Efforts to “sell” physical fitness to the American people have been much in the news recently. Some of these appeals to the virtues of exercise have been highly emotional and in some ways have taken on aspects of a fad. An effort to present a balanced view of physical fitness is offered here.

PHYSIOLOGIC ASPECTS OF PHYSICAL FITNESS

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Physical fitness has been frequently in the news in the past few years, especially since Mr. Kennedy has called attention to the “softness” of American youth and has vigorously urged programs of physical education to improve the fitness of young Americans. This phenomenon is unusual for peacetime, since in the past it has been the Draft Boards and the Armed Services who have discovered that a large fraction of American boys have inadequate levels of physical and emotional fitness to meet the demands of military service.

Perhaps the factor most instrumental in bringing fitness to attention is the wounding of national pride by the poor showing American boys and girls have made on tests which have also been applied to children in several European countries and in the Far East. Interpretation of some of the tests is subject to serious criticism, but there is no doubt that significant differences exist in muscular performance and general fitness for athletics.

Howard Knuttsen¹ has recently reported a study of boys and girls in public schools in Copenhagen, having used the American Association for Health, Physical Education, and Recreation Youth Fitness Test which had been standardized on 8,500 American children of comparable ages.² The comparison was made for the nonaquatic events in the battery of tests. The Danish girls exceeded the American averages in all seven tests; 71 per cent of the Danish girls were equal to or better than the American 50 percentile score in the 50-yard dash and they excelled even more in the other events. Comparable figures for superiority in other events were 76 per cent for the softball throw, 82 per cent for sit-ups, 89 per cent for standing broad jump, 90 per cent for pull-ups, 96 per cent for the shuttle run, and 99 per cent for the 600-yard run-walk. Most of these are tests of muscle strength, skill, and speed, but it is significant that the Danish girls excelled by the greatest margin in the 600-yard run, the test that puts the greatest demand on the general physiologic responses of the body—the integrated circulatory and respiratory responses to strenuous exercise.

The results for boys were slightly less unfavorable to the Americans, but the Americans were superior in only one event—the softball throw. As in the case of the girls, the American boys' performance was poorest in the test that makes the greatest physiologic demands—the 600-yard run; 45 per cent of the Danish boys did as well in this event as the best 10 per cent of American boys and 96 per cent did as well or better than the American average.

The differences in fitness are striking whether the comparisons are based on age groups alone or whether they are standardized for height and weight. The results are not really surprising when one considers the contrast in living habits between the two countries—one a country characterized by bicycle riding, walking, and general sports participation, and the other a country better
known for automobiles, television, and exercise avoidance.

Fitness has many of the attributes of a virtue—everyone should be in favor of it and no one against it. I believe there are sound reasons for promoting a higher level of physical fitness; many of these are valid psychological and social reasons, and it is not my task to elaborate or to defend them. I also believe, however, that promotional efforts are becoming excessive, and that beneficial effects are postulated which are not supported by valid evidence. In the long run uncritical claims that robust physical fitness will prevent mental and physical illness and delay the onset of senescence can only hurt the program for promoting an improvement of physical fitness.

My responsibility here is to consider the physiologic aspects of fitness and its relation to health. It is necessary to consider definitions, since physical fitness is a term that has managed to avoid precise definition. The coach defines it in terms of proficiency in sports, the industrial physician in terms of productivity and absenteeism, and others in terms of their particular interests.

The term physical fitness naturally evokes the question "fitness for what?" a logical question, but one which annoys some people. I am tempted to think that the crux of the problem for those trying to improve levels of physical fitness may be to define more precisely what the objectives are and to obtain better evidence for beneficial results; without such evidence it will be very difficult to motivate people, in view of our present cultural characteristics.

Fitness is a relationship between a function and a task, or the use we make of the function. One of the most fundamental of physiologic principles is that within wide limits the use of a function improves the function. Increasing the demand increases the capability of responding to the demand.

More specifically, physical fitness in physiologic terms is the capability of the body to respond to the high metabolic demands of physical work and exercise, with minimum evidence of strain.

It should be emphasized that there are basic hereditary differences in capacity for physical fitness, involving such matters as neuromuscular coordination, reaction time, emotional balance, somatotype, and the like. However, given a hereditary endowment, everyone has the capability of improving his skill, stamina, and strength, unless prevented by serious disease.

Physiologic response to exercise involves many of the systems of the body. Locally, increasing use leads to some increase in size of muscle and potentially much greater increase in strength. Local circulation improves, possibly through increase of the capillary bed, although this is difficult to establish. If large muscle masses are involved, a complex and highly integrated set of events takes place, basically a response to greatly increased demands for gas exchange in the tissues. During severe exercise the demands for O₂ may increase to 10 or 15 times the resting level, with corresponding increases in the evolution of CO₂ and other metabolic products. These demands would severely upset the homeostasis of the body were it not for the great and precisely regulated increases of respiratory ventilation and cardiac output per minute. These effects, mediated mainly through the autonomic nervous system, and accompanied by the buffering capacity of body fluids, enable the body to maintain essential constituents at nearly normal values in all but the most severe exercise. That is, the great increase in production of acids during exercise is handled by physiologic mechanisms in such a way that the pH of the blood remains essentially constant; this is one of the conditions required for effective function of the brain.

Repeated exercise leads to some increase in skill and possibly a slight in-
crease of efficiency, but mainly to an increase in the ability of physiologic mechanisms to maintain a given level of activity at lower “cost.” The changes in response of the circulatory and respiratory systems to repeated exercise can be used as measures of improvement of physical fitness.

If physical fitness is to be improved, the stress must be continually increased, by raising the exercise rate or by adding some new stress such as changing the environment to a hot humid climate or to a high altitude. The latter environmental conditions add to the demands on the circulatory system and respiratory system, to increase the dissipation of heat or to compensate for the lower concentration of O₂ in the inspired air.

The physically fit person is able to maintain a given exercise rate at a lower cost to his homeostatic mechanisms and therefore is capable of increased endurance. Or, he can maintain a higher work rate at a physiologic cost which is not excessive.

Many physical fitness tests are indirect means of measuring the cost of physiologic compensation for the metabolic demands of exercise. President Kennedy has called upon school authorities to “use valid fitness tests to determine pupils’ physical abilities and evaluate their progress.” We need to give more attention to the significance and validity of tests, which have been developed by the hundreds, without much agreement as to objectives, reliability, specificity, and the like. In this broad field I shall mention only the tests that relate to the total physiologic response of the organism. The most direct of these is the capacity of the body to use O₂ under conditions of maximum work. This measurement is most suitable for laboratory use, but it has also been used recently in field studies of physical fitness of Arctic Indians who were accustomed to an outdoor life of hard work.³ The Indians did not measure up to the fitness levels of Olympic athletes, although they were much better than sedentary white men.

Since the various circulatory and respiratory responses are closely integrated, one finds that over a wide range of exercise the O₂ uptake is highly correlated with pulse rate, cardiac output, respiratory minute volume, and blood lactate. Therefore, the mere counting of heart rate provides a simple and reliable index of the physiologic response to exercise. The heart rate is not easy to count accurately during vigorous exercise and would not be practical as a fitness test were it not true that the recovery of heart rate to normal values is highly correlated with the level of physical fitness. These facts are the background of several general fitness indexes which involve the recovery rate of the pulse after standard periods of demanding exercise such as stepping up and down from a bench. The exercise must be severe in order to elicit the full scope of responses of the physiologic mechanisms. The severity also assures that a high degree of motivation is present to complete the test. Without motivation the test is meaningless as a measure of physiologic response, although practical conclusions can be drawn from a person’s failure to complete the test when he is obviously not exerting himself.

A test such as the Harvard Step Test⁴ will give a wide range of values when applied to a heterogeneous group. When a program to improve fitness is applied to the group, the mean scores on the test will improve, but more importantly, each individual has a guide to the success of his own efforts to improve fitness.

Turning to the problem of motivation for better physical fitness, we have to admit the complexity of the problem and the present lack of evidence. Not much fitness is necessary for our usual sedentary activities and there is little evidence that a high level of fitness does more than increase our reserve capacity to perform exercise or to withstand such stresses as high temperature or low barometric pressure. There is no evidence
that physical fitness has any association with resistance or susceptibility to any infectious disease. If any diseases are prevented, they are some forms of orthopedic disability and possibly coronary atherosclerosis to some degree. Certainly many other factors are also important in the causation of these diseases, and without prolonged and skillful epidemiological studies we will not be able to assess the role of exercise and fitness in preventing disease.

Dr. J. N. Morris and his associates have made some of the most interesting observations on the association of coronary heart disease with levels of exercise. They found that drivers of London buses were likely to have more severe heart attacks and at an earlier age than conductors, who spent much of their time running up and down from the upper deck. However, the differences in emotional stress were difficult to settle, and Morris' group later found that the drivers were slightly heavier than conductors not only when they developed heart disease, but when they first took their jobs, as evidence by greater girth of uniforms requested by drivers. This observation suggests a self-selection factor which may be as important as the other factors previously suspected.

One of the problems in such epidemiologic studies is that fitness usually varies so much even within a brief part of the life span. In studying diseases that apparently develop insidiously, like atherosclerosis or cancer, the epidemiologist tries to observe populations in which suspected etiologic or preventive factors have been present and relatively constant over long periods of time. This is a complex and difficult task.

Lacking well-established negative factors for motivation, one turns to the possible positive ones. Until someone can measure health in terms of "vitality," "energy," or psychological factors, however, one is left with only vague arguments for better physical fitness.

Physical fitness is bound to be low if our daily habits do not include hard physical work or exercise. Our contemporary society has taken away these daily demands and we see the results in low physical fitness. Since our highly mechanized society and industry have taken away the primary causes of good physical fitness, we shall have to find new personal and socially acceptable reasons for changing our living habits to include a larger amount of physical work or exercise. We can hope that these reasons will be positive rather than negative; that is, that increased exercise, work, and sports participation will be shown to improve health, and not that exercise should be taken in order to avoid a "coronary" or a "nervous breakdown." However, both kinds of evidence are extremely difficult to obtain.

REFERENCES


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