Physical Activity and Women's Health

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A NOTE FROM THE EDITORS

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HIGHLIGHT

> "We have failed—in physical education and medicine—to clarify for women the importance of habitual physical activity, physical fitness, and maintenance of 'normal' body weight. We must mount new educational efforts to develop culturally sensitive and ethnic-specific health messages and programs."

Many more women are active today compared to when the first studies of activity in America were conducted. However, as a group, girls and women are still less active than boys and men. Some of this difference in activity between males and females can be explained by the historical disparity in opportunities for females. Since 1972, when Title IX was implemented, more females have become involved in organized sport. We have yet to discover the effects of this increased participation on lifetime activity among females.

Much of the literature concerning health benefits of physical activity is based on studies done primarily with men. Only recently have large-scale studies been initiated to investigate the effects of physical activity on women's health and wellness. Chris Wells, the author of this paper, has been a pioneer in the study of physical activity for women. As you will see, much more research studying girls and women is necessary, but much has been accomplished in recent years. Diseases often thought to be "diseases of men" affect women as well as men. The evidence now suggests there are many health benefits for females who become regularly involved in physical activity.

This article clearly shows that women, especially women of color, are more likely to be sedentary. Sedentary living increases risk of heart disease, various cancers, hypertension, stroke, and non-insulin diabetes. Controlling body fatness, another factor that is related to increased risk of chronic diseases, is also associated with inactivity. Continued efforts that focus on increasing physical activity among girls and women will reduce the risk of chronic diseases and death.

INTRODUCTION

Healthy People 2000 sets forth the nation's health goals for the next decade (Public Health Service, 1990). One of three primary goals is to reduce health disparities among Americans. This goal addresses reducing preventable disease and death from chronic diseases among racial and ethnic minorities in the United States. Also of importance is the disparity that exists among women as compared to men and among women of different racial and ethnic groups. It is significant that of eight priorities for health promotion and disease prevention, increased physical activity and fitness leads the list. If we could *increase* physical activity and *decrease* obesity, the reasoning goes, much of the premature death, disease, and disability of high-risk populations could be virtually eliminated. But, what is the relationship between physical activity and health in women? Can a strong case be made for increasing physical activity in women as a primary preventive measure for major chronic disease? Will increasing physical activity reduce risk of disease and improve the health and wellness of women? Is physical activity as beneficial for women as research has shown it to be for men?

This paper will address this issue by presenting the growing body of evidence for the beneficial relationships between physical activity (including exercise and physical fitness) and the major chronic diseases in women, with special reference to race and ethnicity. It will be evident that American women need to make significant lifestyle modifications to alter their health risks, and that health and educational professionals must mount new efforts to develop culturally appropriate and sensitive health programs and educational materials.

But, first, how physically active are American women?

HOW PHYSICALLY ACTIVE ARE AMERICAN WOMEN?

The most current data on habitual physical activity are from the Behavioral Risk Factor Surveillance System (BRFSS), a state-based, random-digit-dialed telephone survey that collects self-reported information from a representative sample of people 18 years of age and older. In 1992, BRFSS data were available from 55,506 women from 48 states and the District of Columbia (Prevalence of recommended levels . . . , 1995). These women were asked about the frequency, duration, and intensity of their leisuretime physical activity (LTPA) during the preceding month. Respondents were categorized as having (1) no LTPA, (2) irregular activity that did *not* meet the recommended criteria for either vigorous physical activity (≥20 minutes per day of vigorous physical activity on ≥3 days per week) or the newer moderate activity recommendation (accumulation of >30 minutes per day of moderate activity on ≥5 days per week) (Summary Statement, CDC and ACSM, 1993). Only 27.1 % of these women reported participation in recommended activity levels, and 30.2% reported no leisuretime physical activity whatsoever. The prevalence of no LTPA increased with age from 25.6% among women 18 to 34 years to 42.1 % among women over age 65. Racial/ethnic disparity was clearly evident. Black non-Hispanic women were less likely to be active (43.6%) than Hispanic women (40.2%) or white non-Hispanic women (27.6%). Physical inactivity was inversely related to income. Women with ≤$14,999 annual household income were most likely to have no LTPA (40.2%), and women with ≥$50,000 annual income were least likely to have no LTPA (21.2%).

BRFSS data from 1991 and 1992 were combined to increase precision of prevalence estimates for minority populations (Prevalence of selected . . . , 1994). Sedentary lifestyle was defined as reported participation in fewer than three 20-minute sessions of LTPA per week excluding usual job-related physical activity. A sedentary lifestyle was reported most frequently among black women (68%) and least frequently among white women (56%). When racial/ethnic data were further stratified by level of education, the prevalence of sedentary lifestyle varied inversely with education within all five population groups. These data are shown in Table 8.1.

TABLE 8.1

Prevalence of sedentary lifestyle in U.S. women, by race, ethnicity, and education level. Behavioral risk factor surveillance system, United States, 1991–1992.

Women	White	Black	Hispanic	Asian/ Pacific Islander	American/ Alaskan Native
Sedentary Lifestyle	56.4	67.7	61.9	64.1	64.7
Education Level					
<12 years	72.0	78.2	73.6	76.6	68.5
12 years	63.3	70.0	58.2	70.5	70.0
>12 years	48.8	59.5	53.4	49.9	62.4

Adapted from: Prevalence of selected risk factors for chronic disease by education level in racial/ethnic populations—United States, 1991–1992. *Morbidity and Mortality Weekly Report, 43(48),* pp. 895, 897. December 9, 1994.

Other estimates of physical activity among American women have been equally low. Caspersen et al. (1986) estimated that 30.2% of American women were sedentary, 31.3% were irregularly active, 31.5% were regularly active at low levels of intensity, and that only 7% of women were sufficiently active to achieve the 1990 physical activity objectives for the nation. Ford et al. (1991) reported that women of higher socioeconomic status (SES) living in Pittsburgh spent significantly more time per week in LTPA, job-related physical activity, and household physical activity than did lower SES women. They estimated that only 7% of lower SES women expended ≥2,000 kcal/week, the energy expenditure linked to lower allcause mortality in college alumni (Paffenbarger et al., 1986), compared to 16.8% of higher SES women.

Under the general assumption that low habitual energy expenditure results in obesity (excessive body fat), another way to estimate population specific physical activity is to assess body weight relative to height. BRFSS data on prevalence of overweight using body mass index (BMI = weight in kilograms divided by height in meters squared) ≥27.3 as the definition of overweight, indicates that black women have the highest prevalence of overweight (37.7%), followed by American Indian/ Alaskan Native women (30.3%), Hispanic women (26.5%), white women (21.7%), and Asian/Pacific Islander women (10.1%) (Prevalence of selected . . . , 1994). In addition, the prevalence of overweight varied inversely with level of education with all five population groups. Except for the low prevalence of overweight in Asian/Pacific Islander women, these values correspond to those of Table 8.1 for sedentary lifestyle.

LEADING CAUSES OF MORTALITY IN AMERICAN WOMEN

In 1990, four of the ten leading causes of death in American women were chronic diseases directly associated with modifiable behavioral factors including physical inactivity or sedentary lifestyle. They were heart disease, certain forms of cancer (specifically, breast and colon cancers), cerebrovascular disease (hypertension and stroke), and non-insulin-dependent diabetes mellitus (NIDDM) (National Center for Health Statistics, 1993). McGinnis and Foege (1993) summarized reports that attributed dietary factors and sedentary lifestyles with 22 to 30% of cardiovascular deaths, 20 to 60% of cancer deaths, and 30% of diabetes deaths. The only more prominent behavioral contributor to mortality than diet and physical inactivity was use of tobacco.

Table 8.2 presents age-adjusted mortality rates for chronic diseases associated with sedentary lifestyle in U.S. women by race and ethnicity. Coronary heart disease (CHD) and cerebrovascular disease (stroke) are the two leading causes of death in all five population groups. Diabetes ranks as the third leading cause of death from chronic disease in black, Hispanic, Native American/Alaskan Native, and Asian/Pacific Islander women (exceeding death rates from lung cancer, breast cancer, chronic obstructive pulmonary disease, and colorectal cancer) (Centers for Disease Control, 1994).

TABLE 8.2

Age-adjusted mortality rates*, U.S. women, 1990.

Native	American/ Islander	Asian/	Alaskan	Pacific	White	Black	Hispanic	Native
CHD	130.2	148.3	147.1	74.5	73.7			
Stroke	45.8	68.7	45.4	31.4	43.7			
Breast Cancer	29.1	33.4	25.0	12.1	11.9			
Colorectal	17.0	22.9	15.0	9.7	9.9	Cancer		
Diabetes	14.8	37.1	27.6	1.0	11.8			

*Rate per 100,000 persons adjusted to the 1980 standard U.S. population.

Adapted from: Centers for Disease Control and Prevention (1994). *Chronic Disease in Minority Populations,* pp. C-3–C-4, Atlanta, GA: Centers for Disease Control and Prevention.

Morbidity data correspond closely to mortality data. Table 8.3 provides age-adjusted prevalence of chronic disease in U.S. women between 1986 and 1990. Health disparities among racial/ethnic groups are evident with exceedingly high morbidity from chronic diseases that are major causes of death among black, Hispanic, and Native American/Alaskan Native women compared to white and Asian/Pacific Islander women.

TABLE 8.3

Age-adjusted prevalence* of chronic disease, U.S. women, 1986–1990.

Native	American/ Islander	Asian/	Alaskan	Pacific	White	Black	Hispanic	Native
Hypertension	10.96	19.73	10.55	13.82	8.35			

Diabetes	2.36	4.89	3.53	5.04	2.38
Coronary Heart Disease	1.83	1.42	3.53	n.a.	n.a.
Stroke	0.98	1.20	1.10	n.a.	n.a.

*Per 100,000.

Adapted from: Centers for Disease Control and Prevention (1994). *Chronic Disease in Minority Populations,* Atlanta, GA: Centers for Disease Control and Prevention.

The remainder of this paper will describe evidence linking sedentary lifestyle/physical inactivity with diseases of the heart, hypertension and stroke, breast and colorectal cancer, and non-insulin-dependent diabetes mellitus.

PHYSICAL INACTIVITY AND DISEASES OF THE HEART IN WOMEN

According to the American Heart Association, in 1991, 51.8% of all deaths from "total cardiovascular diseases" occurred in women (American Heart Association, 1994). The National Heart, Lung, and Blood Institute (Public Health Service, 1992) reports that one in ten women 45 to 64 years of age has some form of heart disease, and that this increases to one in four in women over age 65. Major modifiable risk factors include smoking, high blood cholesterol, high blood pressure, and physical inactivity. The following discussion will exclude smoking.

Physical activity and blood cholesterol in women. A blood lipid profile that places an individual at risk consists of elevated total cholesterol (TC), elevated low-density lipoprotein-cholesterol (LDL-C), and elevated triglycerides (TG). High levels of high-density lipoprotein-cholesterol (HDL-C) are considered protective from CHD. Women generally have higher HDL-C and lower LDL-C values than men prior to menopause. This is attributed to estrogen, which interferes with the uptake of LDL-C in arterial walls. Following menopause, HDL-C values decline, LDL-C values increase, and TC values increase, sometimes well above those of age-matched men.

Following a meta-analysis to examine the effect of exercise training on serum lipids in women, Lokey and Tran (1989) concluded that training was associated with lower TC, TG, and TC/HDL-C, but not to changes in HDL-C or LDL-C. The average age of the subjects was 29.5 years, and the women with the most atherogenic lipid profiles benefited the most. In 20- to 40-year-old women, 24 weeks of walking yielded an increase in HDL-C independent of walking intensity (Duncan et al., 1991). In the Healthy Women's Study, a longitudinal study that is following originally premenopausal women through menopause, women with higher physical activity had the least age-related weight gain and the least decline in HDL-C (Owens et al., 1992). At the beginning of the study, only women reporting >2000 kcal/week energy expenditure had significantly better profiles for TC, TG, LDL-C, and HDL_2-C (Owens et al., 1990).

In their review, Shoenhair and Wells (1995) concluded that cross-sectional data strongly support an inverse relationship between current physical fitness and TC, TG, TC/HDL-C, and HDL-C/LDL-C. HDL-C values appear to be elevated in only the most highly fit women. Pre- and postmenopausal athletes have less atherogenic lipid profiles than sedentary or less active women matched for age and menopausal status (Rainville & Vaccaro, 1984; Harting et al., 1984; Stevenson et al., 1995).

Physical activity and blood pressure in women. In the Healthy Women's Study, systolic blood pressure was lower in women expending >500 kcal per week, and diastolic blood pressure was lower in those expending >1000 kcal/week compared to sedentary women (Owens et al., 1990). In the Stanford Community Health Survey, lower diastolic blood pressure was associated with both vigorous exercise (Sallis et al., 1986a) and moderate intensity exercise (Sallis et al., 1986b). In 1991, Reaven et al. reported a significant inverse relationship between physical activity and blood pressure in women. They reported that the most active women had systolic blood pressures 9–24 mmHg lower and diastolic blood pressures 3–13 mmHg lower than the least active women after accounting for differences in body mass index.

A strong relationship also appears to exist between physical fitness and blood pressure in women. In the Aerobics Center Longitudinal Study, Gibbons et al. (1983) reported that cardiovascular fitness was independently associated with lower blood pressure. In Canadian women, blood pressure was significantly lower in subjects with the highest fitness classification (Jette et al., 1992).

Physical inactivity and cardiovascular disease in women. Very few studies have been completed on physical inactivity and CVD in American women (for an extensive review including international literature, see Schoenhair & Wells, 1995). In a homogeneous population of 17,000 Seventh-Day Adventist women, a population at relatively low risk for CVD, occupational and leisuretime activity was combined and subjects were grouped into three activity classifications. A strong inverse relationship was found between physical activity and CHD mortality. Relative risk ratios for the "high," "moderate," and "low" activity groups were .41, .61, and 1.0, respectively (Fraser et al., 1992). After 24 years of observation, an active lifestyle lowered the age-adjusted incidence of CHD and myocardial infarction in Framingham women by a factor of 2.5 (Kannel & Sorlie, 1979).

In a classic prospective study of allcause mortality in the predominantly white, upper SES population of the Aerobics Center Longitudinal Study, Blair et al. (1989) reported a strong inverse relationship between cardiorespiratory fitness and death from cardiovascular disease. Women in the lowest quintile of physical fitness had an age-adjusted death rate from cardiovascular disease of 7.4 (per 10,000 person-years) compared to 2.9 and 0.8 for women in fitness groups 2–3 and 4–5. Women in the lowest fitness category had an age-adjusted relative risk of 8.0 when compared with women in fitness quintiles 4 and 5.

In summary, there is strong observational and experimental evidence that physical inactivity plays a significant role in the development of cardiovascular disease in women, and that habitual physical activity and at least a moderate level of cardiorespiratory fitness offers protection from these diseases in women as well as in men.

PHYSICAL INACTIVITY, HYPERTENSION AND STROKE IN WOMEN

Nonfatal stroke is the leading cause of disability among American women. Risk factors for stroke include hypertension, heart disease, and smoking. Approximately two-thirds of all stroke victims have hypertension (HT). Until age 64, HT is more prevalent in men, and thereafter is more prevalent in women (Cowley et al., 1992). There is increasing prevalence of HT with age, and wide disparity among race/ethnic groups ranging from 2% in young white women to 83% in black women over 65 (Public Health Service, 1990, p. 392).

In the subjects originally studied by Gibbons et al. (1983), and followed for one to 12 years, Blair et al. (1984) reported that low physical fitness was an independent contributor to the risk of developing hypertension (RR = 1.52) after controlling for sex, age, baseline blood pressure, baseline body mass index, and follow-up interval. In a related study, lower fitness was significantly related to the increased incidence of nonfatal stroke (Blair et al., 1989).

A strong inverse relationship between LTPA and death from stroke was observed in postmenopausal women (Paganini-Hill et al., 1988). Those who were physically active less than 30 minutes per day had twice the age-adjusted mortality from stroke as women who were active at least one hour per day.

Although there is less research available, it seems clear that habitual physical activity reduces the risk of hypertension in women, and consequently, is a primary preventive measure against stroke.

PHYSICAL INACTIVITY AND BREAST AND COLORECTAL CANCERS IN WOMEN

Data on cancer relative to physical activity have been inconsistent and difficult to interpret because cancer represents not one disease, but many distinct, site-specific diseases. To further complicate the situation, risk factors are specific to each disease. Nevertheless, over the past decade, increasing evidence indicates that physical activity is associated with decreased overall cancer mortality and decreased incidence of specific types of cancers (Sternfeld, 1992; Lee, 1995). The cancer site most frequently studied in relation to physical activity is colon cancer, and findings overwhelmingly support an inverse relationship. The two most likely potential mechanisms by which physical activity may be protective of colon cancer are (1) shortened intestinal transit time, and (2) decreased levels of body fat. Shortened intestinal transit time is thought to decrease the amount of contact between possible carcinogenic substances and intestinal mucosa, but evidence remains controversial on this matter. For several cancers (including colon and breast cancers), high levels of body fat are associated with increased risk.

Most research on physical activity and colon cancer has focused on occupational physical activity in men. Clearly, men with sedentary jobs have increased risk of colon cancer (Sternfeld, 1992). One of the most comprehensive studies that included women was a case-control study of Utah residents that took into account differences in dietary patterns and body weight, confounding factors not usually controlled (Slattery et al., 1988). Comparing both occupational and leisuretime activities, the sedentary individuals of both sexes were at nearly two-fold increased risk for colon cancer.

The relationship between physical activity and breast cancer is less clear, but several studies in American women suggest that risk may be lowered in those who are habitually active. An extensive review of this subject is now available including international studies (Kramer & Wells, 1996). Only studies utilizing American subjects are reviewed here. In 1985, Frisch et al. assessed prevalence of breast cancer in 5,398 former collegiate women athletes and nonathletes from 10 colleges and universities from classes spanning 56 years. A higher percentage of former athletes reported they were currently exercising than nonathletes. Comparing the prevalence of breast cancer between the two groups, the nonathletes had 1.85 times the risk of the former athletes, strong evidence for an inverse relationship between lifetime physical activity and breast cancer.

From the National Health and Nutrition Examination Survey database (NHANES I), Albanes et al. (1989) examined breast cancer incidence relative to baseline recreational and nonrecreational physical activity levels. After 10 years of follow-up, premenopausal women with high levels of activity were associated with slightly *increased* risk of breast cancer. Among postmenopausal women, however, high physical activity conferred a protective effect.

More recently, Bernstein et al. (1994) studied the *timing* of physical activity relative to estrogen exposure in premenopausal women from Los Angeles County. Using a case-control study design, they report a strong dose response relationship between leisuretime exercise since menarche and decreased risk of breast cancer. Women reporting 3.8 or more hours per week of exercise since menarche had a 50% reduction in breast cancer risk. A 30% reduction was observed in women reporting one to three hours per week of exercise since menarche. A slightly weaker relationship was observed among nulliparous women. The observed benefit of exercise was attributed to reduced exposure to endogenous estrogen subsequent to shorter luteal phases and higher incidence of anovulatory menstrual cycles. An even more recent study (Thune et al., 1996) confirmed the beneficial relationship between physical activity and breast cancer and reported the largest benefits in premenopausal women, the period when age-specific mortality rates for breast cancer are highest.

High to moderate levels of habitual physical activity may decrease lifetime exposure to endogenous sex hormones in two ways: (1) prior to menopause, high levels of physical activity may delay menarche, decrease the number of ovulatory cycles, and hence reduce exposure to endogenous estrogen (Frisch et al., 1980; Bernstein et al., 1987), and (2) following menopause, maintenance of low levels of adipose tissue may mediate the conversion of androgenic compounds to extraglandular estrogen (Siiteri, 1987; Hershcopf & Bradlow, 1987).

In summary, lifetime physical activity appears to reduce the risk of colon cancer and breast cancer in white women, but there is an obvious need to incorporate minority women into future research on these topics.

PHYSICAL INACTIVITY AND NON–INSULIN-DEPENDENT DIABETES MELLITUS IN WOMEN

About 14 million Americans have diabetes, with 95% having non–insulin-dependent diabetes mellitus (NIDDM). Tables 8.2 and 8.3 indicate that certain minority women have exceedingly high mortality and prevalence rates from this adult-onset chronic disease. Diabetes is a leading cause of death in women, and a leading cause of adult blindness, leg and foot amputations, circulatory disease, kidney failure, and birth defects. In NIDDM, the pancreas may secrete insulin, but cells and tissues of the body are insulin resistant, and consequently, patients are characterized by high levels of insulin (hyperinsulinemia) and blood glucose (hyperglycemia). Those at highest risk for NIDDM include the overweight or obese, and particularly, those over 40 years of age (American Diabetes Association, 1992).

According to the American Diabetes Association (1990), an appropriate exercise program should be an adjunct to diet and/or drug therapy to improve glycemic control, reduce cardiovascular risk factors, and increase psychological wellbeing in women with NIDDM. Individuals who are most likely to respond favorably are those with moderate glucose intolerance and hyperinsulinemia. Unfortunately, findings from the 1990 National Health Interview Survey (Ford & Herman, 1995) indicate that women with diabetes are less likely to report exercising regularly than women without diabetes. A comparison of the effects of exercise on insulin sensitivity in women with NIDDM recently revealed that low intensity exercise was as effective as high intensity exercise in enhancing insulin sensitivity (Braun et al., 1995). Duration of the two exercise regimes was adjusted so that energy expenditure was equal. This is important because obesity, diabetic complications, and general lack of physical fitness are common in women with glucose intolerance or NIDDM. Prescription of low intensity exercise is no doubt safer and more practicable, especially for older women with NIDDM. A recent community-based study (San Luis Valley Diabetes Study) also demonstrated this. Higher levels of physical activity were associated with improved insulin action in individuals with impaired glucose tolerance (Regensteiner et al., 1995), further supporting the concept that habitual physical activity reduces incidence of impaired glucose tolerance and lowers morbidity from NIDDM.

Two studies directly indicate that habitual physical activity in women is a promising approach to the primary prevention of NIDDM. In one, Frisch and colleagues (1986) report a significantly lower prevalence of diabetes among every age group (20 to more than 70 years) in 5,398 women who engaged in long-term athletic activity compared to their nonathletic classmates. In the other investigation, reduced incidence of NIDDM among women who exercised regularly was observed in a prospective cohort of 87,253 women 34 to 59 years (Manson et al., 1991).

In summary, regular physical activity has an important role in both treatment and prevention of NIDDM through its association with reduced body weight, and its independent effects on insulin sensitivity and glucose tolerance.

OBESITY, MORBIDITY, AND MORTALITY IN WOMEN

Data from nationally representative cross-sectional surveys reveal that prevalence of overweight in U.S. women has increased in all age groups since the 1960s (Kuczmarski et al., 1994). These data also indicate that the prevalence of obesity is substantially higher in black, Hispanic, Pacific Islander, and Native American and Alaskan Native women than in white women (Kuczmarski et al., 1994; Kumanyika, 1993). Altogether, about 32 million American women are overweight or obese. In addition, the particularly high-risk upper-body fat distribution (central adiposity) occurs to a greater extent in some minority populations than in whites (Kumanyika, 1993).

High body weight or weight gain since age 18 in women has been associated with coronary heart disease (Willett et al., 1995), allcause mortality (Manson et al., 1995), and hyperinsulinemia (fasting insulin and insulin following glucose load) (Wing et al., 1992). Lowest mortality among U.S. women was observed in those who weighed at least 15% less than the U.S. average for women of similar age and whose weight had been stable since early adulthood (Manson et al., 1995).

Clearly, high body weight and body fat in women is related to increased incidence of coronary heart disease, hypertension, NIDDM, breast cancer, and allcause mortality. Greater attention to prevention and treatment of obesity in minority populations may help to address critical health issues in American women (St Jeor, 1993).

CONCLUSION

There is an obvious national shortfall in closing the gap in health disparities among Americans—especially, American women. We have failed—in physical education and sport, and in medicine—to clarify the importance of habitual physical activity, physical fitness, and maintenance of "normal" body weight to good health. One major reason is that we have attempted to use health messages, programs, and approaches based on white, middle-class values and culture, and then wondered why they were not enthusiastically embraced. Research and educational efforts must focus on conceptually based programs in schools and communities that are culturally sensitive and ethnic-specific.

REFERENCES

Albanes, D., Blair, A., and Taylor, P.R. (1989). Physical activity and risk of cancer in the NHANES I population. *American Journal of Public Health, 79,* 744–750.

American Diabetes Association. (1992). Alexandria, VA.

American Diabetes Association. (1990). Diabetes mellitus and exercise. Position statement of the American Diabetes Association. *Diabetes Care, 13,* 804–805.

American Heart Association. (1994). *Heart and stroke facts: 1995 statistical supplement*. Dallas, TX: American Health Association.

Bernstein, L., Henderson, B.E., Hanisch, R., Sullivan-Halley, J., & Ross, R.K. (1994). Physical exercise and risk of breast cancer in young women. *Journal of the National Cancer Institute, 86,* 1403–1408.

Bernstein., L., Ross, R.K., Lobo, R.A., Hanisch, R., Krailo, M.D., & Henderson, B.E. (1987). The effects of moderate physical activity on menstrual cycle patterns in adolescence: Implications for breast cancer prevention. *British Journal of Cancer, 55,* 681–685.

Blair, S.N., Goodyear, N.N., Cooper, K.H., & Smith, M. (1984). Physical fitness and incidence of hypertension in healthy normotensive men and women. *Journal of the American Medical Association, 252,* 487–490.

Blair, S.N., Kohl, H.W., Paffenbarger, R.S., Clark, D.G., Cooper, K.H., & Gibbons, L.W. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of the American Medical Association, 262,* 2395–2401.

Braun, B., Zimmermann, M.B., & Kretchmer, N. (1995). Effects of exercise intensity on insulin sensitivity in women with non-insulin-dependent diabetes mellitus. *Journal of Applied Physiology, 78,* 3000–3036.

Caspersen, C.J., Christenson, G.M., & Pollard, R.A. (1986). Status of the 1990 physical fitness and exercise objectives—evidence from NHIS 1995. *Public Health Reports, 101,* 587–592.

Centers for Disease Control and Prevention. (1994). *Chronic disease in minority populations.* Atlanta: Centers for Disease Control and Prevention.

Cowley, A.W., Jr., Dzau, V., Buttrick, P., Cooke, J., Devereux, R.B., Grines, C.L., Haidet, G.C., & Thames, M.C. (1992). Working group on noncoronary cardiovascular disease and exercise in women. *Medicine and Science in Sports and Exercise, 24,* S277–S287.

Duncan, J.J., Gordon, N.F., & Scott, C.B. (1991). Women walking for health and fitness: How much is enough? *Journal of the American Medical Association, 266,* 3295–3299.

Ford, E.S., & Herman, W.H. (1995). Leisure-time physical activity patterns in the U.S. diabetic population. *Diabetes Care, 18,* 27–33.

Ford, E.S., Merritt, R.K., Heath, G.W., Rowell, K.E., Washburn, R.A., Kriska, A., & Heile, G. (1991). Physical activity behaviors in lower and higher socioeco-nomic status populations. *American Journal of Epidemiology, 133,* 1246–1256.

Fraser, G.E., Strahan, T.M., Sabate, J., Beeson, W.L., & Kissinger, D. (1992). Effects of traditional coronary risk factors on rates of incident coronary events in a low-risk population: The Adventist Health Study. *Circulation, 86,* 406–413.

Frisch, R.E., Wyshak, G., Albright, N.L., Albright, T.E., Schiff, I., Jones, K.P., Witschi, J., Shiang, E., Koff, E., & Marguglio, M. (1985). Lower prevalence of breast cancer and cancers of the reproductive system among former college athletes compared to nonathletes. *British Journal of Cancer, 52,* 885–891.

Frisch, R.E., Wyshak, G., Albright T.E., Albright, N.L., & Schiff, I. (1986). Lower prevalence of diabetes in female former college athletes compared with nonathletes. *Diabetes, 35,* 1101–1105.

Frisch, R.E., Wyshak, G., & Vincent, L. (1980). Delayed menarche and amenorrhea in ballet dancers. *New England Journal of Medicine, 303,* 17–19.

Gibbons, L.W., Blair, S.N., Cooper, K.H., & Smith, M. (1983). Association between coronary heart disease risk factors and physical fitness in healthy adult women. *Circulation, 67,* 977–983.

Harting, G.H., Moore, C.E., Mitchell, R., & Kappus, C.M. (1984). Relationship of menopausal status and exercise level to HDL cholesterol in women. *Experimental and Aging Research, 10,* 13–18.

Hershcopf, R.J., & Bradlow, H.L. (1987). Obesity, diet, endogenous estrogens, and the risk of hormone-sensitive cancer. *American Journal of Clinical Nutrition, 45,* 283–289.

Jette, M., Sidney, K., Quenneville, J., & Landry, F. (1992). Relation between cardiorespiratory fitness and selected risk factors for coronary heart disease in a population of Canadian men and women. *Canadian Medical Association Journal, 146,* 1353–1360.

Kannel, W.B., & Sodie, R. (1979). Some health benefits of physical activity: The Framingham study. *Archives of Internal Medicine, 139,* 857–861.

Kramer, M.M., & Wells, C.L. (1996). Does physical activity reduce risk of estrogen-dependent cancer in women? A review. *Medicine and Science in Sports and Exercise, 28,* 322–334.

Kuczmarski, R J., Flegal, K.M., Campbell, S.M., & Johnson, C.L. (1994). Increasing prevalence of overweight among US adults: The National Health and Nutrition Examination Surveys, 1960 to 1991. *Journal of the American Medical Association, 272,* 205–211.

Kumanyika, S.K. (1993). Special issues regarding obesity in minority populations. *Annals of Internal Medicine, 119,* 650–654.

Lee, I. (1995). Physical activity and cancer. *PCPFS Physical Activity and Fitness Research Digest, 2(2).* Washington, DC: PCPFS.

Lokey, E.A., & Tran, Z.V. (1989). Effects of exercise training on serum lipid and lipoprotein concentrations in women: A meta-analysis. *International Journal of Sports Medicine, 10,* 424–429.

Manson, J.E., Rimm, E.B., Stampfer, M.J., Colditz, G.A., Willett, W.C., Krolemki, A.S., Rosner, B., Hennekens, C.H., & Speizer, F.E. (1991). Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. *The Lancet, 338,* 774–778.

Manson, J.E., Willett, W.C., Stampfer, M.J., Colditz, G.A., Hunter, D.J., Hankinson, S.E., Hennekens, C.H., & Speizer, F.E. (1995). Body weight and mortality among women. *New England Journal of Medicine, 333,* 677–685.

McGinnis, J.M., & Foege, W.H. (1993). Actual causes of death in the United States. *Journal of the American Medical Association, 270,* 2207–2212.

National Center for Health Statistics. (1990). Advance Report of Final Mortality Statistics, 1990. Hyattsville, MD: Department of Health and Human Services, 1993. *Monthly Vital Statistics Report, 41(7).*

Owens, J.F., Matthews, K.A., Wing, R.R., & Kuller, L.H. (1990). Physical activity and cardiovascular risk: A cross-sectional study of middle-aged premenopausal women. *Preventive Medicine, 19,* 147–157.

Owens, J.F., Matthews, K.A., Wing, R.R., & Kuller, L.H. (1992). Can physical activity mitigate the effects of aging in middle age women? *Circulation, 85,* 1265–1270.

Paffenbarger, R.S., Jr., Hyde, R.T., Wing, A.K., & Hsieh, C.C. (1986). Physical activity, allcause mortality and longevity of college alumni. *New England Journal of Medicine, 314,* 605–613.

Pagagini-Hill, A., Ross, R.K., & Henderson, B.E. (1988). Postmenopausal estrogen treatment and stroke: A prospective study. *British Medical Journal, 297,* 519–522.

Prevalence of recommended levels of physical activity among women—Behavioral Risk Factor Surveillance System, 1992 (1995). *Morbidity and Mortality Weekly Report, 44(6),* 105–108.

Prevalence of selected risk factors for chronic disease by education level in racial/ethnic populations, United States, 1991–1992 (1994). *Morbidity and Mortality Weekly Report, 43(48),* 894–899.

Public Health Service. (1990) *Healthy people 2000: National heath promotion and disease prevention objectives*. Washington, DC: Department of Health and Human Services. Publication PHS 91-50212.

Public Health Service. (1992). *The healthy heart handbook for women.* National Heart, Lung and Blood Institute, National Institutes of Health, Washington, DC: NIH publication no. 92-2720.

Rainville, S., & Vaccaro, P. (1984). The effects of menopause and training on serum lipids. *International Journal of Sports Medicine, 5,* 137–141.

Reaven, R.D., Barrett-Connor, E., & Edelstein, S. (1991). Relation between leisure-time physical activity and blood pressure in older women. *Circulation, 83,* 559–565.

Regensteiner, J.G., Shetterly, S.M., Mayer, E.J., Eckel, R.H., Haskell, W.L., Baxter, J., & Hamman, R.F. (1995). Relationship between habitual physical activity and insulin area among individuals with impaired glucose tolerance: The San Luis Valley Diabetes Study. *Diabetes Care, 18,* 490–497.

Sallis, J.F., Haskell, W.L., Wood, P.D., Fortmann, S.P., & Vranizan, K.M. (1986a). Vigorous physical activity and cardiovascular risk factors in young adults. *Journal of Chronic Diseases, 39,* 115–120.

Sallis, J.F., Haskell, W.L., Fortmann, S.P., Wood, P.D., & Vranizan, K.M. (1986b). Moderate-intensity physical activity and cardiovascular risk factors: The Stanford Five-City Project. *Preventive Medicine, 15,* 561–568.

Shoenhair, C.L., & Wells, C.L. (1995). Women, physical activity, and coronary heart disease: A review. *Medicine, Exercise, Nutrition, Health, 4(4),* 200.

Siiteri, P.K. (1987). Adipose tissue as a source of hormones. *American Journal of Clinical Nutrition, 45,* 277–282.

Slattery, M.L., Schumacher, M.C., Smith, K.R., West, D.W., & Abd-Elghany, N. (1988). Physical activity, diet and risk of colon cancer in Utah. *American Journal of Epidemiology, 128,* 989–999.

St Jeor, S.T. (1993). The role of weight management in the health of women. *Journal of the American Dietetic Association, 93,* 1007–1012.

Sternfeld, B. (1992). Cancer and the protective effect of physical activity: The epidemiological evidence. *Medicine and Science in Sports and Exercise, 24,* 1195–1209.

Stevenson, E.T., Davy, K.P., & Seals, D.R. (1995). Hemostatic, metabolic, and androgenic risk factors for coronary heart disease in physically active and less active postmenopausal women. *Arteriosclerosis, Thrombosis, and Vascular Biology, 15,* 23–31.

Summary Statement Workshop on Physical Activity and Public Health. (1993). Centers for Disease Control and Prevention and American College of Sports Medicine. *Sports Medicine Bulletin, 24(4),* 7.

Thune, I., Brenn, T., Lund, E., & Gaard, M. (1996). Physical activity and the risk of breast cancer. *New England Journal of Medicine, 336,* 1269–1275.

Willett, W.C., Manson, J.E., Stampfer, M.J., Colditz, G.A., Rosner, B., Speizer, F.E., & Hennekens, C.H. (1995). Weight, weight change, and coronary heart disease in women: Risk within the "normal" weight range. *Journal of the American Medical Association, 273,* 461–465.

Wing, R.R., Matthews, K.A., Kulter, L.H., Smith, D., Becker, D., Plantinga, P.L., & Meilahn, E.N. (1992). Environmental and familial contributions to insulin levels and change in insulin levels in middle-aged women. *Journal of the American Medical Association, 268,* 1890–1985.