Physically active men and women may be less likely than their sedentary peers to become overweight. Caloric restriction in overweight persons produces larger weight losses than does exercise, although more of the weight loss by dieting is from lean body mass. The addition of exercise to diet intervention produces more weight loss than does dieting alone. Exercise has a favorable effect on body fat distribution, with a reduction in waist-to-hip ratio with increased exercise. Exercise is especially important in maintaining weight loss in overweight persons. Several prospective studies have shown that overweight men and women who are active and fit have lower rates of morbidity and mortality than overweight persons who are sedentary and unfit. Therefore, exercise is of benefit to overweight persons, even if it does not make them lean. Exercise is recommended as an important part of a weight control program.

One can evaluate the relation of exercise to body weight control from several perspectives. Physiologists and endocrinologists may be interested in the effect of exercise on basal metabolic rate, fat cell size and distribution, and dietary-induced thermogenesis, whereas psychologists may be concerned about the possible effect of exercise on body image and self-concept, feelings of well-being, and adherence to an exercise plan. Clinicians may focus their attention on the role of exercise in ameliorating disease risk. The perspective taken here is that of epidemiology and public health, with an emphasis on the relation of exercise to weight control and on morbidity and mortality in overweight or obese persons. The topics presented here include brief discussions of the role of exercise in the prevention of weight gain, the effect of exercise on weight loss and maintenance, and exercise and health risks in overweight persons.

Articles selected for this brief review included recent, large, population-based, prospective studies of weight gain in active and sedentary persons; comprehensive review articles of exercise and weight loss; recent large, well-controlled, randomized clinical trials on exercise and weight loss and maintenance; recent representative studies on exercise and body fat distribution; and the most recent population-based, prospective studies on the relation of activity or fitness on morbidity and mortality in overweight men and women. The studies were selected because they contained clear definitions of activity and fitness assessment, relatively complete follow-up, and sound methods (random assignment in the clinical trials and prospective design in the population-based studies).

Exercise and the Prevention of Overweight

Prevention of overweight or obesity depends on long-term maintenance of an isocaloric state. The two principal components of caloric balance are energy intake and energy expenditure. Cross-sectional surveys show that obese persons probably eat fewer calories, or
perhaps the same amount of calories, as do persons of normal weight [1,2]. No convincing evidence exists to suggest that obesity is caused by an excessively high absolute caloric intake. Cross-sectional studies show that caloric expenditure in the obese is less than, or perhaps equal to, expenditure in persons of normal weight [1,2]. Male and female runners report caloric intakes (that are 500 to 600 kcal/d) higher than those of sedentary community controls, yet the runners remain far leaner than their sedentary counterparts [3]. Interpretation of these cross-sectional data is difficult and is complicated by variation in measurement techniques (caloric intake and expenditure are sometimes reported as total calories and sometimes as calories per kilogram of body weight).

The role of exercise in the prevention of overweight is clarified somewhat by new data from prospective population studies. Rissanen and colleagues [4] described the determinants of weight gain in a representative cohort of 6165 women and 6504 men 25 to 64 years old in Finland. These persons were examined in mobile health clinics from 1966 to 1972 and again from 1973 to 1976 (average duration of follow-up, 5.7 years). Significant weight gain (≥ 5 kg in 5 years) occurred in 15.1% of the women and in 17.5% of the men. Adjusted relative risks with 95% CIs for significant weight gain across leisure-time physical activity categories (frequent, occasional, rare) were 1.0, 1.5 (95% CI, 1.1 to 2.0), and 1.6 (CI, 1.2 to 2.2) in women and 1.0, 1.5 (CI, 1.2 to 2.0), and 1.9 (CI, 1.5 to 2.3) in men for the three activity categories, respectively. These relative risks were adjusted for smoking behavior, alcohol and coffee intake, health status, and sociodemographic factors. These investigators also reported results from a later survey (1978 to 1980) of a representative sample of 5673 Finnish men and women 30 to 64 years old. The prevalence of distinct overweight (body mass index (BMI) ≥ 30 kg/m²) was 15.8% for women and 11.3% for men. Adjusted relative risks for distinct overweight were greater than 2.0 for both men and women when rare and frequent leisure-time physical activity categories were compared.

Williamson and colleagues [5] reported on 10-year weight gain in 3515 men and 5810 women in the National Health and Nutrition Survey-I Epidemiologic Follow-up Study. Recreational physical activity was assessed at baseline and at follow-up by questionnaire, and weight was measured at both examinations. Persons classified as having low levels of physical activity at both assessments were more likely to have a weight gain of more than 13 kg than were persons classified as having high levels of physical activity at both examinations. The relative risks for weight gain for low compared with high activity were 2.3 (CI, 0.9 to 5.8) in men and 7.1 (CI, 2.2 to 23.3) in women. This study provides the strongest evidence currently available that remaining physically active may help to prevent age-related weight gain.

We evaluated possible determinants of weight gain in 10 221 men at high risk for coronary heart disease who were participants in the Multiple Risk Factor Intervention Trial (MRFIT) (Unpublished data). Weight gain was defined as an increase in body weight (> 5% of baseline weight) over the course of the study (6 or 7 years). Multiple regression models showed that weight gain was positively associated with initial weight, smoking cessation, relapse after smoking cessation, attempts to quit smoking, and initiation of diuretic medication during the first year of the trial. Baseline physical activity, an increase in activity level during the trial, and age were inversely associated with weight gain. Men who were sedentary at baseline or who did not increase their activity during the trial also were more likely to have greater amounts of weight fluctuation during the course of the study.

Effectiveness of Exercise in Weight Loss
Weight-loss results when a person maintains a negative energy balance for a period of time. The usefulness of increased physical activity in attempts to lose weight is controversial. Most controlled exercise training studies show modest weight loss (usually 2 to 3 kg) in the treated group compared with controls [2]. Nonetheless, some reviewers conclude that "exercise alone appears largely ineffective regarding weight loss" [6], and others suggest that "exercise alone may be useful" [2]. There are factors that may contribute to the confusion surrounding this issue. First, the degree of obesity is probably important. A moderately overweight person (90 kg, for example) who loses 5 kg in a walking program might be considered a treatment success. On the other hand, a 5-kg loss due to an exercise program for a person who weighs 120 kg could be considered inconsequential. A second issue is the length of the study period [2]. Many overweight or obese persons are so unfit that they cannot sustain caloric expenditure sufficient to achieve or maintain a negative energy balance. A sedentary, obese person may require several months to become fit enough to exercise at a level that burns a significant number of calories [7]. Finally, a serious methodologic limitation results from the fact that some of the exercise studies did not evaluate diet, just as many diet studies did not assess exercise habits.

King and Tribble [2] recently reviewed studies on exercise and weight loss. Eleven of these studies included an intervention of exercise plus diet. The average weight loss for patients in these studies after the acute intervention phase was 8.5 kg. All these studies also had a "diet only" group in which the average weight loss was 6.7 kg. The modest additional weight loss of slightly less than 2 kg is consistent with the findings of an earlier extensive review of exercise alone on weight loss by Wilmore [8]. He concluded that exercise training results in modest decreases in total and fat weight as well as in a small increase in lean body weight. The average reduction in the percentage of body fat in the 55 studies reviewed by Wilmore was 1.6%. Wood and colleagues [9] reported a recent study (not included in King's review) in which diet alone and diet plus exercise were evaluated in a large (119 men and 112 women), well-controlled, 1-year randomized trial. The results of this trial are shown in Table 1. The groups combining diet with exercise lost more weight and more fat and had a greater improvement in the abdomen-to-hip ratio than did the groups using diet alone, although the differences were not statistically significant in women. Patients combining diet with exercise achieved this greater success despite having a slightly smaller energy intake deficit. Wood and colleagues also found that the participants using diet plus exercise had greater improvements in their lipoprotein profiles.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Baseline</th>
<th>Control</th>
<th>Diet Only</th>
<th>Diet plus Exercise</th>
<th>Change after 1 Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 119)</td>
<td>(n = 40)</td>
<td>(n = 40)</td>
<td>(n = 39)</td>
<td>(n = 112)</td>
</tr>
<tr>
<td>Body weight, kg</td>
<td>98.4 ± 9.7</td>
<td>17.4 ± 4.8</td>
<td>-5.1 ± 5.8</td>
<td>-8.7 ± 5.7</td>
<td>75.0 ± 7.6</td>
</tr>
<tr>
<td>Fat weight, kg</td>
<td>27.7 ± 5.9</td>
<td>12.8 ± 3.8</td>
<td>-4.1 ± 2.2</td>
<td>-7.8 ± 4.9</td>
<td>26.9 ± 5.4</td>
</tr>
<tr>
<td>Abdomen:hip ratio</td>
<td>0.97 ± 0.04</td>
<td>0.90 ± 0.02</td>
<td>-0.02 ± 0.02</td>
<td>-0.04 ± 0.03</td>
<td>0.87 ± 0.06</td>
</tr>
<tr>
<td>Aerobic power, ml/kg/min/²</td>
<td>3.41 ± 4.9</td>
<td>-0.2 ± 4.1</td>
<td>1.6 ± 5.0</td>
<td>8.6 ± 5.7</td>
<td>27.0 ± 4.2</td>
</tr>
<tr>
<td>Energy intake, kJ/day</td>
<td>10647 ± 2372</td>
<td>155 ± 2627</td>
<td>-2915 ± 2577</td>
<td>-2268 ± 2870</td>
<td>8105 ± 1739</td>
</tr>
</tbody>
</table>

* Adapted from reference 5 with permission.
1 Mean ± SD. 2 Significantly different from the control group (P < 0.05). 3 Significantly different from the control and diet only group (P < 0.05).

Table 1. Body Composition, Fitness, and Energy Intake Changes after 1 Year in Men and Women
Weight alone may not be as important as the distribution of body fat in the prediction of disease risk. Several recent, population-based studies have shown that physically active men and women have lower (more favorable) waist-to-hip ratios than do their sedentary counterparts [10,11,12,13]. This finding is supported by the data from Wood and colleagues [9] shown in Table 1.

In summary, available studies suggest that exercise alone promotes weight loss, but the amount of weight that can be lost quickly is probably less than that achieved through dieting alone. The addition of exercise to caloric restriction appears to increase the amount of weight loss over either treatment used separately.

Effectiveness of Exercise in Weight Maintenance

Long-term maintenance of weight loss is an important factor. King [2] also reviewed long-term weight loss after exercise alone, diet alone, or diet plus exercise. Although differences in study designs, samples, duration of intervention, and duration of follow-up exist, average weight losses over follow-up intervals of from 6 months to 3 years were 4.9 kg in five exercise studies, 4.0 kg in four diet studies, and 7.2 kg in three diet-plus-exercise studies, suggesting that exercise in addition to diet may be more effective than diet or exercise alone.

Persuasive evidence for the benefit of exercise in weight maintenance is provided by Pavlou and colleagues [14]. They enrolled 160 overweight male police officers (average weight at baseline, approximately 100 kg in all intervention groups). The men were randomly assigned to one of four weight-loss diets (diets ranged from 1756 to 4180 kJ per day). One half of the men in each diet group were given a 90-minute, supervised exercise session three times a week; the other men were given education about exercise and asked to maintain their current exercise habits during the 8-week intervention. Participants were re-examined after 8 and 18 months of follow-up. Overall, little difference in weight loss was seen between the groups using diet alone (mean loss, 10.2 kg) and the groups using diet plus exercise (mean loss, 12.2 kg). Exercisers were much less likely than dieters, however, to regain weight during follow-up Figure 1. The follow-up period constituted an observational study, during which participants were free to cross to the other treatment group; some participants later crossed back to their original group. The results indicate that men who continued to exercise or adopted exercise at one or both of the follow-up assessments weighed less than the men who did not exercise.
Exercise, Morbidity, and Mortality in Overweight Persons

In addition to the possibly beneficial effect of exercise on weight loss and maintenance, higher levels of physical activity and physical fitness may benefit overweight persons in other ways. Prospective studies show an inverse association between exercise or fitness level and morbidity and mortality in overweight men and women.

The incidence of nonfatal, non-insulin-dependent diabetes mellitus was shown to be lower in physically active University of Pennsylvania alumni [15] and among participants in the Nurses Health Study [16] Figure 2, top). Not all the participants in these studies were obese, but the data shown are from the highest stratum of BMI (kg/m^2) that is reported in the papers. Overall non-insulin-dependent diabetes mellitus rates were as much as seven to eight times higher in the BMI strata shown in Figure 2 than in the lower BMI strata (data not shown) in the respective studies. The inverse association between exercise and non-insulin-dependent diabetes mellitus rates was much steeper in the heavier men and women compared with the gradients in the lighter participants.
Figure 2. Incidence of diabetes mellitus and death rates in overweight persons by degree of
physical activity and physical fitness. Top. Non-insulin-dependent diabetes mellitus rates in overweight women [16] by categories of weekly vigorous exercise and in overweight men [15] by strata of a physical activity index measured in kcal/week. Middle. All-cause death rates by physical fitness categories for women and men with a body mass index (BMI) greater than 25 kg/m² in the Aerobics Center Longitudinal Study [18]. Bottom. All-cause death rates in men with a BMI greater than 25.4 kg/m² by strata of a physical activity index measured in kcal/wk [19].

Morris and colleagues [17] studied 9376 male British civil servants for approximately 9 years. The investigators recorded 474 coronary events during follow-up. Physical activity was assessed at baseline using a detailed questionnaire covering the previous 4 weeks. Men were assigned to four physical activity categories. The group reporting the highest degree of physical activity (group 1) reported frequent and vigorous aerobic exercise at least twice a week. The least active group (group 4) reported no vigorous exercise. Groups two and three reported intermediate exercise levels. Coronary event rates per 1000 persons (adjusted for age and other risk factors) across the four activity categories in lean men (BMI, < 24) were 1.9, 3.4, 4.3, and 5.5, respectively. Corresponding rates for heavy men (BMI, >= 27) were 1.3, 4.8, 7.1, and 7.3, respectively. The active heavy men had much lower rates than did their sedentary peers. Overweight men in groups one and two were less likely to have a coronary event than were the sedentary but lean men.

We calculated the age-adjusted, all-cause death rates across low, moderate, and high physical fitness categories in 10 224 men and 3120 women who were apparently healthy at baseline [18]. In all BMI strata, the least fit men and women had higher death rates than did participants in the moderate and high fitness groups. Rates for the heaviest participants (BMI, > 25) are shown in the middle panel of Figure 2. A similar analysis from the Harvard Alumni Study is presented in the bottom panel of Figure 2.

In summary, data from these four studies suggest that overweight men and women who are physically active and physically fit will have lower morbidity and mortality rates during follow-up than will their sedentary peers. A mechanism for these findings is suggested in a recent report. Tremblay and colleagues [20] investigated the effects of 15 months of endurance exercise training followed by 14 months of exercise and a low-fat diet on the metabolic profiles of four obese women who had an average baseline weight of 92 kg. After the 29 months of intervention, the women remained overweight (average weight, 81 kg), but plasma glucose, insulin, and most lipid and lipoprotein values were within the normal range.

Conclusions

Although more research is needed, it is reasonable to recommend physical activity for weight loss and maintenance in overweight persons. Most studies found exercise to promote weight loss, although its effects were not large. When added to dietary interventions, exercise resulted in weight losses greater than those achieved by diet alone. Exercise appears to be particularly important in maintaining weight loss during follow-up after active intervention. Overweight men and women seem to benefit from exercise even if they remain overweight, with the more active persons having better risk profiles and lower rates of morbidity and mortality than their sedentary counterparts.

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