Physical activity in the prevention of obesity: current evidence and research issues

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Roundtable held February 4-7, 1999, Indianapolis, IN.

Abstract


Purpose: The relation between habitual physical activity and the prevention of overweight and obesity in adults based on the evidence from the epidemiologic literature is described.

Methods: Literature was reviewed of current findings from large population-based studies of forward directionality in which physical activity was considered as a primary study factor.

Results: The longitudinal evidence suggests that habitual physical activity plays more of a role in attenuating age-related weight gain, rather than in promoting weight loss. Moreover, recent data suggest that increasing amounts of physical activity may be necessary to effectively maintain a constant body weight with increasing age.

Conclusion: Over decades, small savings in excess weight gain accumulate into net savings that may be quite meaningful with regard to minimizing the risk associated with obesity-related disorders. The question remains as to how important maintaining a constant body weight through middle age and into older age is to healthy, already-active people of normal body weight.

Recent survey data from the third National Health and Nutrition Examination Survey (NHANES III) suggest that overweight [i.e., preobesity, defined as a body mass index (BMI = kg·m$^{-2}$) = 25.0-29.9] is present in approximately 32% of the adults living in the United States (7). The overall prevalence of overweight currently is highest in men and women age 60-69 yr (45% and 34%, respectively) and then is progressively lower at older ages (7,11). Trend data further suggest that the population as a group, and particularly African-American women of lower socioeconomic status, is becoming heavier with time and that the increase in prevalence of overweight may be most accelerated among those individuals who are already overweight or obese (11,12). Among respondents to the NHANES-I (1971-1975) Epidemiologic Follow-up Study (1981-1984) who were not overweight (i.e., BMI ≥ 27.8 for men and 27.3 for women) at baseline, the risk of becoming overweight during the 10-yr follow-up was similar in men and women and was highest among adults aged 35-44 yr (16.3% among men and 13.5% among women) (21). The cumulative incidence of major weight gain (≥5 kg), however, was higher in women compared with men and highest among adults aged 25-34 yr (3.9% among men and 8.4% among women). Recently, Flegal and colleagues (7) report a marked increase in the prevalence of obesity (i.e., BMI ≥ 30 kg·m$^{-2}$) between NHANES II, 1976-80 (14.5%), and NHANES III, 1988-94 (22.5%), which corroborates trends observed internationally.
How Effective Is Physical Activity in Reducing Overweight and Obesity?

Evidence statement.

Numerous intervention studies have explored the impact of exercise training of various intensities on the reduction of weight and body fat (see 5 for review). We can conclude from these studies that: 1) physical activity affects body composition and weight favorably, by promoting fat loss, while preserving lean mass; 2) the rate of weight loss is positively related to the frequency and duration of the exercise session, as well as the duration of the exercise program, thereby suggesting a dose-response relationship; and 3) although, the rate of weight loss resulting from increased physical activity is relatively slow, physical activity may nonetheless be a more effective strategy for long-term weight regulation than dieting alone (2) (evidence category B or C).

Less is known about how physical activity patterns affect attained weight and weight gain among the general population—data are especially scarce among younger (<18 yr) and older (>55 yr) age groups, as well as for minority populations.

Observational studies.

The inverse association between physical activity or exercise and body weight has been reported in many cross-sectional epidemiologic studies (see 5 for review). Indeed, these cross-sectional, population-based studies consistently report lower weight or body mass with higher categorical levels of self-reported physical activity—especially for activities of higher intensity, presumably due to the better reporting of these activities. Interpreting cross-sectional data, however, is difficult, because the directionality of the association between physical activity and weight cannot be determined. Naturally, physical activity patterns and choices may affect weight, just as weight may influence physical activity, and both may be heavily influenced by genetic factors (1).

Longitudinal or cohort studies (i.e., those with forward directionality) may give better information on the etiologic impact of physical activity on the risk or development, of excess weight gain over time because, by definition, the exposure (physical activity), measured either prospectively or retrospectively, must precede the outcome. Given the increasing prevalence of overweight in the population and the health consequences associated with this condition, its primary prevention therefore assumes considerable public health significance. Unfortunately, there is a paucity of longitudinal data that examine the role of physical activity on weight gain among the general population. Therefore, the purpose of this paper is to present the current evidence of the epidemiologic relation between habitual physical activity and the prevention of overweight and obesity. Accordingly, we present findings from large population-based studies of forward directionality in which physical activity is considered as the primary study factor on the risk and development of overweight. These findings are all evidence category C, in that they are based on observational data.

Does Regular Physical Activity Prevent Weight Gain in the Population?

Evidence statement.

The hypothesis that physical activity affects body weight inversely is logical, but observational population-based data on the longitudinal relationship between these two variables are somewhat confusing (4,6,8-10,12-15,18,21). Cross-sectional associations between physical activity or fitness and body weight are stronger than those seen longitudinally (3,5), and although there is evidence of a relation to attenuated weight gain, it is not clear that increased physical activity actually prevents or reverses age-related weight gain at the population level (Table 1) (evidence category C).
Several large-scale observational studies have determined a relationship between higher baseline levels of physical activity or improvements in physical activity and either attenuated weight gain (4,6,8-10,12-14) or a lower odds of a significant weight gain (3,6,15,21). Recently, Ching and colleagues (3) studied the relationship between both reported physical activity and a direct indicator of sedentary behavior—TV/VCR viewing—and overweight (i.e., BMI ≥ 27.3 kg·m⁻²) in a large cohort of male health professionals. Cross-sectional analyses of the baseline data yielded results similar to other cross-sectional studies of physical activity and overweight; that is, a strong inverse graded association between quintile of physical activity (MET h·wk⁻¹) and a strong positive gradient between TV/VCR viewing (h·wk⁻¹) and the prevalence of overweight. After 2 yr of follow-up, higher baseline levels of physical activity and lower levels of TV/VCR viewing remained independently related to a lower risk of becoming overweight. The magnitude of the longitudinal relation was much smaller, however, than what was seen cross-sectionally with these same data, presumably due to the relatively lower cumulative incidence of overweight (~5%) over the 2-yr follow-up in that particularly select cohort of male health professionals.

Four-year follow-up data from the Male Health Professionals Study (4) and 2-yr follow-up data from the China Health and Nutrition Survey, 1989-1991 (14) support the notion of an inverse longitudinal relation between increased physical activity and weight gain. Indeed, middle-aged men in the Male Health Professionals study who increased vigorous activity, decreased TV viewing, and stopped eating between meals actually lost 1.4 kg over 4 yr, compared with a 1.4-kg weight gain among the entire study cohort. Further, recent findings from DiPietro et al. (6) in the Aerobics Center Longitudinal Study (ACLS) cohort and Lewis et al. (12) in the biracial CARDIA cohort show that improved cardiorespiratory fitness relates inversely to weight change. Indeed, improvements in treadmill time between the first and second exam significantly minimized weight gain over the respective 7.5-yr and 7-yr follow-up periods. These results were observed in both sexes, although the magnitude of the relationships were stronger and more stable in men than in women in the ACLS cohort. The findings in all four studies (4,6,12,14) were not affected by age, height, baseline weight, baseline fitness or activity level, smoking, number of clinic visits, and length of follow-up.

### Table 1. Summary of longitudinal epidemiologic studies of physical activity and weight change

<table>
<thead>
<tr>
<th>Study Reference</th>
<th>Population Description</th>
<th>Design/Methods</th>
<th>Results</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>DiPietro et al. (6)</td>
<td>Int. J. Obes. 23:55-62, 1999</td>
<td>Middle-aged cohort of 4589 men and 724 women</td>
<td>Prospective (2-yr follow-up); weight measured at 3 time points; fitness determined by GXT</td>
<td>Improvements in fitness related to attenuated weight gain and lower odds of ≥5 or &lt;10 kg in both d &amp; w</td>
</tr>
<tr>
<td>Coskunty (4)</td>
<td>Int. J. Obes. 22:593-601, 1998</td>
<td>Cohort of 19,474 male health professionals (40–75 yr)</td>
<td>Prospective (4-yr follow-up); self-reported weight, activity, and TV viewing</td>
<td>Increased activity related to increased physical activity and weight loss</td>
</tr>
<tr>
<td>Pan et al. (14)</td>
<td>Int. J. Obes. 22:424–431, 1998</td>
<td>Cohort of 3,944 working adults (20–45 yr) in China</td>
<td>Prospective (2-yr follow-up); self-reported level of occupational activity and measured weight</td>
<td>Decreases in fitness related to increased weight gain in both d &amp; w</td>
</tr>
<tr>
<td>Lewis et al. (12)</td>
<td>Am. J. Public Health 97:635-42, 1997</td>
<td>Briskly young cohort of 1033 men &amp; 2955 women (18–50 yr)</td>
<td>Prospective (2-yr follow-up); weight measured at 4 time points; fitness determined by GXT</td>
<td>Higher baseline level of activity related to lower risk of becoming overweight</td>
</tr>
<tr>
<td>Ching et al. (5)</td>
<td>Int. J. Obes. 20:25–30, 1996</td>
<td>Cohort of 22,676 male health professionals (40–75 yr)</td>
<td>Cross-sectional and prospective (2-yr follow-up); self-reported weight, activity, and TV viewing</td>
<td>Higher baseline level of activity related to lower risk of becoming overweight</td>
</tr>
<tr>
<td>Kawachi et al. (9)</td>
<td>Int. J. Obes. 20:1099-1104, 1996</td>
<td>Cohort of 12,700 female nurses (40–75 yr)</td>
<td>Prospective (2-yr follow-up); self-reported weight and activity</td>
<td>Who quits smoking and increased activity gained less weight than those who simply quit smoking over 2 yr</td>
</tr>
<tr>
<td>French et al. (8)</td>
<td>Int. J. Obes. 18:145–154, 1994</td>
<td>Cohort of 1036 male and 1913 female employees (27–55 yr)</td>
<td>Prospective (2-yr follow-up); measured weight, self-reported activity</td>
<td>Higher levels of activity related to attenuated weight gain in both d &amp; w.</td>
</tr>
<tr>
<td>Williamson et al. (21)</td>
<td>Int. J. Obes. 17:279–286, 1993</td>
<td>Representative cohort of 2015 men and 2015 women (20–44 yr) in U.S.</td>
<td>Prospective (10-yr follow-up); reported activity, and measured weight</td>
<td>Low activity at follow-up related to major weight gain (&gt;10 kg) occurring over 10 yr</td>
</tr>
<tr>
<td>Klepes et al. (10)</td>
<td>Am. J. Clin. Nutr. 55:819–822, 1992</td>
<td>Cohort of 387 men and 135 women (42–50 yr)</td>
<td>Prospective (2-yr follow-up); self-reported activity, and measured weight</td>
<td>decreased in weight activity and related to greater weight gain in 30% only</td>
</tr>
<tr>
<td>Owens et al. (12)</td>
<td>J. Chronic Diseases 85:1307–120, 1992</td>
<td>Cohort of 327 men (42–50 yr)</td>
<td>Prospective (3-yr follow-up); self-reported activity, and measured weight</td>
<td>Higher baseline activity related to attenuated weight gain</td>
</tr>
<tr>
<td>Venuprap et al. (11)</td>
<td>Int. J. Obes. 16:1999–2015, 1991</td>
<td>Cohort of 45 older women (71 yr)</td>
<td>Self-reported activity: activity of weight at ages 15, 25, 30, 40, and 55 yr and studied concurrently</td>
<td>V always active had a lower weight index</td>
</tr>
</tbody>
</table>

GXT, graded exercise challenge; TMT, treadmill time; BMI, body mass index (kg·m⁻²). a Weight index calculated from the sum of perception scores (1 = low BMI to 5 = high BMI) from front- and side-view silhouettes and comparison to peers (1 = thinner than; 3 = same as; 5 = fatter than) at ages 12, 25, 40, and 55 yr. b Gender, ♂, men; ♀, women.
A recent cross-sectional analysis by Williams (19) on data from the National Runners' Health Study, suggest that substantial increases in activity level are necessary to maintain body weight with age. The ACLS (6) and The Male Health Professional Follow-up cohort data (4) corroborate these findings in that even among the fitter (6) or most vigorously active (4) men, improvements in treadmill time, fitness class, or vigorous activity were necessary for weight loss over time; indeed, men who were fit and remained fit, or were vigorously active and remained so, actually gained small amounts of weight over the follow-up, even after adjustment for age and smoking. Further, improvements in fitness class among the ACLS cohort demonstrated a stronger protective effect on the odds of a ≥ 5 or ≥ 10 kg weight gain in men than did maintaining the same level of fitness.

Williamson et al. (21) determined the association between the 10-yr change in physical activity level and the magnitude of concurrent weight change in more than 9,000 adults responding to the NHANES I Epidemiologic Follow-up Study (1971-1975 to 1982-1984). Their results suggest that even relative to people who stay very active over time, sedentary people who increase their activity can minimize the excess risk of major weight gain compared to people who decrease their activity, thus supporting the contention of lower risk of becoming overweight with an increase in level of activity over time.

Thus, the longitudinal evidence linking habitual physical activity to the prevention of excess weight gain among the general population or more selective populations seems clear. Most of these findings suggest that physical activity or fitness plays more of a role in attenuating age-related weight gain and preventing significant weight gain, rather than in promoting weight loss. Whereas the magnitude of the relation of improvements in physical activity or fitness and attenuated weight gain appears small in several studies (resulting in small effect sizes), over decades these small savings in excess weight gain accumulate into net savings that are quite meaningful with regard to minimizing the risk associated with obesity-related disorders (9). Moreover, results from the ACLS (6) and the Male Health Professional Follow-up (4) cohorts, as well as cross-sectional trend data from Williams (19) suggest that increasing amounts of physical activity may be necessary to effectively maintain a constant body weight with increasing age. The question remains as to how important maintaining a constant weight through middle and into older age is to healthy, already-active people of normal body weight.

RESEARCH PRIORITIES

Clearly, there is a need for additional longitudinal research on the relation between physical activity and weight gain at the population level. Suggestions for research priorities comprise several areas ranging from descriptive epidemiology, to the testing of more complex etiologic hypotheses in the population, to the linking of population-based research to that which is laboratory- or clinical-based, in order to test more mechanistic hypotheses.

1. Tracking or Surveillance Studies

One of the primary limitations of the longitudinal, epidemiologic research done thus far is the lack of multiple measures of both physical activity and body weight. Typically, physical activity is determined at baseline, with body weight measured at baseline and then again at follow-up. Surveillance studies that track physical activity patterns and body weight over 10-20 yr with measurements of both taken at 2- to 5-yr intervals are extremely important to describe accurately the contribution of physical activity to long-term weight regulation. Naturally, more sophisticated statistical techniques are needed to analyze these multiply repeated data appropriately. Random-effects regression modeling (16) is a technique that models on the trajectory of change in weight over several consecutive years for each individual and then computes the average effect of physical activity level on those trajectories, while simultaneously controlling for changes in other influential variables.

2. Powerful Longitudinal Studies of Women

To date, the majority of studies of physical activity and body weight have involved larger populations of men than women (3,4,6,8,10,17,19). Several investigators have noted that women (particularly premenopausal women) are more resistant to weight change with physical activity due to a greater proportion of less lipolytically responsive
gluteofemoral adipose tissue. Because women seem to have the highest risk of substantial weight gain through middle age, public health interest would render it logical to study this group more intensely than men.

3. TOP

Longitudinal Studies through Transitions

Currently we have no longitudinal data on infants, adolescents, and young and older adults with regard to physical activity and weight change. These recommended studies would be further enhanced if the particular cohort were followed through a period of natural change in their physiology—for example: 1) infancy through adolescence; 2) adolescence to age 30 yr; 3) middle age to older age (65 yr); and 4) pre- through peri-, through post-menopause. In addition, few population-based studies have assessed the association between these variables in older (i.e., ≥65 yr) men and women. Thus, little is known about the benefits of physical activity to weight maintenance (i.e., the prevention of weight loss) and subsequent health outcomes in older age.

3. TOP

Improved Epidemiologic or Statistical Methods

Inconsistent or confusing longitudinal relationships may be a consequence of several methodological issues, which make interpreting the data quite difficult. These issues include: a) a low prevalence of higher-intensity physical activity in the general population; b) measurement error with regard to self-reported activity, especially that of lower-intensity; c) inappropriate time-frame of the physical activity assessment; d) effect modification by age, sex, and weight status; and e) failure to adjust for important statistical confounders, such as diet and smoking. Thus methods of assessing lower-intensity activity with accuracy (that is, validity and precision) over several time points, as well as sample sizes that are large enough to allow ample power for stratification by age, sex, and/or weight status and for the statistical control of important confounding variables are requisite to well-designed longitudinal studies of the population.

4. TOP

Linking Field-Based with Laboratory- or Clinical-Based Studies

Epidemiologic studies have been extremely important to our understanding of the etiologic relationships among numerous risk factors and disease or functional outcomes as they are observed in the general population. What these studies lack, however, is the ability to identify the specific physiologic mechanisms that explain these observed statistical associations. By drawing representative subsamples from large cohort studies for more intensive laboratory or clinical study, we can begin to: a) map genetic determinants of weight regulation in order to differentiate their impact from behavioral determinants; b) identify signaling pathways and mechanisms of energy balance from the cellular- to the applied, whole-body-level in children and adults; and c) determine the magnitude of impact of structural (anatomical) changes on functional changes at the whole-body level. This information can then be translated back to the population level in terms of specific interventions designed to prevent substantial weight gain and obesity throughout the lifespan.

In memory of my mentor Ethan R. Nadel, Ph.D., FACSM.

REFERENCES TOP


Keywords:
EPIDEMIOLOGY; EXERCISE; LONGITUDINAL; OVERWEIGHT; RISK