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Energy Expenditure and Weight Management

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Introduction

Poorly balanced diets and the lack of physical exercise are key factors in the increase of obesity and other metabolic diseases in modern societies. Here are answers to some of the most popular questions concerning overweight, obesity, Daily Energy Requirements and general weight management. Let's understand these terms:

Overweight

As defined by the Centers for Disease Control and Prevention (CDC), overweight refers to increased body weight in relation to height when compared to some standard of acceptable or desirable weight.

Obesity

As defined by the CDC, obesity refers to an excessively high amount of body fat or adipose tissue in relation to lean body mass based on body composition assessment.

Percent Body Fat (% Fat)

Percentage of overall body weight that is fat mass. To estimate total fat mass, multiply the total body weight by the percentage body fat.

Lean Body Mass (IBM)

Percentage of overall body weight that is nonfat (e.g., muscle, bone, blood, fluids, organs). Related to basal metabolic rate (BMR). To estimating lean body mass, subtract the fat weight from the total body weight.

Relationship of Body Composition to Health and Body Fat Distribution Pattern

High Body Fat

High body fat, especially abdominal fat, is associated with risk of obesity-related diseases like: Diabetes, Coronary artery disease, Heart failure, Stroke, Certain cancers (e.g., pancreatic, colon, possibly breast and prostate), Sleep apnea, Arthritis and Hypertension (high blood pressure).

Low Body Fat

Low body fat may be desirable for aesthetics or athletic performance, but it also may be indicative of disease processes, especially if weight loss is sudden. Association with the following should be considered: Eating disorders (e.g., anorexia, bulimia), Digestive and other diseases involving malabsorption of nutrients, certain cancers.

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Body Fat Distributions

- Central or Android Pattern ("Apple" Shaped): Body fat accumulation in the abdominal area. More common in men. Also termed abdominal obesity.
- Peripheral or Gynoid Pattern ("Pear" Shaped): Body fat accumulation in the hips and thighs, More common in women, at least before menopause.

Health Risk Associated with Android Obesity (Abnormal Fat)

- Abdominal fat is more highly correlated with metabolic risk factors (e.g., insulin resistance, high blood pressure, elevated fasting blood glucose level, elevated blood lipid and lipoprotein levels) than with BMI.
- Android obesity is the central feature of the Metabolic Syndrome, a condition in which several CHD risk factors are clustered (e.g., insulin resistance, dyslipidemia, elevated blood pressure).
- Risk factors associated with this syndrome act synergistically to increase cardiovascular disease morbidity and mortality.

Daily energy requirements and expenditure

Basal Metabolic Rate - BMR

Your basal metabolic rate, or BMR, is the minimum calorific requirement needed to sustain life in a resting individual. It can be looked at as being the amount of energy (measured in calories) expended by the body to remain in bed asleep all day!

BMR can be responsible for burning up to 70% of the total calories expended, but this figure varies due to different factors (see below). Calories are burned by bodily processes such as respiration, the pumping of blood around the body and maintenance of body temperature. Obviously the body will burn more calories on top of those burned due to BMR.

BMR is the largest factor in determining overall metabolic rate and how many calories you need to maintain, lose or gain weight. BMR is determined by a combination of genetic and environmental factors, as follows:

- **Genetics** - Some people are born with faster metabolisms; some with slower metabolisms.
- **Gender** - Men have a greater muscle mass and a lower body fat percentage. This means they have a higher basal metabolic rate.
- **Age** - BMR reduces with age. After 20 years, it drops about 2 per cent, per decade.
- **Weight** - The heavier your weight, the higher your BMR. Example: the metabolic rate of obese women is 25 percent higher than the metabolic rate of thin women.
- **Body Surface Area** - This is a reflection of your height and weight. The greater your Body Surface Area factor, the higher your BMR. Tall, thin people have higher BMRs. If you compare a tall person with a short person of equal weight, then if they both follow a diet calorie-controlled to maintain the weight of the taller person, the shorter person may gain up to 15 pounds in a year.
- **Body Fat Percentage** - The lower your body fat percentage, the higher your BMR. The lower body fat percentage in the male body is one reason why men generally have a 10-15% faster BMR than women.

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- **Diet.** - Starvation or serious abrupt calorie-reduction can dramatically reduce BMR by up to 30 percent. Restrictive low-calorie weight loss diets may cause your BMR to drop as much as 20%.
- **Body Temperature/Health** - For every increase of 0.5C in internal temperature of the body, the BMR increases by about 7 percent. The chemical reactions in the body actually occur more quickly at higher temperatures. So a patient with a fever of 42C (about 4C above normal) would have an increase of about 50 percent in BMR.
- **External temperature** - Temperature outside the body also affects basal metabolic rate. Exposure to cold temperature causes an increase in the BMR, so as to create the extra heat needed to maintain the body's internal temperature. A short exposure to hot temperature has little effect on the body's metabolism as it is compensated mainly by increased heat loss. But prolonged exposure to heat can raise BMR.
- **Glands** - Thyroxin (produced by the thyroid gland) is a key BMR-regulator which speeds up the metabolic activity of the body. The more thyroxin produced, the higher the BMR. If too much thyroxin is produced (a condition known as thyrotoxicosis) BMR can actually double. If too little thyroxin is produced (myxoedema) BMR may shrink to 30-40 percent of normal. Like thyroxin, adrenaline also increases the BMR but to a lesser extent.
- **Exercise** - Physical exercise not only influences body weight by burning calories, it also helps raise your BMR by building extra lean tissue. (Lean tissue is more metabolically demanding than fat tissue.) So you burn more calories even when sleeping.

Short Term Factors Affecting BMR

Illnesses such as a fever, high levels of stress hormones in the body and either an increase or decrease in the environmental temperature will result in an increase in BMR. Fasting, starving or malnutrition all result in a lowering of BMR. This lowering of BMR can be one side effect of following a diet and nothing else. Solely dieting , i.e. reducing the amount of calories the body takes on, will not be as affective as dieting and increased exercise. The negative effect of dieting on BMR can be offset with a positive effect from increased exercise.

How to Calculate Basal Metabolic Rate (BMR)

The first step in designing a personal nutrition plan for yourself is to calculate how many calories you burn in a day; your total daily energy expenditure (TDEE). TDEE is the total number of calories that your body expends in 24 hours, including all activities. TDEE is also known as your "maintenance level". Knowing your maintenance level will give you a starting reference point from which to begin your diet. According to exercise physiologists William McArdle and Frank Katch, the average maintenance level for women in the United States is 2000-2100 calories per day and the average for men is 2700-2900 per day. These are only averages; caloric expenditure can vary widely and is much higher for athletes or extremely active individuals. Some triathletes and ultra-

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endurance athletes may require as many as 6000 calories per day or more just to maintain their weight! Calorie requirements may also vary among otherwise identical individuals due to differences in inherited metabolic rates.

Methods of determining caloric needs

There are many different formulas you can use to determine your caloric maintenance level by taking into account the factors of age, sex, height, weight, lean body mass, and activity level. Any formula that takes into account your lean body mass (LBM) will give you the most accurate determination of your energy expenditure, but even without LBM you can still get a reasonably close estimate.

The "quick" method (based on total bodyweight)

A fast and easy method to determine calorie needs is to use total current body weight times a multiplier.
Fat loss = 12 - 13 calories per lb. of bodyweight
Maintenance (TDEE) = 15 - 16 calories per lb. of bodyweight
Weight gain: = 18 - 19 calories per lb. of bodyweight

This is a very easy way to estimate caloric needs, but there are obvious drawbacks to this method because it doesn't take into account activity levels or body composition. Extremely active individuals may require far more calories than this formula indicates. In addition, the more lean body mass one has, the higher the TDEE will be. Because body fatness is not accounted for, this formula may greatly overestimate the caloric needs if someone is extremely overfat. For example, a lightly active 50 year old woman who weighs 235 lbs. and has 34% body fat will not lose weight on 3000 calories per day (255 X 13 as per the "quick" formula for fat loss).

Equations based on BMR.

A much more accurate method for calculating TDEE is to determine basal metabolic rate (BMR) using multiple factors, including height, weight, age and sex, then multiply the BMR by an activity factor to determine TDEE. BMR is the total number of calories your body requires for normal bodily functions (excluding activity factors). This includes keeping your heart beating, inhaling and exhaling air, digesting food, making new blood cells, maintaining your body temperature and every other metabolic process in your body. In other words, your BMR is all the energy used for the basic processes of life itself. BMR usually accounts for about two-thirds of total daily energy expenditure. BMR may vary dramatically from person to person depending on genetic factors. If you know someone who claims they can eat anything they want and never gain an ounce of fat, they have inherited a naturally high BMR. BMR is at it's lowest when you are sleeping undisturbed and you are not digesting anything. It is very important to note that the higher your lean body mass is, the higher your BMR will be. This is very significant if you want to lose body fat because it means that the more muscle you have, the more calories you will burn. Muscle is metabolically active tissue, and it requires a great deal

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of energy just to sustain it. It is obvious then that one way to increase your BMR is to engage in weight training in order to increase and/or maintain lean body mass. In this manner it could be said that weight training helps you lose body fat, albeit indirectly.

The Harris-Benedict formula (BMR based on total body weight)

The Harris Benedict equation is a calorie formula using the factors of height, weight, age, and sex to determine basal metabolic rate (BMR). This makes it more accurate than determining calorie needs based on total bodyweight alone. The only variable it does not take into consideration is lean body mass. Therefore, this equation will be very accurate in all but the extremely muscular (will underestimate caloric needs) and the extremely overfat (will overestimate caloric needs).

Men: BMR = 66 + (13.7 X wt in kg) + (5 X ht in cm) - (6.8 X age in years)
Women: BMR = 655 + (9.6 X wt in kg) + (1.8 X ht in cm) - (4.7 X age in years)
Note: 1 inch = 2.54 cm.
1 kilogram = 2.2 lbs.

Example:
You are female
You are 30 yrs old
You are 5' 6 " tall (167.6 cm)
You weigh 120 lbs. (54.5 kilos)
Your BMR = 655 + 523 + 302 - 141 = 1339 calories/day
Now that you know your BMR, you can calculate TDEE by multiplying your BMR by your activity multiplier from the chart below:

Activity Multiplier
Sedentary = BMR X 1.2 (little or no exercise, desk job)
Lightly active = BMR X 1.375 (light exercise/sports 1-3 days/wk)
Mod. Active = BMR X 1.55 (moderate exercise/sports 3-5 days/wk)
Very active = BMR X 1.725 (hard exercise/sports 6-7 days/wk)
Extra. Active = BMR X 1.9 (hard daily exercise/sports & physical job or 2X day training, i.e marathon, contest etc.)

Example:
Your BMR is 1339 calories per day
Your activity level is moderately active (work out 3-4 times per week)
Your activity factor is 1.55
Your TDEE = 1.55 X 1339 = 2075 calories/day

Katch-McArdle formula (BMR based on lean body weight)

If you have had your body composition tested and you know your lean body mass, then you can get the most accurate BMR estimate of all. This formula from Katch & McArdle takes into account lean mass and therefore is more accurate than a formula based on total body weight. The Harris Benedict equation has separate formulas for men and women because men generally have a higher LBM and this is factored into the men's formula. Since the Katch-McArdle formula accounts for LBM, this single formula applies equally to both men and women.

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BMR (men and women) = 370 + (21.6 X lean mass in kg)

Example:
You are female
You weigh 120 lbs. (54.5 kilos)
Your body fat percentage is 20% (24 lbs. fat, 96 lbs. lean)
Your lean mass is 96 lbs. (43.6 kilos)
Your BMR = 370 + (21.6 X 43.6) = 1312 calories
To determine TDEE from BMR, you simply multiply BMR by the activity multiplier:

Example:
Your BMR is 1312
Your activity level is moderately active (work out 3-4 times per week)
Your activity factor is 1.55
Your TDEE = 1.55 X 1312 = 2033 calories

As you can see, the difference in the TDEE as determined by both formulas is statistically insignificant (2075 calories vs. 2033 calories) because the person we used as an example is average in body size and body composition. The primary benefit of factoring lean body mass into the equation is increased accuracy when your body composition leans to either end of the spectrum (very muscular or very obese).

REE based on age and body weight

For Children based on age
Upto 12 yrs = 1000 + (100 x age in yrs) kcal/day
= 1000 + (100 x 5 yrs) kcal/day
= 1500 kcal/day

Age range (years)	**Equation to derive REE (Kcal/day)**	**Age range (years)**	**Equation to derive REE (Kcal/day)**
Male		**Female**	
0-3	(60.9 x wt) - 54	0-3	(61.0 x wt) - 51
3-10	(22.7 x wt) + 495	6-10	(22.5 x wt) + 499
10-18	(17.5 x wt) + 651	10-10	(12.2 x wt) + 746
18-30	(15.3 x wt) + 679	18-30	(14.7 x wt) + 496
30-60	(11.6 x wt) + 879	30-60	(8.7 x wt) + 829
60	(13.5 x wt) + 487	60	(10.5 x wt) + 596

Estimation of Resting Energy Expenditure/Need Based on Age and Body Weight
Eg. If an athlete body weight = 65, height = 167 cms and age = 23.

REE = (15.3 x wt) + 679
= 15.3 x 65 + 679
= 994.5 + 679
= **1673.5 kcal/day**

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Estimation of Energy Expenditure/Need Based on Activity Level

Activity Category	Energy as Multiple of REE	Kcal/Min.
Resting		
Sleeping and reclining	REE x 1.0	1 - 1.2
Very Light		
Seated and standing activities, painting trades, driving, laboratory wok, typing, sewing, ironing, cooking, playing cards, playing musical instruments.	REE x 1.5	Upto 2.5
Light		
Walking on a level surface at 2.5 to 3 mph, garage work, electrical trades, house cleaning, childcare, golf, sailing and table tennis.	REE x 2.5	2.5 – 4.9
Moderate		
Walking 3.5 to 4 mph, carring loads, cycling, lawn tennis and dancing.	REE x 5.0	5.0 – 7.4
Heavy		
Walking with load uphill, tree felling, heavy manual digging, climbing, playing, football, and soccer.	REE x 7.0	7.5 – 12.0

Source: Food and Nutrition Board USA

Daily Energy Requirements

Personal energy requirement = Basic energy requirements + Extra energy requirements

Basic energy requirements

For every kg of body weight 1.0727 kcal is required every hour. [An athlete weighing 65kg would require 1.0727 * 24hrs * 65kg = **1673.5 kcal/ day**]

Extra energy requirements

For each hours of moderate training you require 5.3635 kcal for each kg of body weight. (For a two-hour training session our 65kg athlete would require 5.3635 * 2hrs * 65kg = **697.257 kcal**)

Personal energy requirement = basic energy requirements + extra energy requirements
=1673.5 + 697.257
= **2370.757 kcal**

An athlete weighing 65kg who trains for two hours would require an intake of approx. **2370.757 kcal**

Energy Fuel

Like fuel for a car the energy we need has to be blended. The blend that we require is as follows:

- 57% Carbohydrates (sugar, sweets, bread, cakes)
- 30% Fats (dairy products, oil)

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- 13% Protein (eggs, milk, meat, poultry, fish)

The energy yield per gram is as follows:

- Carbohydrate - 4 kcal,
- Fats - 9 kcal and
- Protein - 4 kcal

(Note: 1 calorie = 1 kcal)

Dietary Requirements of a 65 kg Athlete

- **Carbohydrates** - 57% of 2370.757 – 1351.331 kcal - at 4 kcal per gram – 1351.331 /4 = 337.832 grams
- **Fats** - 30% of 2370.757 = 711.227 kcal - at 9 kcal per gram = 711.227 / 9 = 79.025 grams
- **Protein** - 13% of 2370.757 = 308.198 kcal - at 4 kcal per gram = 308.198 /4 = 77.049 grams Our 65kg athlete requires: 337.832 (338) grams of **carbohydrates**, 79.025 (79) grams of **fat** and 79.025 (79) grams of **protein**

Recommended Calorie Distribution of 2370.757 kcal

Breakfast	= 25% (592.689 kcal)
Mid Meal	= 10% (237.075 kcal)
Lunch	= 25% (592.689 kcal)
Evening Snacks	= 15% (355.613 kcal)
Dinner	= 20% (474.151 kcal)
Bed Time	= 5% (118.537 kcal)

Total	100% (2370.757 kcal)
	======

Adjust your caloric intake according to your goal

Once you know your TDEE (maintenance level), the next step is to adjust your calories according to your primary goal. The mathematics of calorie balance are simple: To keep your weight at its current level, you should remain at your daily caloric maintenance level. To lose weight, you need to create a calorie deficit by reducing your calories slightly below your maintenance level (or keeping your calories the same and increasing your activity above your current level). To gain weight you need to increase your calories above your maintenance level. The only difference between weight gain programs and weight loss programs is the total number of calories required.

Negative calorie balance is essential to lose body fat.

Calories not only count, they are the bottom line when it comes to fat loss. If you are eating more calories than you expend, you simply will not lose fat, no matter what type of foods or food combinations you eat. Some foods do get stored as fat more easily than others, but always bear in mind that too much of anything, even "healthy food," will

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get stored as fat. You cannot override the laws of thermodynamics and energy balance. You must be in a calorie deficit to burn fat. This will force your body to use stored body fat to make up for the energy deficit. There are 3500 calories in a pound of stored body fat. If you create a 3500-calorie deficit in a week through diet, exercise or a combination of both, you will lose one pound. If you create a 7000 calories deficit in a week you will lose two pounds. The calorie deficit can be created through diet, exercise or preferably, with a combination of both. Because we already factored in the exercise deficit by using an activity multiplier, the deficit we are concerned with here is the dietary deficit.

Calorie deficit thresholds: How low is too low?

It is well known that cutting calories too much slows down the metabolic rate, decreases thyroid output and causes loss of lean mass, so the question is how much of a deficit do you need? There definitely seems to be a specific cutoff or threshold where further reductions in calories will have detrimental effects. The most common guideline for calorie deficits for fat loss is to reduce your calories by at least 500, but not more than 1000 below your maintenance level. For some, especially lighter people, 1000 calories may be too much of a deficit. The American College of Sports Medicine (ACSM) recommends that calorie levels never drop below 1200 calories per day for women or 1800 per day for men. Even these calorie levels are extremely low. A more individualized way to determine the safe calorie deficit would be to account for one's bodyweight or TDEE. Reducing calories by 15-20% below TDEE is a good place to start. A larger deficit may be necessary in some cases, but the best approach would be to keep the calorie deficit through diet small while increasing activity level.

Positive calorie balance is essential to gain lean bodyweight

If you want to gain lean bodyweight and become more muscular, you must consume more calories than you burn up in a day. Provided that you are participating in a weight-training program of a sufficient intensity, frequency and volume, the caloric surplus will be used to create new muscle tissue. Once you've determined your TDEE, the next step is to increase your calories high enough above your TDEE that you can gain weight. It is a basic law of energy balance that you must be on a positive calorie balance diet to gain muscular bodyweight. A general guideline for a starting point for gaining weight is to add approximately 300-500 calories per day onto your TDEE. An alternate method is to add an additional 15 - 20% onto your TDEE.

Adjust your caloric intake gradually

It is not advisable to make any drastic changes to your diet all at once. After calculating your own total daily energy expenditure and adjusting it according to your goal, if the amount is substantially higher or lower than your current intake, then you may need to adjust your calories gradually. For example, if your determine that your optimal caloric intake is 1900 calories per day, but you have only been eating 900 calories per day, your metabolism may be sluggish. An immediate jump to 1900 calories per day might actually cause a fat gain because your body has adapted to a lower caloric intake and the sudden

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jump up would create a surplus. The best approach would be to gradually increase your calories from 900 to 1900 over a period of a few weeks to allow your metabolism to speed up and acclimatize.

Measure your results and adjust calories accordingly

These calculations for finding your correct caloric intake are quite simplistic and are just estimates to give you a starting point. You will have to monitor your progress closely to make sure that this is the proper level for you. You will know if you're at the correct level of calories by keeping track of your caloric intake, your bodyweight, and your body fat percentage. You need to observe your bodyweight and body fat percentage to see how you respond. If you don't see the results you expect, then you can adjust your caloric intake and exercise levels accordingly. The bottom line is that it's not effective to reduce calories to very low levels in order to lose fat. In fact, the more calories you consume the better, as long as a deficit is created through diet and exercise. The best approach is to reduce calories only slightly and raise your daily calorie expenditure by increasing your frequency, duration and or intensity of exercise.

Inappropriate Methods of Weight Loss

There is no "quick fix" for weight loss. Decreasing caloric consumption and increasing caloric expenditure through exercise remains the most effective method for long-term weight loss and maintenance. Myths of weight loss include the following:

- **Spot Reduction** -Spot reduction is the idea of exercising specific body parts to reduce fat in that area. In reality, fat loss is spread over most of the body and throughout most tissue, though certain areas may be resistant to fat loss irrespective of the area exercised.
- **Saunas**
  Rationales for use include: Lose weight quickly. May be used by athletes who need to compete at a reduced body weight (e.g., wrestlers, boxers, bodybuilders).
  Inappropriate for weight loss, because: Weight lost is water weight. Risk of dehydration and electrolyte loss. Risk of heat-related illnesses (e.g., heat exhaustion, heat stroke). Water weight is quickly regained with fluid replenishment.
- **Vibration Belts**
  Rationales for use include: Mechanical manipulation of a certain body part will "break down" fat. No sweat involved by user.
  Inappropriate for weight loss, because: Does not lead to actual breakdown of stored body fat. Little or no energy expenditure by client. It is not possible to spot reduce a body part by exercising that body part.
- **Body Wraps**
  Rationales for use include: Lose weight quickly. May be used by athletes who need to compete at a reduced body weight (e.g., wrestlers, boxers, bodybuilders). Use as a "toning" mechanism for specific body part areas.
  Inappropriate for weight loss, because: Weight lost is water weight. Risk of dehydration and electrolyte loss. Spot reduction is not possible. Water weight is quickly regained with fluid replenishment.
- **Electric stimulators**
  Rationales for use include: Increase muscle size by electrical stimulation. Effortless calorie expenditure.
  Inappropriate for weight loss, because: Spot reduction is not possible. No significant energy expenditure.

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- **Sweat Suits**
  Rationales for use include: Lose weight quickly. May be used by athletes who need to compete at a reduced body weight (e.g., wrestlers, boxers, bodybuilders).
  Inappropriate for weight loss, because: Weight lost is water weight. Risk of dehydration and electrolyte loss. Risk of heat-related illnesses (e.g., heat exhaustion, heat stroke). Water weight is quickly regained with fluid replenishment.
- **Fad Diets**
  Rationales for use include: Possibility of rapid weight loss. Special food combinations. Elimination of certain foods.
  Inappropriate for weight loss, because: Any diet will lead to weight loss if energy intake is reduced. Very low energy intake (also known as "very low calorie diets") may lower RMR and stimulate physiological processes that conserve energy expenditure, thus making weight loss even more difficult. Risk of nutritional deficiencies because of elimination of certain foods or food groups. Long-term safety and efficacy generally are not known.
  Clearly, some individuals are successful with fad diets. Current scientific evidence, however, does not support widespread or long-term use of these diets.

Modifying Body Composition

One pound of body fat contains stored energy in the amount of 3,500 kilocalories (kcal). An energy deficit of 3,500 kcal generally is considered to be necessary to lose one pound. Genetic differences may be associated with variability of this value.

- **Diet alone -** Losing more than 1 to 2 pounds of fat mass (= 0.5-1 kg) per week is not recommended, as it may lead to decreased lean body mass and lower resting metabolic rate. Greater weight loss during the first several weeks of a diet program is common, but this loss likely due to water loss associated with glycogen depletion.
- **Exercise Alone -** To create a sufficient energy deficit, longer duration aerobic activities are usually emphasized. The energy expenditure of different activities varies; therefore, it is difficult to prescribe a specific duration of exercise (It is necessary to approach a weekly caloric expenditure of 2,000 kcal or more forsignificant weight loss to occur and be maintained. This level is associated with 4 to 6 hours per week of aerobic, weight-bearing exercise). The BMR remains elevated in the postexercise period, particularly after high intensity exercise. Whether this additional energy expenditure contributes significantly to weight loss is not known. Classic resistance training exercise does not contribute significantly to exercise caloric expenditure; however, it does help to maintain or increase lean body mass. Maintenance of lean body mass preserves RMR and may be important for weight management.
- **Diet plus exercise -** Reasonable energy deficits using a combination of diet and exercise may lead to a weight loss of 1 pound (0.5 kg) per week. For example, decreasing caloric intake by 250 kcal/day and increasing caloric expenditure by 250 kcal/day results in a total weekly deficit of 3,500 kcal. Through exercise, lean body mass can be maintained or increased, especially with resistance training exercise. Maintenance of healthy eating habits combined with exercise leads to better outcomes for long-term weight management.

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