Training to Muscular Failure: Is It Necessary?

Michael H. Stone[1], PhD, CSCS; T. Jeff Chandler[2], EdD, CSCS; Michael S. Conley[3], MS, CSCS; James B. Kramer[4], MS, CSCS; and Meg E. Stone[5]
[1]Exercise Science, [5]Athletic Dept., Appalachian State; [2]Lexington Clinic Sports Medicine Ctr., Lexington, KY; [3]Exercise Science, University of Georgia; [4]Athletic Dept., Georgia Tech

IT IS NOT UNCOMMON FOR some athletes, weight trainers in particular, to exercise to muscular failure or near failure on a regular basis. In fact the concept of training by using an RM value to plan the training regimen tends to promote this practice. For this discussion, exercise to muscular failure is defined as the inability to maintain appropriate technique or to complete a muscle contraction due to fatigue.

There is little objective information on the efficacy of training to failure. The purpose of this paper is to discuss the possible physiological effects of such training and to examine the general concept of training to failure on a regular basis.

Rationale for Training to Failure

First we will examine the rationale for training to failure. During a typical set of resistance training exercises, as some motor units become fatigued and drop out, additional motor units must be recruited if the activity is to continue (1, 15). The recruitment of additional motor units as a result of fatigue may provide added stimulus for hypertrophy and strength gain (15). Although they offer little data, proponents suggest that training to failure—and at times performing forced repetitions and negatives—increases the effect of fatigue, which enhances adaptation to the training stimulus as a result of increased motor unit activation (2).

Rationale for Not Training to Failure

If fatigue and exercise to failure were in fact the critical strengthening stimulus, then simply training to failure with a light resistance should produce marked strength gains. However, this does not appear to be the case (1). Furthermore, increasing the resistance of the exercise with heavier weights also recruits more motor units (1) and has been correlated with both gains in maximum strength and the hypertrophy response (3).

Reviews of the published research suggest that training intensity (average weight lifted per day, week, etc.) and relative intensity (% 1-RM) are the more important factors in inducing a training effect for gains in strength and power (1, 19), especially in experienced weight trainers (11, 19). Thus it may be argued that using heavier weights and not constantly training to failure provides appropriate stimulus, especially for strength development.

Performance Gains

Some studies have examined training to failure using one set versus training with multiple sets not performed to failure (7, 11, 12, 16, 20). Although there are some exceptions (16), these studies generally indicate that multiple sets are superior to single sets in producing increases in maximum strength, power, and

high intensity exercise endurance (10, 12), especially in experienced weight trainers (10, 11), and that training to failure may not be advantageous.

However, these studies generally examined the training adaptations associated with only one set to failure (not multiple sets) versus multiple sets not done to failure, and did not directly examine the effects of training to failure.

So far no studies have *directly* examined training to failure versus not training to failure. Direct comparisons between the two would be extremely difficult because the work would have to be equalized. However, Stowers et al. (20) did compare multiple sets to failure versus multiple sets not to failure using minimally trained subjects. They investigated the performance effects of 1 set to failure (8–12 reps/set), 3 sets to failure (8–12 reps/set), and a periodized program (no training to failure) over a period of 7 weeks.

The rationale for training to failure is the belief that this will enhance the hypertrophy response.

The results of Stowers et al.'s study (20) suggested that all 3 groups improved equally in the bench press. The results for the 1-RM squat, vertical jump, and vertical jump power index indicated that the gains over 7 weeks were, 1 set to failure < 3 sets to failure < periodization. This suggests that training to failure is not necessary for optimal gains.

Many bodybuilders train to failure typically using multiple sets. The rationale for training to failure is the belief that this will enhance the hypertrophy response. Although bodybuilders often do this, there is little information to support the practice of training to failure (21). On the other hand, weightlifters rarely if ever intentionally train to failure, yet they do attain great strength and power.

Furthermore, the mean cell size of specific muscles in weightlifters has not been shown to differ statistically from that of the same muscle in bodybuilders (22), nor is there any evidence that the long-term hypertrophy response of specific muscles trained by both groups of athletes is greater in bodybuilders (21). This would suggest that consistently training to failure offers no advantage in helping one gain muscle mass.

■ Potential Adverse Effects of Training to Failure

The possible adverse effects of training to failure must also be considered when designing a training program. This is important not only in sports training but perhaps even more so when considering a wellness/general fitness population.

Overtraining

Heavy weight training, especially when using large muscle mass exercises, can lead to chronic overwork in a relatively short time (18). Fry et al. (6) had experienced weight trainers train with very high intensities in the squat (1-RM, 10×1, 6 days a week). When an attempt was missed, the weight was reduced for subsequent attempts. Fry et al. found that overwork symptoms, including diminished strength and power performance, could be induced in as little as 2 or 3 weeks.

In a comparison of training/supplemental methods, Nimmons et al. (14) noted that their group of experienced subjects who consistently trained to failure (including performing negatives and forced repetitions) had markedly inferior results on strength and power performance tests compared to those in 2 programs not training to failure. Based on performance and physiological data, Nimmons et al. suggested that the group training to failure was showing early signs of overwork by 6 weeks.

In the study by Stowers et al. (20), symptoms of overwork, including diminished performance in leg and hip maximum strength and power, were noted among some of the subjects in the 3-sets-to-failure group within 7 weeks. Longer periods of training to failure would likely result in marked increases in the incidence of overwork symptoms.

This contention is supported by our own observation. For example, it is not uncommon for weight trainers, especially advanced strength/power athletes, to show symptoms of overwork within 3 to 4 weeks after beginning a program that requires exercise to failure.

Musculoskeletal Injuries

Although little objective data is available, there is reason to believe that constant training to failure may increase the incidence of both musculoskeletal overload injuries and acute injuries. Overuse injuries result from repetitive microtrauma to the musculotendinous unit (9). The overload injury model (8) describes the process by which fatigue and repetition are related to musculotendinous injuries. Repetitive use may eventually lead to inflex-

ibility, muscle weakness, and imbalances in muscle strength in a particular area (8). Continued use may cause pathological injury. Repetitive-use (overuse) injuries are the most commonly seen in exercising populations.

One example of a repetitive-use injury that may be related to fatigue and overuse is tennis elbow. Although many other factors such as technique, racquet, string tension, and grip size are involved, tennis elbow results when the volume of work (number of strokes) exceeds the individual's strength/endurance and flexibility base.

This also holds true for many of the repetitive-strain injuries commonly observed in the workplace. Required to perform a competitive task, the worker experiences fatigue and potential overuse injuries. Although, in these examples, exercising to failure does not necessarily occur, a common factor that has been identified and linked to overuse injuries is fatigue (8). It is logical to believe that consistent exercise to failure would exacerbate fatigue and increase the potential for overuse injuries.

In the developing immature athlete, growth plate injuries are an area of concern (13). In the past most of this concern was focused on lifting heavy weights. However, it may also be important to examine the effects of training to failure on injuries to the growth plate. Osgood Schlatter's disease, a disorder in young athletes where the patellar tendon attaches to the tibia near a growth plate, is an example of an injury that may be related to repetitive exercise training (running, jumping, etc.) to the point of excessive fatigue.

Similar injuries may occur elsewhere in the body of immature athletes as a result of constant training to failure and high fatigue levels. Therefore the resistance, volume load (reps × weight lifted), and number of repetitions should be considered when developing a training program, especially for the immature athlete.

The chance of a traumatic (acute) injury may also increase with training to failure, such as the athlete who uses improper technique and body position in an attempt to accomplish one more repetition when training to failure. Injury may also occur if the athlete is too fatigued to rack the bar properly. There should always be spotters present to help prevent this situation. When a higher number of repetitions is performed in any conditioning program, "failure" should be defined as the point at which the individual is too fatigued to perform any more repetitions using proper technique.

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Cardiovascular Response

Training to failure may cause adverse physiological responses. For example, the highest blood pressure responses occur at failure during a set of resistance exercise (4, 5). Therefore peak blood pressure may be reduced by not performing exercises to failure. Although high momentary peak BP may not be a problem for healthy people, it can be harmful to persons with a compromised cardiovascular system. Thus, using methods that result in somewhat lower BP response may reduce the potential for harm.

Psychological Aspects

As with other aspects of training to failure, there is little or no objective data to help one make an intelligent decision on the practice. Some coaches argue that training to failure helps the athlete toughen up psychologically. Other coaches insist that training to failure teaches the athlete to fail and that instead it is more reasonable to coach the athlete to succeed by using a protocol that does not end in failure. Obviously more study is needed in this area.

Practical Considerations

The data imply that consistent training to failure may not be advantageous and in fact can be counterproductive in the long run, due to increased potential for overtraining and developing overuse injuries. This suggests that training to muscular failure should be minimized and other training strategies should be employed instead.

One important method of training, especially to enhance strength and power, concerns using well-planned programs with sufficient and appropriate variation in volume and intensity of training exercise such as periodized programs (17, 19). Variation should include adding heavy, moderate, and light intensity days to the training plan (10, 19). This can be achieved by (a) modifying RM training or (b) using relative intensity.

Modifying RM Training

We have often observed weight trainers consistently training to failure when using RM protocols. Sometimes this occurs because

the prescribed set and repetition protocol the trainee is attempting to follow uses a range of RMs per set, for example 3–5 RMs per set, rather than a standardized protocol, for example 3 × 5 RM. Thus the trainee (and some relatively advanced athletes who should know better) attempts to accomplish 5 reps with a weight more suitable for 3 or 4 reps.

Another common problem associated with RM training is not taking into consideration the accumulated fatigue associated with the training program. For example, if a specific weight is used for an RM value early in the week, it is not uncommon for the trainee to attempt the same weight when repeating the exercise later in the week. This can increase the likelihood of failure due to accumulated fatigue (19).

When using standardized RM values, one should take care to perform only the required number of repetitions and not consistently train to failure. Light and moderate days (less than RM values or a percentage of the RM value) should be planned and used (19).

Relative Intensity

Changes in the relative intensity from day to day can easily be used to vary volume load and intensity (19). This method is commonly used by many strength/power athletes.

In our opinion, occasional short-term periods (1 to 3 weeks a year) of training to failure may be used as part of a long-term training plan. While this short-term period may produce beneficial effects, longer periods of training to failure are inadvisable.

■ Summary

Currently there is little evidence that training to failure will enhance strength, power, or hypertrophy. Constant training to failure over a relatively long period (>7 weeks) may be counterproductive to one's attempts to increase strength, power, or hypertrophy. Until there is more research substantiating the benefits, constant training to failure is inadvisable. ▲

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Michael H. Stone, President of the NSCA, is a professor of exercise science at Appalachian State University. He has held teaching/research positions at LSU and Auburn, and has published widely on the topic of strength training. A nationally ranked weightlifter in the 1970s and early '80s, Mike has coached several national and international weightlifters including one Olympian.

T. Jeff Chandler is Director of Research and Education at the Lexington Clinic Sports Medicine Center. He is a sport science advisor to the Lexington Tennis Club, Van der Meer Tennis Center, U.S. Professional Tennis Registry, and K-Swiss. He received his doctorate from Auburn University in 1986 and is a Fellow of the American College of Sports Medicine.

Michael S. Conley is an NASA fellowship recipient at the University of Georgia, studying muscle physiology. He receives his PhD in June 1996. Mike completed an internship at the U.S. Olympic Training Center, and in 1993 received an MS in exercise physiology from Appalachian State University. He will attend medical school at Indiana University in the fall.

James B. Kramer, a nationally ranked weightlifter, is the assistant strength and conditioning coach at Georgia Tech. He completed a weight room/resistance training internship at the U.S. Olympic Training Center, and in 1992 received a master's in exercise physiology from Appalachian State University.

Meg E. Stone, assistant track & field coach at Appalachian State, received a teaching certificate from Dunfermline College in 1973 and a degree from Arizona in 1984. She is finishing her master's from Arizona. A 7-time All-American, Meg still holds the NCAA outdoor shot and discus records and was a member of 2 Olympic teams representing the UK.