Influence of exercise adherence level on modifiable coronary heart disease risk factors and functional-fitness levels in middle-aged men

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The study investigated the potential health benefits of two levels of short-term exercise intervention, compared with non-intervention, on selected modifiable coronary heart disease (CHD) risk factors and functional fitness states in middle-aged men. All subjects underwent medical screening and signed informed consent before carrying out a standardized graded treadmill walk which required exercise up to 85% of age-predicted maximal heart rate. The results of the test were used together with musculoskeletal fitness assessments, for the prescription of a personalized exercise programme lasting 14 weeks. In all, 55 subjects were classified by adherence into high (HA, $n = 20$), low (LA, $n = 19$), or non-adherence (NA, $n = 16$) groups according to the degree of documented participation in the programme based on standard criteria (American College of Sports Medicine 1978, 1990). In addition, the respective groups of subjects were classified according to other modifiable and non-modifiable CHD risk factors and compared by self-reported levels of activity and sport involvement as well as perceived body weight classification. The results indicated that there were more comprehensive improvements in functional fitness including significant gains in aerobic endurance capacity, muscular endurance and flexibility in the HA group compared with the LA and NA groups. However, there was little or no change in the modifiable CHD risk factors in any of the respective groups, although anthropometric indices of weight, body mass index (BMI), skinfolds and waist:hips ratio tended to decrease in the HA and LA groups but increased marginally in the NA group. Resting systolic blood pressures declined slightly in all groups, but serum total cholesterol remained unchanged irrespective of adherence level. The findings suggest that while functional fitness status gains may arise from optimal adherence level to short-term exercise conditioning, these are not matched by health gains in terms of amelioration of modifiable CHD risk factors. However, the level of adherence may be related to the recognized presence of other known CHD risk factors.

Keywords: Exercise adherence, CHD risk factors, fitness, middle-aged men

The benefits of regular physical activity in the promotion of health-related fitness and the amelioration of coronary heart disease (CHD) risk factors has received much attention recently with a consensus of agreement among investigators concerning its importance. A meta-analysis of studies concerning CHD and physical activity¹ suggested that the literature supported the inference that physical activity is inversely and causally related to the incidence of CHD. Furthermore, the study concluded that the relative risk of inactivity as a factor in the development of CHD appears to be of similar magnitude to that of hypertension, hypercholesterolaemia and smoking. Therefore it was suggested that in preventive health programmes designed to ameliorate CHD risk, regular physical activity should receive the same attention as other modifiable risk factor management techniques, such as the control of blood pressure, reduction of serum cholesterol and the elimination of smoking.

The benefits of exercise amelioration of modifiable CHD risk factors such as reductions in blood pressure and cholesterol levels have been widely reported in the literature². The reduction of resting blood pressure after a single bout of exercise in both normal and hypertensive patients³, together with the reduction in submaximal exercise systolic blood pressure after exercise training^{4,5} suggest that exercise-induced effects of blood pressure regulation may contribute towards a reduction in CHD risk by lowering of blood pressure levels². Thus, exercise may serve as a preventive modality in the amelioration of the age-dependent rise in blood pressure as well as exerting its effects through a reduced frequency of arterial hypertension development^{6,7}.

The influence of physical activity in the modification of blood lipid profiles as a potential for CHD risk factor reduction has also been acknowledged⁸. Various types of exercise regimens including long-term, low-level activity⁹, as well as shorter-term aerobic programmes¹⁰ and resistive exercise/circuit weight training routines¹¹ have been reported to influence blood lipid levels favourably. However, the influence of body weight loss and dietary changes is

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thought likely to contribute to the beneficial effects observed in lipid profile modification and subsequent improvement in CHD risk status².

The population of Northern Ireland has not shared the recent successes of North America, Australia and several European countries in the reduction of the incidence of CHD over the last two decades¹². One of the reasons postulated to account for this significant decrease in the levels of CHD in these countries is the concomitant increase in habitual levels of physical activity and associated positive health behaviour. At least part of this increased participation in regular physical activity may be attributed to the enhanced public awareness of the relationship between health and fitness and the provision for fitness programmes in the workplace¹³⁻¹⁶. However, when the present study was conducted there were no such operational workplace programmes in Northern Ireland. Furthermore, there appeared to be a distinctly different social attitude towards health and well-being, as well as current practice, in terms of workplace provision of corporate health and wellness programmes by Northern Ireland's employers¹⁷, which together may limit the potential effectiveness of such programmes compared with the other countries. Therefore, the present investigation was designed to determine the effects of adherence levels to a supervised short-term, workplace exercise programme on selected modifiable CHD risk factors and functional fitness levels in a group of middle-aged men volunteers.

Methods

Subjects

In all, 55 middle-aged men volunteers participated in the study. The subjects were self-selected from the middle and upper management levels of a multinational telecommunications company located on the outskirts of Belfast, Northern Ireland. The group comprised men of different socioeconomic status – social classes I and II professional and intermediate (OPCS). All subjects were screened initially by obtaining a medical history, a series of pulmonary function tests and an examination by the company medical officer. Written informed consent was obtained from each subject before participation in the investigation.

Procedures

On arrival at the laboratory, the subjects completed a detailed exercise history and current physical activity questionnaire. A 32 µl fasting blood sample was drawn from the subject's finger to determine total cholesterol level (Reflotron system, Boehringer Mannheim, Lewes, UK), and resting blood pressure was obtained by a trained nurse using standard auscultatory techniques. A range of anthropometric measurements was then taken, including height and weight, skinfold thicknesses and estimated body fat percentage¹⁸, and body girth dimensions for determination of waist to hips ratio. The subject then sat while a standard V-5 electrocardiogram recording was obtained and blood pressures were subsequently

obtained before the start of the exercise test, which was conducted by an exercise physiologist with a cardiologist in attendance. The usual range of resuscitation equipment was available, including a defibrillator.

The exercise test consisted of a walk on a treadmill (P. K. Morgan, Chatham, UK) at a freely chosen speed at zero grade for an appropriate period of time to familiarize the subjects with the test requirements. This was followed by a modified Bruce protocol¹⁹ which required the subject to walk at a fixed speed of 5.65 km hr⁻¹ at zero grade followed by an initial gradient increase of 5% with subsequent increases of 2.5% with each incremental period of 3 min duration. The chosen endpoint of the test was 85% of age-related maximal heart rate which was predetermined using a standardized method²⁰. Exceptions to this criterion were cases where subjects displayed irregular electrocardiogram (ECG) patterns, abnormal blood pressure responses, or chose voluntarily to terminate the test prematurely. ECG recordings (Cardiokinetics Life Trace 18, Cardiokinetics, Salford, UK) and blood pressure measurements (auscultatory techniques) were obtained during the last 30 s of each incremental exercise period. Total time for walking as well as the incremental stage of the test termination were recorded as measures of endurance. Three additional specific physical fitness tests were then completed which were directed at musculoskeletal function, including grip strength, hip flexibility and abdominal endurance as outlined in the Eurofit test battery²¹. All subjects subsequently received a comprehensive confidential personal report detailing the findings from the various tests, along with a consultation with the programme director, and the company's medical officer where necessary.

Intervention

After initial assessment each subject was issued with a voluntary, individualized exercise prescription based on their performance during the initial exercise test. Unless otherwise contraindicated, each programme was designed to meet the criteria of the guidelines for aerobic conditioning²² and the subsequent revision of these criteria²³. A wide range of activities was offered including walking, running, bicycling, cycle-ergometry, rowing, simulated cross-country skiing and resistance training using a multigym fixed weight system. The subjects were supervised closely during the 14-week period of the conditioning programme and were instructed to record their exercise activities accurately in terms of exercise mode, intensity, duration and frequency of each session.

The data collected on activity participation permitted subjects to be classified into groups depending on their level of adherence to the exercise programme. Adherence levels were determined using an equation developed for determination of a total activity metabolic index (AMI)²⁴ where the overall AMI is:

$$\text{Total AMI} = \Sigma(I \times M \times F \times T)$$

where *I* represents intensity coded in METS (resting metabolic equivalent), *M* the number of months, *F*

the frequency per month, and *T* the duration of each activity or exercise session. The total AMI score is believed to be closely associated with total kilocalories expended on leisure-time physical activity, a value of particular relevance in weight control²⁴, and thus exercise for health.

Three discrete levels of physical activity were then obtained, in terms of light, moderate, and heavy AMI which were equated with non-adherence (NA), low adherence (LA), and high adherence (HA) levels in the present study. The HA group demonstrated an activity index which satisfied the American College of Sports Medicine (ACSM) criteria²² for aerobic conditioning. However, since the time of completion of the present study the ACSM revised and updated the criteria for aerobic conditioning²³. The implications of these revisions now indicate that the LA classification conformed to the necessary levels prescribed to maintain cardiorespiratory fitness²², while the HA group conformed to the level necessary both to maintain and advance cardiorespiratory fitness²³. After the 14-week conditioning period, subjects underwent the same battery of tests completed before the intervention programme. Thus data were available for both pre- and post-intervention, which permitted an evaluation of the effects of participation in each adherence level category.

Data analysis

After detailed analysis of the activity records the subjects were divided among the three exercise adherence level groups of NA, LA and HA for both pre- and post-intervention analyses. The data obtained from the pre-intervention tests were analysed using a one-way analysis of variance to determine if any significant differences existed between the three combinations of paired groupings before the intervention was applied. Similarly, this procedure was

applied to the post-intervention data to evaluate effects of adherence level upon the variables under investigation. Each adherence level group data were further analysed using a repeated measures analysis of variance to determine within group differences before and after the intervention period, with a *post hoc* Scheffe test applied to determine specific mean differences contributing to significant *F* ratios identified by the analysis of variance procedures.

Results

There were no significant differences in mean age, height and weight at the initiation of the exercise programme in the respective exercise adherence level groups (Table 1). However, the LA group tended to be slightly younger and taller but lower in body weight and body mass index (BMI), compared with the NA and HA groups.

The coronary risk profile of each adherence level group indicated that there was a relatively even match among groups in terms of CHD risk factors, with the notable exceptions of history of heart disease in the family and elevated total serum cholesterol, both of which were seen to be more frequent in the HA group (Table 2). Nevertheless, there were no contraindications to exercise programming displayed by individual members of the respective adherence level groups.

The initial subjective estimates by each exercise adherence level group in terms of reported exercise and physical activity (EPA) profiles, present physical fitness levels, and perceived *versus* actual body weight classifications revealed several interesting anomalies (Table 3). While the respective groups were reasonably well matched in terms of 'sedentary' and 'moderately active' representations, few subjects considered themselves to be 'active' or 'highly active' – categories commensurate with minimal levels necessary for maintaining²² or enhancing²³ aerobic fitness status. Furthermore, in the NA group physical fitness perceptions were at variance with the reported EPA profiles, whereby the majority of subjects considered themselves to be 'moderately active', while the distribution between 'very unfit' and 'moderately fit' was even. In the HA and LA groups there was a sequential rise in the 'moderately fit' to 'unfit' ratio, respectively, and the self-reported fitness level profiles closely matched the EPA perceptions. However, none of the subjects in any group regarded themselves as 'trained', although the

Table 1. Physical characteristics of subjects within each exercise adherence level group

Exercise adherence level	Age (years)	Height (cm)	Weight (kg)	BMI (kg m ⁻²)
NA (n = 16)	42.7(8.9)	174.8(7.4)	79.0(14.8)	25.6(4.3)
LA (n = 19)	37.6(9.7)	175.6(5.9)	76.5(8.8)	24.8(2.2)
HA (n = 20)	41.3(10.7)	174.8(8.8)	80.1(9.4)	26.2(2.3)
Total (n = 55)	40.4(7.0)	175.1(6.9)	78.5(11.43)	25.5(3.4)

Values are mean(s.d.)

Table 2. Coronary risk profiles of the respective exercise adherence level groups

Exercise adherence level	CHD diag (n)	CHD family (n)	CHD death (n)	Rheum fever (n)	Abn ECG (n)	Hypertensive (n)	Hypercholes (n)	Smoke (n)	>35 years (n)
NA (n = 16)	1	6	3	1	0	2	9	3	10
LA (n = 19)	1	4	5	1	0	0	6	2	9
HA (n = 20)	1	13	6	1	1	3	13	2	13
Total (n = 55)	3	23	14	3	1	5	28	7	32

n, number; CHD diag, coronary heart disease previously diagnosed; CHD family, history of coronary heart disease in immediate family; CHD death, premature death in immediate family due to coronary heart disease; Rheum fever, previously had rheumatic fever; Abn ECG, abnormal electrocardiogram previously diagnosed; Hypercholes, hypercholesterolaemia; smoke, regular cigarette smoker

Table 3. Reported levels of physical activity, physical fitness and body weight perceptions of the respective exercise adherence level groups

Exercise adherence level	Present level activity				Present level fitness			
	Sedentary	Moderately active	Active	Highly active	Very unfit	Moderately fit	Trained	Highly trained
NA (n = 16)	5	11	0	0	8	8	0	0
LA (n = 19)	4	14	1	0	4	15	0	0
HA (n = 20)	5	12	3	0	7	13	0	0
Total	14	37	4	0	19	36	0	0

Exercise adherence level	Exercise habits		Perceived body weight				Classification ²⁵ overweight (actual)
	Involved in exercise programme	Involved in regular sport	Under weight	Ideal weight	Slightly overweight	Very overweight	
NA (n = 16)	1	6	1	5	8	2	8
LA (n = 19)	6	12	0	7	10	2	13
HA (n = 20)	2	7	1	3	14	2	15
Total	9	25	2	15	32	6	36

LA group indicated involvement in exercise and regular sports participation more frequently than either the NA or HA groups. Finally, in terms of perceived body weight classifications, few considered themselves 'underweight', while the distribution of 'overweight' was similar and the numbers considered to be 'ideal weight' formed a minority across the respective groups. However, a majority of subjects within each respective group considered themselves to be 'slightly overweight', which corresponded closely with those classified over 10% ideal body weight²⁵.

In general the results observed among the three levels of adherence to the 14-week aerobic conditioning programme indicated selective improvements in some functional fitness variables with little or no change in the modifiable CHD risk factors (Table 4). In the respective LA and HA groups there were significant increases of 13% and 43% in treadmill exercise times (both $P < 0.001$) and concomitantly, 7% and 13% in the number of treadmill stages completed (both $P < 0.05$), but no significant change in either measure in the NA group. Furthermore, at the pre-programme test the LA group had significantly

Table 4. The influence of exercise adherence level to aerobic conditioning on modifiable CHD risk factors and functional fitness levels

Variables	Groups					
	NA (n = 16)		LA (n = 19)		HA (n = 20)	
	Pre	Post	Pre	Post	Pre	Post
TM time (min)	13.6(2.4)	14.0(2.7)	14.6(4.3)	16.5(4.3)	10.9(3.4)	15.9(3.3)
TM stage (No.)	4.6(0.7)	4.5(1.6)	4.6(1.0)	5.1(1.1)	3.7(1.1)	5.0(1.0)
HR (beats min ⁻¹)	165.0(6.0)	166.0(8.0)	165.0(10.0)	166.0(12.0)	162.0(13.0)	164.0(13.0)
Syst BP (mmHg)	129.0(14.7)	123.0(16.3)	120.0(10.9)	118.0(11.6)	125.0(18.6)	123.0(12.2)
Diast BP (mmHg)	76.2(9.7)	78.3(9.5)	71.7(7.8)	72.5(8.1)	76.7(12.0)	77.2(8.6)
Weight (kg)	79.0(14.8)	79.4(14.4)	76.5(8.8)	75.8(8.5)	80.2(9.4)	79.0(9.5)
BMI (kg m ⁻²)	25.6(4.3)	25.7(4.3)	24.8(2.2)	24.4(1.9)	26.2(2.3)	25.9(2.0)
Σ4 Skinfolds (mm)	49.6(16.4)	52.1(16.7)	44.6(15.0)	43.0(10.7)	45.7(12.4)	43.9(9.2)
Estimated body fat (%)	22.9(4.7)	23.2(4.6)	20.7(4.5)	20.6(4.2)	21.3(4.2)	20.9(4.2)
Waist: hips ratio	90.1(5.8)	91.5(5.7)	91.1(5.0)	90.6(4.4)	92.1(4.7)	90.7(4.3)
Cholesterol (mmol l ⁻¹)	5.86(1.51)	5.89(1.68)	5.03(1.36)	5.15(1.04)	5.58(1.31)	5.51(1.33)
Grip strength (kg)	52.9(6.8)	52.8(6.3)	52.7(8.5)	52.6(7.10)	54.3(6.70)	52.7(6.10)
Abdominal endurance (No. per 30 s)	16.7(4.9)	21.2(5.3)	18.7(4.0)	22.9(4.70)	17.3(3.5)	22.7(6.0)
Flexibility (cm)	7.7(4.8)	7.2(5.4)	5.7(6.8)	5.6(6.9)	6.9(4.8)	8.6(6.1)

Syst BP, systolic blood pressure; Diast BP, diastolic blood pressure
Significance levels: * $P < 0.05$; † $P < 0.01$; ‡ $P < 0.001$
Values are mean(s.d.)

longer treadmill exercise times and number of treadmill stages completed (both $P < 0.005$) than the HA group. However, while there were marginal post-programme decreases in end exercise heart rates and resting systolic and diastolic blood pressures in all three adherence level groups, these were not significant.

Similarly there were no significant anthropometric changes among the three levels of exercise adherence after the conditioning programme, although there was a trend towards a slight decrease in body weight, body mass index, sum of four skinfolds, estimated body fat percentage and waist:hips ratio in the LA and HA groups, which contrasted with the marginal increase in these measures in the NA group. However, serum total cholesterol levels remained unchanged over the duration of the study. Finally, significant improvements in abdominal endurance were observed in the NA group (22%, $P < 0.05$) and in the respective LA and HA groups (22% and 31%, both $P < 0.01$) as well as an increase in flexibility in the HA group (24%, $P < 0.05$), but no significant change in grip strength in any group after the intervention programme.

Discussion

The present study investigated the responses of selected modifiable CHD risk factors, and functional fitness levels to a short-term (14-week) aerobic conditioning programme in relation to three levels of adherence by middle-aged men. The results suggested that in comparison with non-adherence (NA) and low adherence (LA), high adherence (HA) to a standard set of physical activity guidelines²³ led to a more comprehensive improvement in a range of functional abilities including aerobic endurance, muscular endurance and flexibility. However, in terms of modifiable CHD risk factor status, while there were trends towards systolic blood pressure and body weight reductions associated with LA and HA, there was no evidence to suggest changes in serum total cholesterol levels regardless of the level of adherence.

Enhanced aerobic endurance capacity was evidenced by significant increases in treadmill exercise times and the number of exercise stages completed by the LA and HA groups with the latter recording the largest improvement in both parameters after the conditioning programme. These findings are in agreement with increased endurance capacity observed in a similar population group who participated in an exercise programme using similar guidelines¹⁴. Furthermore, the increases in treadmill exercise performances by the LA and HA groups were accompanied by marginal but non-significant increases in end exercise heart rates which suggested an improvement in exercise tolerance of the respective groups of subjects.

The changes in anthropometric dimensions in general reflected the levels of adherence to the conditioning programme. Body weight changes showed a significant reduction in the HA group, a

non-significant trend towards a reduction in the LA group, but little or no change in the NA groups over the 14-week period. These relatively modest body weight decreases of 2.4% and 2.0% in the HA and LA groups, respectively, were similar to those documented in previous studies^{14, 26}. However, even though body weight decreased most profoundly in the HA group, which exercised above the minimal standard guidelines²³, the weight reduction observed may have been assisted by other factors such as dietary modification which was not assessed. Furthermore, the small but non-significant reduction in BMI noted in all groups was not accompanied by any discernible changes in the estimated percentage of body fat, which suggested that no change occurred in body composition in the respective groups.

In each of the three adherence level groups resting systolic blood pressure showed a tendency toward a small but non-significant reduction after the conditioning programme, while resting diastolic blood pressure remained relatively unchanged. However, it was considered unlikely that normotensive subjects such as those in the present study would benefit from exercise conditioning related blood pressure reductions observed in subjects with mild or borderline hypertension^{27, 28}. Serum total cholesterol levels remained relatively unaffected by the conditioning programme regardless of the level of exercise adherence. This suggested that, unlike other studies of longer duration, which have demonstrated significant reductions in cholesterol^{24, 29}, the duration of 14 weeks used in the present study was insufficient to modify total cholesterol levels. This conclusion is supported by the findings of other studies using exercise programmes of similar duration which failed to demonstrate significant changes in cholesterol level^{26, 30, 31}. It has been suggested, therefore, that exercise alone has little effect on total cholesterol level³¹, although significant changes in other CHD risk factor lipid fractions e.g. high density lipoprotein (HDL): low density lipoprotein (LDL) cholesterol ratio may occur after exercise training without alteration in total cholesterol level¹¹.

An evaluation of the initial coronary risk profile of the respective exercise adherence level groups (Table 2) indicated that the HA group had a relatively higher incidence of family CHD along with elevated serum total cholesterol level than the NA and LA groups. The presence of these factors therefore may have influenced the exercise participation level by the HA group given the recent publicity concerning the prevalence of CHD risk factors in Northern Ireland and its status as world leader in premature mortality from CHD¹². Indeed, it has been suggested that willingness to take part in, along with type and amount of exercise performed, as well as adherence level to such programmes may be related to the presence of one or more CHD risk factors²⁹. However, the level of adherence to the conditioning programme in the present study did not appear to be related to the subjective perceptions of level of activity, fitness status or personal body weight characteristics (Table 3), but may have been influenced by the involvement in similar programmes, other sport activities and the relatively overweight

levels demonstrated by the LA and HA groups (Table 3).

In conclusion, the findings of the present investigation suggested that differences in exercise adherence level to a short-term (14-week) conditioning programme may selectively influence specific function levels of fitness and modifiable CHD risk factors. Furthermore, the results indicated that adherence to the minimum level of exercise suggested by standard guidelines²³ produced fewer positive improvements in low adherence compared with high adherence, while the isolated change noted in non-adherence, for example improved muscular endurance, may have been attributable to habituation effects alone. Nevertheless, it was evident that the relatively short duration of the conditioning programme utilized by the present study produced relatively fewer beneficial effects when compared with similar programmes of longer duration. However, the reduced benefits of short-duration conditioning programmes must be set against the problems of adherence, maintenance, and drop-out rate associated with more prolonged time-scales.

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