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ABSTRACT

This paper reviews the relationships between physical fitness and body composition and their combined effect on health. After discussing the epidemiologic evidence for a protective effect of physical fitness on the health risks associated with obesity, it describes the Aerobics Center Longitudinal Study, an ongoing observational study that provides data on the relationships between physical fitness and a variety of health outcomes, as well as other studies. Epidemiologic evidence demonstrates a strong protective effect for physical activity and physical fitness on the health risks associated with obesity. Probable mechanisms for the protective effect of physical activity include the reduction and/or reversal of the development of a progressive disease process known as insulin-resistance syndrome, which is closely associated with obesity. A major benefit of physical activity is that it leads to specific reductions in levels of abdominal obesity and induces beneficial metabolic changes that limit the underlying disease process related to fat and dyslipidemia, hypertension, hyperinsulinemia, reduced glucose sensitivity, and ultimately non-insulin dependent diabetes mellitus. Overall, research suggests that the health risks of obesity are largely controlled if a person is physically active and physically fit. (Contains 28 references.) (SM)

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Research Digest
Physical Activity Protects Against the Health Risks of Obesity

President's Council on Physical Fitness and Sports

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President's Council on Physical Fitness and Sports

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Physical Activity Protects against the Health Risks of Obesity

Introduction

Considerable attention has been placed on the increasing prevalence of obesity in our society. One population-based study (Mokdad et al., 1999) indicated that the prevalence increased from 12 to 18.9% from 1991 to 1998. Another study (Troiano & Flegal, 1998), using a different set of national data, indicated that the prevalence of obesity increased from 14.5% to 22.5% over the past 2 decades. The trends are similar for men and women and are consistent across different ages and socioeconomic classes. While all of these data are cross-sectional, the magnitude and repeatability of the changes suggest that these trends reflect real changes in the population prevalence of obesity.

There are major public health consequences associated with these trends. Obesity has been linked to a variety of serious diseases and metabolic disorders including Type II diabetes, hypertension, dyslipidemia, coronary heart disease, gall bladder disease, respiratory diseases, various cancers and osteoarthritis (Pi-Sunyer, 1999). The direct economic costs of treating obesity in the United States are estimated at over 70 billion dollars (Colditz, 1999). The fact that obesity increases with age combined with the rapidly expanding elderly population suggests that the problems are likely to even get worse in the near future. These trends are troubling and have caused obesity to be recognized as one of the leading public health problems facing our society. The World Health Association released a report on preventing and managing the global epidemic of obesity (World Health Association, 1998). At the same time, the National Institutes of Health released a report on the identification, evaluation and treatment of overweight and obesity (National Institutes of Health, 1998). In 1999, the American College of Sports Medicine convened a meeting to describe the role of physical activity in the prevention and treatment of obesity and its co-morbidities. These recent developments reveal the current emphasis being placed on addressing the obesity epidemic.

Because there is little reason to suspect changes in genetics over this short time frame, the most common explanation for the recent trends in obesity is that a variety of environmental and behavioral influences have combined to make it harder for individuals to maintain weight balance. Hill & Melanson (1999) recently presented a conceptual model describing some of these influences. The model suggests that the availability of high fat, energy dense foods, coupled with large portion sizes and low costs of fast foods have combined to drive up energy intake. Conversely, declines in work related physical activity, reduced activity of daily living and increases in sedentary behavior tend to drive down daily energy expenditure values. While some of these changes may be subtle, they appear to be exerting large influences on the population.

Obesity is clearly a multifactorial problem but there is some evidence that physical inactivity may play a more pivotal role in the overall process. An ecological review of secular trends (Jebb & Moore, 1999) recently suggested that the prevalence of obesity is more strongly related to decreases in energy expenditure than to increases in energy intake. DiPietro (1999) reached a similar conclusion in a review of studies on the prevention of weight gain. She indicated that habitual physical activity plays a critical role in attenuating the age-related weight gain that is commonplace in our society. She further suggested that an increasing amount of activity might be needed to maintain a constant body weight with age.

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While physical inactivity appears to be a strong contributing factor to the etiology of obesity, studies on the effectiveness of physical activity in promoting weight loss have been less than encouraging. Because physical activity increases energy expenditure, it is reasonable to assume that the combination of diet plus exercise would be more effective than dieting alone for weight loss. A recent review of 13 controlled studies found that this is rarely the case (Wing, 1999). Only two of the 13 studies reported statistically significant differences in weight loss from the diet plus exercise regimen compared to diet alone. The conclusion from this review was that "*...exercise does not significantly increase initial weight loss over and above that obtained with diet only.*" When the effect of exercise on weight loss was studied without corresponding dietary modifications, exercise was found to promote weight loss in only one of five randomized controlled trials (Ross & Janssen, 1999).

These results present a confusing picture. Physical activity is clearly viewed as being essential to the prevention of weight gain but fairly ineffective (at least in clinical trials) at promoting weight loss. On an individual level, the failure of exercise to contribute to weight loss in a predictable manner could be a major deterrent to continued involvement in an exercise program. Overweight individuals who begin an exercise program would likely remain motivated only if they see some changes in body composition resulting from their efforts.

On the positive side, recent evidence suggests that physical activity confers health benefits that are largely or entirely independent of changes in body composition. These findings suggest that overweight and obese individuals can obtain the same benefits of physical activity as lean individuals. While the overall health benefits of physical activity have become well accepted, the general assumption (even among many within the scientific community) has been that the benefits are contingent or dependent on corresponding changes in body composition. While physical activity can lead to changes in body composition, the amount of change depends on an individual's genetics, individual variability in metabolism and possibly other lifestyle behaviors. The cellular and metabolic adaptations occurring as a result of physical activity appear to be independent of these changes. Therefore, an overweight or obese person can have good cardiovascular health as long as he/she remains active and possesses a reasonable level of fitness. This is clearly an important message that should be conveyed to individuals who have struggled with weight control all their lives.

The purpose of this article is to review the relationships between physical fitness and body composition and their combined effect on health[2]. First we will review the epidemiological evidence for a protective effect of physical fitness on the health risks associated with obesity. Probable mechanisms for this protective effect will then be described. A summary of these observations will focus on the implications of these findings for the treatment and prevention of obesity.

Epidemiological Evidence for the Protective Effect of Physical Activity

The science of epidemiology is predicated on identifying and explaining causes of diseases in the population. The general approach is to compare the prevalence or rates of diseases in populations exposed to certain potential risk factors against populations not exposed to these risk factors. This is typically evaluated with a statistic known as a relative risk ratio (death rate in those exposed to a risk factor/death rate in those not exposed to that factor). Different exposure variables are studied to identify the factors that increase risks for specific diseases or outcomes. In these studies, it is important to discount other competing explanations through progressive advances in design and more complex analyses. Examples from the Aerobics Center Longitudinal Study will be used to describe the progression of epidemiological research used to examine the protective effects of physical activity/physical fitness on the health risks associated with obesity.

The Aerobics Center Longitudinal Study

The Aerobics Center Longitudinal Study (ACLS) is an on-going observational study of individuals who have come to the Cooper Clinic in Dallas, Texas for preventive medical examinations. A major strength of the database is that objective measures of cardiorespiratory fitness from maximal exercise treadmill tests are included in the comprehensive medical exam. This has allowed the relationships between physical fitness and a variety of health outcomes to be examined in a large cohort over an extended period of time.

Preliminary evidence for a protective effect of fitness came from a study focused primarily on the benefits of cardiorespiratory fitness for reducing risks of all cause mortality (Blair et al., 1989). As a way to document the persistence of these effects, comparisons were made for individuals in three different categories of body mass index - BMI (< 20, 20-25 and > 25). In these analyses, individuals in the bottom 20% of the age and sex group distribution for treadmill time were classified as unfit and

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those in the top 40% were classified as high fit. The results suggested that fit individuals with higher BMI values had lower mortality rates than unfit individuals with low BMI's. Because this study only examined moderate levels of overweight (BMI > 25), additional confirmation was required to test the strength of the findings.

A subsequent study (Barlow, Kohl, Gibbons, & Blair, 1995) was conducted to examine similar relationships among a larger sample (nearly 26,000) of men across three higher BMI ranges (< 27, 27-30 and > 30). In all three BMI categories, moderately fit individuals and highly fit individuals were found to have lower relative risk for all-cause mortality than individuals in the unfit category. A follow-up study (Lee, Jackson, & Blair, 1998) repeated the analyses after excluding men with previous myocardial infarction, stroke or cancer at baseline and adjusting for exam year, smoking habit and alcohol intake. The definition of unfit participants was the same as in previous studies but in this study, all individuals above the 20th percentile were classified as "fit". Comparisons also were made using the fit and lean individuals (< 25 BMI) as the reference group rather than making comparisons separately for each BMI category. Unfit individuals in each BMI category had greater risk of dying as compared with the fit and lean group (relative risks ranged from 1.68 to 2.24). An interesting observation from this study was that there were no differences in relative risk for fit individuals in the three different BMI categories. Fit overweight men had no greater risk than fit lean men (See Figure 1).

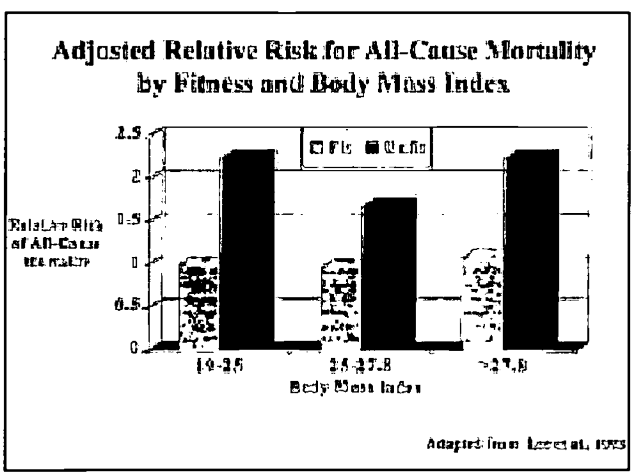

Figure 1.

A limitation of the previous studies was a reliance on BMI as the indicator of body composition. To address this issue, another study (Lee, Blair, & Jackson, 1999) examined the relationship of cardiorespiratory fitness to mortality with more specific measures of body composition. The study evaluated the risks for all-cause mortality among men who had received a body composition assessment (either sum of 7 skinfolds or underwater weighing) and a cardiorespiratory fitness assessment. Individuals were classified as lean if they had body fat levels less than 16.7%, normal if they had body fat levels from 16.7 - 25% and obese if they had body fat levels greater than 25%. Relative risks for unfit individuals ranged from 1.62 to 2.07 compared with lean and fit men (See Figure 2). The investigators also examined the relationships on a subsample of participants who also had waist circumference measurements. These participants were divided into 3 waist girth strata (< 87 cm, 87 to 99 and > 99). The relative risks for these comparisons were even higher – ranging from 2.05 to 4.88. The greatest risk was found for the lean unfit group but this may have been due to the smaller sample from this particular category. The main message from the study was that risks are higher for unfit men at all three waist circumference categories.

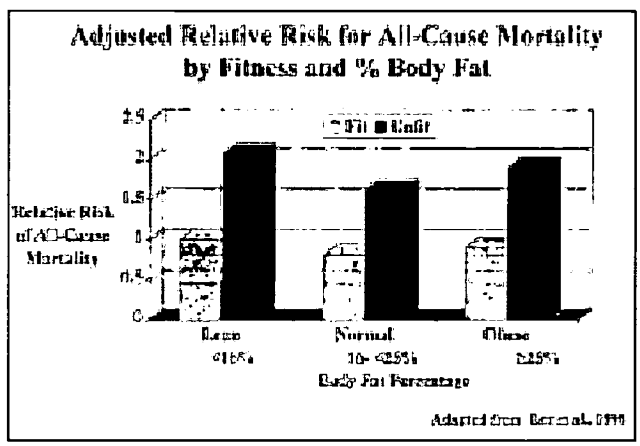

Figure 2.

The most comprehensive analysis on the topic compared the relative importance of various cardiovascular risk factors on cardiovascular disease and all-cause mortality across different body composition categories (Wei et al., 1999). In this study, the investigators categorized men from the ACLS database into three different BMI levels (< 25, 25-29.9 and > 30) and then sub-classified by the presence or absence of six different mortality predictors (cardiovascular disease, type II diabetes, cholesterol,

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hypertension, current smoking status, and low fitness). Low fitness was found to be an independent predictor of mortality in all body mass index groups even after adjusting for all of the other mortality predictors. This suggests that being unfit is a risk that adds to the risks already associated with other risk factors. The magnitude of the relative risks for low fitness in this study was as high or higher than those for the other established co-morbidities.

Summary of Epidemiological Evidence

The studies reviewed above demonstrate a strong protective effect for physical activity and physical fitness on the health risks associated with obesity. Consistent differences in health risks were evident between fit and unfit individuals among all body composition categories. Persistence in the proposed protective effect is also evident in the fact that the results have been found to be similar for a number of different indicators of body composition, including BMI, body fatness, fat free mass and waist circumference. These effects were also found to be independent of potential confounding variables as well as the presence of other risk factors. While the relationships reviewed here were demonstrated with fitness as an outcome, similar relationships have been reported in studies using physical activity as the primary exposure variable (Paffenbarger & Hyde, 1984). Additional work is needed but the current findings provide compelling evidence to support the view that the health risks of obesity can be largely managed through physical activity.

The reason this evidence has been relatively slow to surface is that few epidemiological studies have examined physical activity and body composition as related, but independent, exposures. With respect to health, studies linking physical activity and fitness with health typically control for some aspect of body composition. In contrast, studies linking body composition with health have rarely considered the moderating influence of physical activity and fitness. The erroneous assumption has been that overweight or obese individuals would, by default, be unfit. In a comprehensive review of the current literature on this topic, Blair and Brodney (1999) identified 24 articles that evaluated health outcomes across levels of both physical activity/fitness and some indicator of body composition. Sufficient data were available to summarize outcomes of all-cause mortality, coronary heart disease, hypertension, type 2 diabetes mellitus and cancer. The studies consistently showed that active or fit men and women were protected against the health risks of overweight or obesity. The authors concluded that "...active obese individuals actually have lower morbidity and mortality than normal weight individuals who are sedentary." (p. S646).

Probable Mechanisms for a Protective Effect

Physical activity provides protection against the health risks of obesity primarily by reducing and/or reversing the development of a progressive disease process known as insulin-resistance syndrome or Syndrome X. This syndrome is closely associated with obesity and is characterized by the clustering of insulin resistance and hyperinsulinemia, dyslipidemia, essential hypertension, glucose intolerance, and an increased risk of non-insulin dependent diabetes mellitus and cardiovascular disease (Landsberg, 1996; Opara & Levine, 1997; Timar, Sestier, & Levy, 2000). Before describing the moderating influence of physical activity, the general mechanisms underlying insulin resistance syndrome will first be described.

While research is still accumulating on the specific mechanisms, the general disease process is related to the presence of abdominal body fat - particularly visceral fat (Despres, 1993; Chisholm, Campbell, & Kraegen, 1997). Abdominal body fat is characterized by an increased responsiveness to lipoprotein lipase. Because of its high lipolytic activity, abdominal adipocytes readily release free fatty acids (FFA) into the circulation. These FFA are carried directly to the liver through the portal circulation where they are converted into very-low density lipoproteins (VLDL) and ultimately LDL cholesterol. The high levels of FFA may also lead to enhanced lipid oxidation and reduced glucose oxidation. These changes can result in high levels of blood glucose and lead to a reduced sensitivity to insulin. The increased levels of FFA in the portal circulation also act directly to inhibit insulin clearance by the liver resulting in hyperinsulinemia. High levels of insulin in the presence of elevated glucose tend to promote reductions in insulin sensitivity and hasten the development of non-insulin dependent diabetes mellitus. The increased insulin levels also are associated with increases in blood pressure as insulin is thought to increase sodium retention in the kidney. Thus, high levels of abdominal obesity are directly related to dyslipidemia (elevated levels of LDL and triglycerides), hypertension, hyperinsulinemia, reduced glucose sensitivity and ultimately non-insulin dependent diabetes mellitus.

Physical activity induces beneficial metabolic changes

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that limit the progression of this underlying disease process. A major benefit of physical activity is that it leads to specific reductions in levels of abdominal obesity (Ross & Janssen, 1999). The enhanced lipolytic activity of these fat cells allows fatty acids to be released and metabolized more readily than other fat depots. While overall weight loss from exercise is limited, studies have indicated that changes in abdominal body fat levels can occur without corresponding weight loss or total fat loss. Studies have also demonstrated that physical activity has a direct effect on improving overall metabolic profiles (e.g. normalization of insulin levels and improved glucose homeostasis). In a review of these studies (Kelley & Goodpaster, 1999), the improvements in insulin action were found to occur without concomitant changes in weight and/or body composition. While there appears to be some chronic adaptations that occur as a result of regular exercise performed over a period of time, there are also observations that indicate that some benefits are related to the acute effects following individual bouts of activity. The fact that physical activity exerts some of its positive influence independent of changes in body composition is consistent with the findings from the epidemiological studies reviewed earlier.

Summary and Conclusions

The general assumption in our society is that overweight or obese individuals are probably physically inactive and unfit. Conversely, most people would assume that a thin individual is probably physically active, physically fit and healthy. These characterizations are gross oversimplifications and don't take into account the complex metabolic relationships that influence body composition, fitness and health. It is clearly possible for overweight individuals to maintain high levels of fitness. Through participation in regular physical activity, it is also possible for overweight individuals to have good health and low risks for chronic disease.

While the public health concerns about the increasing prevalence of obesity are well founded, they may be misplaced. The epidemiological studies reviewed here suggest that the health risks of obesity are largely controlled if a person is physically active and physically fit. The protection appears to come, at least in part, from positive metabolic changes that occur as a result of regular participation in physical activity. Because most of these changes have been found to occur independent of changes in body composition it may prove more successful to promote physical activity for its own sake - without emphasizing or expecting corresponding changes in body composition. If a larger percentage of the population became physically active, the public health burden associated with obesity would be greatly reduced. This conclusion should not be interpreted to dismiss the health risks associated with obesity, but rather to emphasize the moderating influence of physical activity and physical fitness on these risks. The implications of this distinction for the clinical treatment of obesity and for health promotion in general are described below.

Implications for Treatment

With regard to treatment, physicians routinely counsel patients about the health risks of obesity and typically prescribe various weight loss treatments to address the issue. Guidelines published by the National Institutes of Health (1998) recommend that physicians test for the presence of other coexisting diseases (co-morbidities) such as diabetes and hypertension since the presence of additional risk factors has been shown to compound overall health risks. The results reviewed here suggest that low fitness (and/or lack of physical activity) should be considered as equally important when evaluating health status of overweight or obese individuals. As previously stated by Wei et al., (1999), it is as important for a clinician to assess an obese patient's fitness status as it is to measure fasting plasma glucose an cholesterol, evaluate blood pressure and inquire about smoking habits.

Implications for Health Promotion

Weight loss is frequently cited as one of the most common reasons for beginning an exercise program. In light of the negative results from studies on physical activity and weight loss, continued efforts in this direction may be counterproductive. Many obese individuals have become frustrated with exercise since their efforts often do not lead to corresponding changes in weight or body composition. Rather than encouraging these individuals to lose weight it is more appropriate and probably more effective to encourage them to just become physically active. If regular physical activity is performed, physical fitness will improve to the extent possible and lead to positive metabolic outcomes. These changes will provide significant benefits for health regardless of any changes in body weight. The focus on behavior rather than an outcome (e.g. weight loss) also offers motivational advantages for obese individuals since it increases the likelihood that they can be successful and feel positive about their efforts. Specific guidelines and strategies for using physical activity in this way have previously been published (Leermakers, Dunn, & Blair, 2000).

It is important to point out that only modest amounts of physical activity are needed to attain some protection against the health effects of obesity. The cutpoints used to define the high risk (low fitness) category in the ACLS is the lowest 20% of the age-specific fitness distributions for both men and women. When expressed in absolute levels of fitness, the cutpoints for young adults (20-39 years) are approximately 8.1 and 10.5 METS (or a VO2 max of 28 – 35 ml/kg/min), for women and men, respectively. Similar cutpoints for middle aged adults (40-59 years) are approximately 7 and 9.5 METS (or a VO2 max of 25 – 33 ml/kg/min) . These fitness levels can be achieved with modest amounts of physical activity. A recent study examining activity levels of ACLS participants (Stofan, DiPietro, Davis, Kohl, & Blair, 1998) indicated that an average leisure time energy expenditure of 525 to 1650 kcal per week for males and 420 to 1260 kcal/week for females were associated with moderate to high levels of fitness. These levels of activity can easily be attained by following the current public health guidelines for physical activity, which recommend 30 minutes of moderate activity on most days of the week (Pate et al., 1995).

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The PCPFS enlists the active support and assistance of individual citizens, civic groups, private enterprise, and voluntary organizations to promote and improve the physical activity and fitness of all Americans and to inform the public of the important link which exists between regular activity and good health.

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Physical Activity and Fitness Quote

"If a larger percentage of population became physically active, the public health burden associated with obesity would be greatly reduced. This conclusion should not be interpreted to dismiss the health risks associated with obesity, but rather to emphasize the moderating influence of physical activity and physical fitness on these risks."

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[1]The concepts behind this originated while Dr. Welk was the Director of the Childhood and Adolescent Health Division, Cooper Institute.
[2] Much of the content for the present article was based on the recent ACSM Roundtable meeting and the subsequent publication of various review articles (Blair & Bouchard, 1999).

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