SUDDEN DEATH – A SIGNIFICANT HAZARD OF EXERCISE?*

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SUMMARY

Sudden and unaccustomed physical activity may precipitate ventricular fibrillation, myocardial infarction, and sudden death. Evidence supporting this contention is drawn from a review of physio-pathology, reported antecedents of infarction and death, and the experience of exercise test centres and gymnasia. In some reported series risk of precipitating ventricular fibrillation in a coronary-prone population has been as high as 2 episodes per 1000 man hours of physical activity. Such an incidence has important medico-legal implications for fitness test centres and gymnasia. Despite the challenge of devising an exercise prescription that will avoid such hazards, current evidence suggests the long term effects of increased physical activity improve the prognosis of both the sedentary business men and the coronary-prone individual.

The majority of physicians and physical educators who recommend exercise as preventive therapy for the middle-aged patient are themselves exercise enthusiasts – they have a strong personal commitment to the idea that exercise is good for health. This is a view that I share. Physical activity could certainly add enjoyment to the years of many city-dwellers, and there is also increasing circumstantial evidence that activity may lessen the chances of developing many of the diseases of middle-age such as myocardial infarction and maturity-onset diabetes.

However, the critical investigator must weigh the advantages of such militant activism against the rather frequent reports of sudden death during or immediately following physical activity. Personal experience includes an apparently healthy 23 year old University student who died after hanging several minutes from the parallel bars in a gymnasium, and a middle-aged janitor who died while running up several flights of stairs to attend to a burst watermain. The latter gentleman had completed a multi-stage step test some weeks earlier; this was symptomless, but the stress E.C.G. showed obvious ST segmental depression and multiple arrhythmias as maximum effort was approached. The sole difference between the laboratory test and the subsequent fatal episode seems the association of exercise and anxiety in the latter.

Are reported episodes of death during physical activity a mere coincidence, one more example of selective newspaper reporting? If not, then there are important practical and medico-legal implications for those who prescribe exercise and carry out exercise tests on a clinical or experimental basis.

The Perspective of History

How has the incidence of sudden death changed over the years? Data from many western nations shows an apparent "epidemic" of ischaemic heart disease. In part, this is due to a reclassification of picturesque conditions such as a "fatty degeneration of the heart" (1) However, there is also a real increase, particularly in men. The figures of the U.K. registrar general, 1931-1948, as cited originally by Morris (2), show an increase in death rate per 100,000 in age and sex specific groups (50-54, 60-64) for both coronary arterial disease and angina pectoris (A), chronic myocardial disease (including myocardial infarction) (B), and the sum of A + B. More recent figures from the U.S. (31) suggest that this trend is continuing into the 1960s. From Canada, we have the figures of Anderson and LeRiche, collected in the province of Ontario (4). Official statistics for Ontario show a sharp increase in deaths from ischaemic heart disease between 1931 and 1961, and a careful scrutiny of the original death certificates indicates a very similar increment in "probable" cases of ischaemic heart disease. Much of the increase is due to sudden deaths, 30 per 100,000 men aged 45-64 in 1901, 60 per 100,000 in 1931, and 130 per 100,000 in 1951. In the age group 40-64, 90% of deaths occurring within two hours of the onset of symptoms are due to either hypertensive or arterio-sclerotic heart disease (5).

Which factor in our changing environment can be blamed for the increased number of sudden deaths? Many aspects of life have changed in the twentieth century. The pace of life is faster, but with the possible exception of those who are moving up the social scale, the main "stresses" of modern corporate life are probably attendance at business luncheons and over-eating. Cigarette consumption commenced to be a significant social phenomenon about 1910 (3).

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Entertainment changed from participation to a passive spectator act. Industries became automated, and vast numbers of motor vehicles were registered. The overall level of physical activity can hardly be blamed for the rising toll of deaths, since the evidence points to a diminished average daily caloric expenditure. Thus, in the U.S., daily per capita food consumption dropped from 3440 kCal in 1930 to 3130 kCal in 1965 (6). Wastage of food scarcely abated over this period, and we must conclude that the level of physical activity declined. Unfortunately, this does not exonerate physical effort as one possible cause of sudden death; it is still conceivable that the immediate triggering factor is the occasional performance of heavy unaccustomed work, particularly by those who are physically unfit.

The Physio-pathology of Sudden Death

Jokl (7, 8) maintains that exercise never causes death in a normal heart. This is probably true, but is not particularly helpful, since atherosclerosis commences at an early age in most North Americans. Studies of children and of troops dying in combat show that atherosclerotic deposits can be quite well developed even in the young adult (9, 10).

Jokl's analysis of 76 cases of sudden death during exercise confirmed atherosclerosis as the commonest problem, coronary narrowing or occlusion being noted in 34 cases. Rupture of the heart or a major blood vessel occurred 22 times (aorta 11, cerebral 5, cardiac 4 and pulmonary vessels 2). Aortic rupture is usually secondary to atherosclerotic or syphilitic disease, and thus occurs in the older person. However, rupture of a berry aneurysm in the circle of Willis can occur in a young and previously healthy young man. Cardiac rupture is often associated with an unsuspected infarct; sometimes the diagnosis may be missed because of a severe psychosis (11), but even in psychiatrically normal individuals up to 25% of infarcts may pass unrecognised (12), perhaps as a self-medicated "attack of indigestion." Cardiac failure was blamed in 17 cases; chronic infection or degenerative conditions (8 cases) are most likely with malnutrition (alcoholics, patients in under-developed countries), while acute viral infections (5 cases) may sometimes account for the general ill-health that often precedes infarction. Congenital lesions (4 cases) are relatively rarely implicated.

About a third of Jokl's series gave a history of sustained isometric effort such as wrestling or carrying a heavy load, but in a further third quite prolonged rhythmic work such as cycling seems to have been responsible.

"Sudden death" has many possible physio-pathological connotations, particularly if the statistics include all patients dying within 24 hours of

the onset of symptoms. However, if interest is restricted to the first two hours, ventricular fibrillation is largely responsible (13, 14, 15). There are several possible mechanisms whereby physical activity could increase myocardial irritability and thus the risk of fibrillation.

Cardiac work-load is increased by rise of heart rate and/or systolic blood pressure. At the same time, a shortening of diastole and the increase of systolic pressure restrict coronary perfusion of the left ventricle. A relative oxygen deficiency of the sub-endocardial tissue may persist into the post exercise period, particularly if a catastrophic fall of blood pressure is encouraged by passive standing and/or an excessively hot shower (16). At the same time, potassium ions are liberated into the plasma from the active muscles (17), sodium ions may be lost in sweat, and particularly if the patient is anxious there is hyperventilation and an increase of plasma catecholamines, all of which increase myocardial irritability.

Ventricular extrasystoles are generally held to be of two types (18, 19). One is present at rest and becomes less frequent during exercise. As far as we know, this condition is benign. The other type is aggravated by or arises for the first time during exercise (20) and becomes even more apparent during the recovery period. This type seems an accompaniment of otherwise symptomless atheroma in the middle-aged person, and particularly if of multifocal origin is associated with both ischaemic depression of the ST segment of the electrocardiogram and a subsequent risk of sudden death (21, 22, 23).

Lastly, exercise may contribute to a frank infarct. This could arise simply from a relative myocardial ischaemia, attributable to the various factors we have already discussed. In other individuals, movement of the ventricular wall or increased coronary blood flow could precipitate haemorrhage into a pre-existing atheromatous plaque (24) or lead to impaction of an embolus in a branch of the coronary arterial tree. There are thus good physio-pathological grounds for supposing that exercise could precipitate sudden death through either an arrhythmia or a myocardial infarction.

Epidemiological Studies

Does physical activity ever have the disastrous effects suggested above? The question would seem susceptible to epidemiological analysis. If physical activity contributes significantly to infarction, one should find a disparate member of episodes during the three portions of the day devoted to sleep, work (usually sedentary or light activity) and leisure (when most intensive energy expenditures are made).

Unfortunately, such a simplistic analysis is rarely possible. Published reports commonly suffer from a dilution of data. Information on coronary attacks in the

middle-aged and relatively healthy wage-earner is confounded with data on very elderly patients in whom the flame of life burns but feebly. As Yater et al. have noted (25), the proportion of coronary victims dying at rest increases with their age. Further, even among the middle-aged, any consequences of physical activity could well be masked by statistics for that 90% of the population who engage in little or no deliberate activity either at work or in their leisure hours (26, 27). Again, data are usually reported as "coronary attacks" or "ischaemic heart disease," without distinguishing several very different physio-pathological entities, including (a) ventricular fibrillation, (b) lodgement of an embolus, (c) haemorrhage into an atheromatous plaque, and (d) cardiac failure following progressive thrombosis of a coronary vessel. Whereas the conditions (a) – (c) could all conceivably be precipitated by exercise, (d) seems much more likely to develop while a patient is asleep. Lastly, the classification of activity is usually inadequate if not misleading. Bed rest for example may be a modest description which hides a substantial proportion of patients whose attack was induced by sexual activity. Much of the older literature has been summarized by Friedberg (28). Phipps (29) assembled a series of 437 cases. Deliberate physical exercise was noted in 13%, and moderate or usual exertion in a further 18%. On the other hand, sleep was noted in only 8%. Master (30) set out to disprove the association of disease and exertion, and claimed to have done so by showing only 2% of 1108 cases to follow unusual exertion. However, a surprising 16% were walking, and another 9% were engaged in moderate activity, bringing the total of those active to 27%. Other of the older authors repeat this story. Fitzhugh (31) found 24% engaged in violent exertion, and 33% in moderate exertion. Cooksey (32) had 17% giving a history of unusual exertion, Smith (33) 60%, and French (34) 33%. Yater (25) looked at attacks in young soldiers, and commented the number was twice that expected during effort. Fitzhugh (31) commented that the precipitating exertion was associated with fatigue, inadequate sleep, and emotional strain, while French & Dock (34) gave some interesting examples of the type of activity associated with infarction – cranking a car in cold weather, lifting a heavy trunk, pushing a stalled car, rowing, and long hikes up hill. They pointed out that the majority of tasks had either not been done previously, or at least had not been done for many years.

Turning to more recent data, Moritz and Zamchek (35) looked at the antecedents of sudden and unexpected death in soldiers. Their subjects were presumably younger and physically more fit than the average coronary victim and twice the anticipated number of sudden deaths occurred during strenuous activity. Adelson (36) found 55% engaged in light activity, 5% in strenuous activity, and only 21% asleep; however, his population consisted largely of alcoholics

and vagabonds. Spain & Bradess (37) examined sudden coronary deaths in Westchester County, N.Y., and found that 14% of those with atherosclerotic lesions and 16% of those with thrombotic lesions had been engaged in what they described as "unusual" physical activity at the time of attack. Armstrong et al. (38) noted that of 226 medically unattended sudden deaths, a surprising 43 (19%) occurred "on the street". Wikland (39) also found 27% of his men and 25% of women were walking or running at the time of attack; only 4% of men and 6% of the women were asleep, but a large percentage (52 and 56% respectively) were resting; it is not clear whether lack of sleep reflected pleasure or pain. Against such reports, Pell & D'Alonzo (40) found 60% of ischaemic heart disease deaths in wage earning men occurred during sleep or rest, and Kuller et al. (3) found no relationship of sudden death to time of day, season, place, occupation or activity. Friedman and his associates (41) distinguished sudden death (within 24 hours of the onset of symptoms) from instantaneous death (within 30 sec of the onset of symptoms); the latter were almost always due to an arrhythmia, with more than half developing during or immediately after physical exertion.

Simonson & Berman (42) have recently summarized the experience of Russian investigators. Findings seem much as in the west. Myocardial infarction is by no means rare in young Russians, the male/female ratio is much higher for young than for older patients and excessive physical effort – running, skiing, athletic games and the lifting of heavy loads seems the commonest cause of attack in the young.

The antecedents of coronary attacks in women have received relatively little study. Bengtsson (43) found 2% of women were under mental stress and 15% were physically active at the time of attack. Romo (44) compared activity patterns in men and women. Some 6% of the men were engaged in strenuous activity at the time of attack, and a further 9% presented a history of strenuous activity immediately prior to attack (including formal sports, snow-shovelling and the carrying of heavy loads). However, perhaps because such activities are less frequent for women, only 1% of the female patients had been engaged in strenuous activity. As in most other studies, both sexes showed a small deficit of cases between midnight and 6 a.m.

So to summarize epidemiological work, many authors have found some relationship between physical activity and sudden death, but there is not complete unanimity on this association.

The Toronto Study

Dr. T. J. Kavanagh and I have had opportunity to make further study of the antecedents of myocardial

infarction in a population of relatively young coronary victims attending an exercise-centred programme at the Toronto Rehabilitation Centre (45). Data is now available on attacks in 203 patients. This material is important because it refers specifically to young and early middle-aged patients, the group where prevention has the greatest economic importance.

In the year preceding the coronary attack 79 of the 203 men noted an increase of body weight the increase being more than ten pounds in 50 of these patients, while only 16 noted a decrease ($P < 0.001$). Physical activity was normal in the majority of patients (no change in 123/203), but 130 of the 203 reported increased business problems and only 3 a decrease ($P < 0.001$), while 61 had increased social and domestic problems and only 2 a decrease ($P < 0.001$).

It has recently been suggested that an apparent "sudden" death or infarction is often preceded by a period of malaise. Symptoms are often vague and hard to pin-point. Perhaps an accumulation of business worries leads to excessive smoking, an abnormally large intake of coffee, loss of physical condition or a gain of body weight. In some instances, acute infection or a disturbance of electrolyte balance may have a more direct impact on myocardial irritability. Only 9 of our 203 patients could identify a clear cut fever or upper respiratory infection, but 73 felt unwell in the week preceding the attack, whereas only 11 noted an improvement of health ($P < 0.001$). In about two thirds of the group, the complaints — chest pain, angina, shortness of breath, arm pain, lump in the throat, indigestion, gas in the stomach, and irregular heart beat — could perhaps be interpreted as incipient myocardial oxygen lack. Others merely complained of tiredness, nervous tension or depression. As over the one year period, in the week prior to attack business problems (106/203 increased, 8/203 decreased, $P < 0.001$) and social and domestic problems (42/203 increased, 4/203 decreased, $P < 0.001$) were important, but there was no significant change in physical activity.

On the day prior to the attack, 85 of 201 patients felt unwell (information is incomplete on the remaining two). Vigorous physical activity was reported by 51 of 201 and heavy lifting by 47 of 202. In contrast, unusual annoyance (41/203), business problems (40/203) and social and domestic problems (25/203) were less common than in the entire year preceding the attack. The largest monthly totals of attacks were for January, February, October and November. This suggests a concentration when business activity was high. Fresh wet snow was reported by 25/202, cold or very cold weather by 87/203, snow shovelling by 9/203, an humid heat by 35/203. The association between heat stress and cardiac deaths is well recognised in the south of the U.S.A. Despite newspaper headlines, snow-shovelling is a

much less clear-cut antecedent. Variables include the depth and wetness of the snow, the chill factor, and a possible requirement of rapid shovelling soon after breakfast.

Perhaps the most interesting comparison is between the anticipated activity patterns of the 45 year old Toronto business man and the activities actually reported at the time of attack. We expected, for example, about 7.7 hours of sleep per day, corresponding to 81 attacks among 233 primary and secondary attacks; however, there were only 48 attacks during sleep. Likewise, at least 70 attacks should have occurred at work, but there were only 30 such incidents. In contrast, odd jobs and sports should not have accounted for more than 5 cases apiece, yet the totals were 21 and 30 respectively. Walking also accounted for 13 rather than the anticipated three cases. Our data thus shows a striking deficiency of attacks during sleep and sedentary work, with a corresponding excess during periods of physical activity.

Specific types of exercise associated with an attack include snow-shovelling (9), walking (13), running (8), curling (4), tennis (2), baseball (1), soccer (1), basketball (1), hockey (1), squash (1), showering after a gym class (1), dancing (1), icebreaking (1), admitted sex (2), and various other heavy domestic chores (14). Although quite a popular summer activity in the Toronto area, no-one reported a heart attack while swimming; this may reflect the wide distribution of this activity among the body muscles. In a number of instances, activity followed closely on a heavy meal, or was associated with emotional stress — for instance, defending a curling trophy, and — in one of the walkers — visiting the house where he had spent a hard and struggling childhood.

Dining was reported at about the expected frequency (observed 11, anticipated 13), but in several episodes there were comments of banquets, over-eating, and entertaining. Fifteen attacks occurred while driving (anticipated 13); we have obtained heart rate recordings on drivers in Toronto, and except at difficult entries to expressways, the rate is quite low, often 75-80/min. Several of our miscellaneous incidents involved attendance at a hospital or a doctor's office for treatment of an unrelated condition. In Toronto, at least, the physician is still an authoritarian and even an awe-inspiring figure, and we would do well to ponder methods of making medical examinations a more human and less frightening experience for our patients.

Like the other investigations cited, there are limitations to the Toronto study. We were dependent on what the patient could or would tell us about both his illness and his personal life in response to a multiple choice questionnaire. It could thus be argued that many of our statistics merely reflect the bleak nature of life in

Toronto or a faulty framing of our questions. To counter this criticism, we administered the same questionnaire to 57 healthy colleagues of our post-coronary patients. Business worries were "increased" in only 16 of 57 during the year prior to completion of the form, 14 of 57 in the preceding week, and 4 of 57 on the preceding day. Likewise, social and domestic problems were "increased" in only 14 of 57 over the preceding week and 2 of 57 on the preceding day. Only 8 of 57 noted annoyance on the preceding day, and only 4 of 57 a deterioration of health in the preceding week. The one point of similarity with the post-coronary patients was a report of weight gain by 28 of the 57. Nevertheless, it could still be argued that perception of the questions asked was modified by the critical experience of a coronary attack.

Because of the location of our rehabilitation centre, the majority of our patients are white-collar workers, and in other communities more episodes might be found at work. In Brisbane, the State Compensation Board accepts 400-500 cases per year (about a third of the total coronary victims among employed males in Queensland) as being caused or aggravated by daily work, usually work of a physical nature. Further, our sample was restricted to survivors of the acute attack, men who recovered sufficiently to engage in a rehabilitation programme. The active and exercise-centred plan of treatment undoubtedly attracted an above average percentage of men with hypomanic achievement oriented personalities (46), although careful exercise histories do not suggest our group were particularly sports oriented either at school or in the years immediately preceding their attack. The diagnosis of infarction was proven by electrocardiography and/or serum enzyme changes, but we were undoubtedly dealing mainly with milder cases of infarction, and in about a quarter of our sample there was less than the classical twenty minutes of chest pain. Nevertheless, the Toronto study provides support for the view that exercise can provoke a myocardial infarction, particularly if played aggressively under competitive or emotional stress.

Experience of Gymnasia and Fitness-testing Facilities

A further possible epidemiological approach is to review the experience of gymnasia and exercise test facilities. The problem with this approach is that we are dealing with an infrequent occurrence. Even a very busy laboratory hardly accumulates enough data to yield accurate statistics. If the test facility is in a hospital, the population examined is usually biased in the direction of the middle-aged and the coronary prone, and performance of the test involves not only exercise but anxiety regarding the test result.

Exercise testing. Two well known workers in this area

are Bruce & McDonough (47). They set the hazard of clinical exercise testing at one attack of ventricular fibrillation for every 3000 maximum effort tests, an one attack for every 15,000 sub-maximum tests. Many of their cases of ventricular fibrillation were successfully resuscitated, partly because the coronary vasculature of those tested was adequate for rest if not for maximum effort, and perhaps more importantly because a superbly-trained emergency team was at hand.

Rochmis and Blackburn (48) surveyed 73 medical centres. Results were similar except that no difference was found between maximum and sub-maximum effort. Sixteen deaths occurred in 170,000 exercise tests, nine within an hour or less of the stress; a further 40 patients were admitted to hospital on account of severe chest pain and/or arrhythmias. The majority of those affected were suspected or proven cases of ischaemic heart disease; however, it is not known how many of the total population of 170,000 were coronary prone.

The experience of several other individual investigators may be noted briefly. Brock (49) experienced three fatal episodes in a series of 17,000 work evaluation tests. Ellestad (50) had no deaths in 4000 maximum deaths, but about 0.9% of patients developed ventricular tachycardia — Kattus & McAlpin (51) had two episodes of ventricular fibrillation (one fatal) in 500 treadmill tests, and Phibbs (52) reported "three major complications including a massive current of injury and ventricular flutter" in 787 tests.

There is perhaps some evidence that the Master two-step test is less hazardous than maximum exercise; three series (53-55) totalling 4266 cases report no significant arrhythmias other than one evanescent tachycardia.

It could be argued that most of the above series were performed in a doctor's office if not a hospital setting, and that the majority of patients were the coronary-prone, referred for a specific cardiac evaluation. This objection cannot be levelled at the experience of Beard & Owen (56) of the U.S. National Aeronautics and Space administration. They carried out 1385 sub-maximal exercise tests on 248 male executives with a mean age of 41; the group was free of clinically detectable cardiovascular disease, and quite surprisingly *no one* demonstrated an ischaemic response to exercise as judged by the usual ST segment criteria. Nevertheless, 34% developed an arrhythmia on one occasion, and 13% on several occasions, ventricular and arterial premature contractions being the commonest type of abnormality.

Sports gymnastic activity. It is even more difficult to obtain statistics for the hazards of sports and gymnastic activity performed by free-living patients. Some anecdotal reports suggest there is an appreciable risk —

thus Fox (42a) noted that over a one year period, eight deaths of men wearing jogging clothes were reported from Orange County, California. Hinckle and his associates (57) suggest that if ventricular arrhythmias are provoked by ordinary levels of physical activity, then there is usually underlying coronary arterial disease. One interesting approach to the hazards of mass sport participation comes from the study of Scandinavian ski contests. Åstrand (personal communication) notes that two large cross-country ski events in Sweden have together drawn up to 10,000 entrants per year for about 50 years. Many are middle-aged, yet there have been only two fatalities, both in 1971. The races are held in March, and are rather unique to the Swedish sports scene. It is thus likely that many of the entrants are well-trained, and that some of the "coronary prone" are eliminated by symptoms or even death. However, the Finnish experience is similar. Vuori (58) found only 10 fatalities in 12 million man-hours of long distance cross-country skiing; between a half and three quarters of the villagers participated in the events that he examined and he calculated that the death rate was only about four times that of a comparable population under resting conditions.

In North America, there is an understandable reluctance to publicize episodes that would curtail enrollment in commercial gymnasias. Any victims, one supposes, are hurriedly moved from exits to entrance hallways and made to look as though trying to get in! On the basis of reports reaching Ontario newspapers, a figure of one attack per 2500 gymnasium hours was estimated for the coronary prone middle-aged business man who attended an unsupervised gymnasium programme (59). Subsequent to the publication of this statistic, criteria for admission to medically unsupervised exercise programmes in Ontario were greatly tightened, and in the last two years the frequency of such episodes has apparently diminished, almost to vanishing point. However, Pyfer (60) has recently quoted an incidence of 8 attacks of ventricular fibrillation per 50,000 gym-hours in Seattle. At the Toronto Rehabilitation Centre, Dr. Kavanagh and I now have accumulated over 100,000 man-hours of exercise experience, with only one episode of ventricular fibrillation, in a man who insisted on exercising unsupervised, in defiance of all our rules. We think our happy experience is due to individual prescription, careful monitoring, careful progression, and avoidance of isometric work.

Implications for Policy

The above statistics need close and critical examination. However, it is clear that the risks of vigorous, unaccustomed and poorly supervised exercise can be appreciable. To set the data in perspective, we could assume that an average exercise test lasts for only 10 minutes. The risk of a test would then be 2 attacks

per 1000 man *hours*, whereas a middle-aged driver sitting in the padded comfort of a double-deck bus has a risk of no more than 2.7 attacks per 1000 man *years*.

Should we then conclude that exercise is fundamentally bad? Should it be banned both as an investigative procedure and as a means of preventive therapy? Paradoxically, the answer is no! Firstly, exercise need not increase the risk 10,000 fold. Vuori's data show that in the average middle-aged man the risks of strenuous exercise can be held to a fourfold increase over resting values. Furthermore, although exercise may apparently precipitate a "coronary" attack, it is serving mainly to reveal the presence of a badly damaged coronary vascular tree, highly susceptible to both emotional and physical stress. The affected individual is going to succumb in the next few months. It is thus preferable for the critical incident to occur in a laboratory or gymnasium, where help is at hand rather than in a remote area of the backwoods, or indeed the bedroom of a neighbour's house! Further, it is misleading simply to quote an attack rate of 2 episodes per 1000 man hours of physical activity, or even a fourfold increase of risk, since we have then focussed simply on the brief period of the day when the victim has been active. No account has been taken of what may be an improved prognosis for the remaining 23 hours of the day. A small gain in prognosis (5-10%) could easily wipe-out a fourfold rise in risk during an hour of activity. Again, few men can avoid a combination of exercise and anxiety at some point in their lives. Judicious regular physical activity prepares for such emergencies, and through an improvement of overall fitness reduces the relative stress incurred. There is already much epidemiological evidence that regular vigorous activity reduces the risk of developing myocardial infarction (61) and makes an equally beneficial impression on the recurrence rate in those who have already sustained a "coronary attack" (62, 63). While none of the existing studies are conclusive, a definitive answer should emerge from the current Ontario multi-centre trial (63).

A Safe Exercise Prescription

Granted that unusual exercise can provoke an infarct in the coronary prone person, how may the safety of both the initial exercise test and the subsequent exercise prescription be improved?

Within the consulting room or laboratory, care must be taken to minimize anxiety. Do not display unnecessary complicated apparatus. Avoid tenseness, mystery or an authoritarian manner. It is often helpful to carry out a preliminary brief practice of the exercise and defer the formal test to a second visit. Safety of test administration depends upon

- i) an adequate preliminary medical examination (64,

- 65) including a twelve-lead resting electrocardiogram,
- ii) the personal presence of the responsible physician for all testing of patients over the age of forty,
- iii) the continuous monitoring of blood pressure and electrocardiogram during the tests (34, 35),
- iv) rigid criteria for halting an investigation (34, 35)
- v) an efficient, well-trained and well-equipped resuscitation team.

If arrhythmias and/or significant depression of the electrocardiogram appear during the exercise testing, the pulse rate corresponding to such an occurrence must be noted, together with the corresponding work load or oxygen consumption. The prescribed activity, usually in the form of a total jogging distance and time, is then arranged so that the intensity of effort falls just short of this danger level. Where possible, the patient should be taught to count his pulse by carotid palpation, and to recognise both abnormalities of rhythm and angina; this will help him to keep within his prescription. He must further be warned that business worries, warm weather and other adverse circumstances may require a temporary reduction of his training programme. Advancement of the exercise prescription must be at the behest of his physician, with repetition of the office test if there is any reason to be dissatisfied with progress. Other obvious precautions include an adequate warm-up and warm down before and after exercise, with avoidance of isometric effort and excessively hot or excessively cold showers following exercise.

Much that has been written here may seem negative to the committed exercise enthusiasts. However, I would suggest it is important to credibility. And to set the matter in perspective, I would finally agree with Dr. P. O. Åstrand that while exercise may have some risks, there is an even greater need for careful medical examination of the city-dweller who proposes to take no further exercise.

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If the patient wishes to exercise on his own, the physician must show reasonable skill in advising a ceiling to such activity compatible with the joint goals of improving health and avoiding precipitation of infarction; however, if such competence has been shown, there would seem little possibility of subsequent medico-legal problems. On the other hand, if poorly supervised group activity is offered to a coronary-prone population in a gymnasium, criticism could arise. There is need for a careful review of legislation governing exercise-test centres and gymnasia with respect to both the medical cover that is available and the facilities provided for resuscitation of any "coronary" victims. If exercise testing is to make its full potential contribution to the health-care delivery system, it will also be necessary to revise medical curricula, particularly in those schools that currently give no instruction in this special area of knowledge.

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