EXERCISE PRESCRIPTION – NORTH AMERICAN EXPERIENCE

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ABSTRACT

The principles of exercise prescription are reviewed with respect to North American experience. The required regimen must be safe, therapeutically effective, and ensure a high rate of compliance. Precautions to increase the safety of exercise are discussed. Cardiac emergencies are sufficiently rare events (< 1 in 200,000 hours even in post-coronary classes) that the need for immediate medical supervision of a well-designed programme can be questioned. The prime determinant of the response to training is the intensity of effort relative to the individual's initial fitness. Post-coronary patients often have a great potential for training due to their previous inactivity, but this will not be realised if the prescribed exercise is of insufficient intensity. Exercise programmes are plagued by a high 'drop-out' rate; 50% of normal middle-aged volunteers are lost in 6 months, and even with post-coronary programmes losses can be 60-70% over 4 years. Simple suggestions are made for improving compliance with the required exercise prescription.

Morris (page 220) and Fentem (page 223) have reviewed evidence that exercise may be beneficial for health from an epidemiological and a physiological viewpoint respectively. This paper will discuss practical problems of devising an exercise prescription for both normal and 'post-coronary' patients, with particular reference to North American experience.

The general principles of exercise prescription are simple. As with administration of a drug, the dose used must be safe but therapeutically effective. Further, treatment must be life-long, so that continuing compliance with the required regimen is a serious concern.

CONSIDERATIONS OF SAFETY

Incidence of cardiac emergencies

Tunstall-Pedoe (page) has discussed the problem of sudden death associated with exercise. It is a rare idiosyncrasy, and it is thus difficult to estimate its precise incidence. Nevertheless, there is some evidence that exercise increases the likelihood of a ventricular dysrhythmia (Shephard, 1974; 1975a).

W. Haskell (personal communication) surveyed the experience of 25 North American *post-coronary programmes*, operating at 86 locations. A total of 8092 cases had spent 949,568 hours in supervised exercise; 54 cardiovascular complications had arisen, 10 of which were fatal. The chances of cardiac arrest were thus 1 in 29,674 for each hour of exercise that was performed. The survey included events that occurred ten or more years ago, when knowledge of exercise prescription was rudimentary, and there were no formal procedures for the training and certification of class-leaders (American College of Sports Medicine, 1975). Restricting his analysis to recent history, Haskell found that the fre-

quency of cardiac arrest dropped to 1 in 268,922 hours of exercise, this value being not much greater than the chance rate for the 'post-coronary' patient.

In contrast to Haskell's experience, the Seattle group continue to see one episode of cardiac arrest as often as every 3000 hours of exercise (Pyfer *et al.*, 1975). Reasons for this discrepancy are as yet unexplained. In Toronto, we have encountered three cardiac emergencies during or soon after an exercise class, a rate of one episode in 216,000 hours.* Furthermore, about a quarter of the non-fatal myocardial infarctions referred to us for rehabilitation were apparently precipitated by exercise (Kavanagh & Shephard, 1973). To date, there have been 52 recurrences of infarction in the Ontario multi-centre exercise-heart trial; 10 occurred during and a further 7 within 3-4 hours of vigorous exercise.

Detecting high-risk individuals

Attempts to detect individuals who will have an adverse response to exercise have had only a very limited success (Kavanagh & Shephard, 1978).

We might suspect that the patient who succumbs would have a 'Type A' personality (Friedman & Rosenman, 1974). Not only is this a coronary risk factor in itself, but it tends to make the person concerned exercise in an injudicious fashion. The initial episodes of infarction certainly provide many histories of excessive and unaccustomed exercise, undertaken in a competitive fashion (Kavanagh & Shephard, 1973). In subsequent rehabilitation, the person who has had a coronary attack during exercise tends to progress faster than his col-

* The 'chance' rate for fatal and non-fatal reinfarctions for the Toronto population is one episode per 364,000 patient hours.

leagues. If a Type A person is told that he can improve his fitness by exercising 30 minutes per day, he may well attempt to accomplish this goal more quickly, taking twice the prescribed exercise each day. If he exercises in a group setting, he may find difficulty in accepting that others can progress to high doses of exercise faster than himself. If he participates in individual sport, he is unable to lose games such as tennis and squash with good grace. And always, he brings to his activity problems of home and office. Nevertheless, if adherence to the prescription is carefully monitored by the class supervisor, a patient with Type A personality can participate safely in a vigorous 'post-coronary' exercise programme. Indeed, in one of our recent trials (Rechnitzer *et al.*, in preparation), the subsequent mortality was higher in Type B individuals (5.85 deaths per 100 person-years) than in those with Type A characteristics (3.88 deaths per 100 person-years).

Other warnings of an adverse response to effort include horizontal or downward sloping depression of the ST segment of the electrocardiogram, and polyfocal ventricular extrasystoles that become more frequent during exercise.

Simple precautions

Several simple precautions can increase the safety of a given prescription. Fever, with an attendant risk of viral myocarditis, is an absolute contra-indication to exercise after infarction.

Problems during exercise often reflect myocardial ischaemia secondary to an excessive rise of systemic blood pressure. The patient should thus be advised to compete only against himself, to avoid the hypertension associated with sustained isometric effort (Lind & McNicol, 1967), and to moderate his prescription when under psychological pressure. It may also be helpful to teach him to recognize ventricular extrasystoles and early angina, so that he can moderate his activity if such symptoms develop.

Incidents of cardiac arrest are more frequent *after* than *during* activity. In the recovery period, there is probably a fall of diastolic pressure, with an attendant reduction of coronary perfusion. McDonough & Bruce (1969) described two episodes of ventricular fibrillation that developed during showering. Two of three cardiac emergencies in the ten year operation of our Toronto programme also occurred in the first few minutes following formal activity — one man was showering, and the other awaiting a taxi to return home. The practical implications are to minimize postural hypotension by a thorough warm-down, control of temperature and humidity in changing areas, and avoidance of prolonged standing. Locker space should also be kept under surveillance, and showers fitted with an alarm signal.

Medical supervision

(a) Healthy middle-aged subjects

The ostensibly healthy middle-aged North American is usually given a medical certificate by his physician, and then exercises under the supervision of a trained physical educator. In the United States (Cooper, 1970; Erb, 1970; Kattus, 1972) — a resting electrocardiogram is taken if the patient is over 30 years of age, while a full 'exercise stress test' with multiple lead electrocardiogram is given to those over 35-40 years of age. Payment for such services is normally the responsibility of the patient, although in some instances a part of the cost may be covered by a private insurance scheme. Canadian physicians have been sceptical concerning the usefulness of such extensive pre-exercise examinations (Cumming, 1973), and in the context of universal pre-paid medical care, the Canadian government has been reluctant to endorse the mass examination of normal adults as a pre-requisite for entry into a physical activity programme (Orban, 1972). Alternatives that have been explored include a simple 7-question 'physical activity readiness' questionnaire ('Par-Q', Chisholm, *et al.*, 1975), a self-administered fitness test (the Canadian Home Fitness Test, Bailey, *et al.*, 1976; Shephard *et al.*, 1976) and a more sophisticated version of the same procedure administered by health professionals (Lauzon, 1978). We (Cox & Shephard, in preparation) have recently compared responses to the Par-Q questionnaire with reactions to a formal exercise stress test. A total of 1130 subjects presented for examination, 223 (19.7%) making a positive response to one or more items on the questionnaire. Eight of the subjects were judged as unsuitable candidates for exercise testing, because of resting e.c.g. abnormalities, marked hypertension or orthopaedic problems. The questionnaire picked out all of these individuals. However, 16 of 23 subjects who developed premature ventricular extrasystoles, and 37 of 53 subjects who developed ST segmental depression during exercise were not identified. The commonest positive response (101 subjects, 8.8% of the sample) was to the question 'Has a doctor ever said your blood pressure is too high?' Only 15 of our sample actually had a diastolic blood pressure higher than 90 mm Hg, 3 of these 15 being missed by the question on hypertension. At present, we must thus conclude that the 'Par-Q' questionnaire has fair sensitivity, but is lacking in specificity. Further refinement of the instrument plainly is needed.

(b) 'Post-coronary' patients

Most patients with known cardiac disease currently carry out their exercise prescription under the direct supervision of a qualified physician. However, the cost/effectiveness of such an approach is now coming under close scrutiny, both in Canada and the United States.

In Toronto, we have experienced one cardiac emergency per 216,000 patient-class hours. Given a class-size of 50 patients, this would amount to only one episode per 4320 class hours, or one episode per gymnasium year. The event is rare relative to the cost of medical supervision. If all post-coronary patients were to receive thrice weekly sessions of supervised exercise, there would be a nightly demand for 12,000 physicians in the United States, and 1200 in Canada (Shephard, 1979). Let us further assume this number of staff could be recruited and were willing to work for a modest honorarium of \$50 per night. Allowing \$40 for the cost of gymnasium and support staff, the total expense would be some \$90 (£45) per night, \$13,500 per supervised class-year, and more than \$400,000 per attempted resuscitation. Even if the resuscitation is successful this is an expensive method of adding ten years to a patient's life; with a relatively brief period of training, paramedical personnel could have performed the same function much more cheaply.

In Toronto, we offer a tapered programme. Patients are normally accepted at our out-patients facility 2-3 months following infarction. Over the first three months, they attend the centre twice per week, receiving carefully monitored instruction in the techniques of exercise, pulse counting and symptom recognition. Progress is then reviewed. If we are satisfied with the clinical status, response to laboratory exercise tests and mastery of training procedures, the patient graduates to a once weekly supervised class. On intervening days, he uses a home prescription that specifies a distance to be walked or jogged, the time allotted, and symptoms to be avoided. Fulfillment of the prescription is monitored by a daily diary record that notes the principal voluntary activities, corresponding pulse rates, and any symptoms that may have developed.

We are examining the possibility of subsequent graduation to a programme where the patient only attends one session in 8 weeks. Current experience suggests that if such a programme is initiated after a year of once weekly attendance, gains of condition are maintained but there is little further improvement of performance (Shephard & Kavanagh, in preparation). In essence, the programme is safe, but produces a less than optimal conditioning effect.

At one time, U.S. physicians were adamant that 'post-coronary' patients should not exercise except under the immediate supervision of a physician. However, they also are now realizing that such a plan is unrealistic, except perhaps for the very wealthy patient. While groups such as Blue Cross Insurance are beginning to cover the expenses of rehabilitation, they also are insisting upon a cost/effective approach. A typical scheme might call for three supervised sessions per week for three months, 2 supervised sessions per week for a

further 3 months, and a final 6 months with 1 supervised session per week. The intention is not that the patient will take progressively less exercise, but rather that he will discover ways of doing this for himself within the community (Fox — personal communication, 1978). Such an approach may work quite well if the patient is progressing favourably, but it is unlikely to sustain a therapeutically effective training load if the patient is nervous or is encountering periodic symptoms. Such individuals need the reinforcement of a periodic visit to a rehabilitation centre, where performance can be evaluated by an expert and the exercise prescription can be adjusted upwards or downwards as appropriate.

Musculo-skeletal injuries

Musculo-skeletal injuries are a common reason for poor exercise compliance in middle-aged and 'post-coronary' patients (Kilbom *et al.*, 1969; Mann *et al.*, 1969). Precautions to reduce such problems include (1) an adequate 'warm-up' and 'warm-down', (2) a gradual increase of training loads (two weeks is a sufficient interval between progressions in young patients, but older individuals need additional time — 3 weeks if aged 40-50 years, and 4 weeks if aged 50-60 years), (3) careful enquiry regarding previous joint or back problems (the prescription for affected individuals should be based on swimming or cycling rather than jogging), (4) an appropriate choice of footwear (shoes should have a well-cushioned heel of adequate height and provide good ankle support), (5) an avoidance of hard surfaces (such as concrete sidewalks and concrete floors covered by vinyl tile) and (6) the taking of special care on uneven and slippery surfaces (such as rough grass or ice).

THERAPEUTIC EFFECTIVENESS

Factors determining the response to a training programme have been the subject of several reviews (Shephard, 1965; 1975b; 1977; Pollock, 1973). Potential variables include the intensity, frequency and duration of training sessions, the total amount of work performed and the initial fitness of the subject. However, the most important variable is usually the intensity of the required activity relative to initial fitness.

Intensity

A study commonly quoted is that of Karvonen *et al.* (1957). They exercised young medical students for 30 min, 4-5 times/week. A treadmill heart rate of 135 beats/min proved an ineffective training stimulus, but training did occur at heart rates of 160-180 beats/min. Subsequent authors have described these results rather carelessly, often without reference to the age or the fitness of the initial sample. The threshold heart rate that Karvonen and his associates observed has been reported as equivalent to 60% of maximum oxygen intake (141 beats/min in a young man), 60% of the difference

between resting and maximum heart rate (145 beats/min in a young man) and even 60% of the maximum heart rate (117 beats/min).

A threshold of around 140 beats/min is realistic for a fit young man, but the key to conditioning at different ages is an increase of activity relative to the demands of normal life. For many North Americans, a heart rate greater than 110 beats/min is an unusual experience (Shephard, 1967), and in such subjects a level of 120 beats/min is an effective initial stimulus (Shephard, 1968; Sidney & Shephard, 1978). The American College of Sports Medicine (1975) has recommended a sliding scale of intensity, commencing at 63% of functional capacity in the most severely disabled patients, and progressing to 80% of functional capacity in the most fit subjects. They also recommend that individual peaks of effort should not exceed 90% of functional capacity.

In the 'post-coronary' patient who has spent some weeks in the bed of an intensive care unit, the early training heart rate may be lower than 120 beats/min. Effort may also be limited by angina, e.c.g. ST segmental depression, or the onset of ventricular dysrhythmias rather than by exhaustion. The intensity of the initial prescription must then be adjusted to take account of the adverse response to exercise. Some authors require exercise to a fixed proportion (for example 60%) of the directly measured symptom-limited maximum oxygen intake. This is a safe approach, but the selected heart rate may then be under 100 beats/min, so that the programme is therapeutically ineffective. An alternative (Shephard & Kavanagh, 1975) is to determine the heart rate at which untoward symptoms and signs appear, prescribing a jogging distance and time that yield a heart rate some 10 beats/min below this symptom threshold.

Duration

The minimum necessary duration of training sessions remains controversial. Bouchard *et al.* (1966) claimed that some training was produced by 10 minute exercise sessions at a heart rate of 130 beats/min, but most North American authors regard a minimum duration of 30 minutes per session as more appropriate. This may be difficult to accomplish when a patient is first discharged from hospital, and in such circumstances the programme begins with two 15 minute sessions per day.

Frequency

Most North Americans recommend 4-5 sessions of exercise per week to induce training, and a minimum of 3 sessions a week to maintain condition. Pollock *et al.* (1969) for example, found significantly more improvement of middle-aged men with 4 than with 2 sessions of activity per week.

Progression

As the individual's condition improves, the intensity of effort must be increased if training is to continue; the exercise heart rate must be not only sustained, but even augmented. Within reason, the heavier the training schedule, the faster the progress that is achieved. In normal healthy individuals, an upper limit to progress is set by the risk of musculo-skeletal problems. Effort should be moderated if there is more than pleasant tiredness on the day following a work-out.

Progression of the post-coronary patient is conveniently regulated by the pulse counts reported during the daily training sessions (Kavanagh, 1976). As soon as diary records show a consistent fall of exercise heart rate, a patient can be asked to cover the prescribed distance in a shorter time (for example, the time allotted for a 2 mile walk can be reduced progressively from 40 to 35 and then to 30 minutes). Once the 30 min walk is giving too low a heart rate, the distance is extended and the process is repeated.

Normal response

In a healthy middle-aged adult, training typically induces a 20% increase of maximum oxygen intake (Shephard, 1969; 1977). The potential for training is great in 'post-coronary' patients, since they often enter a programme with a maximum oxygen intake that is but 70% of the age-related normal value. In a series of 610 cases followed for 3 years, the average gain of maximum oxygen intake was 22.6% (Shephard & Kavanagh — in preparation). However, patients vary widely in their responsiveness. Some (apparently those who are older and have more severe disease) show little response despite faithful training (Kavanagh & Shephard, 1973). Others progress to the point of participating in one or more marathon events (Kavanagh *et al.*, 1977), with a 60-100% increment of maximum oxygen intake. Interestingly enough, the development of fitness proceeds more slowly than in a healthy subject. There are some early gains as the patient returns to normal daily activity, but the major improvements that lead to marathon participation may not appear for two or more years (Shephard, 1979).

Some physicians are so concerned about the safety of 'post-coronary' programmes that they prescribe homeopathic doses of exercise. Inadequate prescription plus a poor patient compliance has compromised several large controlled trials attempting to demonstrate the value of exercise programmes following myocardial infarction (Shephard, 1979). The universities of Southern Ontario are currently engaged in one such controlled trial (Rechnitzer *et al.*, 1975). Subjects have been allocated in a stratified random fashion to one of two regimens — 'intense' exercise, and 'light' recreation. Over a two year

period, the intensely exercised group has shown a progressive decrease of heart rate at a fixed oxygen consumption, while the light recreational group has shown no change of performance (Cunningham *et al.*, 1977). However, more detailed analysis of data shows that over the first 2 years of observation only a half of the high intensity exercisers — those with a poor level of fitness — have shown a significant decrease of exercise heart rate; presumably, some centres were too cautious in their attempts to condition the fitter members of this group.

Choice of programme

A well-designed programme includes a brief warm-up, a substantial period of endurance activity, a game that provides fun and group interaction, and a final warm-down.

The warm-down is conveniently based on light calisthenics, since many subjects expect such activities in a fitness programme. With cardiac patients, it is important to avoid sustained isometric effort. Note also that calisthenics as performed only too often do not contribute to the development of cardiorespiratory fitness.

The endurance work can include any form of vigorous effort that involves the large muscles of the body. Many North American programmes place the emphasis upon slow but long distance jogging. The main attractions of such an approach are (a) it is relatively easy to estimate the energy expenditures involved, and (b) the facilities required are minimal — an outdoor track or park in the summer, and an indoor track or even hospital corridors in the winter. The U.S. National Exercise and Heart Disease Project (Naughton, 1978) has stressed the need for training the arms as well as the legs, and in the first 14 weeks after enrolment their patients exercise at a series of stations that include not only a bicycle ergometer, treadmill and stepping bench, but also an arm ergometer and a shoulder wheel. Subsequently, they participate in jogging, swimming, cycling, sports and games. Swimming and cross-country skiing are good forms of exercise for the post-coronary patient, but because of wide variations in the efficiency of such activities it is difficult to standardize their intensity. Interval work may be helpful in cases with angina, but the average post-coronary patient prefers continuous activity (Shephard & Kavanagh, 1975).

Games such as tennis and squash, although good from a motivational point of view, are not advisable in the early stages of post-coronary rehabilitation. Amateur players often make substantial isometric contractions of their wrist muscles, and the Type A personality also finds it difficult to reconcile his prescribed ceiling of effort with a wish to defeat his rivals. Team games such as volleyball help to foster a group spirit, and a skilful instructor can regulate both the overall intensity of the game and the effort of individual players.

The 'warm-down' usually takes the form of 5-10 minutes slow walking. This should be followed by a shower at a moderate temperature. Clothes should be changed while sitting down.

COMPLIANCE

Current experience

As with many types of prescription, long-term compliance with an exercise regimen is poor. H.L. Taylor (personal communication) conducted a three-centre trial on middle-aged men with a high risk of subsequent myocardial infarction; 50% of this population had ceased exercising within 6 months of recruitment.

A better compliance rate might be anticipated in post-coronary patients, since the 'critical event' arouses interest in an exercise prescription. Nevertheless, attrition rates are still high. In the Southern Ontario multi-centre trial (Rechnitzer *et al.*, 1975), there has been an equal loss of subjects from high intensity and light recreational groups, and we estimate that between 60 and 70% of our population will no longer be active participants at the end of the 4 year investigation. The U.S. National Study (Naughton, 1978) hopes to reduce attrition by requiring a 3-month trial of exercise prior to random allocation of subjects. Some studies of normal adults suggest that the 'drop-out' rate diminishes after a few months experience of an exercise programme. In the Southern Ontario multi-centre trial one laboratory noted a high early attrition rate but our overall experience does not support the hypothesis of a subsequent improvement in compliance — expressed in percentage terms, losses of subjects are as great for the fourth as for the first year of observation.

Much depends on the charisma of the class-leader; given an outstanding programme director, much higher rates of compliance are possible. In Toronto, we have followed 610 patients for an average of 3 years. More than 70% continued to attend the rehabilitation centre regularly. At the end of the 3 year period we contacted the remainder of the group by telephone and thus established that 82.8% of the sample were still undertaking at least three activity sessions per week, while only 3.4% were taking no deliberate exercise.

Improving compliance

(a) Identifying the 'drop-out'.

Much recent effort has been directed towards identifying the exercise 'drop-out'. According to philosophy, such individuals can be either ignored or given additional support.

Two studies of healthy subjects (Massie & Shephard, 1971; Sidney & Shephard, 1978) have shown that the poor complier is unfit, with a low maximum oxygen intake, and an above average body weight, skinfold thickness, and percentage of body fat. He is also likely to be a smoker, engaged in blue collar work, with an extraverted, Type B personality and a poor credit-rating.

The immediate reason given for leaving an exercise programme is usually lack of time or lack of interest. Perceptions of the programme generally remain positive (G. Andrew — personal communication), and even in the post-coronary group it is uncommon to find a medical reason for stopping exercise.

(b) Programme design

Compliance is naturally helped by a programme that takes account of the interests, aptitudes and expectations of the participant, and exploits the facilities and equipment available to him. It is also helpful to build a substantial component of the required activity into the normal daily rhythm — items such as a regular fast walk to the station, climbing of the office stairs, and use of hand-operated rather than power-equipment such as lawn-mowers. Where possible, both the interest and the participation of other members of the family should be encouraged.

In general, group programmes have a higher compliance rate than individual prescriptions (Massie &

Shephard, 1971). However, extraverts are particularly likely to respond to group therapy while some introverts prefer a more solitary type of exercise.

(c) Feed-back of results

Another valuable method of increasing compliance is positive reinforcement through the feedback of improving test results. This was seen as one important role of the Canadian Home Fitness Test (Shephard *et al.*, 1976). In post-coronary programmes, the feedback is given most appropriately and most effectively by a physician, and this is an important argument in favour of active medical involvement in the rehabilitation process. Each patient should make a personal contract with the physician that he will make an attempt honestly to meet his prescription. Completion of a daily activity record is a valuable stimulus to fulfilment of this contract, and provides a basis for feedback discussion. Even if a patient wished to be dishonest, it would be almost impossible to invent appropriate pulse counts simulating the training process. The diary records thus give the class supervisor an early warning if the exercise that is being undertaken is either excessive or inadequate relative to what he has prescribed.

Constraints of time prevent the review of other important practical facets of exercise prescription. However, I anticipate many of these questions will be raised in our discussion period.

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