Why The Confusion on Muscle and Metabolism?

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In his book, *LifeFit*, America's leading epidemiologist, Ralph Paffenbarger, MD, makes the following statement regarding the effects of muscle gain and metabolic change. "Indeed, when you replace 10 pounds of fat with 10 pounds of muscle, your weight remains the same but you can expect to expend 500 or more additional kilocalories each day at rest" (page 122). In other words, Dr. Paffenbarger ascribes the resting metabolic requirement for a pound of muscle at 50 calories per day.

In her book, *Ultimate Fitness*, author Gina Kolata quotes world-renown exercise physiologist Claude Bouchard as saying "Skeletal muscle burns about 13 calories per kilogram of body weight over 24 hours when a person is at rest" (page 230). In other words, Dr. Bouchard ascribes the resting metabolic requirement for a pound of muscle at less than six calories per day. He supports his opinion by saying that a man who weighs about 155 pounds has about 62 pounds of skeletal muscle, which accounts for approximately 22 percent of his resting metabolism (1600 calories resting metabolism x 22 percent used by muscles = 352 calories used by muscles ÷ 62 pounds of muscle = 5.7 calories per pound by muscle per day at rest). Dr. Bouchard therefore states that, "Weight lifting has virtually no effect on resting metabolism" (page 230).

Although Dr. Bouchard's mathematical calculations seem to make sense, they definitely do not line up with the classic research studies on this topic. In 1994, two exceptionally well-conceived and well-conducted research studies examined the effects of strength training on muscle development and resting metabolic-rate. One study was

conducted by Campbell and his research associates at Tufts University, and the other study was conducted by Pratley and his research associates at the University of Maryland.

At Tufts University, the subjects performed progressive resistance exercise three days a week for a period of 12 weeks. Each training session consisted of four standard strength exercises, each of which was performed for three sets of eight to 12 repetitions. After three months of training the subjects, on average, added 3.1 pounds of lean (muscle) weight and lost 4.0 pounds of fat weight. As a result, their resting metabolic rate increased by 6.8 percent, or approximately 105 calories per day. At face value, this finding would indicate that a pound of muscle uses about 35 calories per day at rest (105 calories per day ÷ 3 pounds of muscle = 35 calories per day per pound of muscle).

At the University of Maryland, the subjects performed progressive resistance exercise three days a week for a period of 16 weeks. Each training session consisted of 14 standard strength exercises, most of which were performed for one set of 10 to 15 repetitions. After four months of training the subjects, on average, added 3.5 pounds of lean (muscle) weight and lost 4.2 pounds of fat weight. As a result, their resting metabolic rate increased by 7.7 percent, or approximately 120 calories per day. At face value, this finding would indicate that a pound of muscle uses about 34 calories per day at rest (120 calories per day ÷ 3.5 pounds of muscle = 34 calories per day per pound of muscle).

It is interesting to note that in both of these studies, the same strength training program that increased lean (muscle) weight by about three pounds, likewise increased resting metabolic rate by about seven percent. It is also interesting to note that in both of these studies, the strength training programs responsible for these impressive results were relatively basic and brief. The Tufts University subjects performed just 12 sets of exercise per session (3 sets of 4 exercises), and the University of Maryland subjects completed 17 sets of exercise per session (1 set of 11 exercises and 2 sets of 3 exercises). These represent essentially 30-minute workouts that are manageable both time-wise and energy-wise for most adults and seniors. It is nothing short of remarkable that such modest investments in strength exercise can produce such profound physical outcomes.

Although a few studies on this topic have not noted increases in muscle mass and resting metabolic rate as a result of strength training, these have involved relatively large reductions in caloric intake. Of course, when calories are significantly restricted the body assumes a starvation/survival mode, and does not respond in the same manner as when the appropriate amount of calories are consumed. Essentially all studies that do not involve low-calorie diets show significant increases in muscle mass and resting metabolic rate after 10 weeks or more of sensible strength training.

As I mentioned, at face value the results of these studies indicate that a pound of new muscle uses about 35 calories a day at rest. However, this is undoubtedly a high estimate because it assumes that the **only** training-induced change is the addition of new muscle tissue, which is **entirely** responsible for the metabolic increase. I submit that **all** of the skeletal muscle impacted by the strength training program experiences an increase in protein turnover. In other words, I suggest that **all** of the trained muscle tissue has a higher resting metabolic rate than it had prior to the exercise program. Of course, I can't state how many additional calories each pound of trained skeletal muscle utilizes, but it may be on the order of 1.5 calories per pound of muscle tissue. Let's go back to Dr. Bouchard's example and do some calculations to see if this makes sense.

If a 155 pound man with a resting metabolic rate of 1600 calories per day has approximately 62 pounds of skeletal muscle, and each pound uses 5.7 calories per day at rest, then the contribution to his resting metabolism is about 353 calories (62 pounds of muscle x 5.7 calories per pound = 353 calories). However, if the strength training program adds three pounds of muscle tissue for a total of 65 pounds of skeletal muscle, and if each pound of trained muscle now uses 7.2 calories per day at rest (a 1.5 calorie increase), then the new contribution to his resting metabolism is about 468 calories (65 pounds of muscle x 7.2 calories per pound = 468 calories). This represents about 115 additional calories burned each day at rest, (353 calories to 468 calories = 115 calories), which increases his resting metabolic rate by approximately seven percent (1600 calories per day x 7 percent = 112 more calories). This metabolic increase is consistent with the research findings by both Campbell et al. and Pratley et al.

I am therefore suggesting that a standard three-month strength training program may produce the following effects in previously sedentary adults and seniors:
1. Increase lean (muscle) weight by about 3 pounds.
2. Increase daily resting metabolic rate in **all** of the trained muscle by about 1.5 calories per pound (from 5.7 calories per pound to 7.2 calories per pound).
3. Increase overall resting metabolism by about 7 percent.

It definitely makes sense that muscle tissue subjected to regular strength training has a higher metabolic rate than untrained muscle tissue. Our research indicates that regular strength training elicits an increased rate of muscle protein synthesis (Pikosky, Faigenbaum, Westcott and Rodriguez 2002), which should elevate tissue energy utilization throughout the day. In other words, strength exercise appears to have an elevating effect on muscle tissue metabolism (e.g., 1.5 calories per pound of muscle per day), and this relatively small increase multiplied by **all** of the trained skeletal muscle leads to a significantly higher resting metabolic rate. This explanation appears to be more plausible than assuming that new muscle tissue uses 35 calories per pound per day, or that trained skeletal muscle still uses only 5.7 calories per pound per day.

Summary

Based on the classic research studies conducted at Tufts University and the University of Maryland, standard programs of progressive resistance exercise can increase lean (muscle) weight by 3.0 to 3.5 pounds and resting metabolic rate by 6.8 to 7.7 percent after three to four months of regular training, respectively. It is postulated that the increased resting metabolism results from a small increase in energy utilization by **all** of the strength trained skeletal muscle. If this is an accurate assumption, strength trained muscle may use approximately 1.5 more calories per pound per day than untrained muscle (7.2 vs 5.7 calories per pound per day). Such an adaptation could account for the approximately seven to eight percent elevation in resting metabolism observed in the reported research studies.

In conclusion, strength training does have a significant elevating effect on resting metabolic rate, and is therefore a highly beneficial exercise for increasing daily calorie utilization and enhancing fat loss. It would appear that the metabolic increase occurs in **all** of the strength trained muscle tissue, and that the additional energy utilization may be about 1.5 calories per pound of muscle per day.

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References

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Summary of classic studies on muscle and metabolism

Research Study	Strength Training Program	Training Frequency	Training Duration	Change Muscle Tissue	Change Resting Metabolism
Campbell et al. Tufts University	4 exercises 3 sets 8-12 reps	3xweek	12 weeks	+3.1 lbs	+6.8%
Pratley et al. University of Maryland	14 exercises 1 set/2 sets 10-15 reps	3xweek	16 weeks	+3.5 lbs	+7.7%