Relationships Between Exercise or Physical Activity and Other Health Behaviors

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Synopsis

Physical activity may indirectly influence health behaviors such as overeating, smoking, substance abuse, stress management, risk taking, and others.

Substantial evidence indicates that physical activity is positively associated with weight control and caloric intake. The data weakly support the hypothesis that physical activity and smoking are negatively associated.

Few data are available to evaluate the association between activity and alcohol consumption, alcoholism, substance abuse, stress management, preventive health behaviors, and risk-taking behavior.

The effect of physical activity on the incidence of certain diseases is established (*1,2*), and it appears that these effects are produced through both direct and indirect mechanisms. For example, physical activity may directly help prevent hypertension by lowering elevated plasma catecholamine levels and may indirectly affect hypertension risk by producing weight loss. The full impact of physical activity on health and disease can be appreciated only when both the direct and indirect effects are considered and possible causal mechanisms are described. Some possible relationships by which physical activity might influence disease are presented in the chart. We recognize that these relationships may also go in the other direction—disease may influence physical activity or other health behaviors, or both.

Considerable interest currently exists in how physical activity indirectly influences health by acting through other behaviors, such as smoking or overeating. If these indirect effects can be documented, the relationships are of importance not only to epidemiologic research, but also to health education and health promotion programs.

This is a review of the evidence on the association of exercise and physical activity with other health behaviors, such as smoking or overeating; a summary of existing research; and recommendations for future studies. We consider both voluntary and required activities and use the definitions of exercise and physical activity proposed by Caspersen and coworkers (*3*). Since the focus is on behavior, we will not discuss physical fitness, except as a marker for exercise and physical activity. We found virtually no information on the interrelationships between exercise or physical activity and other health behaviors in children and youth; consequently the discussion is limited to adults.

Methods

We sought scientific articles pertaining to the relationships between exercise and physical activity patterns and smoking, alcohol intake, substance abuse, diet, weight control, stress management, risk-taking behavior, and preventive health examinations both by reviewing known articles and reference lists in those articles and via MEDLINE, one of the data bases of the National Library of Medicine's MEDLARS system. From the extensive list of articles obtained by these procedures, we selected more than 40 for a thorough review based on the title, context of the reference, or contents of the abstract. We excluded articles from final consideration for (*a*) uncertain definition of exercise or physical activity, (*b*) uncertain definition of other health behaviors, or (*c*) incomplete description of the demographic characteristics of the group studied. We examined each article carefully to determine if data relating exercise or physical activity to any of the health behaviors previously listed were presented.

Several problems are encountered in reviewing research on exercise and physical activity (*4*). First, there are no consistent definitions of these terms used by different authors. Also, assessments of exercise and physical activity have been crude and imprecise (*5*); therefore, much misclassification occurs in studies of exercise behavior and, in turn, may obscure the relationships between exercise or physical fitness and other behaviors. To compound the problem, some of the other health behaviors, such as diet and stress management, are equally difficult to assess. Furthermore, many of the papers that report on health behaviors do not present intercorrelations or cross-tabulations of exercise and physical activity with the other behaviors.

In addition to surveying existing research, we conducted new data analyses. Data from the National Survey of Personal Health Practices and Consequences (NSPHPC) and the Behavioral Risk Factor Survey (BRFS) were analyzed by the Center for Health Promotion and Education's Behavioral Epidemiology and Evaluation Branch at the Centers for Disease Control. A NSPHPC data tape from telephone surveys from 1979 and 1980 was provided by the National Center for Health Statistics (NCHS). The BRFS data were collected by telephone interviews during 1981–83 as the first phase of the ongoing CDC-State surveys of behavioral risk factors (*6*). Both surveys have some of the same measurement and misclassification problems described earlier. Two significant strengths of the NSPHPC and BRFS surveys are that there was good quality control of data collection and that the samples are large and representative of the noninstitutionalized United States adult population.

Results

Results are grouped by the association of exercise or physical activity with weight control, diet, smoking, alcohol and other substance abuse, stress management, preventive health behaviors (such as medical or dental checkups), and risk-taking behavior. In many cases we could not determine whether the papers dealt with exercise or physical activity; in those cases, we chose the more general term of physical activity.

Weight control. Although weight is a physical dimension and not a behavior, weight control is determined by the behaviors of exercise, physical activity, and diet. Weight control is discussed separately from diet because of the significance of overweight as a health problem for Americans and the strength of the evidence on the association between physical activity and weight. We focus on the beneficial aspects of this relationship. Negative aspects, such as anorexia nervosa, are discussed by Taylor and coworkers (*2*).

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It is well established that more active individuals weigh less than those who are sedentary. This relationship is supported by extensive epidemiologic research and is confirmed by a great deal of experimental research on humans and animals. Despite the strong link between physical activity and weight, some details regarding specific contributions and mechanisms remain to be explained, and the question of whether or not inactivity is a cause or consequence of overweight remains to be answered.

Physical activity and weight are inversely associated in cross-sectional studies. In the Tecumseh community health study, researchers obtained four skinfold measurements and administered an extensive questionnaire on physical activity to a random sample of community residents (*7*). These population-based data clearly illustrate the association between habitual activity and body fatness. The sum of four skinfolds was 92 for the 273 persons in the least-active category, 87 for the 818 in the intermediate group, and 84 for the 275 residents in the most-active category. The difference between means was significant at $P < 0.05$. Exercise habit is also associated with body mass index (BMI (kg/m^2)) in recent community surveys in Minnesota (*8*), in both men and women at a preventive medicine clinic (*9,10*), and in the NSPHPC and BRFS surveys (table 1).

Prospective and intervention studies confirm the cross-sectional observations. Several excellent reviews on physical activity and overweight have been published recently (*11–14*). Epstein and Wing (*12*) used the technique of meta-analysis. They selected only articles with adequate sample size and design, allowed for quantitative estimation of energy expenditure, and used initially sedentary subjects who were not on planned diets. Sixteen studies met these criteria and were included in the meta-analyses.

Table 1. Percentage[1] of specific health-related behaviors, by level of activity and survey source

Health-related behavior	NSPHPC (N = 2,985) Miles run or jogged per week			BRFS (N = 17,135) Kilocalories per kilogram-day		
	5 or more	1–4	0	3 or more	Less than 3	0
Less than 120 percent of recommended weight	78.4	79.8	74.0	82.7	76.4	71.7
Almost always uses seatbelts	24.9	22.2	18.9	27.5	23.6	19.4
Did not have 5 drinks or more on 1 occasion in past month[2]	....	....	....	79.7	76.5	78.7
Less than 56 drinks per month	82.1	92.4	86.8	92.2	92.6	92.7
Drove after too much to drink[2]	....	....	....	94.6	93.1	93.7
Does not smoke cigarettes	63.4	65.2	60.8	68.8	68.3	63.3
Number of cigarettes smoked per day by smokers[3]	18.7	19.9	22.7	18.6	19.7	21.7
Visits dentist within 12 months[4]	62.3	62.1	57.2	....	....	....
Physical examination within 24 months[4]	73.0	66.8	63.4	....	....	....
Blood pressure checked within 24 months[4]	94.8	92.0	90.7	....	....	....
Pap smear within 24 months[4,5]	81.1	82.8	79.2	....	....	....
Breast examination within 24 months[4,5]	93.4	84.9	82.4	....	....	....
In activity category:						
Number	319	924	1,742	3,530	7,094	6,511
Percent	10.7	31.0	58.4	20.6	41.4	38.0

[1] Adjusted for age, sex, and education.
[2] Data not available for NSPHPC.
[3] Actual number, not percent.
[4] Data not available for BRFS.
[5] Women only.

NOTE: NSPHPC (National Survey of Personal Health Practices and Consequences) raw data obtained from the NCHS (National Center for Health Statistics). BRFS (Behavioral Risk Factor Survey) data obtained from the CDC (Centers for Disease Control).

Epstein and Wing's summary gives a state-of-the-art presentation of what is currently known about exercise and weight. Specifically, they concluded that overweight persons are better characterized as underexercised rather than overfed, exercise produces a reliable and measurable effect on weight loss, little is known about who benefits most from programs, and exercise tends to produce slow weight loss. Other reviewers (*11,13,14*) mention the problem of adhering to an exercise program, the need for combinations of treatment, and the combining of routine and programmed activities as factors contributing to the success or failure of exercise in weight control. Physiologically beneficial effects of exercise in weight control include preservation of lean body mass and the acute effect of exercise on appetite suppression. (*11*).

Diet. Few good studies exist which explore the association between exercise or physical activity and dietary composition. Available data suggest that more active individuals have higher caloric intakes. There appears to be little difference in dietary composition between activity groups. The principles of thermodynamics are valid in the human body; thus, active individuals should have higher caloric intakes than inactive persons. These data have been reported in several cross-sectional studies (*15–18*), although some of the correlations are quite low. In one study, men and women runners reported a caloric intake of approximately 600 kcal a day more than for community controls (*15*). These runners were quite active, the men running 40 miles and the women 35 miles per week. Short and Short reported high caloric intakes (some in excess of 10,000 kcal a day) by competitive university athletes (*19*). Although at least one study (*20*) found no difference in caloric intake between running and nonrunning women, it is reasonable to conclude that higher activity levels require higher caloric intakes, at least when weight is maintained.

If more active persons have higher caloric intakes, what happens when a previously sedentary individual initiates an exercise program? Most exercise training studies have not provided detailed dietary analyses to address this question. Using 3-day records for diet assessment, Wood and coworkers found no difference in total calories or any other nutrients between exercisers and controls over a 1-year period (*21*). Whether this was due to inadequate assessment, insufficient exercise differences between groups (although exercisers ran about 9 miles per week over the last several months), or whether exercise and caloric intake are not related is unclear.

There is, however, a significant correlation ($r = 0.45$) in the exercise group between miles run per week and increase in daily caloric intake. There is also a significant positive correlation between change in caloric intake and change in caloric expenditure (estimated by a 7-day physical activity recall) in the exercisers. There were highly statistically significant increases in total calories (367 kcal) and carbohydrate intake (70 g) in a subset of 14 men from the study just mentioned who were followed for 2 years (*22*). These men were the more enthusiastic runners from the study group and averaged about 12 miles per week by year 2.

Researchers using more precise estimates of energy balance or conducting studies in metabolic disorders report both a positive association (*23,24*) and no association (*25,26*) between energy intake and expenditure. These studies are methodologically superior to the ones previously described; but since the study groups tended to be small and highly selected, the results may not be generalizable.

Individuals may differ in their metabolic responses to diet and exercise and in the efficiency with which fat (relative to starch and protein) is metabolized and stored (*27*). Smokers and nonsmokers may also exhibit different metabolic responses (*28*). These differences notwithstanding, within the boundaries which epidemiologic and design limitations permit, it is correct to state that active persons eat more than inactive persons.

In summary, both logic and the principles of thermodynamics strongly indicate that more active individuals eat more, and starting an exercise program should cause an increase in caloric intake.

It is also important to examine the relationship between physical activity and the composition of the diet. Because active individuals eat more calories, dietary composition should be expressed as a percent of calories or as per 1,000 calories of intake. For example, two people may consume the same number of calories as fat but differ in the percentage of fat in the daily diet because one is more active than the other and, therefore, consumes more calories per day.

Although a few studies (*20,22,29*) report differences in a few nutrients among groups with different levels of activity, nearly all comparisons of nutrient intake (after adjustment for total caloric intake) were not different across activity strata. Alcohol intake was the only dietary component assessed in the NSPHPC and BRFS surveys. Drinking practices did not differ across activity categories (table 1).

Other studies have used less quantitative methods, such as a food-frequency approach and general-eating-practices questionnaire for dietary assessment. Kannas (*30*) found sedentary individuals eat more irregularly and are less likely to have a nutritious breakfast, but the correlations are less than 0.30. The Canada Fitness Survey (*31*) reported that among adults, 51 percent of the active, 45 percent of the moderately active, and 43 percent of the sedentary eat a good breakfast. Treadmill test results can be used to categorize or rank individuals on physical fitness. Although test performance has a genetic component, it is heavily influenced by current physical activity habits. Thus, treadmill test performance can be viewed as a marker for activity status. Women patients from the Cooper Clinic in the higher fitness categories reported lower intake of alcoholic beverages, coffee, and tea (*32*).

Epstein and Wing summarize what is currently known about exercise and weight. Specifically, they conclude that overweight persons are better characterized as underexercised rather than overfed, exercise produces a reliable and measurable effect on weight loss, little is known about who benefits most from programs, and exercise tends to produce slow weight loss.

These differences became trivial in multiple regression analyses, after controlling for other lifestyle and demographic variables. Leon and coworkers also reported an inverse association between treadmill time and coffee, tea, and cola consumption in 175 men (*33*). In a prospective study of more than 900 men at the Cooper Clinic, change in treadmill time was compared with change in reported food frequency (*34*). Changes in fitness and changes in diet were essentially unrelated.

Smoking. It is intuitively appealing to assume that exercise and smoking are incompatible behaviors and thus should be highly negatively associated. Most of the studies we reviewed categorized individuals according to their smoking status, such as nonsmokers, ex-smokers, or current smokers. Some of these papers also report cigarettes smoked per day. The two measures of smoking habit—status and volume—give similar results. Data support the assumption that smoking and physical activity are negatively associated, but not very strongly. Some studies report no association between activity status and smoking behavior (*35–38*); several cross-sectional studies have found a weak negative association between leisure-time physical activity and smoking (*30,39–41*).

Viewed a little differently but with similar results, Folsom and coworkers (*8*) found that men aged 25–44 who do not smoke average 30–35 kcal per day more of high-intensity activity than men who do smoke. Holme and coworkers (*40*) and Bjartveit and coworkers (*39*) report a strong positive association between occupational physical activity and smoking. This observation may be confounded by the influence of socioeconomic status on smoking behavior. Sedentary individuals in the BRFS and NSPHPC surveys were somewhat more likely to be current smokers (table 1). A similar trend across activity categories was found in Canada (*31*). Both the NSPHPC and BRFS surveys found a slight trend toward more cigarettes smoked per day in inactive smokers.

Physical fitness is negatively associated with smoking in multivariate analyses (*10,32,33*). Whether this is indirectly due to an association of exercise or physical activity and smoking or whether smoking decreases treadmill test performance cannot be determined. Folsom and coworkers report a negative association between a metabolic byproduct of smoking (serum thiocyanate) and reported leisure-time physical activity (*8*).

Two recent cohort studies, in which changes in smoking status on physical activity can be examined, do not indicate that increased activity leads to reduced smoking. Smokers in the treatment group of a randomized clinical trial on exercise effects were no more likely than controls to stop smoking during a 1-year study (*22*). Men who increase their physical fitness level are just as likely to continue smoking as men who do not improve (*42*).

Alcohol and other substance abuse. The data on alcohol consumption and physical activity are confusing. The NSPHPC and BRFS surveys show no association between physical activity category and drinking practices (table 1). Higher levels of physical fitness are associated with lower alcohol intake in women (*32*), but not in men (*33*). Physical activity may be positively associated with alcohol consumption (*8,15*), but the findings are inconsistent (*16*). In prospective studies, changes in physical fitness (*34*) or exercise status (*21*) are not associated with changes in alcohol intake.

We found one study on the use of exercise as a treatment for alcoholism (*43*). When compared with nonexercising control groups, exercise group participants had higher abstinence rates at 3 months. Approximately one-third of the controls abstained, whereas two-thirds of the exercisers were abstinent. We found no other data on alcoholism or controlled substance abuse and physical activity. The behavioral, cognitive, and emotional aberrations consequent to alcoholism and substance abuse make it unlikely that the victims of these disorders would engage in a voluntary health practice such as exercise.

Stress management. Exercise has been touted in the lay press as an antidote for stress. We were unable to find any data on the association between exercise or physical fitness and the behavior of stress management (for example, practicing relaxation or "talking it out" with someone). A few recent papers address exercise and Type A behavior pattern (*44*), psychological profile (*45*), reactivity to stress (*46*), and its use as a stress buffer (*47*). A more complete discussion of these issues is given by Taylor and coworkers (*2*).

Preventive health behaviors. Individuals with higher levels of physical activity may be more likely to use preventive health services. Langlie found that the more active adults drawn from a random community survey are also more likely to obtain dental checkups and maintain their immunizations (*35*). Williams and Wechsler report that more active individuals are more likely to obtain medical and dental checkups and have a TB test (*48*).

In the NSPHPC survey, more physically active individuals were more likely to have had both a physical examination and a blood-pressure check within the last 24 months. Women in the NSPHPC survey who were most active were more likely to have had a breast examination in the past 24 months but were not more likely to have obtained a Pap smear (table 1). Adequate sleep may also be associated with physical activity (*48,49*), although the evidence is weak. The generalizability of some of these samples can be questioned, and frequently the assessment of exercise and other behaviors was relatively crude.

Risk-taking behavior. Several authors comment on a positive association between physical activity and seatbelt use, good driving habits, and less general risk taking (*35,48,50*). Demographic variables may confound these results. However, the NSPHPC and BRFS surveys were adjusted for age, sex, and education and also showed a positive association between physical activity level and the prevalence of seatbelt use. It is unreasonable to assume a causal relationship for risk-taking or preventive health examinations and exercise; however, all may be indirectly related to a general orientation of health protection, promotion, or prevention.

Interrelations of health behaviors. Health behaviors may or may not be related. It is well established that clustering of cardiovascular risk factors occurs (*51*). Some of this clustering could be due to a grouping of some health behaviors known to be associated with risk factors. Conversely, demographic or other factors may play a more powerful role.

We found three papers in which a factor analysis was done on several health behaviors (*30,48,52*). Unfortunately, the set of variables is different for the three papers, as are the assessment methodologies for the behaviors. The representativeness of the study populations may be questioned, although two of the samples are drawn from a defined population. Three to five factors emerged from the analyses in these studies. These results indicate that health behavior tends to be multidimensional. In general, exercise variables tended to load on a single factor, although some measure of dietary behavior also loaded on the exercise factor in each of the three reports. This supports the view that there is relatively little overlap between physical activity and other health behaviors, except perhaps for diet.

Summary

Summary information from the papers reviewed in this report is presented in table 2. The studies are classified by design (it should be noted that few cohort or intervention studies have been done), and the references for the associations among physical activity and other health behaviors are listed.

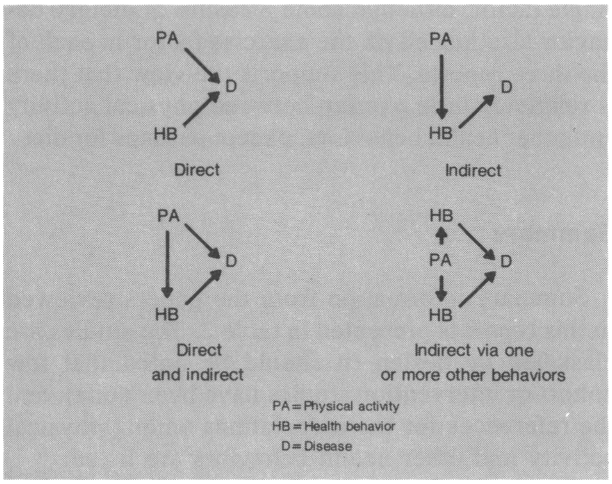
The associations noted in this paper tend to be small, statistically insignificant, or both. Several

Table 2. Summary of reported associations between physical activity and other health behaviors by study design

Health behavior	*Type of associations in cross-sectional studies*	*Type of associations in cohort or intervention studies*
Weight control	Positive—(*7,8,* NSPHPC, BRFS) leisure time activity Positive—(*9,10*) fitness test	Positive—(*11,12,13,14*) review articles
Caloric intake	Positive—(*15,16,17,18*) leisure time activity Positive—(*16,17,18*) occupational activity None detected—(*20*) leisure time activity	Positive—(*22,23,24*) leisure time activity Positive—(*24*) occupational activity None detected—(*21*) leisure time activity None detected—(*25,26*) other measure of activity
Smoking	Positive—(*39,40*) occupational activity None detected—(*35,36,37,38*) leisure time activity None detected—(*37*) occupational activity Negative—(*8,30,39,40,41*, BRFS, NSPHPC) leisure time activity Negative—(*10,32,33*) fitness test	None detected—(*21*) leisure time activity None detected—(*42*) fitness test
Alcohol consumption	Positive—(*8,15*) leisure time activity None detected—(*16*, NSPHPC, BRFS) leisure time activity None detected—(*16*) occupational activity Negative—(*32,*) fitness test	None detected—(*22*) leisure time activity None detected—(*35*) fitness test
Alcoholism	...	Negative—(*43*) leisure time activity
Preventive behavior	Positive—(*35,48*, NSPHPC) leisure time activity Positive—(*48*) occupational activity	
Risk-taking behavior	Negative—(*35,48,50*, NSPHPC, BRFS) leisure time activity Negative—(*48*) occupational activity	

NOTE: italicized numbers match those on the reference list at the end of the paper. NSPHPC is National Survey of Personal Health Practices and Consequences; BRFS is Behavioral Risk Factor Survey.

Associations between physical activity and disease may be direct, indirect, or both



explanations are possible. On the one hand, although generally unpalatable to enthusiasts who hope that physical activity will prove to be the vaccine for unhealthy habits, the reported observations may be true. Physical activity may be unrelated to other healthy behaviors despite our expectations. When related, the relative risk, or the proportion of healthy behavior possibly caused by activity, is disappointingly small. On the other hand, other factors may be operating which, when corrected or better understood, may show the true associations to be stronger than indicated. Misclassification, a problem likely because of the difficulty measuring the behaviors of interest, is likely and will diminish the strength of the apparent association. The incubation period between cause and effect may also produce misclassification if the measurement for some participants is taken after the cause and before the effect.

Finally, perhaps our expectations for physical activity were too high, given the complexity of human behavior. In other words, it is likely that any individual has more than one sufficient cause for a single behavior, such as smoking. Thus, the removal of one sufficient cause will not modify behavior if other sufficient causes remain in force.

What is known. We currently know the following about the relationships between exercise or physical activity and other health behaviors:

1. Even when related, the correlations between activity and other behaviors are low.
2. Habitual physical activity is positively associated with better weight control.
3. High levels of activity are associated with high caloric intake.
4. Smoking may be inversely associated with leisure-time activity. Occupational physical activity is positively associated with smoking habit, although this is likely due to confounding by socioeconomic status.
5. Active individuals may be more likely to engage in some preventive health behaviors.

Recommendations for studies. As we have emphasized throughout this paper, few data are available on the associations between physical activity and other health behaviors. Also, the observed associations tend to be weak. Therefore, many questions remain to be resolved. To help address these major issues, we recommend the following actions:

1. Collect more data on the association between physical activity and stress management behaviors. Very few data are currently available, even though widely held clinical and lay opinion support the use of physical activity for stress management.
2. Conduct intervention studies to determine if vigorous exercise is a useful adjunct to a smoking cessation or alcohol intervention program.
3. Conduct detailed studies to determine the chronic effect of regular physical activity on appetite regulation.
4. Conduct studies on specific population subgroups, such as racial, ethnic, age, and geographic groups. Different settings, such as the worksite or clinical facilities, should also be studied.
5. Conduct studies on the associations between physical activity or exercise and other health behaviors, particularly in children and adolescents. The use of exercise, for example, in a smoking prevention program should be investigated in these age groups rather than in adults whose smoking habits are already established.
6. Conduct studies to refine methods of assessing physical activity (and other health behaviors). Better characterization of the activity pattern of individuals may lead to stronger associations between physical activity and other behaviors, for example, the most active persons may be least likely to smoke.
7. Conduct more detailed investigations to establish a threshold or dose-response relationship in areas where physical exercise appears to be related to other behaviors, such as caloric intake.
8. Use population-based studies to avoid selection bias. Additional analyses on the issues described in this paper should be carried out on the existing

national survey data from the United States and Canada. Additional studies should be done only if more precise characterization of exercise status is obtained. If such studies are conducted, data on physical fitness should also be obtained.

9. Implement cohort studies and, ultimately, randomized clinical trials on physical activity and other health behaviors to address causality issues.

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The Disease-Specific Benefits and Risks of Physical Activity and Exercise

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Synopsis ....

Physical inactivity has been related to the occurrence of coronary heart disease, hypertension, diabetes mellitus, and osteoporosis. The literature was reviewed to determine what is and what is not known about the efficacy and safety of physical activity in each of these conditions.

Although there is a transient increase in the risk of sudden cardiac death during vigorous activity, there is mounting evidence that habitual vigorous activity is associated with an overall reduced risk of coronary heart disease. It is unlikely that this association merely reflects the "selection" that results from sick persons who tend to be less active.

Several studies suggest that physical activity may be related to the prevention and control of hypertension, diabetes mellitus, and osteoporosis. However, additional research is needed to make explicit the risks and benefits of physical activity in each of these conditions.

Finally, future efforts should determine the type, intensity, frequency, and duration of activity required to maximize the benefits and minimize the hazards of physical activity. The public health and clinical significance of these questions requires that they be examined in the most rigorous manner feasible.