

Premeal or Postmeal Exercise

Years ago, when the American diet was first implicated as a culprit in the heart disease epidemic, researchers roamed the world studying the relationship between diet and the incidence of heart disease. They found that diet alone did not account for the presence or absence of the problem; other factors such as a lack of tension and stress or physical activity confounded the relationship. Several researchers have focused on the effect of pre- or postmeal exercise on **postprandial lipemia**, the presence of fat in the blood after a meal. Studies conducted at the University of Florida have shown that exercise before or after a meal is effective in reducing the magnitude and duration of postprandial lipemia (Zauner, Burt, and Mapes 1968). Light exercise proved to be as effective as strenuous effort in this regard. A study on females confirms the ability of prior exercise to increase the utilization of dietary fat (Votruba et al. 2002). Research also indicates that the effect of exercise on postprandial lipemia is greater than and different from the effect attributable to a comparable caloric deficit. A 90-minute walk reduced postprandial lipemia 20 percent below control levels, whereas caloric restriction reduced it only 7 percent (Gill and Hardman 2000).

Lipemia has long been associated with atherosclerosis, reduced myocardial (heart) blood flow, and accelerated blood clotting. Thus, anything that reduces the level of fat in the blood seems prudent and advisable. Vigorous premeal exercise may inhibit the appetite and increase the metabolism of fat and all foods ingested after the exercise. The metabolic rate remains somewhat elevated after exercise, and the ingested foods are used quickly to restore energy burned during exercise. Mild postmeal effort, such as a walk after dinner, also serves to reduce lipemia. Both pre- and postmeal exercise increase caloric expenditure and fat metabolism, lead to improved fitness, and contribute to health and weight control.

While we're on the subject of meals and blood lipids, you should know that the number of meals that you eat influences blood fat levels. By spreading the same number of calories over more meals (three to six), you will lower your cholesterol levels. Apparently, we are able to handle fat better in smaller doses. Conversely, if you avoid meals in an effort to lose weight, your metabolic rate will decline and your cholesterol level will climb. Rapid weight gain may follow your temporary weight loss.

control becomes possible when you realize that your eyes are bigger than your stomach and that your potential for energy intake is greater than your regular energy expenditure.

Increased Caloric Expenditure

Because unfit people tire quickly during exercise, they have limited ability to expend calories. As fitness improves, caloric expenditure rises, with increases in the frequency and duration, and, as one becomes more fit, with intensity of exercise. Becoming more fit is often associated with the inevitable participation in activities that are more vigorous but no longer feel difficult. The fit person does more with less fatigue. Increased fitness undoubtedly contributes to energy expenditure and weight control.

We have studied the effects of training on the perception of effort and fatigue (Docktor and Sharkey 1971). Other studies also confirm the beneficial effects of training on one's perception of effort (Gaskill et al. 2005). As fitness improves, a person can perform more work at the same heart rate and level of perceived exertion. Work levels once perceived

as difficult become less so, and once-fatiguing exertion can be managed with ease. After training, a person can accomplish a given task with a lower heart rate as well as a lower level of perceived exertion. Thus, subjects can burn more energy without experiencing a greater sense of fatigue.

A great definition of physical fitness is the ability to perform the necessary tasks of daily living and still have energy for leisure activities at the end of the day. Becoming more physically active and fit will improve your cognition. It will help you perform better during the day at work or school, stay alert, and have the energy to get out for a walk, a run, or a social engagement.

Further proof of the value of fitness to caloric expenditure is found in the relationship of caloric expenditure to heart rate. Caloric expenditure is related directly to heart rate, but level of fitness also influences the relationship. For people in low-fitness categories, a high heart rate does not indicate extremely high caloric expenditure (see figure 13.5). For those in high-fitness categories, the same heart rate (HR) indicates much higher energy expenditure:

140 HR for very poor fitness level = 6 to 7 calories per minute expended

140 HR for very good fitness level = 12 calories per minute expended

You can use figure 13.5 to estimate your caloric expenditure in any activity. After several minutes of participation, stop and immediately take your pulse at the wrist or throat (use

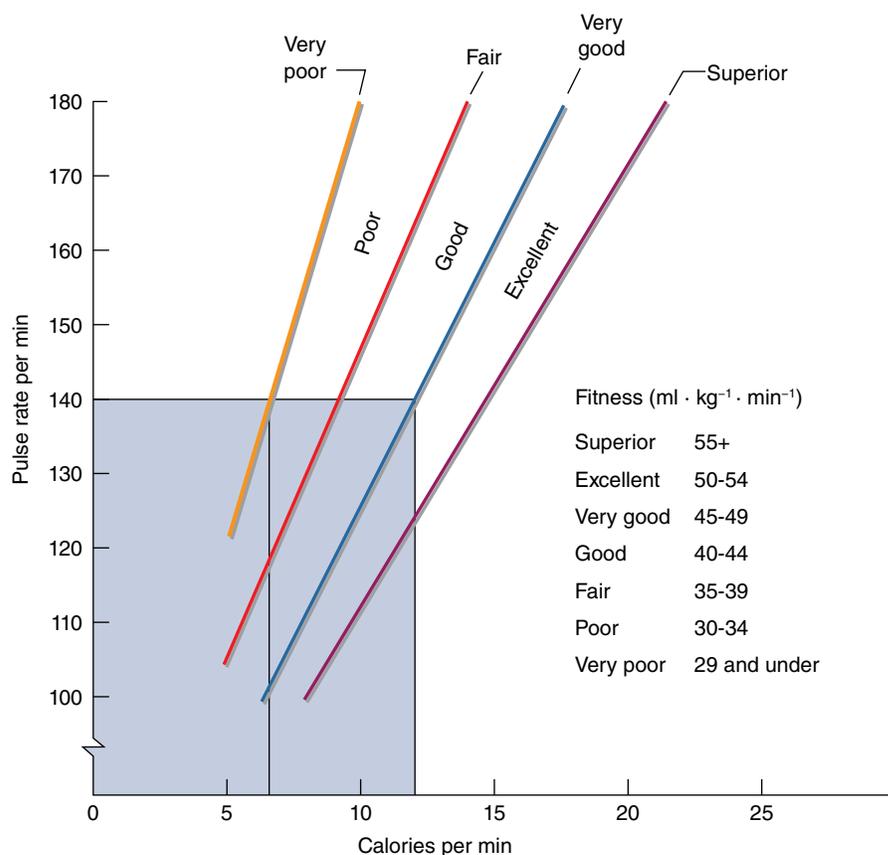


FIGURE 13.5 Predicting calories burned during physical activity from pulse rate.

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gentle contact) for 15 seconds. Multiply by 4 to get your rate per minute. Then use the line corresponding to your fitness level to estimate your caloric expenditure per minute. Notice how caloric expenditure improves (at the same heart rate) as your fitness improves. This finding should convince you that fitness provides extra benefits to those who persevere.

Increased Fat Mobilization

Fat is stored in fat cells in the form of triglycerides (3 molecules of fatty acid and 1 molecule of glycerol). A triglyceride molecule is too large to pass through the wall of the fat cell into the circulation, so when energy is needed, the triglyceride is broken down. The fatty-acid molecules pass into the blood for transport to the working muscles. The hormone epinephrine stimulates a receptor in the fat cell membrane and activates the enzyme **lipase**. Lipase splits the triglyceride molecule, and the fatty acids are free to enter the circulation.

As exercise becomes more intense, we produce lactic acid. The point at which lactic acid begins to accumulate in the blood, the second lactate threshold, indicates when lactate production exceeds removal. At this intensity, a significant portion of energy for metabolism is derived from carbohydrate. You will recall that the second lactate threshold is related to activity and fitness. It may be below 50 percent of the maximal oxygen uptake for the unfit and above 80 percent for the highly trained. But what does that have to do with fat?

Years ago, researchers discovered that lactic acid seemed to inhibit the mobilization of free fatty acids (FFAs) from adipose tissue (see figure 8.4, page 163). The lactic acid blocked the action of epinephrine, thereby reducing the availability of fat for muscle metabolism (Issekutz and Miller 1962). One of the best-documented effects of training is that more work can be accomplished before lactic acid levels rise. After improving fitness, a person who formerly produced lactic acid at a given workload can accomplish the same workload with little increase in lactic acid. This result may be because of a decrease in lactic acid production or an increase in lactic acid clearance. Whatever the case, improved aerobic fitness allows a person to accomplish more work aerobically. The lactate threshold increases, and more fat is available for use as an energy source.

A study of trained subjects illustrates that moderate levels of lactic acid do not affect FFA mobilization and utilization (Vega deJesus and Siconolfi 1988). The fit subjects were able to mobilize fat at the second lactate threshold (4 millimoles lactic acid), which defines the highest



- Improved fitness allows people to burn more fat with less perceived exertion.

level of exercise intensity that a person can sustain during prolonged exertion. These findings help explain the tremendous increase in endurance associated with training. Fat is the most abundant energy source (50 times more abundant than carbohydrate). Improved fitness allows greater access to that immense storehouse of energy.

Greater Fat Utilization

The mobilization of fat does not ensure its metabolism. How does training influence the utilization of FFA as a source of energy for muscular contractions? Studies have shown that trained animals and humans are capable of extracting a greater percentage of their energy from FFA during submaximal exercise. How, then, does fitness influence fat utilization?

Móle, Oscai, and Holloszy (1971) provided convincing proof of the effect of training on FFA utilization. They found that the ability of rat muscle to oxidize the fatty acid

palmitate doubled following 12 weeks of treadmill training. The authors suggested that the shift to fat metabolism was a key factor in the development of endurance fitness and an important mechanism serving to spare carbohydrate stores and prevent low blood sugar during prolonged exertion. Thus, the physically fit person can derive a greater percentage of energy requirements from fat than the unfit subject can. At a given workload, fit subjects may obtain as much as

Lactic Acid

Lactic acid is produced when the breakdown of muscle glycogen to pyruvic acid exceeds the ability of the mitochondria to process the pyruvate. So, the pyruvic acid picks up hydrogen, becomes lactic acid, and begins to accumulate in the muscle and blood. The heart and skeletal muscle can use lactate as a source of energy, and the liver can oxidize it. But when the production of lactate exceeds its removal, the acid level in muscle and blood increases. The rising level of acid in the muscle reduces force production by interfering with muscle contractions and decreases endurance by lowering the efficiency of aerobic enzymes.

90 percent of their energy from fat. Free fatty acids are used during all forms of muscular activity, except for all-out bursts of effort, such as the 100-yard dash. Training even seems to improve the ability of the heart muscle to oxidize fat (Keul 1971).

When exercise begins, the initial source of energy from fat is from intramuscular fat, a supply that is enhanced with training. When prolonged activity depletes intramuscular fat, the body uses fat that comes from adipose tissue by way of the blood (Coggan and Williams 1995). Improved fitness increases the availability of fat through mobilization of FFAs, as well as from an increase in enzyme activity. Both contribute to the rate of FFA utilization.

Reduced Blood Lipids

Blood lipids—cholesterol and triglycerides—have been associated with the incidence and severity of coronary heart disease. They are related to other risk factors, including diet, overweight, and lack of exercise. Findings suggest that fitness training also influences the lipids.

Triglycerides

Dietary fat intake shows up in the blood as chylomicrons, large clumps of triglycerides. Most of the triglycerides are removed from the plasma in the capillaries adjacent to muscle and adipose tissue. The liver clears any remains from the circulation. Chylomicrons are responsible for the milky appearance of blood plasma following a meal (postprandial