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controversies in metabolism

How do resistance training, diet and age affect resting metabolic rate?

Most personal trainers and fitness professionals would agree that resistance training is essential to a well-rounded exercise program for healthy, active individuals. The fitness, medical and musculoskeletal benefits of resistance training are certain. But what about the effects of resistance training on resting metabolic rate? This column addresses many of the common controversies associated with metabolism and its relationship with resistance exercise, diet and age.

Metabolism 101: Basics and Terms

Human metabolism represents the sum total of the living cells' energy-producing and energy-utilizing reactions. Energy balance is determined by the interaction between caloric intake and storage versus energy expenditure. **Total daily energy expenditure** (**TDEE**) is the term used to describe how much energy is used (or how many calories are burned) by an individual during a 24-hour period. TDEE is made up of three primary components:

- resting metabolic rate (RMR)
- thermic effect of physical activity (TEPA)
- thermic effect of feeding (TEF)

RMR, which accounts for 60%–75% of all calorie-burning processes, is the amount of energy required to keep the homeostatic processes (the regulation of organ systems and body temperature) performing. The second component of energy expenditure, **TEPA,** accounts for 15%–30% of daily calorie burn and is the most variable of the three main determinants of TDEE, since the exact percentage of expenditure depends upon an individual's activity level, including both structured exercise and nonstructured activities such as shivering and fidgeting. (The term *NEAT,* or *nonexercise activity thermogenesis*, has recently been coined to describe this nonstructured movement [Levine et al. 2005]).

The final component of daily energy expenditure, **TEF,** is the energy required for the digestion, absorption, transport, metabolism and storage of consumed food. TEF accounts for approximately 10% of daily expenditure.

Muscles' Key Contribution to RMR

Skeletal muscle, which composes up to 40% of adult human body weight, is influenced by genetics, physical activity, nutrition, hormones, disease and trauma (Rasmussen & Phillips 2003). Muscle contains 50%–75% of all the proteins in the human body, making it the central tissue for amino acid metabolism. Resistance training promotes hypertrophy (a net gain in muscle mass) over an extended period of time when protein synthesis (growth) exceeds protein catabolism (breakdown). Protein synthesis is also stimulated by a high amino acid supply, which is regulated by anabolic hormones (growth hormone, insulin-like growth factors and testosterone). Protein synthesis and catabolism account for approximately 20% of RMR (Rasmussen & Phillips 2003).

What Is the Metabolic Rate of Muscle Tissue?

Although muscle is the largest tissue in the entire body, its estimated metabolic rate is much less than has been advertised in the consumer media and suggested by many ill-informed fitness product advertisers. The complex scientific estimations of the energy expenditure of body tissues are derived by taking measurements of oxygen concentrations across arteriovenous cell membranes in conjunction with measurements of blood flow (Elia 1992). The scientific estimation of the metabolic rate of muscle is about 10–15 kilocalories per kilogram (kcal/kg), or approximately 4.5–7.0 kcal per pound (lb), per day (Elia 1992). However, Sparti and colleagues (1997) stress that there can be much individual variability to these estimates, depending upon a person's age, level of body fat, body temperature and sympathetic nervous system activity. Muscle tissue contributes approximately 20% to TDEE, whereas fat tissue contributes approximately 5% (for individuals with about 20% body fat). It is fascinating to note that the combined energy expenditure of the heart, lungs, kidneys, brain and liver represents up to 80% of the TDEE (Elia 1992). These organs have a metabolic rate that is 15–40 times greater than the equivalent weight of muscle and 50–100 times greater than that of fat tissue (Elia 1992).

How Much Does Resistance Exercise Affect Metabolism?

In a recent comprehensive research review, Donnelly and colleagues (2003) note that the majority of peer-reviewed resistance training studies (lasting 8–52 weeks) show increases of 2.2–4.5 lb of muscle mass. These researchers suggest that an increase of 4.5 lb of muscle mass would probably increase resting metabolic rate by about 50 kcal per day. Although this small change is not nearly as much as some advertisers may suggest, it does help close the gap between energy intake and energy expenditure. Therefore it is appropriate to share (but not overtout) with students and clients that more muscle creates a higher demand for energy, since muscle needs to maintain itself at rest *and* during exercise.

Perhaps one of the most meaningful benefits of resistance training during a reduced-calorie diet is that it helps to prevent the loss of fat-free mass (muscle) (Donnelly et al. 2003).

What Effect Does Diet Have on RMR?

All foods contain calories, which can be thought of as energy units. To lose weight, individuals must burn more calories than they consume; to gain weight, they must consume more calories than they burn. Very low calorie diets often fail because the dieters do not consume enough calories to fuel physical activity, and this underfeeding can diminish metabolic processes. Intense energy-restrictive diets are not only tough to maintain; they actually trigger the body to suppress its RMR by as much as 20% (Hill 2004). Biological processes adapt to what the body perceives as a state of famine (a valid threat to our ancestors); the body increases metabolic efficiency by burning fewer calories to do a given amount of work (Benardot & Thompson 1999). Bernadot and Thompson add that underfeeding may also interfere with the body's ability to synthesize muscle because of a lower production of insulin-like growth factor (IGF-1) and the body's decrease in power-producing capacity.

Low-carbohydrate diets may also be a problem. Eating carbohydrates provides a "protein-sparing" effect; a person who eats too few carbs needs to use some protein for energy, rather than for building and repairing muscle. Therefore, low-carbohydrate diets are not recommended for individuals training to enhance muscular fitness (Benardot & Thompson 1999).

How Does Age Affect RMR?

The metabolic rate per kilogram of body weight in young children (6 years old and younger) is about two times greater than that in adults (Elia 1992). Increasing age equates to decreasing RMR because organs, which account for a large percentage of RMR, are a larger proportion of a young person's body. Infants and children have a very high RMR because they are growing rapidly. A great part of their body weight is metabolically active tissue (heart, lungs, brain, liver, kidneys). A 25% drop in RMR between the ages of 6 and 18 is expected as more adult proportions are reached, and then an additional drop of 2%–3% each decade is predictable. This downward progression of RMR in later life can be attributed to the loss of fat-free mass due to physical inactivity (and may also be due to malnutrition, especially in older adults). Fortunately, this trend can be minimized with regular resistance training throughout the aging cycle.

metabolism quiz

Test your knowledge with this true-or-false quiz.

1. Exercising first thing in the morning increases all-day energy expenditure and metabolism more than a workout later in the day.
2. Spicy foods elevate metabolism.
3. The fitter a person is, the faster his or her metabolism is.
4. "Yo-yo dieting," which causes people to repeatedly lose weight and regain it, permanently diminishes an individual's metabolism.
5. Certain medications can slow down metabolism.

Answers

1. False. The number of calories expended during a workout depends on the intensity and duration of the workout, regardless of whether it is in the morning, afternoon or evening.
2. True. Foods like peppers and chili do elevate body temperature slightly, which increases metabolism by small increments. However, this elevation is not sufficient to make a difference in the body's ability to expend enough calories to aid in weight loss.
3. True and false. As a person becomes fitter and gains muscle mass, he or she burns more calories at rest. However, the energy intakes of some exercise enthusiasts are not sufficient to meet the demands of their exercise programs. This imbalance may eventually reduce resting metabolic rate.
4. False. Research does not indicate that yo-yo dieting permanently slows down any component of metabolism.
5. True. Certain prescription drugs (such as medications for depression) have been shown to lower metabolism.

Practical Application

Use this knowledge to educate your clients about some of the complexities of metabolism and to explain how it may be affected by resistance exercise, diet and age. For clients seeking weight management goals, continue to reinforce that the successful energy balance equation involves cardiorespiratory exercise (to increase energy expenditure), resistance exercise (to preserve muscle mass) and a carefully planned dietary lifestyle (to decrease energy intake).

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