Strength Training and Metabolism

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Metabolism:
"Chemical changes that utilize energy and result in tissue and compound building (anabolism) or breakdown of substrates and release of energy (catabolism)." The preceding definition of metabolism was taken from the Dictionary of Sport and Exercise Sciences (1). From this definition one will be able to understand how strength training can influence metabolism. There are three ways strength training can alter metabolism 1) the workout session itself; 2) the post-training oxygen consumption following exercise; and 3) the addition of muscle mass. Let's take a look at each:

The Workout Session:
Muscles contracting under heavy loads require energy. They also produce heat which is a by-product of muscular contraction. How much strength training increases metabolism will vary depending upon the amount of muscle mass involved in an exercise and the level of resistance used. Obviously a squat or leg press exercise will utilize a greater amount of muscle mass than a biceps curl exercise and consequently have a greater energy cost. The metabolic rate or energy expenditure has been estimated to vary from five to ten calories per minute, depending on whether large or small muscle groups were involved in the exercise. Hunter et al (2) investigated the influence of the resistance load on metabolic rate. Seventeen subjects performed a bench press a intensities range from 20% to 80% of one repetition maximum. They found that the economy of the weight training exercise decreased as the resistance load increased. This indicates less muscular efficiency at the heavier weights, and/or that stabilizing muscles participated more, which in turn will increases the energy utilization during exercise. For example, the subjects used almost 12 times as much energy (calories) doing one repetition at 80 percent of 1 RM as opposed to one repetition at 20 percent 1 RM even though work only increased by a magnitude of four. Within each bench press load (20%-80%) there was a high relationship between work performed and energy expended. This finding is in agreement with research performed by Kuehl et al (3) who found the caloric expenditure during resistance training correlates with the total weight lifted. Hunter and colleagues indicate those individuals who are interested in body composition changes should train at 60 to 80 percent 1 RM. The metabolic rate is higher at increased loads, thus causing a greater number of calories utilized.

The Post-Workout Oxygen Consumption:
There are several factors which influence the excess post exercise oxygen consumption (resynthesis of creatine phosphate in muscle, lactate removal, restoration of muscle and blood oxygen stores, elevated body temperature, post exercise elevation of heart rate and breathing, elevated hormones). Elliot et al (4) examined the post-exercise oxygen consumption of strength training exercise. Metabolic rate was measured for nine subjects after 40 minutes of cycling (80 percent of maximal heart rate), 40 minutes of circuit training (50% of individuals' 1 RM x 15 repetitions for 4 sets), 40 minutes of heavy resistance lifting (80-90% of 1 RM x 3-8 repetitions x 3 sets), and a control interval. All forms of exercise increased the metabolic rate immediately after exertion. For circuit and heavy resistance lifting, the increase also was significant 30 minutes after exertion. The absolute total increment in caloric use after exertion was comparable among circuit training , heavy lifting, and cycling. However, cycling was less than both forms of weight training.

When one actually examines the energy cost or calories burned during the post-exercise period it is relatively small. Some researchers have commented that the post-exercise effect is sufficiently small that it does not have a major role in the control of weight loss. These same researchers data suggest that the extra oxygen consumption following each of a typical monthly series of 15 exercise sessions (50 minutes at 50% of maximal oxygen uptake) could lead to a cumulative loss of 1 kg of adipose tissue; if such a rate of loss were sustained for 12 months, the individual concerned could have trimmed a not so insignificant 12 kg of fat from his or her waistline.

The other factor to consider with the post-exercise is the fuel which is utilized. Strength training exercise tends to burn/utilize carbohydrate during the actual training session. However, after a workout more fat is burned to meet the energy demands of your body. The more carbohydrate burned during an exercise period, the more fat burned after exercise. Research performed by Brooks and Gaesser (5) as well as Bahr and Sejersted (6) confirm that the higher the exercise intensity, proportionately more fat will be burned during the recovery phase. Recent research at Colorado State University (7) examining the effect of a resistance training on postexercise energy expenditure and resting metabolic rate, concluded that strenuous strength training can elevate metabolic rate for extended periods, and that this enhanced metabolism is due to oxidation of body fat.

The Addition of New Muscle:
It is well established the properly performed high intensity strength training stimulates the development of muscle mass. The additional muscle mass will alter metabolism in two ways. First, resting metabolic rate is increased when one gains muscle mass. While the energy expenditure per pound of lean body mass does not change, the addition of more muscle mass means a larger energy expenditure or higher metabolism at rest.

Second, the more muscle mass one has the greater the post exercise oxygen consumption. When strength trained individuals were compared to nontrained individuals, there was no difference in post exercise oxygen consumption per pound of muscle. However, since the strength training individuals have more muscle mass, they burn more calories during the post exercise period.

Conclusion:
Strength training increases energy expenditure during a training session. The high intensity or anaerobic nature of strength training indicates a high utilization of carbohydrates during a training session. During the post-exercise recovery period, energy expenditure is elevated for a period ranging from two to fifteen hours (7). The increased energy demands are obtained by burning more calories, and a good portion of the calories are coming from fat stores.

The addition of muscle mass on an individual will cause an increase in the number of calories that are burned/utilized at rest. So it is comforting to know while one is exerting themselves through a high intensity workout, that the hard work will result in a faster metabolism that continues to burn calories even after the workout.

References:

1. Anshel, MH. Editor. Dictionary of the Sport and Exercise Sciences. Human Kinetics Publishers. Champaign, IL. 1991.
2. Hunter G, Blackman L, Dunnam L, Flemming G. Bench press metabolic rate as a function of exercise intensity. Journal of Applied Sport Science Research 2(1): 1-6, 1988.
3. Kuehl K, Elliot D, Goldberg L. Predicting caloric expenditure during multi-station resistance exercise. Journal of Applied Sport Science Research 4(3): 63-67, 1990.
4. Elliot DL, Goldberg L, Kuehl KS. Effect of resistance training on excess post-exercise oxygen consumption. Journal of Applied Sport Science Research 6(2): 77-81, 1992.
5. Brooks G, Gaesser GA. End points of lactate and glucose metabolism after exhausting exercise. Journal of Applied Physiology 49: 1057, 1980.
6. Bahr, Sejersted. Metabolism 40: 836, 1991.
7. Melby C, Scholl C, Edwards G, Bullough R. Effect of acute resistance exercise on postexercise energy expenditure and resting metabolic rate. Journal of Applied Physiology 75(4): 1847-1853, 1993.
8. VanEtten L, Westerterp K, Verstappen F. Effect of weight training on energy expenditure and substrate utilization during sleep. Medicine and Science in Sports and Exercise 27(2): 188-193, 1995.
9. Bosselaers I, Buemann B, Victor O, Astrup A. Twenty-four hour energy expenditure and substrate utilization in bodybuilders. American Journal of Clinical Nutrition 59: 10-12, 1994.
10. Gore C, Withers R. Effect of exercise intensity and duration on postexercise metabolism. Journal of Applied Physiology 68: 2362-2368, 1990.
11. Webb P. Energy expenditure and fat-free mass in men and women. American Journal of Clinical Nutrition 34: 1816-1826, 1981.
12. Weinsier R, Schutz Y, Bracco D. Reexamination of the relationship of resting metabolic rate to fat-free mass and to the metabolically active components of fat-free mass in humans. American Journal of Clinical Nutrition 55: 790-794, 1992.
13. Powers Sk, Howley ET. Exercise Physiology: Theory and Application to Fitness and Performance. Wm. C. Brown Publishers. Dubuque, IA, 1995.