Workshop on Epidemiologic and Public Health Aspects of Physical Activity and Exercise: a Summary

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Synopsis

The Workshop on Epidemiologic and Public Health Aspects of Physical Activity and Exercise was conducted by the Centers for Disease Control on September 24–25, 1984. Fundamental topics were identified prior to the workshop, and experts were invited to participate. Ten papers were written, discussed at the workshop, revised, and are herewith published.

The beneficial effects of physical activity on health are becoming progressively more apparent. A reduced risk of coronary heart disease, desirable weight control, and the reduction of symptoms of anxiety and mild to moderate depression are established. Beneficial effects on hypertension, type II diabetes, osteoporosis, and certain psychiatric and psychologic conditions apear likely but require additional study.

Although the importance of physical activity to health is becoming better established, several important gaps in our knowledge remain. Physical activity is a complex behavior that is difficult to measure, and the accuracy of most measurement instruments is not known. Knowledge of the patterns of physical activity within our society and the determinants of those patterns is limited.

Information on the rates of mechanical, metabolic, and psychologic risks of physical activity is largely absent. In addition, there is a need to know more about the dose-response effects of physical activity, the differential effects on various subgroups of the population, the specific dimensions of activity which effect different aspects of health, and the efficacy of various intervention and promotional strategies.

Each paper stands as an independent contribution to the literature. As a group, the authors of these papers have provided the public health and scientific communities with a succinct yet comprehensive summary of the status of knowledge plus specific recommendations for future research in the areas of physical activity, public health, and epidemiology.

In 1975, MILTON TERRIS observed that "physical fitness and physical education have no respected place in the American public health movement" (*1*).

Less than 10 years later, however, the situation has changed markedly. In response to the growing body of evidence that regular physical activity produces substantial physical and emotional benefits, the Public Health Service specified "Physical Fitness and Exercise" as 1 of the 15 areas of greatest importance for improving the health of the public (*2,3*).

In September 1983, the Centers for Disease Control (CDC) created the Behavioral Epidemiology and Evaluation Branch (BEEB) within the Division of Health Education, Center for Health Promotion and Education. The major responsibility of BEEB is the epidemiologic study of physical activity.

Workshop Description

As a major step in both the development of the Branch and the promotion of the epidemiologic study of physical activity by others, BEEB staff organized the preparation of 10 scientific papers and conducted the Workshop on the Epidemiologic and Public Health Aspects of Physical Activity and Exercise on September 24–25, 1984. The purposes of the papers and workshop were (*a*) to provide the public health and scientific communities with a summary of the current status of our knowledge in this area and (*b*) to provide recommendations for future research.

Preparation for the workshop began with the identification of nine topics of epidemiologic and public health importance. Two experts for each

topic were invited to participate in the workshop and to prepare the review papers. Suggested outlines for each paper were prepared by BEEB staff and reviewed and revised by the authors of the papers. A member of BEEB was assigned to each of the papers to participate in its preparation and to provide liaison between the invited experts and BEEB.

Before the experts prepared the review papers, BEEB staff prepared a paper discussing the definitions of physical activity, exercise, and physical fitness (*4*). The paper was circulated among the participants to promote uniformity of terminology. We have revised it based on the suggestions of the participants, and it is the first in this set of review papers. The remaining nine papers were circulated in draft form to all participants approximately 1 month before the workshop. Participants and staff are listed below.

The workshop spanned 2 days and consisted of a series of large and small group discussions. In addition to the authors and the BEEB staff, representatives of six Federal agencies and three State health department organizations participated in these discussions.

Following the workshop, the authors made final revisions.

Summaries of the Workshop Papers

1. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research (*4*). Physical activity is movement produced by skeletal muscles that results in energy expenditure. Exercise is a subset of physical activity that is planned, structured, repetitive, and has the improvement or maintenance of physical fitness as an objective. Physical fitness is a set of attributes, some of which are health related, that people have or achieve. Extra attention was given to "exercise" because it often is used interchangeably with "physical activity." Common usage, however, suggests that it has characteristics that separate it from many other physical activities.

Workshop Participants

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'The effect of low-intensity activity, such as walking, is an area of great interest. It appears likely that the greatest gain in the risk-benefit relationship per unit change in physical activity occurs at the lower end of the activity spectrum. As a whole, the population is likely to benefit more if the least active begin to do a little than if the most active do even more.'

The main thrust of the paper is that physical activity has many dimensions or components. In order to evaluate and compare pubished reports, investigators need to recognize and describe the specific components of physical activity that they have studied.

Not all participants supported these definitions, but all endeavored to use them in the papers wherever possible. Whether these definitions endure and achieve widespread use is less important than the recognition that generally acceptable and consistently used definitions will greatly facilitate progress in this area. The definitions proposed are reasonable starting points for discussion.

2. Assessment of physical activity in epidemiologic research: problems and prospects (*5*). Physical activity is a complex behavior with many interrelated dimensions. It has been measured in a variety of ways ranging from direct calorimetry to a single query about how active one is. Each method captures only part of the entire physical activity spectrum. In addition, different dimensions of activity may be related to different dimensions of health. Therefore, the specific concerns of a survey or study determine the most appropriate method. At present, recall procedures seem to be the best method for large population studies.

In spite of the large number of measurement methods currently in use, little has been done to determine the reliability and validity of the various methods. Research must be undertaken in this crucial area to assure the accuracy of our conclusions about the relationships between physical activity and health.

3. The descriptive epidemiology of leisure-time physical activity (*6*). Inconsistent and inadequately detailed measurement of activity in population surveys badly hampers a thorough description of the active population. It appears, however, that during their leisure time, only about 20 percent of adults perform the amount of physical activity generally recommended for cardiovascular fitness (*7*). In our society, men who are younger and of higher socioeconomic status are more likely to be active than other groups of men or women. In spite of what seems to be a national consensus that North Americans get more vigorous leisure-time exercise than one or two decades ago, the hard evidence supporting the consensus is sparse, coming mostly from Canada and from surveys of selected groups in the United States that are discussed later in this paper.

4. The determinants of physical activity and exercise (*8*). We are only beginning to understand why some people are physically active and others are not. The behavior is determined, at least in part, by characteristics of the person, the environment, and the activity itself. Important differences probably exist, depending on whether the behavior is just being adopted or is being maintained, and whether it occurs within a supervised program or is scheduled and conducted more spontaneously by the individual.

Whereas the paper describes many potentially predictive associations, the final conclusion is that we are very uncertain about the determinants of physical activity. Previous experience in sports, family and peer support, self-motivational characteristics, and positive feelings resulting from the activity seem important; the evidence supporting the importance of accessible facilities, time restraints, and various climatic conditions is less conclusive.

Progress in identifying the determinants will require a careful and studied blend of behavioral and epidemiologic sciences in which both maintain their essential characteristics. Epidemiologic methods will need to utilize behavioral concepts, theories, and measurement devices to explore this vital area. Childhood experiences that predispose to an active adult life and the critical interactions within and among personal and environmental factors seem to be particularly important fields for research.

5. Relationships between exercise or physical activity and other health behaviors (*9*). The expectation that physical activity, particularly exercise, may have a favorable influence on other important health behaviors is firmly established only for weight con-

trol. In other areas the evidence to date is only suggestive. Reported associations are small, insignificant, or both, and causality cannot be determined. Research on associations is hampered not only by the difficulties of measuring physical activity but also of measuring the other behaviors. Body weight and smoking status are rather easily measured and categorized. On the other hand, alcohol use and stress management are more difficult to measure and the most desirable behaviors with respect to alcohol consumption and stress management are not established. Nevertheless, the potential of exercise for favorable effect on other behaviors deserves more investigation, especially in relation to smoking, alcohol and other substance abuse, and stress management.

6. The disease-specific benefits and risks of physical activity and exercise (*10*). Habitual vigorous physical activity reduces the risk of coronary heart disease (CHD) and sudden death. The reduction is the result of protection and not merely the selection of less susceptible individuals. The protective effect is independent of other risk factors, such as hypertension, obesity, smoking, and family history, and may actually provide relatively more protection for those with hypertension and obesity than those without these risk factors. The temporarily increased risk of sudden death during vigorous physical activity is outweighed by the overall reduced risk of coronary heart disease from habitual vigorous activity. Several studies suggest that habitual exercise or physical activity may prevent or control hypertension, osteoporosis, or Type II diabetes. Little or no information is available on the effect of habitual activity on cancer, respiratory diseases, or arthritis.

For all the disorders, the dose-response effect needs to be explored in more detail. It is of great importance to determine the effects of beginning an exercise program in early, middle, or later life. Distinction needs to be made between the effect of vigorous physical activity and less vigorous activity that is performed over a longer period of time, yet results in an equivalent expenditure of energy. For coronary artery disease, the protective effect accrues from vigorous physical activity of any type, but it would be of importance to know if exercise, as defined by Caspersen and co-workers (*4*), has any additional benefit over other categories of physical activity, such as occupational activity. It will aso be important to establish if the effects are mediated via physical fitness, metabolic changes (metabolic fitness), or some other mechanism.

'A recurrent theme of discussion was that the benefits and risks cannot be considered in isolation. It may be necessary to study them separately, but the overall effect of physical activity on the health of the population requires that both be known, both be studied with equal care, and that both be considered dispassionately. The potential overall beneficial impact of physical activity on health will be poorly served if activity patterns are recommended indiscriminately for all groups without regard for the subgroup-specific benefits and risks.'

7. The risks of exercise: a public health view of injuries and hazards (*11*). The potential hazards of physical activity or exercise are legion. They may be acute or chronic, mechanical, metabolic, or psychologic. They may be specific to the activity, to the age or sex of the participant, or both.

Data permitting the calculation of incidence rates for any of these potential problems are essentially nonexistent. Even for the six most commonly reported aerobic activities among adults in the United States—walking, jogging, swimming, cycling, calisthenics, and racket sports—there is almost no information about the incidence of acute mechanical injuries, let alone metabolic, psychologic, or chronic effects. Empirical data about the risk of walking, the most common activity, are absent. The benefits of physical activity must be considered in light of the risks, and data about risks should be collected with the same care that has been and is being applied to the study of the benefits.

8. The relation of physical activity and exercise to mental health (*12*). The beneficial effects of physical activity or exercise on various aspects of mental health are potentially large. Unfortunately, few studies have been performed or reported with sufficient care so that valid conclusions can be drawn. Physical activity and exercise do alleviate the symptoms of mild to moderate depression and, in the general population, reduce the symptoms of anxiety. The area requires research with greater attention to methodology so that the conclusions

are sound even if the benefits are absent or smaller than originally postulated. Particularly fruitful for research are the areas of substance abuse, psychologic stress, and coronary-prone (type A) behavior. In all areas, the particular dimension or dimensions of activity that produces the effect needs to be determined. The potentially detrimental effects of activity, especially habitual vigorous exercise, need additional attention.

9. Physical activity and exercise to achieve the health-related components of physical fitness (*7*). Physically active persons have fewer health problems. The most diverse benefits to health accrue from physical activity characterized by the rhythmical contraction of large muscle groups that move the body over distance or against gravity. The activity can be performed at moderate intensity (50 to 70 percent of maximal oxygen consumption) or, more conversationally, at about "half-speed," and should be done at least every other day. Not known, however, is whether the health benefits are mediated through improvements in physical fitness or are achieved through some other pathway such as improved serum lipoprotein profile, fibrinolytic activity, decreased platelet stickiness, or other metabolic changes that might be called metabolic fitness. Some health benefits seem to be achieved through activity that does not improve cardiorespiratory endurance. Yet to be determined are the specific characteristics of physical activity that lead to specific improvements in health.

10. The promotion of physical activity in the United States population: the status of programs in medical, worksite, community, and school settings (*13*). Exercise programs at the worksite, exercise recommendations or prescriptions by health care providers, and physical education in the schools have potential for beneficially modifying exercise behaviors of large numbers of people of all ages. A community-based program to promote physical activity can provide support for behaviors triggered in the worksite, medical setting, or school programs and also may provide the primary contact for persons who may not otherwise be reached.

It seems likely that behavioral change is most likely when these forums and others provide overlapping encouragement for the adoption and maintenance of regular exercise behavior. There is evidence that worksite programs, medical professionals, and schools favorably influence exercise behavior. However, the components of an effective program in any setting are unknown. "Success" may differ between and within settings and depend upon the program-specific objectives, which may not stem from health-related concerns. The community setting is the most complex and, to date, community-based programs have not demonstrated communitywide changes. Persons responsible for programs need to establish clear objectives before initiating the program. Researchers need to help evaluate the individual programs and identify components of success across different programs.

Recurrent Themes

Several themes recurred throughout the papers and the discussion during the workshop. These can be organized into four major groups.

1. Conceptual. Physical activity, physical fitness, health, and disease are complex concepts—their interrelationships even more so.
2. Methodologic
   a. Measurement issues
   b. Epidemiologic study design issues
3. Major knowledge gaps
   a. Dose-response information, especially the effect of low-level activity
   b. Population subgroup information
   c. Information about children and adolescents
   d. Secular trends
4. Miscellaneous
   a. Benefits and risks are both important and should be considered in concert.
   b. Variability of "certainty" among papers
   c. Omissions of the workshop

Conceptual issues. Physical activity, physical fitness, health, and disease are complex multidimensional concepts that relate to each other via an equally complex array of demographic and cultural variables (fig. 1). Meaningful discussion of their interrelationships, causal or otherwise, requires that the specific dimensions under discussion be described as carefully as possible. The complexity of the potential interrelations should not deter investigation of these relationships or unduly hamper use of current knowledge. It does mean that future research should carefully consider and describe the components of physical activity, fitness, or health with which it is concerned. Equally important, established facts must be accurately presented when they are disseminated, lest unrealistic expectations be engendered.

Methodologic issues. Throughout the set of workshop papers there is a repeated call for reliable and

valid measurement instruments. We do not necessarily need more instruments nor, in all cases, are we certain we need better instruments. We do need to determine precisely what a given instrument measures and how accurately it measures it. The complexity of the concepts under study precludes the possibility that a single instrument will be suitable in all situations. What is needed is that (*a*) the instrument be selected or developed with the specific dimensions of activity, health, or fitness to be studied firmly in mind and (*b*) the accuracy of the instrument be determined.

A second methodologic issue pertained to the most desirable form of epidemiologic study design. Here again, the papers and discussions do not suggest that one kind of design is always superior to all others but rather that the design be appropriate to the goals and objectives of the study. The major types of epidemiologic studies are:

- Observational studies
  - Cross-sectional studies
  - Case-control studies
  - Cohort (longitudinal) studies
- Experimenal (randomized) studies

A large number of the studies of physical activity have been cross-sectional studies or surveys. Assuming adequate attention to the definition of what is being measured, the device to measure it, and the population being studied, cross-sectional studies describe the distribution or range of a characteristic in a population. If performed at regular intervals over a sufficient length of time, cross-sectional studies not only provide information about secular trends—a remarkable gap in our knowledge about physical activity—but they also provide information about differences among cohorts. The cross-sectional study, however, often does not obtain historical information in sufficient detail to estimate the relative risks. Case-control studies do allow an estimate of the relative risk and can be usefully employed to study physical activity. Cohort or longitudinal (that is, time-span) studies allow the calculation of absolute and relative rates and should receive greater emphasis than they have received in the past. Experimental studies with randomization of subjects is the purest design, but often they may be unfeasible, impractical, or unethical.

Overall, the investigation of the relationships between physical activity and health will require (*a*) a greater emphasis on longitudinal studies (both natural history and intervention) and case-control studies; (*b*) more attention to definition, measurement, sampling, and periodicity for cross-sectional studies; and (*c*) some experimental studies.

Figure 1. Relationships between physical activity, physical fitness, health benefits, and sociodemographic variables

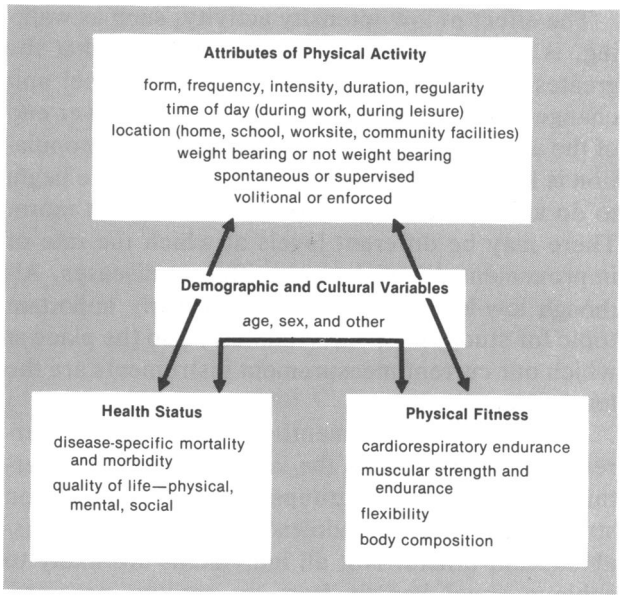
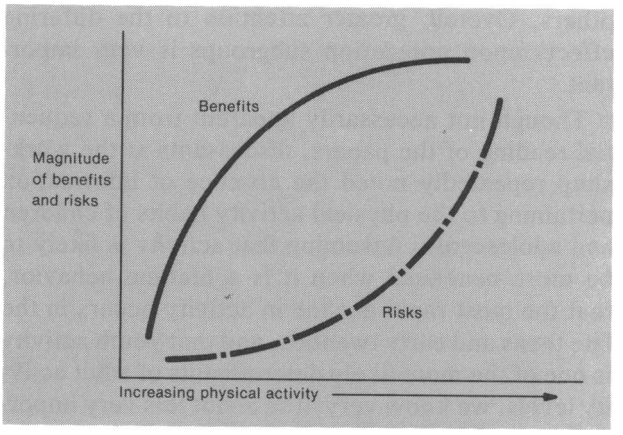


Figure 2. Theoretical relationships of benefits and risks with level of physical activity



Major gaps. In almost every paper, the paucity and necessity of dose-response information are mentioned. This should not be mistaken for the search for a single optimal level below which there is no benefit and above which one reaps full reward. On the contrary, the interest in dose-response information stems from the recognition that dose is probably inversely related to likelihood of participation and from the necessity to compare benefits and risks (as described subsequently), both of which are almost certainly dose-related. The increase in benefits may be greatest at low levels and diminish with increasing activity. Risks, on the other hand,

may be less at lower levels and become increasingly more frequent and severe at higher levels (fig. 2).

The effect of low-intensity activity, such as walking, is of great interest. It appears likely that the greatest gain in the risk-benefit relationship per unit change in physical activity occurs at the lower end of the activity spectrum (*7*). As a whole, the population is likely to benefit more if the least active begin to do a little than if the most active do even more. There may be different levels at which the rate of improvement diminishes for different diseases. Although low-level activity is a particularly important topic for study, it is, unfortunately, also the place at which our current measurement instruments are the least discriminatory.

Another frequently mentioned deficiency of currently available data is the lack of information pertaining to specific subgroups within the population such as children and adolescents, elderly, the disabled, and others. Not all individuals are likely to achieve equal benefit from an activity program. Some groups of persons are more likely to become injured than others, and some are more likely to respond favorably to a specific intervention than others. Overall, greater attention to the differing effects upon population subgroups is very important.

Though not necessarily apparent from a sequential reading of the papers, discussants at the workshop repeatedly noted the absence of information pertaining to the physical activity habits of children and adolescents. Assuming that activity is likely to be more beneficial when it is a lifetime behavior, that the most rapid decline in activity occurs in the late teens and early twenties, and that youth activity is one of the more likely determinants of adult activity levels, we know very little about this very important area. The patterns and determinants of childhood and youth physical activity and the behavioral patterns that are more likely to carry over into adulthood should be ascertained.

The near absence of data that would enable us to examine secular trends in physical activity patterns at a national level is disappointing and discouraging, but not surprising, given the relatively recent interest in this area shown by the public health community. The few data available from national surveys in Canada and opinion polls in the United States suggest a recent increase in leisure-time physical activities (*6*).

During the workshop, unpublished information about secular trends of two selected populations that supports the impression that vigorous leisure time activity has increased was discussed.

A series of studies of men from the northern Midwest dating back to 1957-60 suggest that the average daily caloric expenditure from total leisure-time activity, and especially from vigorous leisure-time activity, has increased. The surveys used similar versions of the Minnesota Leisure Time Physical Activity Questionnaire and included railroad workers (1960), men from Minneapolis and St. Paul who were screened as potential participants in the Multiple Risk Factor Intervention Trial (1975), and recent midwestern population surveys (1979–83), according to a Sept. 25, 1984 personal communication from D. R. Jacobs, Jr., M.D., University of Minnesota School of Public Health.

Data from the surveys of Harvard alumni also show that the amount of leisure-time physical activity has increased in recent years. The methods for the survey of Harvard alumni have been reported (*14,15*). Examination of the percentage of alumni who participated in selected activities shows marked changes in both cross-sectional and birth-cohort frequencies (see table). Although there is a slight decline with age in the proportion of men who reported climbing up 50 or more stairs per day both in the cross-sectional and cohort data, the trend over time is slight. The proportion of men who reported walking five or more blocks daily has no meaningful change with age or time. In contrast, there is a consistent and decided increase in the proportion of men who participated in sports in both cross-sectional (columns) and birth-cohort (diagonals) frequencies. Similar changes occurred in the proportion who played vigorous sports—for example, running, jogging, swimming, court sports (see table).

Generalization to the U.S. population from behavioral changes reported from a series of cross-sectional studies of men in Minnesota and for a cohort of Harvard alumni may not be warranted. However, these data, in combination with the data summarized by Stephens and co-workers (*6*), do provide persuasive evidence that the amount of vigorous leisure-time physical activity has increased in the past 10 to 15 years in the North American population. However, we can neither quantify the increase nor be sure that the increase applies to all subgroups of the population. It is hoped that future surveillance systems will address these issues with a more systematic and quantitative approach.

Miscellaneous. A recurrent theme of discussion was that the benefits and risks cannot be considered in isolation. It may be necessary to study them separately, but the overall effect of physical activity on

Changes over time in specific physical activities among Harvard alumni by cross-sectional age group and by cohort, 1962–77

Activity and survey year	Percentage of subjects by age						
	35–39	40–44	45–49	50–54	55–59	60–64	65–69
Climbed 50 or more steps per day:							
1962	67	68	[1] 57	...	...	...	...
1966	68	70	64	67	65	65	58
1977	...	66	69	62	60	60	57
Walked 5 or more blocks per day:							
1962	78	76	[1] 78	...	...	...	...
1966	77	74	75	77	79	79	76
1977	...	72	75	75	72	77	73
Participated in any sport activity: [2]							
1962	50	52	[1] 38	...	...	...	...
1966	54	52	55	54	47	38	34
1977	...	91	93	88	85	82	81
Participated in vigorous sport activity: [2]							
1962	38	38	[1] 27	...	...	...	...
1966	46	42	40	38	26	18	14
1977	...	83	82	70	71	62	55

1 Based on less than 10 subjects.
2 Sports activity included sports generally considered to require comparatively little energy output (for example, bowling, golf, yardwork). Vigorous sport activity included sports generally considered to require more energy (for example, running, skiing, swimming).

the health of the population requires that both be known, both be studied with equal care, and that both be considered dispassionately. The potential overall beneficial impact of physical activity on health will be poorly served if activity patterns are recommended indiscriminately for all groups without regard for the subgroup-specific benefits and risks.

An inconsistency among the papers is the variation in the degree of certainty of the conclusions. There is no way to establish equivalent criteria of truth for papers dealing with as broad a spectrum of topics as these. In some areas, much has been accomplished and the conclusions are unquestionable; in others, uncertainty remains. For the most part, the authors' claims are conservative. In addition, it should be apparent to the reader that a single study carries less weight of certainty than several, assuming all to be of equivalent quality. We know the most about the reduced risk of cardiovascular disease produced by increased levels of physical activity. In contrast, we know the least about the determinants of physical activity and the rates of adverse affects.

Finally, although quite encompassing, the set of papers omits topics of potential importance. Decisions had to be made about what could be adequately discussed in each paper given the limitations of space. In most instances, topics were excluded because the data were either insufficient in quality or quantity to merit discussion or because the topic seemed of less importance to a series of papers pertaining to public health than to papers devoted to other areas of the health sciences.

In retrospect, some issues probably deserved more attention. For example, topics of particular or unique importance to the health of women and economic issues are not addressed. Although other omissions may be noted, the overall spectrum of public health issues discussed in these papers is remarkable in breadth.

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Physical Activity, Exercise, and Physical Fitness: Definitions and Distinctions for Health-Related Research

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Synopsis

"Physical activity," "exercise," and "physical fitness" are terms that describe different concepts. However, they are often confused with one another, and the terms are sometimes used interchangeably. This paper proposes definitions to distinguish them.

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. The energy expenditure can be measured in kilocalories. Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities. Exercise is a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness. Physical fitness is a set of attributes that are either health- or skill-related. The degree to which people have these attributes can be measured with specific tests.

These definitions are offered as an interpretational framework for comparing studies that relate physical activity, exercise, and physical fitness to health.

THE EPIDEMIOLOGIC STUDY of any concept or event requires that the item under investigation be defined and measured. The common and professional uses of the terms "physical activity," "exercise," and "physical fitness" reveal a need for clarification. This paper, therefore, defines physical activity, exercise, and physical fitness, with the hope that each definition will provide a framework in which studies can be interpreted and compared. Ideally, standardized terminology will promote greater understanding of the relation between physical activity, exercise, physical fitness, and health.

Physical Activity

Several elements of physical activity have been identified (see box page 127). Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. The amount of energy required to accomplish an activity can be measured in kilojoules (kJ) or kilocalories (kcal); 4.184 kJ is essentially equivalent to 1 kcal (*1*). Technically, the kJ is preferred because it is a measure of energy expenditure; however, historically the kcal, a measure of heat, has