BRITISH PILOT STUDY OF EXERCISE THERAPY

I. MIDDLE-AGED MEN

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ABSTRACT

The physiological and biochemical effects of a carefully graduated course of vigorous gymnasium training with two or three weekly exercise sessions lasting only 15 minutes have been studied in middle-aged London business men.

Activity diaries and psychological questionnaires indicated that these men had a positive attitude to exercise which was probably greater than average. The gymnasium exercises caused a large oxygen debt and considerable rises in plasma catecholamines and lactate levels. A close correlation was found between the pulse rate during exercise and the Borg scale of perceived exertion, so that both could be used to ensure that short periods of exercise were sufficiently vigorous to produce a training effect, and protect against over-exertion. The acceptability of this particular exercise regime was shown by the low fall-out and injury rate.

It is suggested that this exercise training programme possesses many features which are advantageous if increased physical activity is to be more widely used as a method of reducing some of the risk factors in coronary heart disease.

INTRODUCTION

Exercise is now being recommended increasingly, both in its own right as an enjoyable recreational pastime (1) and as a means of preventing some of the diseases associated with urban life, particularly coronary heart disease (2, 3). In view of the current interest in "exercise therapy", both to prevent and treat coronary disease, we thought it appropriate to report a pilot study of a course of gymnasium training designed to enhance cardiovascular fitness in middle-aged men.

There have been several studies of the effects of physical training in middle-aged men, especially in Scandinavia (4-6) and America (7-10), but no multi-disciplinary investigations in this field have been reported in Great Britain. The need for a broadly based approach to such studies is illustrated by the wide range of advantages attributed to exercise listed in Table I.

Ideally, such exercise should be safe, acceptable, fitness-producing and economic. On the basis of "firstly do no harm", safety must be the over-riding factor in advising the unfit adult who wishes to exercise. Acceptability is the next consideration, as the finest schemes are

TABLE I

Mechanisms by which physical activity may reduce the occurrence or severity of coronary heart disease. (after Fox et al. (11))

Physical activity may:

INCREASE	DECREASE
Coronary collateral vascularization	Serum levels of:
Coronary vessel size	Cholesterol
Myocardial efficiency	Triglycerides
Efficiency of peripheral blood distribution and return	Free fatty acids
Fibrinolytic capability	Glucose intolerance
Arterial oxygen content	Obesity — adiposity
Red blood cell mass and blood volume	Platelet stickiness
Thyroid function	Arterial blood pressure at rest
Growth hormone production	Heart rate
Tolerance to stress	Vulnerability to dysrhythmias
Prudent living habits	Neurohormonal over-reaction
"Joie de vivre"	Strain associated with psychic "stress"

useless if they remain unused. Fitness, in the sense of increased physical well-being, is the aim of most who

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exercise. Economy is essential for wide acceptance, not only from the financial aspect, but also in terms of the closely related factors of the time and space required.

The opportunity to study a form of exercise which appeared to offer many of these features arose in this country from a collaboration between the late Dr. Harold Lewis of the Medical Research Council and Mr. Alistair Murray, Director of the City Gymnasium in London.

SUBJECTS

The study group consisted of a total of 302 men, mean age 37 years (range 26-57), with no history of cardiac disease, who had enrolled at the gymnasium for a course of physical training.

For ethical reasons the General Practitioner's consent had to be obtained in writing before individuals could take part in the study, even though they were participating fully in gymnasium activities. This often delayed the initial investigations for several weeks, during which time a considerable "training" effect became apparent. Also, as these individuals were paying standard fees, it was found to be difficult to raise the question of time-consuming and mildly inconvenient research procedures in the early weeks without putting the more nervous of them off the idea of exercise altogether. There was thus an unintended bias towards selection of the more robust and less anxious individuals, and towards those who had already attended the gymnasium for several weeks.

THE EXERCISE PROGRAMME

The exercise programme used was a carefully graded course of physical training designed by Mr. Alistair Murray. Each person exercised for 15 minute periods two or three times each week, starting at very low work rates, and frequently monitoring his own pulse rate to ensure that it remained within the predetermined limits (fig. 1). The rhythmic submaximal movements were predominantly isotonic rather than isometric in character, (12) light weight loading being introduced only gradually and carefully in relation to observed progress to maintain the training effect of a short period of exertion. In addition to "free" exercises, adjustable weight training equipment was used, and the intensity of the exercise increased by weight increments of just 2-3 lbs, using a formula involving the product of repetitions and resistance in pounds (Repounds). This exercise intensity score (Repounds) enabled work rates to be replicated, increased or decreased, and related quantitatively to changes in physiological and biochemical variables. The City Gymnasium Programme consisted of 10 varied movements, closely approaching the ideal of whole-body exercise, and avoiding the monotony inherent in training limited muscle groups, for example on

Fig. 1. Pulse rate ranges for healthy men at different stages of gymnasium training.

a stationary bicycle.

A psychophysical scale comprising equal intervals from 6 to 20 was used to rate perceived exertion (13). Values on this scale when multiplied by 10 are known to correspond closely with the exercise heart rate, and this was found to be the case during most of the vigorous exercise period (fig. 2).

Fig. 2. Pulse rate of a healthy, trained 40 year old man during gymnasium exercise, showing correlation with mean ratings of perceived exertion in 13 men.

PHYSIOLOGICAL STUDIES

The exercise intensity scores achieved at each session in the gymnasium showed large and progressive rises over a six-month period (fig. 3). The 40 men exercising three times each week showed a larger increase ($p < 0.001$) than a group of 30 attending twice a week. These results imply considerable rises in effort capacity at a given pulse rate, as only a slight increase in exercise pulse rate was allowed in the training programme.

Fig. 3. Mean ($\pm$ S.E.) increase in exercise intensity score with length of gymnasium training for 40 men exercising three times each week, compared with 30 men exercising twice weekly.

The oxygen uptake during a standard schedule of the 10 exercises was studied at the gymnasium in 13 healthy men aged between 26 and 53 years (mean 37 years), with an average height of 175.7 cm (range 168.0-185.7 cm) and weight of 80.4 kg (range 66.0-106.2 kg). Body fat, estimated from skinfold thickness measurements, amounted to 19.5% of body weight (range 12.5-27.3). Resting pulse rate averaged 65 beats/min (range 52-88) and mean resting blood pressure was 124/78 mm Hg (systolic range 165-95, diastolic range 90-52). Mean resting oxygen uptake ($\dot{V}O_2$) measured by a Douglas bag technique was 310 ml/min (range 235-409 ml/min). Subjects then performed the standard schedule of 10 exercises, completed on average in 10 minutes (range 7½-12 minutes). Oxygen uptake was measured over the whole exercise period and again during 10 minutes of recovery in the supine position. Exercise intensity score varied widely in the different subjects, the average being 6920 "Repounds"/min (range 3870-10520), i.e. rather higher than the average for a larger group in fig. 3. Exercise

oxygen uptake averaged 1750 ml/min (range 1340-2140), equivalent to 21.9 ml/kg/min (range 15.2-28.2), and it was estimated that this represented 50-65% of the maximum $\dot{V}O_2$. Exercise intensity score correlated significantly with oxygen uptake ($r = 0.64$). This correlation was improved by relating the score to excess oxygen uptake, i.e. exercise $\dot{V}O_2$ minus that at rest ($r = 0.78$). The oxygen debt averaged 3.5 litres (S.D. ± 1.7).

Another group of 19 healthy men, mean age 44.5 years (range 35-54) were studied during an increasing work rate test (14) on a cycle ergometer. These studies were performed in the exercise laboratory at the Royal Postgraduate Medical School, Hammersmith Hospital, on four occasions, twice during their first week of involvement in the study, which was often their second or third week of training, and again eight and 14 weeks later. The test was stopped when heart rate reached 85% of the maximum value predicted from the subject's age (fig. 1). Two periods of submaximal exercise (300 and 600 kpm/min, 50 and 100 watts respectively) were also performed and ventilation ($\dot{V}E$), oxygen uptake ($\dot{V}O_2$) and heart rate measured.

The results of the cycle ergometer tests are shown in Table II, with cardiac frequencies and ventilation interpolated to oxygen intakes of 1.0 to 1.5 litres/min. At the initial assessment the values of cardiac frequency and ventilation at standard oxygen intakes were similar to those found previously for non-athletic middle-aged men (14, 15). Repeat studies after a further eight and 14 weeks of the gymnasium programme showed no significant changes in heart rate or ventilatory response during exercise. Thus, despite the improved ability to perform the gymnasium exercises, no improvement in performance was demonstrated on the cycle ergometer.

TABLE II
Performance on Cycle Ergometer

Oxygen uptake ($\dot{V}O_2$)	Mean heart rate $\pm$ SD (bts/min) at standard $\dot{V}O_2$		Mean ventilation $\pm$ SD (l/min) at standard $\dot{V}O_2$	
	1.0 l/min	1.5 l/min	1.0 l/min	1.5 l/min
1st test	105.6 $\pm$ 15.3	129.7 $\pm$ 17.9	22.1 $\pm$ 3.3	37.4 $\pm$ 3.2
2nd test (8 weeks later)	103.0 $\pm$ 12.0	126.0 $\pm$ 17.9	24.7 $\pm$ 3.4	37.0 $\pm$ 4.4
3rd test (14 weeks later)	104.0 $\pm$ 4.2	124.3 $\pm$ 18.0	25.8 $\pm$ 3.7	38.9 $\pm$ 4.0

HABITUAL ACTIVITY STUDY

Especially designed diary cards (16) were issued to 40 volunteers who recorded details of their activities during three consecutive working days and weekends. These cards were analyzed according to whether the subject worked in the "City" or was employed elsewhere. The results of the analysis are shown in Table III and IV. There is considerable variation in the activity pattern and an unexpected finding was the large amount of time spent walking by both groups.

TABLE III

Comparison of Activities of all 40 Subjects on Different Days (mean time in minutes/day)

	Weekday	Saturday	Sunday
Bed	456	474	529
Lying	7	20	30
Sitting	628	476	496
Standing	82	96	99
Walking	101	117	78
Dressing	34	31	27
Driving	74	69	46
Gymnasium	24	—	—
Miscellaneous	34	157	134

(The term "miscellaneous" includes golf, tennis, swimming, sailing, gardening, car-cleaning, household repairs).

TABLE IV

Comparison of Weekday Activities of Subjects Working in the City of London and Outside

(mean time in minutes/day)

	City (22 men)	Outside City (18 men)
Bed	460	444
Lying	2	18
Sitting	660	598
Standing	85	85
Walking	104	101
Dressing	31	38
Driving	59	95
Gymnasium	21	23
Miscellaneous	18	38

PSYCHOLOGICAL STUDY

The aim of the psychological study was to characterize the individuals with variables which might subsequently prove valuable in cross-disciplinary analyses of

data on exercise therapy effects. The psychological findings summarized below are descriptive, enabling comparison of the gymnasium group with other UK samples of similar age and social status.

Three variables were investigated:

1. Long-term personality pattern
2. Current emotional status
3. History of recent life events

Subjects were sent a 5-day kit of questionnaires which they filled in anonymously and posted to the investigator. Fifty-one out of the 61 volunteers completed the assignment. Their ages ranged from 26-61 years (mean 39 years).

1. Personality patterns

(a) *Extraversion-introversion* (17). The test includes items designed to characterize the high sociability, liking for activity and impulsiveness of the extrovert, in contrast to reservation, tendency to shyness and self-control of the introvert. Scores for our sample gave a mean of 11.60 ± 3.84 ($n = 47$), values which are very close to those for matched groups of normal UK males.

(b) *Hostility* was assessed by the use of the Hostility and Direction of Hostility Questionnaire (18). For "general hostility" our sample gave a mean of 15.28 ± 5.69 ($n = 46$), slightly but not significantly above the values they published for other normal groups. The sample proved to be slightly more extrapunitive (mean 1.50 ± 6.29) than normal in direction of hostility.

In summary, the personality measures indicated that the sample was fairly typical of a normal population of the same age and socio-economic grouping.

2. Current emotional state

This was assessed by subjects making a daily check over five days against a list of 55 mood items. The list comprised descriptions of moods and emotions; anger, fear, depression and fatigue, alertness and happiness. As with most normal samples, there was a preponderance of positive over negative affect. Fear was less common than other negative moods in the anger and fatigue groups. The relative frequency of moods in the active-alert group was higher than in other normal samples, reflecting the "get up and go" character of the gymnasium population.

3. History of recent life events

It seemed to us to be important to investigate the degree of strain under which a man may be living as a consequence of the need to adapt to a high frequency of

events in his life, whether these be desired by him or not. A measure originated by Rahe (19) was adapted for use with our sample and consisted of 50 items covering events concerning family, employment, health and finances over three periods in the immediate past: 0-6 months, 7-12 months, 1-2 years. The total number of life events recorded by our subjects for the 2-year period varied widely, from 6 to 40, with a mean of 13.3 ± 7.2 . The highest score was in the 0-6 month period, the recency but not the intensity of events affecting their recall. In the absence of comparative data from other UK samples, the interest of the life event data residues in its interaction with other variables, e.g. lipid levels, which will be reported later.

BIOCHEMICAL STUDIES

The biochemical methods used were those described by Taggart and Carruthers (20).

(a) *Short-term effects.* Blood samples were taken before and within a minute of the end of exercise in 107 volunteers. The results are shown in Table V. Both

TABLE V

The Immediate Effects of Exercise in Healthy Volunteers on Blood Chemistry

Variable	Time	n	Mean	S.E.	t	p <
Total	Pre	93	0.78	0.02	17.0	0.001
Catecholamines ($\mu\text{g/l}$)	Post	93	1.42	0.04		
Noradrenaline ($\mu\text{g/l}$)	Pre	93	0.74	0.01	14.4	0.001
Adrenaline ($\mu\text{g/l}$)	Post	93	1.20	0.03		
Adrenaline ($\mu\text{g/l}$)	Pre	93	0.04	0.01	11.4	0.001
	Post	93	0.22	0.02		
Total Protein (g/100 ml)	Pre	107	7.20	0.04	11.9	0.001
	Post	107	7.52	0.04		
Albumin (g/100 ml)	Pre	107	4.52	0.03	9.4	0.001
	Post	107	4.68	0.03		
Globulin (g/100 ml)	Pre	107	2.66	0.03	8.1	0.001
	Post	107	2.84	0.03		
Free Fatty Acids ($\mu\text{mol/l}$)	Pre	108	915	35.4	0.2	N.S.
	Post	108	918	35.9		
Triglyceride (mg/100 ml)	Pre	107	149	8.00	0.8	N.S.
	Post	107	148	7.86		
Cholesterol (mg/100 ml)	Pre	107	250	3.97	5.84	0.001
	Post	107	257	4.04		
Glucose (mg/100 ml)	Pre	104	87.6	1.75	3.53	0.001
	Post	104	91.4	1.98		
Lactate (mmol/l)	Pre	42	1.7	0.12	13.0	0.001
	Post	42	8.6	0.52		

noradrenaline and adrenaline rose during exercise, the former accounting for most of the increase in total catecholamine level (21). The rise in blood sugar correlated poorly with the increase in adrenaline ($r = 0.206$

$p < 0.05$) while the high post-exercise lactate levels are consistent with the finding of a large oxygen debt. Rises in plasma proteins and cholesterol could be accounted for by haemo-concentration. Free fatty acid and triglyceride levels remained high but unchanged after exercise. In the presence of increased plasma noradrenaline levels, the constancy of the free fatty acid and triglyceride levels suggest that lipolysis and fatty acid utilization are considerably augmented by this form of exercise.

(b) *Long-term effects.* In 17 volunteers who continued to attend the gymnasium regularly, from the fourth month onwards no significant changes were found in any of the 11 biochemical variables listed in Table V as measured serially over a period of up to two years. This confirms the findings reported in the second paper that the maximum change in biochemical and haemodynamic variables is achieved within three months of starting the training programme, and is maintained as long as the subject continues to exercise regularly.

DISCUSSION

The aim of this study was to characterize in physiological and biochemical terms a system of weight-assisted gymnasium exercises, and to examine the habitual activity and psychology of the middle-aged men who volunteered for this type of training.

The regime at the City Gymnasium was not very demanding physically. Subjects attended two, or more often three times a week, and performed a period of exercise which lasted an average of 15 minutes on each occasion. The work intensity was estimated to represent 50-65% of the individual's maximum oxygen intake. Such a level of exercise, carried out for only 15 minutes two or three times a week, would not be considered on the basis of other studies carried out on fitter and younger people (22) to be sufficient to result in substantial physiological changes. However, Nordesjö (23), starting with non-athletic students, found a significant training effect with exercise of this intensity, frequency and duration, and that this regime was the most acceptable to those training.

Also, the oxygen debt and increase in blood lactate resulting from the 15 minute period of exercise were larger than would be expected from the oxygen uptake. This may be because some of the exercises carried out in the gymnasium affect predominantly the arm, shoulder and back muscles, and it is probable that these muscles were working closer to their maximum capacity than is indicated by measurement of the whole body oxygen intake during exercise. Such considerations may be important in defining the term "vigorous" in relation to the finding of Morris *et al* (2) that "habitual vigorous exercise during leisure time reduces the incidence of coronary heart disease in middle-age among male sedentary workers".

There are two possible explanations for the absence of significant changes in the responses to exercise in the subjects studied at Hammersmith. One is that the particular subjects studied there were already partly trained at the time they were first studied. This is likely in view of the delay in initiating the investigation due to the need to consent from the subjects' general practitioners. The other is that the training programme involved mainly upper limb and trunk muscle groups not much used in cycling, which therefore showed little change (24).

The psychological characteristics of the gymnasium population studied were reasonably typical of the male population of the same age, but tended to be slightly more extroverted and to have "active" rather than "passive" personalities. This conclusion was supported by the finding that a majority of the subjects who volunteered took part in physically active pursuits, playing golf or squash, swimming, sailing, etc. The measurements made of physical work capacity showed that on average the subjects had a physiological performance similar to that of a moderately active group of the same age.

The most important features of this gymnasium-based exercise programme were its acceptability and safety. The proportion of subjects ceasing exercise before their membership subscription lapsed (drop-out rate) was extremely low for unfit adults taking up any form of exercise, averaging 5, 10 and 15% for the two, six and 12 month attenders respectively. This compares favourably with the findings of Sanne and Wilhelmsen (5) who found that 30% dropped out within one year. Less than 2% of the subjects suffered minor injuries sufficient to make them even temporarily cease training. The few injuries that did occur were nearly all transient mild recurrences of pre-existing "back" troubles.

The individual tuition and supervision of progress by the trained remedial gymnasts running the gymnasium, rather than class exercises, helped to secure an adequate amount of exercise without risk of over-exertion. The need for a considerable margin of safety is emphasized by the tests of cardiac function reported in the second article. The safety of exercise as carried out under these conditions is demonstrated by the fact that although approximately a fifth of the 2,500 people training in the gymnasium over the past seven years were known to have cardio-vascular disease, none suffered a heart attack whilst exercising at the gymnasium (25). In view of the number of sudden deaths occurring in middle-aged sportsmen during exercise, it is suggested that extremely few physical educationists or sports coaches are qualified to deal with the unfit adult (26).

The problems encountered in running this pilot study have mainly been ones of recruitment from a self-

selected group of middle-aged men who are less accustomed to taking part in clinical investigations of this type than their counterparts in many Scandinavian countries. Late enrolment made it difficult to chart changes attributable to this scheme which would, in any case, have required a non-exercising control group. This is included in an extension of this study investigating alterations in coronary risk factors over a longer period. Time pressures and travelling difficulties limited the number of volunteers willing to visit other hospitals for the more detailed physiological and cardiological tests. Although the intensity of work as measured by the "Exercise Intensity Score" is not quantitatively accurate, it served both to regulate the amount of exercise taken and to demonstrate an improvement in physical performance.

This study shows the feasibility and some of the potential beneficial effects of a physical training programme for middle-aged men.

ACKNOWLEDGEMENTS

This study was carried out with grants from the Sports Council, the Medical Research Council and the British Heart Foundation.

We would like to thank Dr. O. G. Edholm, Head of the M.R.C. Division of Human Physiology, National Institute for Medical Research, London, for his advice and guidance in this study. Assistance in collating the results was provided by Miss Sandra Alder.

The study was based entirely on the system of exercises designed and applied by Mr. Alistair Murray of the City Gymnasium. Without his expert knowledge and enthusiasm, and the practical assistance of Mr. Frank Shipman, also working at the City Gymnasium under a grant from the Sports Council, this work could not have been carried out.

We would also like to thank Dr. Marie Hutchinson and Dr. Steven Spiro of the Royal Postgraduate Medical School and Mr. Tom Reilly of Liverpool Polytechnic for their help with the physiological tests. The biochemical analyses were performed mainly at the Institute of Ophthalmology in Professor Norman Ashton's Department.

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