

# The Role of Resistance Exercise in Weight Loss

Jeffrey L. Alexander, MS  
Arizona State University-East

**Keywords:** resistance exercise; weight loss; body fat reduction; resting metabolic rate; fat oxidation; energy expenditure

## ■ What Is the Role of Weight Training in Weight Loss?

**SUCCESSFUL WEIGHT LOSS IS** achieved through the creation of a negative energy balance, wherein the amount of energy taken in is less than the amount burned or utilized through physical activity and/or exercise. There are 2 factors to energy balance: energy intake and energy expenditure. Weight loss can only be achieved through modifying one or both of these factors. The focus of this report is on energy expenditure, keeping in mind that any reduction in energy intake will add to the effects of energy expenditure in creating a negative energy balance and a resultant loss in body mass.

## ■ Can Weight Training or Resistance Exercise Significantly Contribute to the Creation of a Negative Energy Balance?

In comparison to aerobic exercise such as jogging or cycling, resistance exercise appears to have less of an impact on direct caloric expenditure and on creating a

negative energy balance (Table 1). For example, vigorous resistance exercise might burn only 66% of the calories of vigorous aerobic exercise during the same amount of exercise time. However, rest times between resistance exercises as normally performed during weight training were not accounted for in this example; thus, the amount of calories expended during an hour of resistance exercise was likely overestimated.

Despite the relatively low caloric cost of resistance exercise, this mode of exercise may significantly

affect energy expenditure, but more through indirect than through direct means. The indirect effects of resistance exercise on energy expenditure are mainly through increasing resting metabolic rate (RMR). Resistance exercise also enhances fat loss specifically through enhanced postexercise fat utilization, which will aid in weight loss and improved body composition.

### **Increased RMR**

RMR is the amount of energy expended by the body at rest and accounts for about 70% of daily en-

**Table 1**  
**Caloric Cost of Activity: Resistance Versus Aerobic Exercise**

<b>Caloric cost of resistance exercise</b>	<b>Caloric cost of aerobic exercise</b>
70 kg male Vigorous weight training* 6.0 METs or 7.2 kcal/min* 60 min weight training × 7.2 kcal/min = <b>432 kcal</b>	70 kg male Vigorous running (11.5 min/mile)* 9.0 METs or 10.8 kcal/min* 60 min running × 10.8 kcal/min = <b>648 kcal</b>

\* ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription (4th ed.), 2001.

---

ergy expenditure (1). An increase in RMR can have a significant impact on total energy expenditure and the creation of a negative energy balance. This increase in RMR is especially important when taking into consideration that RMR is generally depressed during caloric restriction, as when individuals are dieting (13).

Resistance training may significantly increase RMR by (a) increasing fat-free mass (FFM), (b) increasing plasma catecholamine levels, and (c) through acute or postexercise effects.

### **Increasing FFM**

RMR is highly correlated with FFM, which is body mass accounted for by muscle, bone, and organ tissue. Because muscle mass is the only component of FFM that can be significantly altered, the 2 terms will be used synonymously. Muscle mass alone contributes about 22% to RMR (3). Consequently, any gain or loss of FFM may potentially alter an individual's RMR.

A number of researchers have looked at the effects of resistance exercise on FFM and subsequently on RMR. For example, in 1992, Ballor and Poehlman (2), using a cross-sectional design, assessed the effects of resistance exercise on RMR against a sedentary control. The resistance-trained group had an average of 2.6 kg more FFM and ~7% higher RMR than did the sedentary control group. In 1994, Campbell et al. (5) examined the effects of a 12-week resistance training program on energy expenditure in 12 previously untrained men and women. At the end of the 12 weeks, the FFM increased by 1.4 kg and RMR increased 6.8%. When the increase in RMR was expressed relative to FFM, the change in RMR was no

longer significant, suggesting that RMR increased in these participants based on their muscle or FFM gain.

In addition to increasing RMR through FFM, resistance exercise can help maintain muscle mass and RMR during diet-induced weight loss. During a very low calorie diet (VLCD), significant weight loss occurs. Without exercise, body fat is lost but muscle mass is also significantly wasted. The result of a significant loss of FFM due to dieting is a reduction in RMR.

Participating in resistance exercise during a VLCD maintains and may even increase FFM. A number of studies support this claim (4, 6). Recently, Bryner et al. (4) examined the effects on FFM and RMR of an 800-calorie diet (VLCD) plus resistance training or aerobic training. Twenty participants were randomized into aerobic exercise plus VLCD or resistance exercise plus VLCD so that the group was evenly distributed between both protocols. The aerobic exercise group lost a significant amount of FFM, but the resistance exercise group maintained FFM throughout the 12 weeks of training. Consequently, RMR decreased in the aerobic exercise group but increased in the resistance exercise group.

In 1993, Donnelly et al. (6) conducted a study to examine whether muscle hypertrophy or increases in muscle size could occur during severe caloric restriction (803.1 kcal/d) with resistance exercise. Fourteen obese females were recruited for the study and were randomized to either a diet only (C) or a diet plus weight training (WT) group. Women in both groups lost a significant amount of weight; however, the WT group demonstrated signifi-

cant muscular hypertrophy after the 12 weeks of training, but there was no change in the C group. This study suggests that even during severe caloric restriction muscular hypertrophy is not altered during a resistance exercise program. Maintenance of or an increase in FFM will result in maintenance or an increase in RMR.

In light of the studies reviewed, resistance exercise may maintain and perhaps increase RMR in dieting and nondieting individuals through an increase or maintenance of FFM.

### **Increasing Plasma Catecholamine Levels**

Endurance training increases plasma norepinephrine levels (10). The increase in norepinephrine results in an increased carbohydrate (CHO) and lipid metabolism or breakdown and thus an increase in RMR. If the same is true for resistance training, an increase in norepinephrine levels should increase RMR. In one study, the effects of resistance exercise on norepinephrine levels in the blood were examined.

In 1994, Prately et al. (11) performed a study that looked at the effect of resistance training on RMR and norepinephrine levels in older men. Thirteen older men (~58 years old) participated in a 16-week heavy strength-training program. RMR and plasma norepinephrine levels were measured before the program started and after completion. RMR increased significantly (7.7%) as did plasma norepinephrine levels (36%). The results of this study suggest that resistance training increases plasma catecholamine levels, resulting in a contribution to increased RMR. The exact contribution of catecholamine levels to RMR was not determined in this study and is still unclear.

---

### **Postexercise Effects on RMR**

During recovery from exercise, metabolic rate is maintained above resting values, a phenomenon referred to as excess postexercise oxygen consumption (EPOC). EPOC may significantly contribute to energy expenditure. However, it has been suggested that for EPOC to significantly contribute to energy expenditure after resistance exercise the training must be strenuous (requiring a high volume with a large number of sets and moderate resistance or intensity) (11). The results of several studies support this hypothesis (7, 9).

In 1993, Melby et al. (7) conducted a study to examine the acute effects of resistance training on postexercise energy expenditure and RMR. Seven male participants completed 90 minutes of resistance exercise; RMR was then measured for 2 hours postexercise and again the next morning (~15 hours postexercise). RMR remained elevated for the 2 hours postexercise and after 15 hours RMR continued to remain elevated (+9.4%). Similar results were recently found in female participants following a similar program (9). RMR remained elevated for 3-hours postexercise and remained elevated the morning after exercise (+4.2%).

These studies demonstrate the potential for resistance exercise to contribute to energy expenditure. However, because the resistance exercise sessions performed in the previous studies were strenuous (high volume), nonathletes may struggle with or be unable to complete such a routine. When developing a resistance training protocol for untrained individuals with weight loss as a primary goal, strength and conditioning professionals should start the partici-

pant at a lower intensity and gradually progress the individual to an intensity appropriate for eliciting maximal increases in RMR.

The contribution of resistance exercise to RMR through increased FFM, elevated catecholamine levels, and EPOC has been established. Through increasing RMR, resistance exercise may contribute to increased daily energy expenditure, net negative energy balance, and therefore increased weight loss.

### **■ Increased Fat Oxidation**

Fat oxidation, in the simplest terms, is the breaking down of fat for energy. Resistance exercise can cause an increase in fat oxidation both acutely and chronically (7, 11). The mechanism by which fat oxidation acutely increases is thought to be the increased use of CHO to replenish glycogen stores in the muscles (7). Glycogen is the stored form of glucose that supplies the muscles with energy during exercise. Because CHO is being stored at a greater rate after exercise than before exercise, the body must utilize fat as a primary source for energy. Increases in fat oxidation may also be attributed to an increase in catecholamines, which results in an increased rate of lipolysis or fat oxidation (11).

A few researchers have looked at this relationship between resistance exercise and fat oxidation. Recently, Osterberg and Melby (9) measured the effects of resistance exercise on RMR and fat oxidation. These authors discovered a 62% increase in fat oxidation 16 hours postexercise. Trueth et al. (12) found similar results in elderly women (12). After 16 weeks of resistance training, resting fat oxidation had increased by 63% and 24-hour fat oxidation had in-

creased by 93%. The resistance training program used by Trueth et al. was fairly moderate, with a lower volume than that of Osterberg and Melby. There may be differences in the effects of resistance exercise on fat oxidation in elderly compared with young individuals. If such differences exist, strength and conditioning professionals should take age into consideration when prescribing a resistance exercise routine for fat or weight loss. Nonetheless, the results for both studies suggest that resistance exercise may play an important role in increasing fat oxidation and, consequently, increasing body fat loss.

### **■ Summary**

The benefits of regular exercise for weight loss have been established for many years. Traditionally, aerobic exercise has been prescribed because of its ability to directly affect energy balance. Often when calorie restriction is used, body fat is lost but muscle mass is also lost, depending on the severity of the caloric restriction. The loss of muscle mass may result in a decrease in RMR, which is contraindicated for weight loss or maintenance of weight after weight loss. Hence, maintaining muscle mass during and after weight loss is an important component to any weight loss program.

Resistance exercise has an indirect impact on weight and fat loss through increasing RMR and enhancing fat oxidation. Increasing or maintaining muscle mass or FFM, increasing serum catecholamine levels, and enhancing postexercise utilization of energy are all factors that play a role in the ability of resistance exercise to increase RMR. Because resistance exercise maintains or increases

**Table 2**  
**Example Resistance Exercise Routine for**  
**Untrained Individuals**

Lift*	Sets	Repetitions	Rest interval (s)†
1. Bench press	1	10-12	60-90
2. Angled leg press	1	10-15	60-90
3. Overhead shoulder press	1	10-12	60-90
4. Supine hamstring curl	1	10-15	60-90
5. Seated pulley row	1	10-12	60-90
6. Knee extension	1	10-15	60-90
7. Preacher bicep curl	1	10-12	60-90
8. Standing calf raise	1	10-15	60-90
9. Lying tricep extension	1	10-12	60-90
10. Abdominal crunches	1	25-30	30-60

\* Lifts are to be completed in the order listed.

† Rest is defined as rest between lifts and then between sets as individuals perform 2 or more sets.

muscle mass, even during severe caloric restriction, RMR will remain elevated or will be maintained during weight loss. In addition to increased RMR, the rate of fat oxidation is affected both acutely and chronically.

**■ Practical Application:**  
**What Should Strength and Conditioning Professionals Recommend to Those Who Seek Weight Loss as a Desired Goal (Referring to Exercise)?**

Strength and conditioning professionals should prescribe a combination of aerobic exercise and resistance exercise for directly burning calories and for indirectly burning calories and maintaining lean body mass, respectively. For the untrained person, a resistance training program should be low volume and low intensity (1 set, 10-12 repetitions maximum [RM]) and should gradually build to a routine with higher volume and moderate intensity (3 or 4 sets, 8-12 RM) to elicit increases

in RMR (Table 2). For a trained individual, simply increase the number of sets, increase the intensity, and adjust the number of repetitions accordingly. The exercises are ordered in an alternating upper-body and lower-body manner to ensure adequate recovery between exercises (8). Through the use of aerobic and resistance exercise, optimal body weight and physical fitness may be obtained. For fitness professionals, the importance of aerobic and resistance exercise is clear: to achieve optimal health and body weight, we need both. ▲

**■ References**

1. American College of Sports Medicine. *ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription* (4th ed.) Baltimore: Williams & Wilkins, 2001.
2. Ballor, D.L., and E.T. Poehlman. Resting metabolic rate and coronary-heart-disease risk factors in aerobically and resistance-trained women.

3. Bray, G.A., C. Bouchard, and W.P.T. James. *Handbook of Obesity*. New York: Marcel Dekker, 1998.
4. Bryner, R.W., I.H. Ullrich, J. Sauers, D. Donley, G. Hornsby, M. Kolar, and R. Yeater. Effects of resistance vs. aerobic training combined with an 800 calorie liquid diet on lean body mass and resting metabolic rate. *J. Am. Coll. Nutr.* 18:115-121. 1999.
5. Campbell, W.W., M.C. Crim, V.R. Young, and W.J. Evans. Increased energy requirements and changes in body composition with resistance training in older adults. *Am. J. Clin. Nutr.* 60:167-175. 1994.
6. Donnelly, J.E., T. Sharp, J. Houmard, M.G. Carlson, J.O. Hill, J.E. Whately, and R.G. Israel. Muscle hypertrophy with large-scale weight loss and resistance training. *Am. J. Clin. Nutr.* 58:561-565. 1993.
7. Melby, C., C. Scholl, G. Edwards, and R. Bullough. Effect of acute resistance exercise on postexercise energy expenditure and resting metabolic rate. *J. Appl. Physiol.* 75:1847-1853. 1993.
8. National Strength and Conditioning Association. *Essentials of Strength Training and Conditioning* (2nd ed.) Champaign, IL: Human Kinetics, 2000.
9. Osterberg, K., and C. Melby. Effect of acute resistance exercise on postexercise oxygen consumption and resting metabolic rate in young women. *Int. J. Sports Nutr. Exerc. Metab.* 10:71-81. 2000.
10. Poehlman, E.T., and E. Danforth. Endurance training increases metabolic rate and norepinephrine appearance rate in older individuals. *Am. J. Clin. Nutr.* 56:968-974. 1992.



*J. Physiol.* 261(Endocrinology Metabolism 24): E233-E239. 1991.

11. Prately, R., B. Nicklas, M. Rubin, J. Miller, A. Smith, M. Smith, B. Hurley, and A. Goldberg. Strength training increases resting metabolic rate and norepinephrine levels in healthy 50- to 65-yr old men. *J. Appl. Physiol.* 76:133-137. 1994.
12. Trueth, M.S., G.R. Hunter, R.L. Weinsier, and S.H. Kell. Energy expenditure and substrate utilization in older women after strength training: 24-h calorimeter results. *J. Appl. Physiol.* 78:2140-2146. 1995.
13. Wadden, T.A., G.D. Foster, K.A. Letizia, and J.L. Mullen. Long-term effects of dieting on resting metabolic rate in obese outpatients. *J. Am. Med. Assoc.* 264:707-711. 1990.



Alexander

**Jeffrey L. Alexander, MS, ACSM-ES**, is a doctoral student in Exercise and Wellness at Arizona State University-East. He obtained a BS in Health Promotion and an MS in Exercise Physiology and is an adjunct faculty member at the Chandler-Gilbert Community Colleges, Williams and Pecos Campus. His research focus is on strength training as a prevention and treatment for cardiovascular disease and related chronic diseases.

# CONFERENCE AUDIO TAPES

TO ORDER CALL  
**800-815-6826**  
or E-MAIL  
nsca@nsca-lift.org

## Sport-Specific Training Conference San Antonio, Texas • January 10-11, 2002

### COMPLETE SETS

___ CN	Conference Notebook .....	\$25.00
___ CSF	Complete Set of Audio Tapes for Football .....	\$110.00
___ CSB	Complete Set of Audio Tapes for Baseball .....	\$110.00
___ CSA	Complete Set (Football and Baseball both) .....	\$200.00
___ CN	Conference Notebook (Free With Any Complete Set of Audio Tapes)	FREE

### FOOTBALL TRACK

___ F1	"Total Football Training: Innovative, Integrated and Functional" – Rob Rogers, CSCS, Fred Roll, CSCS, Jimmy Radcliffe, Vern Gambetta, MA, Mike Boyle, Rich Tucker .....	\$32.00
___ F2	"NCAA Emergency Response Plan" – Helen Binkley, CSCS, *D .....	\$8.00
___ F3	"Lower Body Exercises & Drills" – Roger Marandino, CSCS, *D .....	\$8.00
___ F4	"Mind to Muscle to Heart – Bringing the Football Field into the Weight Room" – CJ Stockel/Sid Maxwell, CSCS, *D .....	\$12.00
___ F5	"Setting up a High School Strength & Conditioning Program from Start to Finish" – Paul Sharr, Brian Hallmark .....	\$8.00
___ F6	"The Physics and Biomechanical Analysis of Lower Body Offensive Line Play" – Doug Salmon, CSCS .....	\$8.00
___ F7	"Advanced Practical Explosive Exercise Training" – Mike & Meg Stone .....	\$16.00

### BASEBALL TRACK

___ B1	"The Team Approach: Returning to the Game After an Injury" – Fernando Montes .....	\$8.00
___ B2	"Do's and Don'ts in the Weight Room: Overview of Baseball Injuries" – Mark Schickendantz .....	\$8.00
___ B3	"Nutritional Issues with Supplement in Baseball" – Jeff Stout .....	\$8.00
___ B4	"Pitchers Conditioning in Professional Baseball" – Bob Alejo .....	\$8.00
___ B5	"Functional Conditioning for Baseball" – Gene Coleman .....	\$8.00
___ B6	"See the Ball... Hit the Ball: Visual Fitness Issues in Baseball" – Dr. Barry Seiller .....	\$8.00
___ B7	"Coaches Round Table" .....	\$8.00
___ B8	"Road to the Big Leagues" From Draft Day to the Big Leagues" – Frank Vazquez .....	\$8.00
___ B9	"Review of Periodization" – Tudor Bompa .....	\$12.00
___ B10	"Application of Periodization to Baseball" – Tudor Bompa .....	\$12.00
___ B11	"Specificity Training for Catchers: Implications for the Strength & Conditioning Program" – Andrew Fry, PhD, CSCS .....	\$8.00
___ B12	"Off-Season Programming in College Baseball" – Curtis Tsurada .....	\$8.00
___ B13	"Nutritional Issues in Baseball" – Rob Skinner, CSCS .....	\$8.00
___ B14	"Program Design at the Collegiate Level" – David Szymanski, CSCS .....	\$8.00
___ B15	"Managing the Media: Public vs. Private" – Sue Castorino .....	\$8.00

### SHIPPING & HANDLING

**\$1.00 per Tape • \$8.00 per Complete Set • \$3.00 per Notebook**  
Alaska, Hawaii, Canada, and all International Orders  
Please Call for Rates

## Strength and Conditioning Journal Review Board

Jose Antonio, PhD, CSCS  
 Kris Berg, EdD  
 Tony Caterisano, PhD, CSCS, \*D  
 Don Chu, PhD, ATC, CSCS, \*D; NSCA-CPT  
 Michael Deschenes, PhD  
 Avery Faigenbaum, EdD, CSCS, \*D  
 Vance Ferrigno, CSCS, \*D  
 Brian W. Findley, MEd, CSCS, \*D  
 Sue Graves, EdD  
 Mike Greenwood, PhD, CSCS, \*D  
 Kent Guion, MD  
 Everett Harman, PhD, CSCS

Gary R. Hunter, PhD, CSCS  
 Margaret Jones, PhD, CSCS  
 Douglas Kleiner, PhD, ATC, CSCS, \*D  
 William J. Kraemer, PhD, CSCS  
 Daniel J. McHugh, MD, CSCS  
 Curtis Lords, CSCS, NSCA-CPT  
 Michael G. Miller, EdD, ATC, CSCS  
 Rob Panariello, PT, CSCS  
 Nick Ratamess, MS, CSCS  
 Michael Reed, DC, CSCS  
 Kristin J. Reimers, MS, RD  
 Raoul Reiser, MA, CSCS

Stuart Rugg, PhD  
 Wade Russell, MS, CSCS  
 George Salem, PhD, CSCS  
 Wally Schoessow, CSCS  
 Gary Shankman, CSCS, \*D  
 Nestor Sherman, EdD  
 Meg Stone, PhD  
 Michael H. Stone, PhD  
 Christopher Street, MS, CSCS  
 Dennie Uhl  
 Timothy Uhl, PhD, PT, ATC  
 Ben Yaspelkis, III, PhD

## National Strength & Conditioning Association

### Board of Directors

**President** ..... Richard Borden, PhD, PT, CSCS  
**Vice-President** ..... Steven S. Plisk, CSCS  
**Secretary-Treasurer** ..... Jaynie Schram, MPH, MS, PT, ATC, CSCS, \*D  
**Board Members** ..... David Pearson, PhD, CSCS, \*D  
 Andrew Fry, PhD, CSCS  
 John Graham, MS, CSCS, \*D  
 Travis Triplett-McBride, PhD, CSCS

### NSCA National Office

**Executive Director** ..... Robert L. Jursnick  
**Deputy Executive Director/Director of Operations** .. Kim M. Dixon  
**Conference Director** ..... Virginia Meier  
**Advertising Manager** ..... Robyn Curtis

**NSCA National Office:** P.O. Box 9908 • Colorado Springs, CO 80932-0908 • Toll Free 1 (800) 815-6826 •  
 Phone (719) 632-6722 • Fax (719) 632-6367 • Web site: [www.nsca-lift.org](http://www.nsca-lift.org)

### NSCA Certification Commission Executive Council

**Chair** ..... Craig Cisar, PhD, CSCS, \*D; NSCA-CPT, \*D  
**Vice Chairs** ..... Bill Allerheiligen, CSCS  
 Anthony Abbot, EdD, CSCS, \*D; NSCA-CPT, \*D  
 Joe Owens, MS, CSCS, \*D  
**Member:** ..... Marybell Avery, PhD (Public Member)

### NSCA Certification Commission

**Executive Director of Certification** ..... Thomas R. Baechle, EdD, CSCS, \*D; NSCA-CPT, \*D  
**Commission Administrator** ..... Janet Owens  
**Director of Certification Education & Examination Development** ..... Roger Earle, MA, CSCS, \*D; NSCA-CPT, \*D

**NSCA Certification Commission:** 1640 L. Street, Suite G • Lincoln, NE 68508 • Toll Free 1 (888) 746-CERT •  
 Phone (402) 476-6669 • Fax (402) 476-7141 • Web Site: [www.nsca-cc.org](http://www.nsca-cc.org) • Fax-on-Demand Hotline (877) 441-CERT  
 (toll free)

**REGISTRATION ONLINE FOR NSCA EVENTS...  
[www.nsca-lift.org](http://www.nsca-lift.org)**