Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults

AMERICAN COLLEGE of SPORTS MEDICINE®

POSITION STAND

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ABSTRACT

Overweight and obesity affects more than 66% of the adult population and is associated with a variety of chronic diseases. Weight reduction reduces health risks associated with chronic diseases and is therefore encouraged by major health agencies. Guidelines of the National Heart, Lung, and Blood Institute (NHLBI) encourage a 10% reduction in weight, although considerable literature indicates reduction in health risk with 3% to 5% reduction in weight. Physical activity (PA) is recommended as a component of weight management for prevention of weight gain, for weight loss, and for prevention of weight regain after weight loss. In 2001, the American College of Sports Medicine (ACSM) published a Position Stand that recommended a minimum of 150 min·wk^{-1} of moderate-intensity PA for overweight and obese adults to improve health; however, 200–300 min·wk^{-1} was recommended for long-term weight loss. More recent evidence has supported this recommendation and has indicated more PA may be necessary to prevent weight regain after weight loss. To this end, we have reexamined the evidence from 1999 to determine whether there is a level at which PA is effective for prevention of weight gain, for weight loss, and prevention of weight regain. Evidence supports moderate-intensity PA between 150 and 250 min·wk^{-1} to be effective to prevent weight gain. Moderate-intensity PA between 150 and 250 min·wk^{-1} will provide only modest weight loss. Greater amounts of PA (>250 min·wk^{-1}) have been associated with clinically significant weight loss. Moderate-intensity PA between 150 and 250 min·wk^{-1} will improve weight loss in studies that use moderate diet restriction but not severe diet restriction. Cross-sectional and prospective studies indicate that after weight loss, weight maintenance is improved with PA >250 min·wk^{-1}. However, no evidence from well-designed randomized controlled trials exists to judge the effectiveness of PA for prevention of weight regain after weight loss. Resistance training does not enhance weight loss but may increase fat-free mass and increase loss of fat mass and is associated with reductions in health risk. Existing evidence indicates that endurance PA or resistance training without weight loss improves health risk. There is inadequate evidence to determine whether PA prevents or attenuates detrimental changes in chronic disease risk during weight gain.

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This document is an update of the 2001 American College of Sports Medicine (ACSM) Position Stand titled "Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults" (68). This Position Stand provided a variety of recommendations such as the identification of adults for whom weight loss is recommended, the magnitude of weight loss recommended, dietary recommendations, the use of resistance exercise, the use of pharmacological agents, behavioral strategies, and other topics. The purpose of the current update was to focus on new information that has been published after 1999, which may indicate that increased levels of physical activity (PA) may be necessary for prevention of weight gain, for weight loss, and prevention of weight regain compared to those recommended in the 2001 Position Stand. In particular, this update is in response to published information regarding the amount of PA needed for weight management found in the National Weight Control Registry (155) and by the Institute of Medicine (67).

This update was undertaken for persons older than 18 yr who were enrolled in PA trials designed for prevention of weight gain (i.e., weight stability), for weight loss, or prevention of weight regain. Investigations that include older adults (i.e., older than 65 yr) are not abundant. Some concerns exist for the need for weight loss in older adults and for loss of fat-free mass and potential bone loss. This review considers the existing literature as it applies to the general population. However, it is likely that individuals vary in their response to PA for prevention of weight gain, for weight loss, and for weight maintenance. Trials with individuals with comorbid conditions that acutely affect weight and trials using pharmacotherapy were not included (i.e., acquired immunodeficiency syndrome, type 1 diabetes). Trials using individuals with medication and comorbid diseases, such as hypertension, cardiovascular disease (CVD), and type 2 diabetes, were included because these individuals are very prevalent in the United States (US) and individuals with these conditions are frequently in need of weight loss. Throughout this paper light-intensity activity is defined as 1.1 to 2.9 METS, moderate-intensity activity is 3.0 to 5.9 METS, and vigorous activity is ≥ 6 METS (U.S. Department of Health and Human Services Website [Internet]. Washington, DC: 2008 Physical Activity Guidelines for Americans; [cited 2008 Nov 17]. Available from http://www.health.gov/PAGuidelines.) The Evidence Categories of the National Heart, Lung, and Blood Institute (NHLBI) were used to evaluate the strength of the literature and to support recommendations (Table 1).

RATIONALE FOR WEIGHT MANAGEMENT

Overweight and obesity are defined by a body mass index (BMI) of 25 to 29.9 $kg{\cdot}m^{-2}$ and 30 $kg{\cdot}m^{-2}$ or greater, respectively. Together, overweight and obesity are exhibited by approximately 66.3% of adults in the US (107). Both overweight and obesity are characterized by the accumulation of excessive levels of body fat and contribute to heart disease, hypertension, diabetes, and some cancers as well as psychosocial and economic difficulties (55,97,99,147). The cost of treatment of weight reduction is now estimated to exceed $117 billion annually (135). Reduction in the prevalence of obesity was among the major aims of Healthy People 2000 (147), although it is now apparent that this goal was not achieved (148). Reduction in obesity remains a major aim of Healthy People 2010 (146) and of other major health campaigns (i.e., Steps to a HealthierUS Initiative, http://www.healthierus.gov/steps/; Make Your Calories Count, http://www.cfsan.fda.gov/~dms/hwm-qa.html; We Can! http://www.nhlbi.nih.gov/health/public/heart/obesity/wecan/). Management of overweight and obesity is considered an important public health initiative because numerous studies have shown the beneficial effects of diminished weight and body fat in overweight and obese individuals. These beneficial effects include an improvement in CVD risk factors such as decreased blood pressure (85,102,137), decreased LDL-C (24,85,151), increased HDL-C (24,151), decreased triglycerides (TG) (24,43,151), and improved glucose tolerance (30,45). Weight loss has also been associated with a decrease in inflammatory markers, such as C-reactive protein (60,81,139), which have also been associated with the development of CVD (118,119). The NHLBI Guidelines (101) recommend a minimum weight loss of 10%. However, there are also numerous studies that show beneficial improvements in CVD risk factors when weight loss is less than 10% (16,38,56,80,114,150). In fact, beneficial improvements in chronic disease risk factors have been reported with as little as 2–3% of weight loss (30,45,85,141).

POTENTIAL NEED FOR GREATER AMOUNTS OF PA

PA is recommended as an important part of weight management by virtually all public health agencies and scientific organizations including NHLBI (41), Centers for Disease Control (CDC) (57), ACSM (57), and various medical societies (American Heart Association, American Medical Association, American Academy of Family Physicians) (92). Although there are existing recommendations for the amount of PA useful for weight management, recent studies have suggested greater amounts may be needed for most individuals. For example, individuals in the National Weight Control Registry who have maintained weight loss have shown levels of energy expenditure equivalent to walking ~28 $miles{\cdot}wk^{-1}$ (78). Schoeller et al. (126) used doubly labeled water to study women who recently lost 23 ± 9 kg weight to estimate the energy expenditure needed to prevent weight regain. Retrospective analyses of the data were performed to determine the level of PA that provided maximum differentiation between gainers and maintainers. On the basis of these analyses, it was determined that sedentary individuals would need to perform ~80 $min{\cdot}d^{-1}$ of moderate-intensity PA or 35 $min{\cdot}d^{-1}$ of vigorous PA to prevent weight regain. These studies contributed to the 2001 recommendation by ACSM of 200–300 $min{\cdot}wk^{-1}$ of moderate-intensity PA for long-term weight loss, and other published recommendations (i.e., Institute of Medicine [67]) suggest that greater amounts of PA may be necessary for prevention of weight regain after weight loss. In response, we have examined the literature from 1999 to present to

TABLE 1. Level of evidence for evidence statements.

Evidence Statement	Evidence Category
PA to prevent weight gain. PA of 150 to 250 $min{\cdot}wk^{-1}$ with an energy equivalent of 1200 to 2000 $kcal{\cdot}wk^{-1}$ will prevent weight gain greater than 3% in most adults.	A
PA for weight loss. PA < 150 $min{\cdot}wk^{-1}$ promotes minimal weight loss, PA > 150 $min{\cdot}wk^{-1}$ results in modest weight loss of ~2–3 kg, PA > 225–420 $min{\cdot}wk^{-1}$ results in 5- to 7.5-kg weight loss, and a dose–response exists.	B
PA for weight maintenance after weight loss. Some studies support the value of ~200- to 300-$min{\cdot}wk^{-1}$ PA during weight maintenance to reduce weight regain after weight loss, and it seems that 'more is better.' However, there are no correctly designed, adequately powered, energy balance studies to provide evidence for the amount of PA to prevent weight regain after weight loss.	B
Lifestyle PA is an ambiguous term and must be carefully defined to evaluate the literature. Given this limitation, it seems lifestyle PA may be useful to counter the small energy imbalance responsible for obesity in most adults.	B
PA and diet restriction. PA will increase weight loss if diet restriction is modest but not if diet restriction is severe (i,e., <$kcal{\cdot}wk^{-1}$ needed to meet RMR).	A
Resistance training (RT) for weight loss. Research evidence does not support RT as effective for weight loss with or without diet restriction. There is limited evidence that RT promotes gain or maintenance of lean mass and loss of body fat during energy restriction and there is some evidence RT improves chronic disease risk factors (i.e., HDL-C, LDL-C, insulin, blood pressure).	B

determine whether there is sufficient evidence to recommend increased levels of PA for prevention of weight gain, weight loss, and prevention of weight regain.

WEIGHT MAINTENANCE AND CLINICALLY SIGNIFICANT WEIGHT LOSS

The clinical significance of weight maintenance and weight loss is often questioned in studies that provide marginal results. To provide context to a discussion of PA for weight maintenance, weight loss, or prevention of weight regain after weight loss, St Jeor et al. (133) and Sherwood et al. (129) both operationally defined weight maintenance as a change of ≤5 lb (2.3 kg). Stevens et al. (136) recently recommended a definition of weight maintenance as <3% change in body weight with >5% change in body weight considered as clinically significant.

There are also problems with setting operating definitions. Benefits associated with weight maintenance or weight changes likely exist on a continuum and do not operate under a threshold. The definitions above are the product of observational studies and review of the literature. Randomized controlled trials that were designed to provide evidence to answer the question of clinical significance have not been conducted. Indeed, such trials may be unrealistic and may not yield a clear definition. Thus, judgment of clinical significance remains a topic for continued research and under the interpretation of the reader.

Evidence Statement: PA Will Prevent Weight Gain. Evidence Category A. Primary prevention of obesity starts with maintenance of current weight, not weight reduction. The risk for weight gain may vary across time, and the need for PA to prevent weight gain, therefore, may also vary. However, studies that test this promise are lacking. A considerable amount of cross-sectional evidence indicates an inverse relationship between body weight or BMI and PA (5,94). In addition, a small dose–response relationship is shown for the decrease in body weight or BMI as PA levels increase. For example, Kavouras et al. (76) reported a significantly lower BMI (25.9 $kg{\cdot}m^{-2}$) for individuals participating in PA equivalent to at least 30 $min{\cdot}d^{-1}$ for 5 $d{\cdot}wk^{-1}$ when compared to less active individuals (26.7 $kg{\cdot}m^{-2}$). However, Berk et al. (7) found that individuals who initially reported <60 $min{\cdot}wk^{-1}$ of PA and increased to 134 $min{\cdot}wk^{-1}$ of PA had a change in BMI of 0.4 $kg{\cdot}m^{-2}$ across a 16-yr follow-up period, but this was not significantly different from the 0.9 $kg{\cdot}m^{-2}$ increase observed for individuals who remained sedentary at both assessment periods (<60 $min{\cdot}wk^{-1}$). These data suggest that <150 $min{\cdot}wk^{-1}$ of PA will result in a nonsignificant change of weight gain compared to individuals who remain sedentary. However, individuals who were classified as active at both assessment periods and were participating in 261 $min{\cdot}wk^{-1}$ of PA resulted in a significantly lower change in BMI compared to individuals who were initially active (>60 $min{\cdot}wk^{-1}$) at baseline but became less active at follow-up (<60 $min{\cdot}wk^{-1}$). These two studies support the need to maintain a physically activity lifestyle and the need for >150 $min{\cdot}wk^{-1}$ of PA to manage body weight in the long term.

Additional evidence for the effectiveness of greater amounts of PA is provided by McTiernan et al. (95). In their study, prevention of weight gain was investigated in a 12-month randomized, controlled trial that targeted 300 min of moderately vigorous PA per wk. Women lost 1.4 ± 1.8 kg compared to an increase of 0.7 ± 0.9 kg in controls and men lost 1.8 ± 1.9 kg compared to an increase of 0.1 ± 0.1 kg in controls. A nonsignificant dose effect was shown for minutes of PA for women with >250 $min{\cdot}wk^{-1}$ associated with greater weight loss compared to <250 $min{\cdot}wk^{-1}$. For men, a significant dose effect was found for those who reported >250 $min{\cdot}wk^{-1}$ compared to those who reported <250 $min{\cdot}wk^{-1}$. Thus, greater amounts of PA resulted in greater amounts of weight loss. Taken together, the above studies suggest that there is sufficient evidence that moderately vigorous PA of 150 to 250 $min{\cdot}wk^{-1}$ with an energy equivalent of ~1200 to 2000 $kcal{\cdot}wk^{-1}$ (~12 to 20 $miles{\cdot}wk^{-1}$) is sufficient to prevent a weight gain greater than 3% in most adults.

Evidence Statement: PA Will Promote Clinically Significant Weight Loss. Evidence Category B. A negative energy balance generated by PA will result in weight loss, and the larger the negative energy balance, the greater the weight loss. Extreme amounts of PA found with military training (104) or mountain climbing (116) may result in substantial weight loss; however, it is difficult for most individuals to achieve and sustain these high levels of PA. Few studies with sedentary overweight or obese individuals using PA as the only intervention result in ≥3% decreases of baseline weight. Therefore, most individuals who require substantial weight loss may need additional interventions (i.e., energy restriction) to meet their weight loss needs.

Several studies that targeted <150 $min{\cdot}wk^{-1}$ of PA resulted in no significant change in body weight (10,14, 27,98). Donnelly et al. (33), targeted 90 min of continuous moderate-intensity PA (30 min, 3 $d{\cdot}wk^{-1}$) compared to 150 min of moderate-intensity intermittent PA (30 min, 5 $d{\cdot}wk^{-1}$) in women for 18 months. The continuous group lost significantly greater weight than the intermittent group (1.7 vs 0.8 kg), yet neither group lost ≥3% of baseline weight.

Garrow et al. (53) and Wing (154) have reviewed the literature for the effects of PA for weight loss and concluded that weight loss is typically 2 to 3 kg; however, the level of PA was not well described. Interestingly, well-controlled laboratory studies generally find greater levels of weight loss in response to PA. This may reflect a greater amount of PA that is targeted in laboratory studies compared to outpatient studies and verification that participants achieved the targeted amount. For example, Ross et al. (121) showed that men and women who experienced a 500- to 700-$kcal{\cdot}d^{-1}$ deficit for 12 wk had weight loss of 7.5 kg

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(8%) and 5.9 kg (6.5%), respectively. Donnelly et al. (32), used a randomized, controlled trial of 16 months duration that provided 225 min of moderate-intensity PA with a targeted energy equivalent of ~400 $kcal{\cdot}d^{-1}$, 5 $d{\cdot}wk^{-1}$, and verified all sessions of PA in a laboratory. The difference in weight between experimental and controls at 16 months was −4.8 kg for men and −5.2 kg for women. However, these differences were achieved differently. Men who received PA lost weight compared to controls who maintained weight. Women who received PA maintained weight compared to controls who gained weight. These findings may suggest a potential gender difference in response to PA. However, other investigations (134) have not found differences, and further investigation for gender differences seems warranted.

It is likely that any increase in PA has the potential for weight loss; however, it seems that PA <150 $min{\cdot}wk^{-1}$ results in minimal weight loss compared to controls, PA > 150 $min{\cdot}wk^{-1}$ results in modest weight loss of ~2–3 kg, and PA between 225 and 420 $min{\cdot}wk^{-1}$ results in 5- to 7.5-kg weight loss. Thus, a dose effect is apparent for PA and weight loss, and higher doses are capable of providing 3% or greater weight loss from initial weight.

Evidence Statement: PA Will Prevent Weight Regain after Weight Loss. Evidence Category B. It is generally accepted that most individuals can lose weight but cannot maintain weight loss. PA is universally promoted as a necessity for weight maintenance (67,68, 101). Indeed, PA is often cited as the best predictor of weight maintenance after weight loss (78,138). A systematic review of PA to prevent weight regain after weight loss was completed by Fogelholm and Kukkonen-Harjula (47). The majority of studies were observational studies and studies of individuals who were randomized at baseline to exercise or no exercise, or to different levels of PA. Follow-up varied from several months to several years and the results indicated that individuals who engaged in exercise experienced less regain than those individuals who did not, and those individuals who engaged in greater amounts of PA experienced less regain than those with more moderate levels of PA. Only three studies used a design in which individuals were randomized to PA after weight loss (48,87,112), and the results showed that PA had an indifferent, negative, or positive effect on prevention of weight regain. Failure to randomize to PA levels after weight loss is a serious design flaw and diminishes the evidence available for evaluation.

Despite the accepted concept that PA is necessary for successful weight maintenance after weight loss, the amount that is needed remains uncertain and may vary among individuals (70). The CDC/ACSM recommendations for PA specified the accumulation of 30 min of moderate-intensity PA for most days of the week (111). These guidelines were provided for health promotion and disease prevention; however, they were widely interpreted to be useful for weight management. Minimum levels of 150 $min{\cdot}wk^{-1}$ (30 $min{\cdot}d^{-1}$, 5 $d{\cdot}wk^{-1}$) of moderate-intensity PA were also recommended by the ACSM Position Stand in "Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults" for health benefits; however, 200–300 $min{\cdot}wk^{-1}$ was recommended for long-term weight loss (68). Jakicic et al. (69,71) and Andersen et al. (2) provide data from randomized trials that indicate individuals who perform greater amounts of PA maintain greater amounts of weight loss at follow-up of 18, 12, and 12 months, respectively. In particular, Jakicic et al. (69,71) show very little weight regain in individuals who performed >200 $min{\cdot}wk^{-1}$ of moderate-intensity PA. Recently, Jakicic et al. (70) have reported that individuals who achieved a weight loss of >10% of initial body weight at 24 months were participating in 275 $min{\cdot}wk^{-1}$ (approximately 1500 $kcal{\cdot}wk^{-1}$) of PA activity above baseline levels. Likewise, Ewbank et al. (40) found similar results 2 yr after weight loss by a very low energy diet. Retrospectively grouping participants by levels of self-reported PA, individuals who reported greater levels of PA (walking ~16 $miles{\cdot}wk^{-1}$) had significantly less weight regain than individuals reporting less PA per week (4.8–9.1 $miles{\cdot}wk^{-1}$). However, it is important to note that individuals in all three studies mentioned were grouped into PA categories retrospectively and were not randomly assigned to these PA groups after weight loss. Thus, the amount of PA was self-selected and therefore does not provide clear evidence for the amount of PA needed to prevent weight regain.

To explore the effects of levels of PA greater than those normally recommended in weight management programs, Jeffery et al. (74) targeted 1000 and 2500 $kcal{\cdot}wk^{-1}$ for 18 months in two groups of participants, and these levels of PA were randomly assigned at baseline. The actual reported energy expenditure for kilocalories per week at 18 months was 1629 ± 1483 and 2317 ± 1854 for the 1000- and 2500-$kcal{\cdot}wk^{-1}$ groups, respectively. There were no differences for weight loss between groups at 6 months (weight loss), but there were significant differences at 12 and 18 months (weight maintenance) of follow-up with the 2500-$kcal{\cdot}wk^{-1}$ group showing significantly greater weight losses (6.7 ± 8.1 vs 4.1 ± 7.3 kg). This study indicates that greater levels of PA provided significantly lower levels of weight regain. However, the results must be interpreted with caution because there was great variation in the percentage of individuals meeting the targeted energy expenditure, and the behavioral interventions were not equal.

In summary, most of the available literature indicates that "more is better" regarding the amount of PA needed to prevent weight regain after weight loss. However, as indicated above, there are some major flaws in the literature relative to the appropriate research design needed to directly address this question. Specifically, there are no adequately powered studies of sufficient duration with randomization to different levels of PA after weight loss. In addition, the literature is absent of randomized, controlled studies that used state-of-the-art energy balance techniques. Given these limitations, weight maintenance (weight fluctuation <3%) is likely to be associated with ~60 min walking per day (~4 miles·d^{-1}) at a moderate intensity (40,71,126,138).

OVERVIEW OF LIFESTYLE PA

Interventions for weight loss frequently implement behavioral programs that include strategies to integrate PA into the individuals' lifestyle. Examples include supervised exercise, nonsupervised exercise, occupational activity, work around the home, personal care, commuting, and leisure time activities. It is critically important to understand the difference between lifestyle intervention approaches to increasing PA and lifestyle forms of PA. The lack of clear differences between the two has lead to confusion regarding what the term "lifestyle PA" really means.

Part of the confusion comes from the lack of differentiation between a behavioral approach to modifying PA and specific forms of PA classified as lifestyle in nature. The following segments are offered to provide clarity for the purpose of this review.

Lifestyle Approaches to increasing PA. Lifestyle approaches to increasing PA refers to interventions that incorporate behavioral theories and constructs to assist and facilitate increasing PA within one's lifestyle. Examples may include, but are not limited to, inclusion of problem solving, goal-setting, self-monitoring, and relapse prevention strategies based on theories, such as Social Cognitive Theory, Transtheoretical Model, Theory of Planned Behavior, and Health Belief Model. This intervention approach can be used to improve participation in all forms of PA that include structured exercise, leisure time PA, occupational PA, household PA, and PA used for commuting.

Lifestyle forms of PA. Clearly defining lifestyle forms of PA is somewhat more challenging. For the purpose of this review, we define lifestyle PA as any nonstructured form of PA performed that is not intended to constitute a structured period of exercise. For example, walking done for commuting would be considered lifestyle PA. Walking in a structured period of exercise would not be considered lifestyle PA.

Nonexercise activity thermogenesis. Levine et al. (89,90) have developed the concept of nonexercise activity thermogenesis (NEAT), which they define as all energy expenditure that is not from sleeping, eating, or planned exercise programs. This definition does not use the term "lifestyle" and may therefore diminish the confusion between a lifestyle PA approach and forms of lifestyle PA. Regardless of definition, it is apparent that separating PA integrated into the lifestyle in behavioral programs from PA not associated with planned PA is currently confusing and problematic in terms of definition and measurement.

Measurement of lifestyle PA. Lifestyle PA energy expenditure (PAEE) has been measured in observational studies and randomized trials by various methods. Many studies have used self-report PA questionnaires to estimate total PA, and more recently, an objective measurement of PA has been achieved by use of pedometers, accelerometers, inclinometers, or doubly labeled water assessments (6,89,90,93). Although self-report of purposeful PA or exercise is sometimes crude and imprecise, it is even more difficult for individuals to provide an accurate self-report of lifestyle PA. Most adults can remember if they went for a run or to aerobics class and can also accurately report some types of lifestyle activity such as walking to the bus stop or to work. However, it is difficult to accurately quantify overall lifestyle activity because it constitutes hours per day and much of it is not memorable. An example of this was reported by Manini et al. (93) in a study of PAEE and mortality in a group of older adults (93). They assessed PAEE by doubly labeled water and also administered several PA questionnaires. They developed 21 separate estimates of time spent in PA or energy expended in PA from the questionnaire data. Only 8 of the 21 measures were significantly different across thirds of PAEE (low, <521 kcal·d^{-1}; middle, 521–770 kcal·d^{-1}; high, >779 kcal·d^{-1}), which indicate the difficulty of measuring lifestyle PA by self-report.

Evidence statement: lifestyle PA is useful for weight management. Evidence category B. In modern society, most adults spend most of their time sitting, whether at work, at home, or during leisure time. This leads to low levels of energy expenditure and is likely to be an important cause of the obesity epidemic (61,89,90,149). Estimates of the size of the positive energy balance leading to the obesity epidemic range from 10 (149) to 100 kcal·d^{-1} (61). There are numerous observational studies supporting the hypothesis that higher levels of lifestyle PA prevent initial weight gain (6,22,25,35,37,46,49,51,124,144). Many of the recent studies include objective measurement of PA by a variety of methods (6,22,25,37,144), but most of these studies had a cross-sectional design. Chan et al. (17) provided data from 106 sedentary workers who participated in a 12-wk intervention promoting walking. Steps per day were determined by pedometers, and participants had an average increase of 3451 steps per day during the course of the study. There was a greater decrease in waist circumference in those who had a greater increase in steps per day, but there was no association between BMI and increases in steps. There are several large longitudinal studies that used self-report of PA at baseline as a predictor of weight gain over time (28,35,49,113,124). These studies each include more than 1000 participants, and several years of follow-up. One study from Denmark followed up 21,685 men for 11 yr (35). There is consistency across the studies showing that more active individuals gained less weight or were less likely to become obese. However, another cohort of 3653 women and 2626 men in Denmark followed up for 5 yr did not show that inactivity led to obesity but did suggest that those who became obese also became more inactive (113). Several experimental trials have included a lifestyle approach to PA within the intervention (1,2,19–21, 36,49,52,71,132,152,153). In general, the interventions were successful in increasing PA, and this tended to have a beneficial effect on body weight. Many of these trials were relatively short term; but some lasted 1 yr or more (2,20,36, 71,152), with a notable study by Simkin-Silverman et al. (132) that was carried out for 54 months in 535 premenopausal women. A recent systematic review of studies using pedometers to increase PA provides information on how lifestyle PA may affect body weight (12). The investigators reviewed 26 studies on PA programs, 8 of them randomized trials, in which pedometers were used to assess changes in PA. Participants increased their steps per day by more than 2100 in both the randomized trials and the observational studies. Across all studies, participants decreased BMI by 0.38 units (95% confidence interval, 0.05–0.72; $P = 0.03$). Although weight loss seems modest, the review does suggest that it is possible to increase lifestyle PA and that this may result in lower weight.

The studies reviewed here include a wide variety of assessments of PA, diverse populations, and long follow-up. These characteristics of current research provide strong evidence for beneficial effects of lifestyle PA in overall weight management. However, there are inherent difficulties in making specific recommendations about lifestyle PA. First is the lack of a consistent definition on what should be included as lifestyle PA. In addition, there are many different measurement approaches that have been used in the various studies, which make it difficult to provide precise information on specific amounts of PA that should be recommended. Nonetheless, when we consider the emerging evidence on NEAT and inactivity physiology and the relatively small positive energy balance that has produced the obesity epidemic, it is reasonable to conclude that increasing lifestyle PA should be a strategy included in weight management efforts.

Evidence statement: PA combined with energy restriction will increase weight loss. Evidence category A. Examination of the weight loss literature shows that a reduction in energy intake plays a significant role in reducing body weight and this topic has been extensively reviewed (11,50). However, most recommendations for weight loss include both energy restriction and PA. Weight loss programs can vary dramatically in the amount of PA used and the level of energy restriction imposed, with a greater energy deficit producing a greater weight loss. Most weight loss programs either limit energy intake to a specific amount (e.g., 500–1500 $kcal{\cdot}d^{-1}$) regardless of the size or gender of the individuals participating in the program (4,8,9) or select a specific energy deficit through diet (e.g., energy restriction of $-300\ kcal{\cdot}d^{-1}$) and/or exercise (e.g., $-300\ kcal{\cdot}d^{-1}$) to bring about a total energy reduction (e.g., $-600\ kcal{\cdot}d^{-1}$) (18,39,59,72,96).

Virtually all recommendations from public health groups and governmental agencies include the use of PA in conjunction with diet to promote weight loss (57,101,111, 122,145–147). When the energy deficit imposed by diet-only and diet plus PA interventions are similar, weight loss and/or percent change in body weight are similar (4,8,18,39, 58,59,72,82,103,120,140). When energy intake is reduced severely, diet and diet and PA groups tend to have similar results (34). For example, several investigations have used 600–1000 $kcal{\cdot}d^{-1}$ deficits for 12–16 wk, and the group assigned to PA participated in three to five sessions per week of 30–60 min in duration. Weight loss ranged from ~4 to 11 kg (e.g., ~1–1.5 $lb{\cdot}wk^{-1}$), regardless of group assignment (i.e., diet-only or diet plus exercise) (39,72,140). Thus, the addition of PA to severe diet restriction may result in metabolic adaptations that diminish any additive effect of the energy expenditure from PA on weight loss.

In studies where energy restriction is not severe (i.e., 500–700 kcal), there is evidence that diet combined with PA is associated with significantly greater weight loss compared to diet alone. For example, a recent meta-analysis (128) found a small but significant increase in weight loss in diet plus PA programs of 1.1 kg compared to diet-only programs. Curioni and Lourenco (23) compared six randomized clinical trials ranging from 10 to 52 wk that also followed up subjects ($n = 265$) for 1 yr after the weight loss intervention. They found a 20% greater weight loss in diet plus exercise programs (−13 kg) compared to diet-only programs (−9.9 kg) and a 20% greater sustained weight loss after 1 yr (23). In summary, PA and diet restriction provide comparable weight loss if they provide similar levels of negative energy balance. It seems PA will increase weight loss in combination with diet restriction if the diet restriction is moderate but not if it is severe.

A thorough review of the diet literature and recommendations for effective diet counseling are available through the American Dietetic Association position paper on weight management (in press). Exercise professionals should be cautioned regarding the provision of dietary advice to overweight and obese adults. In particular, caution is advised when chronic disease risk factors or known chronic disease are present. Providing specific diet recommendations may be outside the scope of practice for the exercise professional, and the appropriate course of action may require referral to a registered dietitian.

Evidence statement: Resistance training will not promote clinically significant weight loss. Evidence category A. The ACSM Position Stand “Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults” (68) emphasized diet restriction and endurance exercise. Resistance training was not assigned a major role by the authors because it was believed that evidence for the efficacy of weight training for weight loss and maintenance was insufficient. Although the energy expenditure associated with resistance training is not large, resistance training may increase muscle mass which may in turn increase 24-h energy expenditure. Figure 1 represents a model that may reflect a role for resistance training in weight management.

Less research has been conducted using resistance training as part of an exercise intervention compared to aerobic

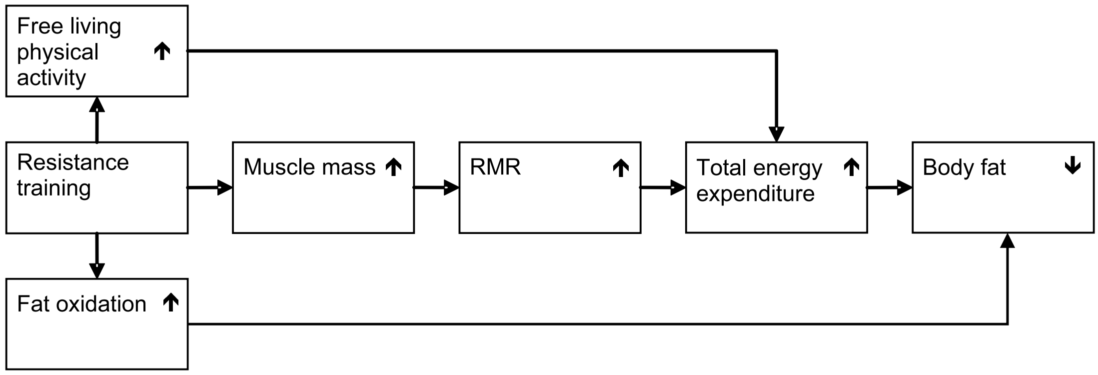

FIGURE 1—Conceptual model of resistance training and the potential effect on energy expenditure. A conceptual model that includes both the energy expenditure from increased muscle mass and the potential energy expenditure from increased activities of daily living. RMR, resting metabolic rate.

exercise. This may be caused by the diminished energy and fat use compared to aerobic exercise during a typical session of the same duration. However, differences in hormonal response to resistance exercise (potential for acute stimulation of metabolic rate and fat oxidation after the activity) and enhancement of muscle protein balance (potential to chronically increase total energy expenditure) provide some justification for the examination of benefits on body weight and composition. Studies evaluating the effect of resistance training on body weight and composition are summarized below. There is less evidence for the effect of resistance exercise on body composition than body weight because some studies did not assess body composition.

Neither randomized controlled (42,108,123,125) nor intervention studies without a sedentary comparison group (63,66,79,88,115) provide evidence for a reduction in body weight when resistance training is performed without any modification of diet. However, the studies since 1999 are equally split concerning whether resistance training will cause a loss of body fat. Some studies report a modest reduction in body fat (63,66,88,125) when resistance training was continued for 16–26 wk, whereas others reported no effect on body fat for interventions of 12–52 wk in duration (44,88,108,115). It is noteworthy that one study (88) reported a differential response on body fat depending on age and gender; reduction in body fat was observed only for older men with no effect for young men or young or old women. Slightly more studies reported an increase in lean mass after resistance training without modification of diet (63,64,108,125) than those reporting no effect (44,115,123). Some of the differences among studies could be secondary to differences in body composition technique used, duration of intervention, or specific exercise prescription. Combining resistance training with aerobic training has been shown to be superior for body weight and fat loss (3,110) and to result in greater lean body mass (110) when compared to aerobic exercise alone in several randomized controlled trials but not others (26).

When resistance training is added to a reduced energy intake intervention, the energy restriction seems to overshadow the resistance training. None of the recently performed randomized controlled trials (73,75,82,117) observed a greater body weight loss for interventions lasting from 4 to 16 wk. Most studies did not detect greater body fat loss with resistance training over energy restriction alone (75,82,117), although one study (73) examined body fat at various sites using magnetic resonance imaging and reported a superior loss of subcutaneous body fat with the combination of resistance training with diet compared to diet modification alone. On the other hand, most studies combining resistance training with energy restriction report improved lean body mass compared to dieting alone (73,75,82,117).

Only two recent randomized controlled studies have examined the effect of resistance exercise on prevention of weight gain or regain after weight loss (84,123). One study demonstrated no difference in weight regain during a 6-month period after a very low energy diet for 90 subjects assigned to walking, resistance training, or no exercise (84). A larger group of subjects (n = 164) was recruited for evaluation of regular resistance training to prevent gain in fat mass for 2 yr (123). No differences were noted in body weight change during this period; however, total body fat decreased more and intra-abdominal fat increased less for the treatment group compared to the control.

There is a potentially interesting interaction between resistance training and dietary protein in interventions with overweight individuals. Two randomized controlled trials compared the effects of resistance training when combined with diets that varied in protein content (31,86). The higher protein intervention was superior for either body weight and total fat lost (86) or prevention of lean tissue loss (31). In one study, this was accomplished through a doubling of the overall protein content of the diet to 1.6 $g \cdot kg^{-1}$ (86), whereas the other (31) used a high-protein supplement (10 g protein) immediately after each resistance workout.

There is little literature and no clear pattern for outcomes of weight and body composition when the dose for resistance training has varied. Only two recent randomized controlled studies compared different resistance protocols within one study (15,26). Campbell et al. (15) compared obese subjects who performed whole-body resistance exercise for 11 wk to those who did only lower-body resistance exercises. There was no difference in the effect of the two exercise plans on body composition. Similarly, no difference in body weight or composition change was noted by Delecluse et al. (26) when comparing moderate- (two sets of 20 repetition maximum (RM) increasing to 8 RM over time) to a low- (two sets of 30 RM) intensity resistance protocol for 20 wk.

Although the effects of resistance training on body weight and composition may be modest, resistance training has been associated with improvements in CVD risk factors in the absence of significant weight loss. Resistance training has been shown to increase HDL-C (65), decrease LDL-C (54,65), and decrease TG (54). Improvements in insulin sensitivity (29,66) and reductions in glucose-stimulated plasma insulin concentrations (65) have been reported after resistance training. Reductions in both systolic and diastolic blood pressure have also been reported after resistance training (77,106).

In summary, resistance training does not seem to be effective for weight reduction in the order of 3% of initial weight and does not add to weight loss when combined with diet restriction. Resistance training increases fat-free mass when used alone or in combination with weight loss from diet restriction. Resistance training may increase loss of fat mass when combined with aerobic exercise compared to resistance training alone. No evidence currently exists for prevention of weight regain after weight loss or for a dose effect for resistance training and weight loss.

PA, weight, and chronic disease risk factors. This position paper is primarily focused on PA and weight; however, it should be acknowledged that there are benefits shown for PA whether weight is lost and perhaps even if weight is gained. For example, data from longitudinal studies such as The Coronary Artery Risk Development in Young Adults Study (CARDIA) (91,105), the Atherosclerosis Risk in Communities Cohort (141–143), and the FELS Longitudinal Study (127,130,131) provide evidence that the prevention of weight gain may be the easiest way to prevent the development of undesirable changes in CVD risk factors (i.e., increased LDL-C, total cholesterol, TG, fasting glucose, and decreased HDL-C). Long-term data (15 yr) from the CARDIA study (91) indicate that regardless of BMI, individuals that maintain a stable BMI minimized the undesirable changes in CVD risk factors that may be associated with aging.

Benefits of PA for the reduction of chronic health risks are seen with minimal weight loss of less than 3%. For example, Donnelly et al. (33) randomized sedentary, moderately obese females to 18 months of either continuous or intermittent exercise. After 18 months of exercise, weight loss was ~2% in the continuous group and ~1% in the intermittent group. Despite the minimal weight loss, both groups had significant improvements in HDL-C and reduced insulin area under the curve after an oral glucose tolerance test. Kraus et al. (83) randomized sedentary, overweight men and women to either a control group, a high-amount, high-intensity group, a low-amount, high-intensity group, or a low-amount, moderate-intensity group. Intensities ranged from 40% to 55% $\dot{V}O_{2max}$ in the moderate-intensity group and from 65% to 80% $\dot{V}O_{2max}$ in the high-intensity groups. Despite minimal weight (<2%) loss in all groups, there were significant beneficial decreases in TG and increases in HDL-C.

Considering that most of the adult population gains weight across time, it is important to determine whether PA attenuates undesirable changes in chronic disease risk factors across time. Data from longitudinal observational studies indicate an association between PA and an attenuation of risk across time. In the Healthy Women Study (109), women who increased PA by ≥300 kcal·wk^{-1} had basically no change HDL-C during a 3-yr period compared to women who decreased PA by ≥300 kcal·wk^{-1} had a 1.9-mg·dL^{-1} decrease in HDL-C. Data from Nurse's Health Study (62) examined the association of sedentary behavior and television watching to the risk of obesity and type 2 diabetes during a 6-yr period. Minimal activity (walking around the house 2 h·d^{-1}) was associated with 9% reduction in obesity and a 12% reduction in type 2 diabetes and walking 1 h·d^{-1} was associated with a 24% reduction in obesity and a 34% reduction in type 2 diabetes. A limitation of these studies is that they are observational in nature and the PA is self-reported.

Few randomized controlled trials have examined the relationship between PA and weight gain. Of the few available that measure CVD risk factors, they examine this relationship in individuals that are at risk for weight gain and utilize interventions that are a combination of PA and nutrition (13,100). Thus, there is not enough literature to determine whether PA prevents or attenuates detrimental changes in chronic disease risk factors during weight gain and such studies are needed. In summary, it seems that minimal amounts of PA improve many chronic disease risk factors. However, there are few published literature on the time course of these improvements; the permanence of these improvements over time, if there are diminishing returns for the amount of weight lost, and the ability of the PA to improve or attenuate increases in chronic risk factors during weight gain are poorly understood and merit investigation.

CONCLUSIONS

Moderate-intensity PA of 150 to 250 min·wk^{-1} with an energy equivalent of ~1200 to 2000 kcal·wk^{-1} seems sufficient to prevent weight gain greater than 3% in most adults and may result in modest weight loss. PA without diet restriction generally provides modest weight loss; however, laboratory studies that provide supervision and greater doses of PA compared to outpatient studies tend to show weight loss at or above 3% of initial weight. PA combined with diet restriction provides a modest addition of weight loss compared to diet alone, and this additive effect is diminished as the level of diet restriction increases. There are cross-sectional and prospective data that PA is associated with prevention of weight regain after weight loss; however, there are no appropriately designed, randomized controlled trials to indicate whether PA is effective for the prevention of weight regain and no information regarding the existence of a potential dose effect. Lifestyle approaches for increasing PA and planned PA are consistently associated with less weight gain compared to inactivity. The effects of lifestyle PA for prevention of weight regain after weight loss are unknown owing to lack of available literature. The effects of resistance training for prevention of weight gain are largely unknown owing to lack of available literature. Resistance training does not seem to be an effective means for weight loss but is associated with numerous other health benefits including decreases in many chronic disease risk factors and increases in fat-free mass and decreases in fat mass. Weight maintenance compared to weight gain seems to protect against an increase in chronic disease risk factors, and in many studies, weight loss as little as 3% has been associated with favorable changes in chronic disease risk factors.

On the basis of the available scientific literature, the ACSM recommends that adults participate in at least 150 $min \cdot wk^{-1}$ of moderate-intensity PA to prevent significant weight gain and reduce associated chronic disease risk factors. It is recommended that overweight and obese individuals participate in this level of PA to elicit modest reductions in body weight. However, there is likely a dose effect of PA, with greater weight loss and enhanced prevention of weight regained with doses of PA that approximate 250 to 300 $min \cdot wk^{-1}$ (approximately 2000 $kcal \cdot wk^{-1}$) of moderate-intensity PA.

These recommendations are consistent with the recent publication of the US Department of Health and Human Services Physical Activity Guidelines for Americans and the accompanying Advisory Committee Report (http://www.health.gov/PAGuidelines/Report/Default.aspx).

This pronouncement was reviewed for the American College of Sports Medicine by the ACSM Pronouncements Committee and by Ross E. Andersen, Ph.D., James D. Dziura, Ph.D., James O. Hill, Ph.D., Laura J. Kurskall, Ph.D., FACSM, and Robert Ross, Ph.D.

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