Physical Activity, Fitness, and Health: The Current Consensus

Roy J. Shephard

The process of the 1992 consensus conference that examined relationships among physical activity, fitness, and health variables is described. Potential sources of physical activity include not only deliberate exercise but also occupational tasks, household chores, and incidental activity such as walking. It is still unclear whether the process (physical activity) or the outcome (physical fitness) is the most appropriate value to measure. Current evidence strongly supports the value of regular physical activity in preventing and treating coronary heart disease, hypertension, end-stage renal disease, Type II diabetes mellitus, osteoporosis, certain forms of cancer, surgical trauma, depression, and anxiety. There is also suggestive evidence of benefit in peripheral vascular disease, mild obesity, the chronic phases of rheumatoid and osteoarthritis, and chronic obstructive lung disease. In other conditions—including cerebrovascular accidents, Type I diabetes, low back problems, bladder problems, immune disorders, neuromuscular disorders, and substance abuse—evidence of benefit is equivocal.

There is now growing recognition, not only among physical educators but also among physicians, that physical activity and fitness influence many aspects of personal health. However, there is much less agreement on those disease states where benefit is well established and other conditions where the evidence is merely suggestive. Likewise, it remains to be clarified whether health professionals should encourage physical activity as a process, or whether prevention and therapy depend upon the attainment of specific fitness standards (Shephard, 1994a).

These questions are not merely of academic interest. They also have vital implications for health policy, as governments strive to contain spiraling medical expenditures and enhance the health of aging populations. Thus in 1992, with the enthusiastic support of the Ontario Ministry of Tourism and Recreation and the Directorate of Fitness and Amateur Sport of the Canadian government, a group of some 100 internationally recognized experts met to develop consensus on the most important issues through well-prepared preliminary analyses of available information and a 4-day small-group consensus-building process. Both the resulting summary document (Bouchard, Shephard, & Stephens, 1993) and detailed documentation supporting the summary statements (Bouchard, Shephard, & Stephens, 1994) have now been published.

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Basic Definitions

There have been many definitions of physical activity, fitness, and health, and we thus thought it important to constrain participants in the consensus process to a common understanding of these terms (Bouchard et al., 1993).

**Physical Activity**

We defined physical activity as "any body movement produced by the skeletal muscles that results in a substantial increase over the resting energy expenditure" (Bouchard et al., 1993, p. 11). It thus included not only exercise (undertaken with the deliberate intent of improving health or physical performance) and sport but also equivalent energy expenditures in other types of active leisure, occupational work, and domestic chores.

**Fitness**

We noted that much of traditional fitness assessment has concentrated upon performance. However, we deliberately focused upon markers of health-related fitness, including indices of morphology (mass for height, body composition and fat distribution, joint flexibility, and bone density), muscle function (power, strength, and endurance), motor abilities (agility, balance, coordination, and speed), cardiopulmonary function (oxygen transport, function of heart and lungs, and blood pressure) and metabolic regulation (glucose tolerance, lipid and lipoprotein metabolism, and choice of metabolic substrate).

**Health**

An earlier consensus group (Bouchard, Shephard, Stephens, Sutton, & McPherson, 1990) had defined health as follows:

A human condition with physical, social and psychological dimensions, each characterized on a continuum with positive and negative poles. Positive health is associated with a capacity to enjoy life and to withstand challenges; it is not merely the absence of disease. Negative health is associated with morbidity, and in the extreme, with premature mortality. (pp. 6-7)

The same definition was accepted for the 1992 consensus meeting. We quickly recognized that the available literature, with its heavy focus upon morbidity and mortality, provided only a very limited insight into overall health status. It was suggested that a comprehensive approach would require consideration of such indices as health-related fitness, both acute temporary and more permanent chronic disabilities, absenteeism, overall social productivity, and the individual’s demand for all types of medical services, including prescribed and nonprescribed drugs. Moreover, survival prospects should be reported not in terms of longevity, but rather as a quality-adjusted lifespan that reflected the summated quality of life on each of a range of criteria at representative points throughout the individual’s life (Kaplan, 1985).
The Underlying Paradigm

The next step in the consensus process was to develop an underlying paradigm that would link physical activity, fitness, and health, taking into account extraneous and potentially confounding variables (see Figure 1). Empirical tests could then be made of each of the postulated linkages.

Heredity

Heredity was seen as having a potential to influence habitual physical activity, health-related fitness, and health directly. Inherited factors might also modify either the impact of a given dose of physical activity upon an individual’s fitness level or the effect of such fitness upon the person’s health. Finally, inherited factors might determine the adoption of adverse behaviors such as smoking or overeating and might influence the impact of these interfering factors upon a given person’s health. Currently, such inherited interindividual differences are accepted as a part of the “noise” complicating the testing of the basic paradigm, although in the future the use of well-defined genetic markers may allow assessments of the health impact of physical activity and fitness independent of constitutional factors.

Other Confounding Variables

Fitness and health status are both influenced by many other confounding factors, including not only personal life-style but also the social and physical environment of the individual (Bouchard et al., 1994).

Lifestyle. Many “behaviors of choice” can affect fitness and health status (Blanding, 1982; Palmore & Jeffers, 1971; Spasoff, McDowell, Wright, & Dunkeley, 1980). Smoking, diet (both total energy intake and food type), and alcohol consumption are particularly important in this context. Each of these variables has at least a weak influence upon both fitness and health status in its own right and (because of linkages to job classification and socioeconomic status) can potentially confound epidemiological assessments based upon either occupation or patterns of leisure activity (Shephard & Bouchard, in press).

Social Environment. A combination of sociocultural, political, and economic factors influence an individual’s participation in physical activity, together with his or her fitness and health status (Stephens & Craig, 1990). In the United Kingdom, for example, there is an 8-year difference of life expectancy between the north and the south of the country (Black, 1993). Social networks can have a powerful influence for or against regular physical activity, fitness, and health. Likewise, public policy can influence the equation through such mechanisms as the facilitation of bicycle commuting, restriction of smoking in public places, and the design of buildings that encourage stair climbing. Personal attributes (age, gender, socioeconomic status, personality, and motivation) further complicate the model (Shephard, 1994a).

Physical Environment. Factors such as air temperature, humidity, barometric pressure, and the concentration of ambient air pollutants influence not only a person’s willingness to engage in physical activity but also the person’s response to exercise. Some environments, both hot and cold, can be quite hazardous for the health of the exerciser (Shephard, 1982).

Statistical Adjustment. The better epidemiological studies have attempted to allow for extraneous factors by including them as covariates or specific terms in a multiple regression model. Nevertheless, it remains difficult to allow fully for intervening variables. Often, they are not known with great precision, and the investigator is unclear whether the variables exert linear, quadratic, or threshold effects. Moreover, if statistical adjustments are made for a multiplicity of such influences, there is a danger that variance that should have been attributed to physical activity is erroneously attributed to the covariates.

Testing the Paradigm: Mechanics of the Consensus Conference

The intent of the consensus conference was to test the paradigm presented in Figure 1 in terms of some 70 health-related conditions. Appropriate internationally recognized scientists with substantial expertise in each of the 70 topics were identified by the symposium organizing committee, and the most productive of these individuals were identified by computer searches of the Science Citation Index and/or the Social Science Citation Index. The participants, thus selected, were charged with the following tasks:

1. To prepare a two-page draft of the consensus statement 3 months before the meeting
2. To prepare a full paper documenting supporting research prior to the meeting
3. To attend the 4-day consensus process, participating in development of the final consensus text (Bouchard et al., 1994).

In developing the supporting papers, reviewers were given specific guidelines
for assessing the quality of available evidence (Hart, 1994). Although the optimum criterion would have been a large-scale, randomized double-blind controlled trial, we recognized that such trials had not been completed and indeed in some cases were not practicable with respect to the health issues of interest. In some instances it was thus necessary to consider, with appropriate weighting, smaller randomized trials of more limited statistical power, together with evidence based upon cross-sectional studies, case control studies, and even case series.

All invited participants received a first draft of the consensus document about one month before the meeting. During the meeting, eight working groups were formed around clusters of related topics. In addition to attending plenary sessions, each working group met for 6–8 hours per day, reviewing the detailed evidence and revising the draft statement until a consensus (although not necessarily a unanimity of opinion) was achieved. For each assigned area of review, the working group also prepared a list of important research questions requiring early study (Bouchard et al., 1993).

Methodological Problems

The 1992 consensus conference recognized that, ideally, the consensus document not only would indicate which conditions were influenced by the habitual physical activity and/or fitness of the subject but also would establish dose–response relationships (Haskell, 1994) that could be used in setting appropriate exercise prescriptions. However, because of difficulties in measuring physical activity and fitness accurately on large populations, there was uncertainty as to whether the process of physical activity or the attained fitness level was the key consideration.

Describing Physical Activity

Many variables influence the impact of physical activity upon health, including the characteristics of the individual, the type of activity, its intensity, its frequency, and its duration.

**Personal Characteristics.** Because of age, gender, and health-related differences in physical fitness, a given pattern of physical activity imposes a widely differing level of relative stress upon different individuals (see Table 1). If the task demand can be related to the individual’s mode-specific peak aerobic effort, the interindividual variation in responses to exercise and training is much reduced. Unfortunately, not all studies provide the necessary information to allow presentation of data in this format.

**Type of Activity.** The epidemiologist almost invariably faces the difficulty of interpreting responses to a physical activity regimen that has been, at least in part, self-selected. The activity that is pursued may be widely distributed over the major muscles of the body, or it may be localized to a few small muscles, with widely differing consequences for cardiovascular and metabolic loading (Kay & Shephard, 1969; Shephard, Bouhlel, Vandewalle, & Monod, 1988). Physical activity may take the form of competitive sport; this is highly motivational for some people, but carries the potential negative health consequences of overtraining, injury, psychological stress, dietary abuses, and doping. In other people, physical activity may become regular, goal-oriented exercise sessions that are designed to improve physical performance, fitness or health; the dose of physical activity will then be more
Table 1  A Characterization of Intensity of Leisure Activity in Relation to Age

<table>
<thead>
<tr>
<th>Categorization</th>
<th>Relative intensity (% VO$_{2\text{max}}$)</th>
<th>Absolute intensity (METs)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Young</td>
</tr>
<tr>
<td>Rest</td>
<td>&lt;10</td>
<td>1.0</td>
</tr>
<tr>
<td>Light</td>
<td>&lt;35</td>
<td>&lt;4.5</td>
</tr>
<tr>
<td>Fairly light</td>
<td>&lt;50</td>
<td>&lt;6.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>&lt;70</td>
<td>&lt;9.0</td>
</tr>
<tr>
<td>Heavy</td>
<td>&gt;70</td>
<td>&gt;9.0</td>
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<td>Maximal</td>
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Occupation offers a substantial daily energy expenditure to only a minority of the current labor force. Moreover, the health of the individual often influences selection into and out of physically demanding jobs, and the simple job classifications available to the epidemiologist give a rather imprecise picture of the individual’s current daily level of physical activity. Domestic chores provide a widely varying source of physical activity. The care of dependents can be physically demanding, and it is often given too low weight when assessing total activity patterns; for this reason, the extent of habitual activity is sometimes underestimated in women. Unstructured leisure activity such as incidental walking, cycling, gardening, and stair climbing is often neglected in assessing population activity levels. However, these items are the most frequent active pursuits of the general population (Canada Fitness Survey, 1983; Stephens & Craig, 1990), and there is growing evidence that for many people such forms of energy expenditure provide an effective basis of physical conditioning (Davison & Grant, 1993; Oja et al., 1991; Porcari et al., 1987; Shephard, 1994a).

Intensity. The basis for the classification of intensity of occupational or leisure activity is frequently a calorimetric estimate of the absolute energy expenditure (e.g., 30 kJ/min), or the intensity expressed as a multiple of basal metabolic rate (e.g., 5 METs). However, as discussed above, it is more appropriate to express the intensity of effort in relative terms, as a percentage of the individual’s mode-specific peak aerobic power, as a percentage of his or her maximal heart rate or as a percentage of heart rate reserve.

A person is rarely able to describe her or his choice of activity in such terms unless she or he is undertaking carefully prescribed exercise. However, the investigator can assess involvement in demanding physical activity from reports of exercise-induced sweating and dyspnea that is sufficient to make conversation diffi-
cult (Shephard & Bouchard, 1994). In the case of sport, a report of occasional participation is also likely to signify less intense involvement than would regular participation, and such a report would in turn imply less intense participation than involvement in a competitive program.

**Frequency.** The health impact of a single bout of vigorous physical activity probably persists for 1–3 days. For many people, activities differ between a weekday and a weekend day (Shephard et al., 1980). It is thus logical to assess the frequency of exercise with respect to a typical week or a typical month. Unfortunately, many activities also show a substantial seasonal variation (Shephard et al., 1978). One approach to this problem is to seek reports for an entire year, but many subjects have difficulty in recalling activities over such an extended period. It is thus preferable to ask individual participants for description of a typical recent week and to allow for seasonal factors by spreading observations systematically over a calendar year.

**Duration.** If a person is engaged in heavy physical work, an exercise class, or a team sport, the duration of an individual exercise bout may be determined with considerable precision, but the timing of unstructured activities varies widely from one occasion to another. The individual is thus asked for a typical duration, stressing that travel, preparations for participation, and subsequent socializing are to be excluded from the estimate. Despite such precautions, the length of exercise sessions is often overestimated (Shephard, 1994a), sometimes to the point that day length vastly exceeds 24 hours!

**Interactive Effects.** The list of variables already presented is sufficient to show the difficulty in conducting experiments to determine an effective minimum dose of exercise. However, the dose–response relationship is further complicated by interactive effects. A quantity of exercise that would have little impact upon either function or health in a very fit person still may have a substantial influence upon a person who begins a program in poor physical condition.

A given intensity of effort may have little impact upon fitness or health if exercise is halted after 5 minutes, but it may prove very effective if the same intensity is sustained for one hour. Likewise, a regimen that is practiced only once per week may have little benefit (or even endanger health), whereas the same activity practiced 3–4 times per week can do much to improve health. Finally, some health-related variables such as body fat content will be affected more by the total weekly energy expenditure (Intensity × Frequency × Duration) than by individual values for these three variables.

**Physical Activity or Fitness?**

The consensus process devoted only a little time to examining the relative importance of physical activity versus the attained fitness level. However, this question has substantial importance in terms of health policy. Should programs be judged in terms of the number of people who are attracted to them, or by any associated changes in community fitness levels? Likewise, should the future prognosis of individuals be predicted from their behavior or from their health-related fitness characteristics (which are heavily influenced by genetic factors)? If the process of participation in the exercise class is intrinsically important, we may be justified in putting a great deal of money into increasing the support of programs that attract an adequate attendance. However, if health depends largely upon attaining a certain level of aerobic power or body fat content, irrespective of process, then it may be
better to enact simple legislation that will encourage people to walk and to cycle to and from work (Shephard, 1994a).

In terms of cardiovascular mortality, the 1992 consensus conference concluded that a high level of physical activity was associated with a twofold protection against cardiovascular disease, whereas a superior initial treadmill endurance time conferred as much as an eightfold advantage of prognosis (Blair, 1994). However, the consensus group members also recognized that the apparent superiority of physical fitness might reflect no more than difficulty in measuring physical activity accurately in groups such as women who were caring for young children (Blair, 1994).

**Beneficial Effects of Physical Activity**

The consensus conference examined both the biological effects of exercise upon the various body systems (with the implications of such changes for health), and a wide range of disease states that were likely to be influenced favorably by regular physical activity (Bouchard et al., 1994). This paper considers only the issue of susceptibility to ill-health: those conditions that can be prevented or treated by exercise.

The conditions of interest immediately can be sorted into three major categories: those where strong and consistent evidence was found supporting a beneficial influence of physical activity and/or attained fitness, those where the evidence was no more than suggestive, requiring further investigation, and those where data were presently inconclusive or negative (Bouchard et al., 1994).

**Strong Evidence**

The following conditions had strong evidence of benefit from regular physical activity:

- Coronary heart disease
- Hypertension
- End-stage renal disease
- Type II diabetes mellitus
- Osteoporosis
- Certain types of neoplasm (colon, breast, reproductive tract)
- Surgical trauma
- Depression
- Anxiety

In the case of coronary heart disease, there is unanimity that protection is gained from both regular aerobic activity and from a high level of aerobic fitness, although further research is needed to decide which of these two characteristics is the more important. Regular physical activity also reduces symptoms, improves function, and reduces mortality subsequent to myocardial infarction. Low-risk survivors of myocardial infarction can undertake an exercise rehabilitation program safely and with only limited supervision.

The resting blood pressure is consistently reduced by regular exercise (Fagard & Tipton, 1994). A meta-analysis of 48 studies has suggested reductions of 3/3 mm Hg in normotensives, 6/7 mm Hg in borderline hypertensives, and 10/8 mm
Hg in hypertensives, although too few of these studies have adopted a randomized, controlled design. The effect, although small, seems of the order that would be anticipated from alternative therapies such as long-term medication; certainly, the decrease of pressures is enough to have a useful impact upon prognosis in hypertension. Regular physical activity apparently has less effect upon the blood pressure observed during an acute bout of exercise, and from a mechanistic point of view, it is also puzzling that the exercise-induced reduction of resting blood pressure does not persist during the hours of sleep.

Prospective studies have suggested that a 6-month period of endurance training can correct much of the accumulated morbidity in the patient with end-stage renal disease, including hypertension, an adverse lipid profile, a poor glucose tolerance, muscle weakness, hematological problems, and psychological dysfunction. However, these same factors often limit compliance and preclude taking an effective dose of exercise (Goldberg & Harter, 1994). There thus remains a need for large-scale studies to examine the long-term impact of exercise upon quality of life, morbidity, and mortality in this class of patient.

There is good cross-sectional and prospective evidence that a sedentary lifestyle increases the risk of developing Type II diabetes mellitus, and an increase of physical activity can improve insulin sensitivity. There is less substantial evidence of benefit in more severe cases of noninsulin dependent diabetes, and the volume of exercise needed for control of the condition may be greater than the patient is able or willing to undertake. In such individuals, there are also dangers of retinal detachment, skin lesions, and hypotension, as in Type I diabetes (Gudat, Berger, & Lefebvre, 1994).

Weight-bearing or resisted exercise normally has a favorable effect upon bone density, maximizing values in young adults, and slowing the subsequent loss of bone mineral with aging (Suominen, 1991). It is less clear whether regular physical activity improves other aspects of bone structure. There seems a ceiling to the useful dose of preventive physical activity in young adults, and bone density diminishes in women who train to the point of inducing amenorrhea (Drinkwater, 1994). Further research is needed to establish how far the exercise-associated decrease in bone density is attributable to a negative energy balance, and how easily any decrease of bone density can be made good once the very heavy training ceases. Further study is also warranted to examine whether the bone density of postmenopausal women who remain physically active and who have an adequate energy and calcium intake is augmented by prolonged estrogen therapy.

Both leisure and occupational activity are associated with a decrease in the risk of colon cancers, possibly by speeding colonic transit (Lee, 1994; Shephard, 1993). There is also more limited evidence that involvement in exercise reduces the risk of cancers of the female reproductive tract and breast, perhaps by reducing body fat; certainly, further study is needed to assess whether exercise operates through a reduction of body fat or other lifestyle variables (Shephard, in press).

Surgical trauma is followed by a period of reduced physical activity and resulting decreases in physical fitness. Specific training programs can correct the loss of cardiac and muscular condition, with benefit to patients after cardiac surgery, renal transplantation, and lower limb amputations (Christensen, 1994).

Moderate doses of exercise are effective in improving mood state, more convincingly in those who are depressed than in those who begin with relatively normal scores (Morgan, 1994). Given the pandemic nature of depression, moderate exercise seems a more acceptable solution than either sustained pharmaco-therapy
or a prolonged course of psychotherapy. However, if exercise is pursued to the point of overtraining, exercise can itself induce depression (Verde, Thomas, & Shephard, 1992). A large proportion of the North American population also suffers disruption of their normal lives by anxiety-related problems, and there is growing evidence that such anxiety is reduced, both acutely (for as much as 2 hours following a single exercise bout) and as a response to several months of progressive aerobic training (Landers & Petruzzello, 1994).

Although regular physical activity has little impact upon the life expectancy of the very old (Heyden, Schneider, & Schneider, 1991; Paffenbarger et al., 1994), there is convincing evidence of gains in quality-adjusted life expectancy; greater aerobic power, muscle strength, and flexibility allow active individuals to perform at levels equivalent to people 10–20 years their junior (Shephard, 1991). In consequence, institutionalization is substantially delayed for that fraction of the population where loss of function is the determinant of dependency. More study is needed to clarify the proportion of seniors falling into this category.

**Suggestive Evidence**

In the following conditions, there is evidence that is suggestive of benefit from physical activity:

- Peripheral vascular disease
- Obesity (mild)
- Chronic phases of rheumatoid and osteoarthritis
- Chronic lung disease

Many studies have claimed that regular physical activity improves physical performance in peripheral vascular disease, but almost all have been small in scale, with no controls. The extent of any reported benefit has varied widely and seems unrelated to the extent of disease or the duration of training (Barnard, 1994).

Exercise programs seem more successful than some other programs for the treatment of mild obesity (Hill, Drougas, & Peters, 1994), in part because they encourage protein retention at the same time that fat is being lost, and in part because they help to counter the autoregulatory decrease of resting metabolism (Shephard, 1994b). However, further study is needed to confirm the extent of such postulated advantages. The energy deficit that can be created by exercising is smaller than would be possible by stringent dieting; it is also difficult to sustain exercise compliance in people who are severely obese (Atkinson & Walberg-Rankin, 1994; Uusitupa, 1991), and such individuals have an above-average susceptibility to musculoskeletal injuries. It has even been suggested that any advantage of fat loss in exercisers may merely reflect the selecting out of individuals who are prepared to change other aspects of their lives, such as diet.

Preliminary studies suggest that therapeutic exercise may have a helpful effect upon outcome in the chronic phases of both rheumatoid and osteoarthritis (Panush, 1994).

A rehabilitation program substantially improves subjective responses to exercise in the patient with chronic lung disease. However, there is little evidence of objective change. In patients with severe bronchospasm, a strengthening of the respiratory muscles may allow a faster inspiration, and thus a slower expiration,
with less airway collapse. Other possible reasons for benefit include a mechanically more efficient pattern of walking, a strengthening of the limb muscles, a reduction of anaerobic effort, and psychological factors (Whipp & Casaburi, 1994).

Inconclusive

For the following conditions, evidence of benefit from physical activity is equivocal:

- Cerebrovascular accidents
- Type I diabetes
- Low back problems
- Bladder problems
- Immune function
- Neuromuscular disorders
- Substance abuse
- Pregnancy

The morbidity and mortality from strokes is a major public health concern, but evidence of benefit from enhanced physical activity is presently equivocal, in part because of problems of research design such as defining cases, controlling confounding variables, and assessing activity patterns. There remains a potential for benefit at least in hemorrhagic stroke, because of the impact of regular physical activity upon systemic blood pressures, but at the same time, exercise-induced increases of blood pressure could cause a short-term increase in risk for a vulnerable subject (Kohl & McKenzie, 1994).

In Type I diabetes, there is some suggestion that regular physical activity reduces the need for insulin, but little to suggest that glycemic control is improved (Giacca, Qing Shi, Marliss, Zinman, & Vranic, 1994). Exercise should be recommended to patients with Type I diabetes only for the general health reasons mentioned above, particularly the prevention of an associated atherosclerosis. Care is needed to avoid hypoglycemia during strenuous exercise. There are also potential complications of retinal detachment (associated with proliferative retinopathy), infection and/or ulceration of the feet (associated with peripheral ischemia and peripheral neuropathy), and postural hypotension (associated with autonomic neuropathy).

Strengthening the back muscles through a regular exercise program might be anticipated to reduce the risk of back pain and back injuries, but there is surprisingly little evidence in the ergonomic literature to support such a hypothesis (Biering-Sørensen, Bendix, Jørgensen, Manniche, & Nielsen, 1994).

There is no evidence that general activity helps bladder problems, although specific pelvic exercises may be of value (Bø, 1994).

Moderate activity appears to have a favorable effect upon certain aspects of immune function, and may be helpful in the treatment of patients with HIV infections. In contrast, either single bouts of strenuous exercise or a period of overtraining induces a depression of immune responses. In most instances, the depression of function does not last long enough to affect the risk of either viral infections or cancer, although there is some evidence that marathon and ultramarathon participation leads to an increase in upper respiratory infections (Brenner, Shek, & Shephard, 1994; Nieman, 1994).
Muscle function is impaired and cardiovascular fitness is low in a variety of neuromuscular disorders such as muscular dystrophies and McArdle's disease. In dystrophic conditions, we might anticipate an improvement in the quality of life from a strengthening of residual muscle function, but surprisingly, there have been almost no studies of this question. Future research needs to ask what types of neuromuscular disease can benefit from exercise, and what are the most appropriate forms of exercise to recommend to such individuals (McCartney, 1994).

Despite theoretical rationale and popular beliefs, there is little conclusive evidence that training programs help in controlling substance abuse (Williams, 1994). Indeed, some conditions, such as abusing steroids and chewing tobacco are more prevalent among athletes. It remains unclear whether the social context of a sport determines if it has a positive or a negative impact upon substance abuse. There is also a need to clarify whether the general benefits of exercise seen in the nonsmoker extend to the person who is a heavy smoker.

Limited evidence suggests that moderate exercise is not harmful to the pregnant woman or to the developing fetus, at least during the middle trimester (Carpenter, 1994; Wolfe, Brenner, & Mottola, 1994). However, further work is needed to examine the potential influence of vigorous exercise upon the incidence of spontaneous abortions during the first few weeks of pregnancy. Further, if there is a substantial rise of core temperature at this stage, the risk of fetal teratomas seems to be increased. In the later stages of pregnancy, overambitious exercise can cause a slowing of fetal heart rate and a decreased glucose supply to the placenta. There is particular need to study the impact of exercise upon such problems of pregnancy as excessive weight gain, diabetes mellitus, and hypertension, and to compare perinatal outcomes between active and sedentary women.

**Harmful Effects of Exercise**

The main risk of increased physical activity is plainly that of causing musculoskeletal injuries (Pate & Macera, 1994). In some forms of highly competitive or adventurous sport, danger may be a stimulus to participation, and the costs associated with such injuries may even outweigh other health benefits. However, there is as yet little information on which to base health policies. There is a need to learn more about personal and environmental predisposing factors, to develop methods of expressing injuries as rates per unit of exposure, and to establish the dose–response relationships for different categories of individual and for different types of activity. The preventive value of such measures as preliminary stretching and weight training exercises also needs further evaluation.

Possible cardiovascular complications of exercise include cerebrovascular accidents, aortic dissection, cardiac arrhythmias, myocardial infarction, and sudden death (Thompson & Fahrenbach, 1994). Little is as yet known about nonfatal cardiovascular complications. In regard to sudden death, current evidence suggests that although the risk is increased 5- to 50-fold while a person is actually exercising, the overall risk of sudden death is reduced approximately by half in the regular exerciser (Shephard, 1981).

Despite many anecdotal reports, there is little conclusive evidence regarding the effects of sport participation or repetitive occupational activity upon the risk of subsequent osteoarthritis (Panush, 1994).

There is growing evidence that for some people, exercise can become a compulsive behavior (Polivy, 1994); this seems closely related to eating disorders.
such as anorexia nervosa and bulimia. More research is needed to decide whether compulsive exercise is indeed distinct from these conditions. Figures are also needed for the prevalence of excessive physical activity in relation to negative energy balance. Such problems seem particularly common in forms of competitive sport where an emphasis is placed upon personal appearance and a slim body build.

**Research Needs**

Many specific research needs have been indicated above. Other issues include an examination of areas where evidence is at present merely suggestive or frankly inconclusive, a definition of optimal doses of physical activity, an exploration of mechanisms so that the impact of a given dose of exercise can be enhanced by appropriate adjuvants, and the establishment of costs and benefits that will allow an appropriate shaping of public policies (Bouchard et al., 1993, 1994). Often, an increase of physical activity is accompanied by a decrease of body mass and a change in various other aspects of personal life-style. There is thus a need to explore how far exercise exerts an independent beneficial effect upon health, and how far it operates indirectly, by modifying these other variables.

Much of the research on physical activity, fitness, and health that has been completed to date has been directed at white males of high socioeconomic status, and comparisons are needed between the exercise responses of this privileged group and those of women, children, the elderly, visible minorities, the socially disadvantaged, and those whose activity patterns are limited by physical or mental handicaps. Given that the majority of the North American population currently engage in little physical activity, it is also necessary to ask what methods can be adopted to persuade people (particularly those with established disease states) to exercise regularly, to examine how far the health benefits of increased activity are attenuated if exercise is not begun until maturity, and to determine whether there is an age ceiling beyond which attempts at vigorous activity may be counterproductive.

**References**


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