Best Practice & Research Clinical Gastroenterology
Vol. 18, No. 6, pp. 1009–1029, 2004
doi:10.1016/j.bpg.2004.06.022
available online at http://www.sciencedirect.com

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# The role of exercise for weight loss and maintenance

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Exercise provides a means of increasing energy expenditure and may help adjust energy balance for weight loss and maintenance. At least 30 minutes a day of moderate intensity aerobic exercise per day is recommended for weight loss and maintenance but greater amounts appear to increase the magnitude of weight loss and maintenance. Resistance training has recently been shown to have positive effects on body composition but does not typically show significant decreases in weight. Regardless of weight loss, both aerobic exercise and resistance training have been shown to diminish risk factors for cardiovascular disease and diabetes. Since exercise is only effective if sustained, behavioural strategies such as self-monitoring, goal setting, social support, etc. are used to help individuals start and maintain exercise programs and show improved results compared to exercise programs without behavioural strategies. The available evidence indicates that exercise is an important component of weight loss and perhaps the best predictor of weight maintenance.

**Key words:** weight loss; weight maintenance; exercise; energy balance; energy expenditure; risk factors; behavioural strategies.

## ENERGY BALANCE

Obesity is the result of excess energy intake compared to energy expenditure. In order to lose weight, a negative energy balance must be evoked and to maintain lost weight, energy balance must be maintained. To illustrate, Figure 1 shows the two sides of energy balance classically depicted by a balance scale. When energy intake exceeds energy expenditure weight gain occurs and when energy expenditure exceeds energy intake weight loss occurs. If energy intake and energy expenditure are matched or 'balanced', weight is stable.

Although the concept of energy balance appears simple, it is deceptively so. Energy intake consists of all ingested foods and beverages with an energy value. Control of energy intake is subject to a host of environmental, behavioural, biological, and genetical influences. Measurement of energy intake is notoriously difficult and prone to error. Men and women routinely under estimate energy intake by 30–50%.[1]

The components of energy expenditure are depicted in Figure 2. Basal metabolism represents the energy needs for survival in a resting state and measurement is logistically cumbersome and is rarely attempted. As a close surrogate, resting metabolism is routinely measured and represents the energy needs of an individual who is at rest. Resting metabolic rate (RMR) generally accounts for approximately 60–75% of 24-hour energy expenditure. Energy required to digest and absorb food accounts for approximately 10–15% of 24-hour EE and is dependent on a number of factors including the size and composition of the meal and the prior and current state of the individual. The energy expenditure of movement is highly variable and is generally conceptualised to represent the energy needs for activities of daily living and planned physical activity or exercise. This component of energy expenditure may comprise from 10 to 30% of

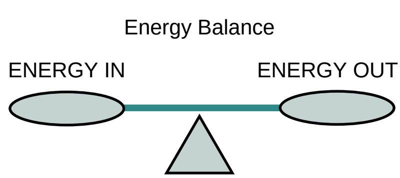


**Figure 1.** Energy balance.

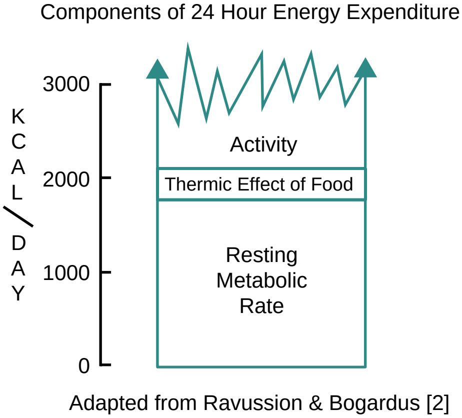


**Figure 2.** Components of energy expenditure.

24-hour energy expenditure. The sum of the components equals total energy expenditure for a 24-hour period.

It may appear that calculating energy intake and energy expenditure is a relatively simple matter of addition and subtraction and indeed, this is frequently the method used to determine the energy values for energy intake and energy expenditure in the attempt to manipulate weight. Unfortunately, it is not so simple because the components of energy balance are interactive. That is, if one component is manipulated, a second component or multiple components may show changes or 'compensation'. When compensation occurs, the manipulation of the components of energy balance may not have the intended result (i.e. weight loss). For example, an individual may attempt to lose weight by evoking a 500 kcal negative energy balance using a low energy diet to diminish the energy intake side of the energy balance equation. However, diets have been shown to diminish resting metabolism and exercise[3]; therefore, the intended energy deficit may be less than planned or absent altogether. The interactive nature of the components of energy balance may explain why actual weight loss rarely equals the calculated expected weight loss when using simple addition and subtraction to calculate the level of energy imbalance (deficit).

## EXERCISE FOR WEIGHT LOSS AND MAINTENANCE

There are limited choices an individual can make in the attempt to evoke a negative energy balance for weight loss or to attain energy balance for weight maintenance. Certainly, the most common method for weight loss and maintenance is diet; however, just as certainly, diet does not provide a long-term solution. Over 50% of individuals who lose weight through diet eventually regain the weight they lost.[4] Dietary restraint is difficult across time; it represents a state of deprivation, and runs counter to the current environment that provides enormous amounts of palatable, high energy, low cost foods, and beverages available at almost any location.

Exercise is the only component on the EE side of the energy balance equation that is under voluntary control. Indeed, if resting metabolism were under voluntary control, an individual could simply over eat and increase their resting metabolism and remain weight stable. In turn, the current obesity epidemic we experience would not exist.

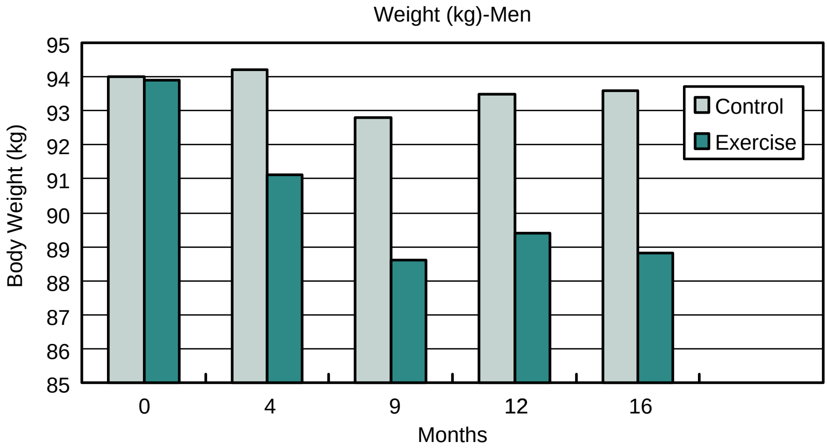


**Figure 3.** Weight loss in men in response to 16-months of exercise.

For exercise to be effective for either weight loss or maintenance, the real question is 'will exercise provide a negative energy balance for weight loss or maintain energy balance for weight maintenance without substantial compensation from other components of the energy balance equation?

When determining if exercise is effective for weight loss it is important to determine the magnitude of weight loss necessary to reduce health risk, not the magnitude necessary to reach a cosmetic or personal goal. There is growing evidence that a weight loss of between 5 and 10% of baseline weight will substantially reduce health risk. Thus, to determine if exercise is effective for weight loss, it is appropriate to determine if exercise will provide a 5–10% reduction over baseline weight. Recent evidence indicates that exercise that expends at least 2000 kcal per week is effective to evoke a weight loss of at least 5% for men and will likely prevent weight gain for women[5] (Figures 3 and 4). This amount of exercise can be obtained with brisk walking 5 days per week for approximately 45 minutes per day.

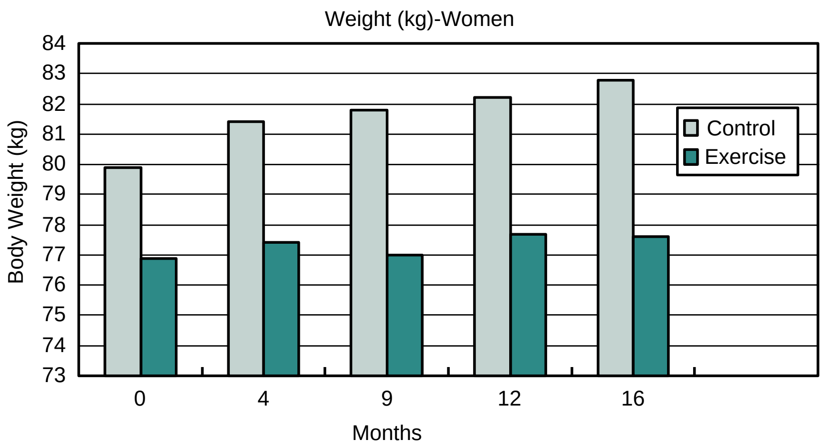


**Figure 4.** Weight loss in women in response to 16-months of exercise.

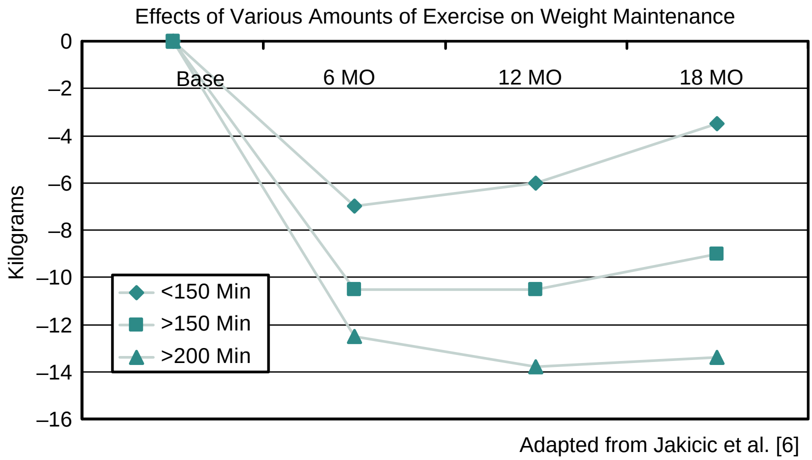


**Figure 5.** Effects of various amounts of exercise on weight maintenance.

Although most individuals can lose weight, weight maintenance is elusive. It is unrealistic to define weight maintenance as maintenance of the lowest weight achieved during weight loss. The term 'weight management' may be more appropriate as it reflects an on-going process where some weight gain may occur followed by management strategies to lose the weight that was gained. The result is a fluctuating 'sine wave' with a weight around which there are reasonable increases and decreases across time. Exercise is perhaps the greatest predictor of weight maintenance. Exercise of approximately 150–200 minutes per week with an energy equivalent of approximately 1000–2000 kcal/wk has been shown to be effective for weight maintenance and is superior to lesser amounts of exercise (Figure 5). For those able to complete even greater amount of exercise (i.e. 2,500 kcal/wk), it appears that weight maintenance is enhanced compared to less exercise (Figure 6).

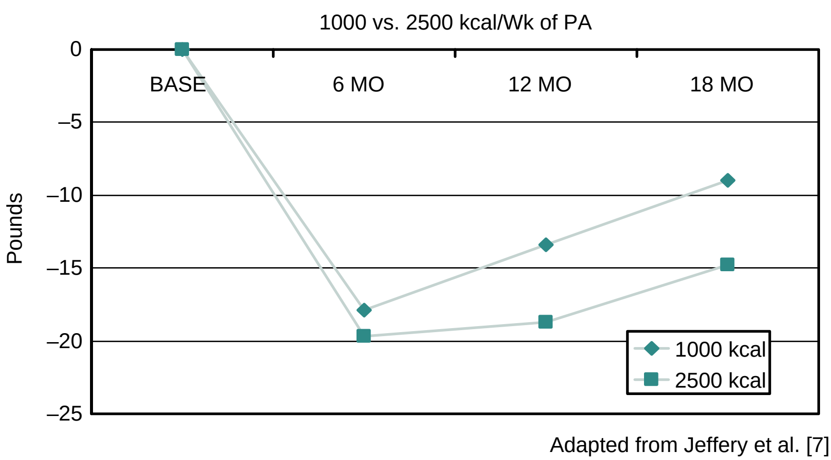


**Figure 6.** Effects of additional exercise on weight maintenance.

In summary, energy balance is the key concept for weight loss and maintenance. Ultimately, energy expenditure must exceed intake for weight loss and must equal intake for weight maintenance. Long-term restriction of energy intake has proven difficult and generally results in weight re-gain over time. Exercise has been shown to provide an energy expenditure that is not fully compensated with other components of the energy balance equation and thus provides a stimulus for weight loss and maintenance.

## BY WHAT MECHANISMS CAN EXERCISE ALTER ENERGY BALANCE?

Exercise may alter energy balance through a variety of mechanisms including the energy expended during the exercise activity, the energy expended shortly after the activity, and the alteration of resting metabolism. The most obvious mechanism for exercise to alter energy balance is through the energy expended during the exercise activity. Energy expenditure during exercise with endurance athletes may reach levels 15 times greater than resting.[8] Previously sedentary but otherwise healthy older adults may reach energy expenditure levels 8-10 times greater than resting.[9] If we assume a static energy balance model (which we use only for illustrative purposes), an individual performing a moderate 30 minutes bout of exercise would likely consume between 150 (sedentary older person walking)-400 kcal (athlete running about 8 mph).[8] Thus, weight should decease in response to the addition of an exercise program.

However, several papers[5,10] in which exercise was performed without energy restriction for more than 12 months have reported no weight loss. In one study, middle-aged, overweight women performed moderate-intensity aerobic activity and did not lose weight or body fat.[10] In another study, college-aged men and women walked on a treadmill at a moderate-intensity, 5 days per week, 45 minutes per day under direct supervision for 16 months.[5] Interestingly, women did not lose weight but men did lose weight suggesting a potential gender difference in the alteration of 24-hour energy balance through long-term aerobic exercise.

A bout of exercise of sufficient duration and intensity not only alters energy expenditure during the exercise activity but for 1–3 hours afterwards. This alteration in energy expenditure is frequently called excess post-exercise oxygen consumption (EPOC). Theoretically, EPOC could increase 24-hour EE and thus, help create a negative energy balance. However, to date, there are no studies that have reported EPOC as a major factor in altering body weight.

Long-term aerobic exercise may alter energy balance through alterations in RMR, which is the largest single component of 24-hour energy expenditure. In cross-sectional studies, the results for exercise are mixed as RMR has been shown to be greater in aerobically trained individuals compared to sedentary individuals[11] while others[12], have not found RMR to be greater in trained compared to sedentary individuals. In short-term studies[13,14], RMR has been shown to increase about 8% in response to aerobic training. The impact of long-term aerobic training on RMR has yet to be studied in a randomized controlled trial.

Resting metabolism can be predicted by lean body mass that is mostly comprised of skeletal muscle. Thus, increases in lean body mass may lead to increases in RMR that in turn may lead to increases in 24-hour energy expenditure. The effects of resistance training on RMR have been mixed with some studies showing increases in

RMR in response to RT[15,16], while others report no increase in RMR in response to resistance training.[17–19] Lemmer et al.[20] has proposed that the conflicting results are largely due to two factors; age and gender of the subjects. Studies in older subjects tended to show increases in RMR while studies in primarily younger subjects tended to show no increases in RMR. Fewer studies are available investigating the effects of resistance training on RMR between men and women but what is available suggests that men respond with greater increases in RMR compared to women. For a thorough discussion of resistance training for weight loss and weight maintenance, please see the recent review by Donnelly, et al.[21]

## RECOMMEND GUIDELINES FOR EXERCISE DURING WEIGHT LOSS AND WEIGH MAINTENANCE

The current guidelines regarding exercise and physical activity can be very confusing to the general public. In 1995, the American College of Sports Medicine (ACSM) recommended that sedentary adults accumulate "30 minutes or more of moderate-intensity physical activity on most, preferably all days of the week".[22] In 1996, similar recommendations were made by the US Surgeon General[23] and the National Institutes of Health.[23] These are the recommendations that are most familiar to Americans, but these recommendations were designed to improve general health and to prevent cardiovascular disease, they were not intended to aid in weight loss or weight maintenance.

The rapid increase in obesity rates has led to a re-evaluation of exercise recommendations. In 2001, the ACSM issued a Position Stand regarding weight loss and weight maintenance and recommended that individuals seeking to lose weight should participate in at least 150 minutes of moderate intensity exercise per week, and to accumulate $>200$ minutes of moderate intensity exercise per week when possible.[25] The ACSM presented evidence to support a greater exercise recommendation (200–300 minutes exercise per week), but the ACSM also acknowledged that 200–300 minutes of exercise per week was unrealistic for most individuals to adopt and maintain. In 2002, the United States Institute of Medicine (IOM) recommended that individuals accumulate 60 minutes per day (420 minutes per week) of moderate intensity exercise for weight maintenance.[26] In 2003, the International Association for the Study of Obesity (IASO) made two separate recommendations.[27] For formerly obese individuals, it was recommended that 60–90 minutes of moderate intensity exercise per day (420–630 minutes per week) was needed to prevent weight regain. The IASO also suggested that 45–60 minutes of moderate intensity exercise per day (315–420 minutes per week) was necessary to prevent an overweight individual from becoming obese.

What is evident by the recommendations is that exercise required for the prevention of weight regain is much greater than the exercise required for general health and disease prevention. As the ACSM acknowledged, this increase in recommendations may not be feasible for most individuals. How can we expect individuals to exercise 60 minutes per day when 60% of Americans do not even meet the minimum of 30 minutes per day?[23] Although it may be difficult for most Americans to find 30–60 minutes per day to exercise, this time commitment may be more manageable if it is broken up into several 10–15 minutes segments during the course of the day.

When compared to continuous exercise, intermittent exercise appears to show similar responses for weight management. Jakicic et al.[6] and Donnelly et al.[10] have both shown that there were no significant differences in the weight changes between groups that either exercised continuously or intermittently over the course of an 18 month weight loss program. Schmidt et al.[28] reported similar findings in overweight females during a 12 week study. Although intermittent exercise may not result in greater weight loss, Jakicic et al.[29] reported that this strategy might be beneficial during the initial stages of an exercise program and allow an individual that would otherwise terminate to continue an exercise program. Intermittent exercise also may be beneficial for individuals that dislike or are unable to exercise for extended periods of time.

Regardless of how the exercise is accumulated there appears that more may be better and there are several randomized studies that support this finding. Jakicic et al.[30] reported that weight loss at 12 months in sedentary women was greater in individuals that exercised more than 200 minutes per week when compared to women that exercised less than 150 minutes per week. Jeffery et al.[7] reported that in overweight men and women an exercise prescription of 2500 kcal per week was more effective at maintaining weight loss at 12 and 18 months than an exercise prescription of 1000 kcal per week. Slentz et al.[31] randomly assigned sedentary overweight men and women to one of three exercise groups: (1) 20 miles per week, vigorous intensity, (2) 12 miles per week, vigorous intensity, and (3) 12 miles per week, moderate intensity. There was a significant dose–response relationship with the high mileage group losing significantly more body weight and body fat than the lower mileage groups. One common factor of all of these studies is that regardless of the exercise prescription, the initial weight loss was similar for all groups within a study. The dose–response relationship was associated with the maintenance of the weight loss and not with the initial weight loss. Thus, it appears that exercise is associated with weight maintenance and not with weight loss.

Data from the National Weight Control Registry (NWCR) supports the idea that a large volume of exercise is necessary to maintain weight loss. In order to participate in the NWCR, an individual must have lost at least 30 lbs and maintained this weight loss for greater than one year. By examining the characteristics of these individuals, one can get an idea of what it takes to be successful at weight maintenance. One characteristic of these individuals that stands out is that they are very active. They report expending approximately 11,830 kJ/wk through exercise, which is equivalent to walking 28 miles per week.[32]

There appears to be a clear dose–response relationship for exercise and weight maintenance, with more exercise providing greater weight maintenance. A recent cross sectional study from Berstein et al.[33] clearly shows this dose–response relationship between EE and odds of becoming overweight or obese. Those individuals in the highest tertile of exercise had a much greater chance of being normal weight than those individuals that were in the lowest tertile of exercise. The results were similar for both genders and across all age ranges.

In summary, consensus is currently lacking on a specific exercise recommendation for weight loss and/or weight maintenance, although it is apparent that exercise is an important component of both. Recommendations for weight loss range from 30 to 60 minutes of moderate intensity exercise per day and from 30 to 90 minutes per day for weight maintenance. Regardless of the specific recommendation, there appears to be a dose–response effect with more exercise associated with more weight loss and greater weight maintenance.

## QUANTIFICATION OF ENERGY EXPENDITURE

Many weight loss and weight maintenance programs incorporate regular exercise as a means to facilitate weight loss or maintain weight loss. When incorporating exercise into these programs it is important to monitor the volume of exercise (i.e. energy expenditure), so that modifications can be made when necessary due to physiological changes, weight loss, etc. However, exercise is a behaviour and energy expenditure is a result of this behaviour. Therefore, methods for measuring exercise and energy expenditure are different. Figure 7 shows the methods that can be used to measure either exercise or energy expenditure and the conceptual difference between the two.[35] The method that is most appropriate to use in research or in the field depends heavily on the question of interest, the data (e.g. the variables of interest) that are collected, the sample size of the population, and the amount of burden both researchers and participants are willing to accept.

Doubly labelled water measures energy expenditure through the use of two different stable water isotopes that are ingested by an individual. The excretion of these isotopes can be measured in the urine and the energy expenditure is then calculated using established equations.[36] The doubly labeled water technique can be used to assess energy expenditure in either a laboratory or field setting[36,37]; however, it is expensive and you can only determine total energy expenditure, not the various components of energy expenditure.

Energy expenditure may be estimated from measured oxygen uptake and this procedure is frequently referred to as indirect calorimetry. Due to the development of

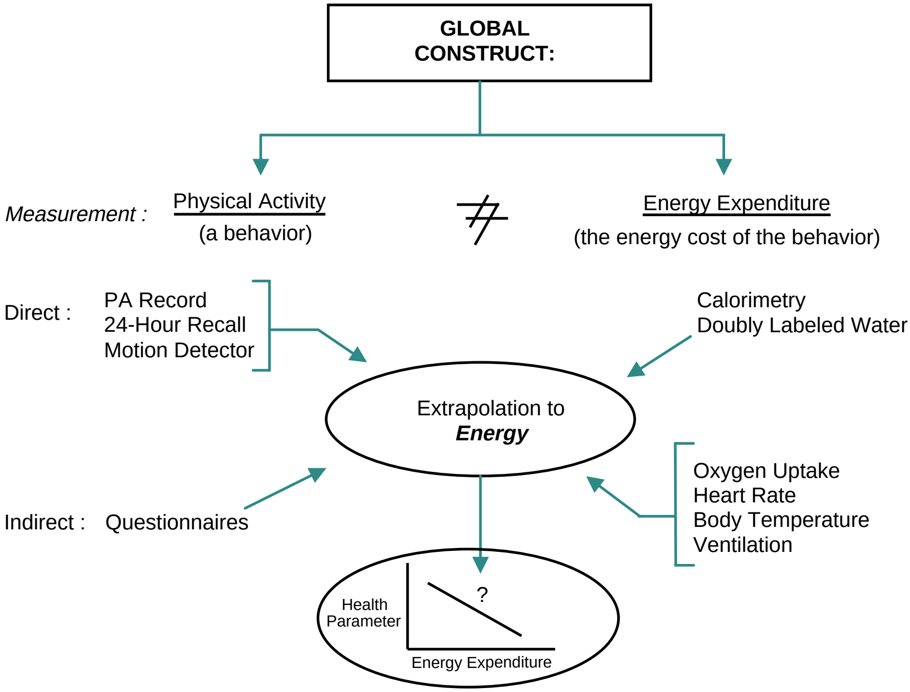


**Figure 7.** A conceptual model of the relationships between movement, physical activity and energy expenditure, as well as methods of assessment.[35]

portable devices, this technique can now be used in the field as well in the laboratory setting. Energy expenditure is estimated based on the relationship between oxygen uptake and the caloric cost of substrate oxidation.[38,39] Thus, if you can measure oxygen uptake, you can estimate energy expenditure. Like doubly labelled water, measurement of oxygen uptake can be cost prohibitive in field settings and thus it is generally found in the research setting.

Accelerometers (motion detectors) and pedometers (step counters) have been used to estimate exercise habits and to estimate energy expenditure. Accelerometers are useful as they are small and unobtrusive and may be worn for extended periods of time. There are many different types of motion detectors and pedometers and the costs vary widely from ∼10.00 to ∼$500.00. Each device has its strengths and weaknesses and some are capable of estimating energy expenditure better than others. For a review of motion detectors and pedometers please refer to the review by LaMonte and Ainsworth.[35]

Heart rate monitors may also be used to estimate energy expenditure and as stated above, there is a known relationship between oxygen consumption and energy expenditure. Studies have shown that a strong relationship exists between heart rate and oxygen consumption.[38,39] Many heart rate monitors can be worn over extended periods of time (days), which allows for the estimation of total energy expenditure or energy expenditure during a specific bout of activity. Further, Strath et al.[40] have suggested that the combination of heart rate measurement with accelerometers may improve the ability to quantify energy expenditure. It should be mentioned that other factors could (i.e. stress, medication) influence a person's heart rate without changing energy expenditure, resulting in diminished accuracy for the estimation of energy expenditure.

A method commonly used to measure exercise and energy expenditure in population studies is physical activity questionnaires. Many different questionnaires have been developed and validated and range from a global recall to a quantitative history.[41] Some questionnaires are scored using an ordinal scale[34], whereas, others can have metabolic equivalent (MET) values or caloric equivalents attached to items and then are summed to give values in MET-minutes per day.[42,43] The use of MET values allows energy expenditure to be estimated and this can be done for energy expenditure of individual activities (i.e. running, mowing the yard, or washing dishes) or summed for overall energy expenditure depending on the structure of the questionnaire. While questionnaires are easy to use and have a low cost associated with them, there also exists a high likelihood for poor recall and other biases (i.e. comprehension, specificity of activities, etc.) to effect the estimation of energy expenditure.

In summary, many methods to quantify EE exist and each method has positive and negative aspects. In general, questionnaires give a reasonable estimate of physical activity and energy expenditure. The challenge lies in determining which method is right for the population under study, the aims of the study and the available resources.

## RESISTANCE TRAINING FOR WEIGHT LOSS AND WEIGHT MANAGEMENT

### Resistance training and 24-hour energy expenditure

The EE associated with resistance training is lower than that typically shown with endurance exercise; however, resistance training may increase energy expenditure by promoting an increase in muscle mass. Muscle mass has a resting energy requirement of

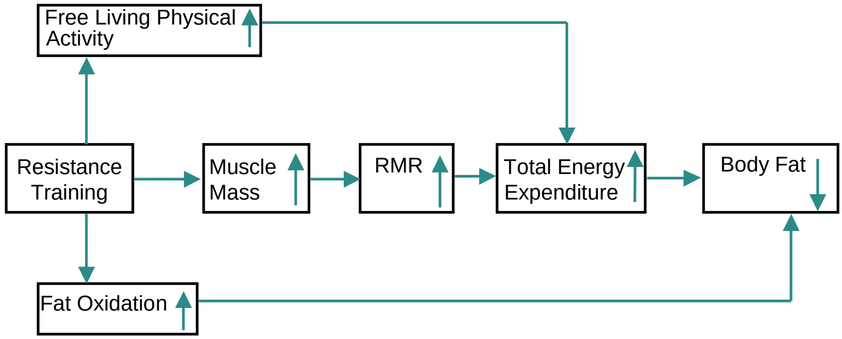


**Figure 8.** Conceptual model of resistance training and the potential effects on energy expenditure that includes both the energy expenditure from increased muscle mass and the potential energy expenditure from increased activities of daily living. RMR, resting metabolic rate.[21]

~ 15–25 kcal per kilogram per day[44] and would utilize energy not just during exercise, but also throughout the day. Thus, although the energy expenditure of resistance training is relatively low, the accumulated energy expenditure across 24-hours may be substantial enough to aid in weight management. Figure 8 represents a model that may reflect a role for resistance training in weight management.

Resistance training may play a role in promoting free-living physical activity or 'activities of daily living'. Increased daily physical activity assessed by portable accelerometers has been shown in response to resistance training in older individuals.[45,46] If obese individuals increase strength in response to resistance training, increases in activities of daily living would not be surprising. This in turn may contribute to total energy expenditure and may promote weight maintenance or weight loss. Recently, Hill et al.[47] estimated that an 'energy gap' of only 100 kcal per day might be responsible for weight gain in 90% of the population. Reduction or elimination of this energy gap would prevent or reduce weight gain in the majority of Americans. An increase in muscle mass of ~ 1–2 kg is commonly reported following resistance training programs[48–50]; therefore, a 2 kg increase in muscle mass may increase daily energy expenditure by ~50 kcal, thus reducing the energy gap to about 50 kcal per day. In addition to increasing total energy expenditure, resistance training also has the potential to increase the utilization of fat as an energy source. For example, Treuth et al.[51] reported a significant decrease in 24-hour respiratory exchange ratio (RER) (0.90–0.82) following 16 weeks of resistance training in older women. This decrease in RER resulted in an increase in 24-hour fat oxidation from 42 to 81 g/day. Although the EE associated with a bout of resistance training is low compared to endurance exercise and the change in daily energy expenditure may be modest, resistance training may contribute to weight management.

## Body weight and body composition

Resistance training without energy restriction generally does not show reductions in body weight. Short-term studies of less than 6 months[52,53] and long-term studies of at least 6 months or greater[54,55] in women[56,57] and men[52,58] and younger[59,60] and older[61,62] participants generally do not show changes in body mass index (BMI) or body weight, although they generally show changes for body composition (i.e. an increase in fat free mass (FFM) and a decrease in fat mass (FM)).

Resistance training in combination with energy restriction generally does not provide additional weight loss compared to energy restriction alone.[63–65] This is likely due to the low energy requirements of resistance training and the potential to maintain FFM or even increase FFM during energy restriction. Indeed, many individuals attempt to retain FFM and lose FM by combining resistance training with moderate energy restriction.

## Recommended guidelines of resistance training

Although resistance training is often depicted as complicated, time-consuming, and requiring the potentially dangerous practice of explosively lifting heavy weights[20] the converse is actually true.[53] In fact, resistance training is a safe, relatively simple activity, which does not necessarily involve using very heavy weights, and takes minimal time. Based on an extensive review by Feigenbaum and Pollock[66], it appears that most of the benefits of resistance training can be accrued from two 15–20 minutes sessions a week. Other investigators have suggested that most of the benefits of resistance training can be achieved with a single set as opposed to multiple sets.[53] It is also apparent that while training studies typically employ 10–15 exercisers, only six to seven movements may be required to strengthen all the major muscle groups and increase muscle mass.[66]

The ACSM recommends that healthy adults perform 1 set of resistance training, 3 day/wk, 8–12 repetitions, using nine exercises. The exercises should incorporate both upper and lower body musculature and be performed in a slow and controlled manner in order to reduce injury. However, the amount of resistance training recommended by the ACSM may be effective in producing significant strength gains but may have limited effect on FFM. It appears that multiple sets (2–4) may be required to increase FFM by maximizing muscle fiber recruitment and, consequently, muscle fiber hypertrophy. However, this may increase the burden on the individual, increasing the potential for injury and, potentially decreasing adherence to the program.[67]

## Summary/Recommendations for resistance training and weight management

BMI is the currently the accepted measure of overweight and obesity. To reduce BMI and the corresponding health risks, weight loss is warranted. Resistance training without energy restriction appears to have a limited role for weight loss; however, resistance training will generally increase FFM and decrease fat mass. This by itself may decrease the health risks associated with overweight and obesity. When used in conjunction with energy restriction, resistance training has been shown to preserve FFM compared to energy restriction alone. However, this effect is not apparent if the energy restriction is severe. If both weight loss and a reduction in BMI are desired, it appears that resistance training has a small impact and adds little to energy restriction alone. In the future, it will be important to determine the amount of increase in FFM necessary to potentially have an impact on weight loss, and to conduct short-term and long-term energy balance studies to determine what components of energy expenditure and energy intake may be altered to reduce body weight in response to resistance training. A more extensive review of resistance training and its effect on body weight management can be found elsewhere.[21]

## HEALTH BENEFITS OF EXERCISE WITHOUT WEIGHT LOSS

Exercise, including aerobic and resistance training, is widely held as having a beneficial impact on health regardless of changes in weight and body composition. There are many studies demonstrating the positive influence of exercise and fitness on cardiovascular disease.[68,69] This positive impact on cardiovascular disease seen with aerobic training is further supported by numerous studies indicating a reduction in many of the major risk factors, including blood pressure, cholesterol, and type 2 diabetes.[70–72]

For example, the results of several observational studies have shown a 30–50% reduction in the risk of developing hypertension in active adults compared to sedentary adults.[73–75] In addition, the results of 40 randomized studies have demonstrated a 7/6 mmHg (systolic/diastolic) reduction in blood pressure in people with hypertension and a 3/2 mmHg (systolic/diastolic) reduction in blood pressure in normotensive individuals after aerobic training.[70] Resistance training has also been shown to lower blood pressure independent of weight loss in hypertensive individuals[76] and individuals with high normal blood pressure.[77,78] This reduction in blood pressure results from both acute and chronic exercise and can last up to 22 hours post exercise.

Aerobic training and resistance training also seem to have a small but meaningful impact on plasma lipids and lipoproteins. Results from 30 randomized controlled trials demonstrate that aerobic training increases high density lipoprotein cholesterol (HDL-C) by 5% on average.[79–81] Similar results have been seen for low-density lipoprotein cholesterol (LDL-C) (5% reduction) and triglycerides (4% reduction) but in fewer studies and with less consistency than the results seen with HDL-C.[79–81] Similarly, several investigations[82,83] have shown significant improvements in blood lipid and lipoprotein levels resulting from resistance training that include reductions in total cholesterol (3–16%) and LDL-C (5–39%) and increases in HDL-C (14–27%).

As with blood pressure and cholesterol, investigations have demonstrated a role for both aerobic training and resistance training in the prevention and treatment of diabetes. It has been shown in several studies that moderate exercise is associated with a 25–50% reduction in the risk of developing type 2 diabetes.[84–86] A larger number of studies have demonstrated a ~10% improvement (ranging from 5–50%) in glucose tolerance in individuals with impaired glucose tolerance.[87–89] Likewise, resistance training seems to improve glucose tolerance[90–92] and the improvement in insulin sensitivity may actually be greater as a result of resistance training compared with aerobic training.[93] The data suggest that the favorable effect of exercise on glucose tolerance and insulin sensitivity lasts up to 72 hours after the exercise bout.

In summary, moderate aerobic and/or resistance training are widely held as effective methods of improving many of the major risk factors for cardiovascular disease, including blood pressure, cholesterol, and type 2 diabetes regardless of weight loss.

## BEHAVIOURAL STRATEGIES FOR INITIATION AND MAINTENANCE OF PHYSICAL ACTIVITY

We know that many individuals will not or cannot initiate weight loss programs and even less are able to maintain weight that has been lost. According to the US Surgeon Generals Report on Physical Activity[94], 'Behavioral strategies to promote diet and PA should be used routinely as they are helpful in achieving weight loss and weight maintenance' (p. 82). The primary reason behavioural strategies are encouraged is that behaviours are learned and can, in turn, be changed or modified. Behavioural strategies are used to induce weight loss by teaching individuals to monitor cues related to weight gain. Behavioural strategies refer to the application of techniques to overcome barriers and to improve adherence in behaviours that are targeted for change (i.e. exercise, diet). Behavioural strategies for weight loss or weight maintenance is not a single technique. The combination of many strategies are generally used and include self-monitoring, goal setting, stress management, social support, relapse prevention, cognitive restructuring, stimulus control, and problem solving.

A mainstay of weight management is self-monitoring. Self-monitoring is the systematic observation and recording of target behaviours and typically includes the use of a diary or record keeping. For example, when monitoring exercise, individuals may be asked to record when they exercised, how long, the type of exercise, and perceived exertion in an activity log.[95,96] For diet intake, individuals typically will record when, where, and what they have consumed. This provides immediate feedback to the individual and provides a record that may be examined by a health professional (i.e. registered dietitian) to determine if the individual is following the prescribed diet or if modifications are necessary.

Goal setting often is part of a behavioural approach to weight loss. Goals should be specific, measurable, achievable, realistic, and time-bound to be effective. The focus of goals should be on actual behaviours instead of results. It is important to have both short and long-term goals to help maintain motivation. Short term goals (i.e., increasing exercise by 15 minutes per day) provide a sense of accomplishment and help the individual maintain motivation to reach his or her long-term goal (i.e., weight loss).[96] In turn, short term goals may contribute to reaching long-term goals that have been associated with successful weight loss and maintenance such as 300 minutes or 2,000 kcal of exercise per week.

Weight management requires vigilance, planning and allocation of time. It does not happen by itself. Although weight loss brings health benefits, it may also be perceived as stressful to the individual. Thus, teaching individuals how to manage stress is generally an integral part of successful behaviour therapy. Teaching stress management techniques such as diaphragmatic breathing and relaxation can be beneficial in reducing stress.[96] In addition, one of the documented, premier benefits of exercise is stress reduction[94] and exercise is an integral part of virtually any weight management program.

Weight management is not conducted in a vacuum. The social environment to which an individual is exposed is likely to exert a great deal of influence on the individual's choices and therefore, behaviour. It is difficult to maintain the desired exercise protocols if social contacts run contrary to these intended behaviours. Improving social support has become a key component of behaviour modification in the attempt to initiate and maintain diet and exercise regimens. Positive family members, friends, or coworkers can help the individual by providing encouragement and motivation and by not purposely providing an environment that will likely lead to poor choices by the individual attempting weight management. For example, if friends and family were to constantly provide energy dense foods as snacks and discourage exercise, this would not be a conducive environment for weight management. Wing and Jeffery[97] have demonstrated that among those assigned to a behaviour modification plus social support group, there was a significantly higher percent of participants who completed treatment and maintained their total weight loss, when compared to a group given only standard behaviour therapy. Ninety-five percent and 76%, receiving social support or no social support completed treatment, respectively and 66 and 24%, who received social support or no social support maintained their weight loss at 10 months post intervention, respectfully.

Like many things in life, weight management is not a straight line from point A (overweight) to point B (reduced and maintained weight). There will be successes and failures along the road to weight maintenance. Relapse prevention training is integral when initiating and maintaining an exercise program. In relapse prevention, patients are taught that lapses are normal and that it is imperative to anticipate these occurrences.[98] Planning for events (e.g. travel, vacation, or work) that may cause a disruption in the individual's plan may help decrease the possibility of a relapse. By planning ahead of time, it is possible to provide individuals with coping strategies so there are constructive reactions when lapses do occur. Patients also should be taught the difference between a lapse (brief) and a relapse (more long-term). Lapses are normal, but it is important to prevent a short-term laps from becoming a permanent relapse.

One of the classic principles of behaviour change is goal setting. Likewise, it is just as classic that many (most) individuals set unrealistic, unachievable goals. It is important to help the individual modify unrealistic goals and inaccurate beliefs about weight loss (i.e. once I lose the weight, I am cured).[94] Rational thoughts should be encouraged and information delivered from the health professional regarding the realistic amount of weight loss to be expected from an exercise program can be instrumental in helping the individuals to make an 'informed decision'. In a study by Foster et al.[99], it was shown that individuals were not happy with their weight loss, even though they had lost 10% of their initial body weight. Thus, it is apparent that individuals need help setting realistic, achievable goals.

The environment in which we live exerts enormous influence over our behaviour in conscious and unconscious ways. For example, if an individual lives in an environment where automobiles are not practical, such as a large city, walking from place to place will be encouraged. Likewise, if a person lives where traffic is sparse and the distance between locations is great, the use of an automobile may be encouraged. To elaborate, if there are no sidewalks or playgrounds, or if safety is an issue, exercise may likewise be discouraged. Thus, the general environment in which an individual lives exerts an influence over exercise behaviours. In turn, identifying and changing the environmental cues that lead to an increase or decrease in targeted behaviours is important.[95]

The environment provides many cues related to exercise; some that an individual can control and some that are beyond control. Cues can be created to encourage exercise by altering the individual's personal environment related to exercise. For example, an individual could place exercise clothes in a visible place to use as a reminder to exercise. Exercise equipment can occupy a prominent place in the home instead of occupying an out of the way space, such as the garage or basement. In this computer age, it is easy to have a prompt to exercise appear on a scheduled basis (i.e. noon) reminding an individual to take a walk or pursue some other exercise activity.

The imagination would be the only limiting factor for a motivated individual to increase the cues for exercise in their personal environment.

Weight management is complex and requires constant vigilance, active participation and planning. However, no plan is foolproof and problems are inevitable. Thus, development of problem solving skills is crucial to a sustained weight management effort. Problem solving is the self-correction of problem areas, or barriers, related to the target behaviour. For example, one of the main barriers for increasing exercise is time. The approach to problem solving includes identifying the barrier (time), generating possible strategies to overcome that barrier, evaluating each strategy for pros and cons, and finally, implementing the strategy.[94] For example, if finding time for 60 minutes of exercise is problematic, an individual may plan to exercise for 2, 30 minutes periods by walking to work and walking home, or exercising at lunch for 30 minutes and then exercising by playing soccer with the children for 30 minutes after work is completed. The challenge is to incorporate problem solving into the daily routine so that when problems arise, the mentality is not if the problem can be solved, but how the problem will be solved.

## CONCLUSIONS

Exercise is an important component of energy balance and is the only component under voluntary control. It therefore provides an avenue for intervention in the attempt to manage weight. However, exercise has generally not been associated with large amounts of weight loss due to the relatively small energy expenditure achieved by exercise. Conversely, exercise is perhaps the best predictor of weight maintenance since it is capable of generating enough energy expenditure to compensate for small positive energy imbalances due to excess energy intake. The amount of exercise that is effective for weight loss and maintenance begins at ~150 minutes per week, although there is growing evidence that greater amounts of exercise may be necessary. The vast majority of energy expenditure is accrued during the exercise session and the amount of energy expenditure above baseline that continues after exercise is completed is dependent on the duration and intensity of the exercise. A variety of methods exist to measure energy expenditure, although it is difficult and expensive if accuracy is paramount. As an alternative to aerobic exercise, resistance training has been promoted as a means of weight control; however, the data to support this is scarce. Regardless of the effectiveness of aerobic or resistance training for weight management, risk factors such as blood lipids, glucose, and insulin are generally reduced. With the advancement of behavioural strategies to promote and maintain exercise, it is likely that a greater number of individuals will be able to successfully achieve the benefits of a long-term exercise program.

**Practice points**

- energy balance is the key to weight loss and weight maintenance
- exercise is under voluntary control and will aid in weight loss and is the best predictor of weight maintenance
- regardless of weight loss, both aerobic exercise and resistance training reduces risk factors for cardiovascular disease and diabetes
- behavioural strategies help individuals initiate and maintain exercise

## Research agenda

- the mechanisms by which exercise alters energy balance are elusive and could be elucidated with carefully conducted energy balance studies using whole-room calorimetery
- the amount and type of exercise with or without diet still needs to be determined for weight loss and weight maintenance
- improved behavioural strategies that are culturally appropriate need development and study
- multi level environmental strategies are needed to improve the likelihood that exercise will be chosen over sedentary behaviour

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