	1.00	-	-	1.0
	Borderline	1.18	0.74	1.86	0.97
	Depressed	2.36	1.21	4.59	1.12
Gender	MALE	1.00	-	-	1.0
	FEMALE	1.00	0.67	1.49	0.76

Table S9 | Model C, a subset of Model A of those who had a BMI measurement. Optimised Cardiovascular survival model ordered by importance of variables to the Model (889 cases, 80 cardiovascular deaths). Pooled hazard ratios are from multiple imputation of missing data

Model Term		complete cases model		Imputed data model	
		Hazard Ratio	Confidence Interval		Pooled Hazard Ratio
			lower .95	upper .95	
Fitness:	High baseline	1.00	-	-	1.00
	Mid baseline	1.90	1.00	3.60	2.47
	Low baseline	3.93	2.07	7.45	4.80
Statin	Yes	0.52	0.31	0.87	0.51
	No	1.00	-	-	1.00
Age category	under 50	1.00	-	-	1.00
	50-59	1.82	0.41	8.15	1.49
	60-69	2.60	0.61	11.10	2.18
	70+	3.64	0.84	15.85	3.57
Gender:	MALE	1.00	-	-	1.00
	FEMALE	1.06	0.61	1.869	0.64.