Tapering for Endurance Athletes

Presented by
Coaching and Sports Science Division
of the
United States Olympic Committee
August 2004

TAPERING FOR ENDURANCE ATHLETES

Definition of Tapering:

Tapering can be defined as *an exercise training technique, which has been designed to reverse training-induced fatigue without a loss of the training adaptations* (1). Simply put, a taper is an attempt to progressively reduce the **physiological** and **psychological** stress of daily training in preparation for an athletic competition (2).

Training Load:

There are essentially three variables that make up an athlete's training stimulus or training load: volume, frequency, and intensity. Fundamentally, a taper is a decrease in one or a combination of these variables. For years, coaches and researchers have experimented with these variables in an attempt to achieve the optimal tapering strategy. A taper that is too long or does not provide a sufficient training stimulus can bring about partial or complete loss of training-induced anatomical, physiological, and/or performance adaptations (i.e. detraining). It is therefore very important for the coach and the athlete to determine how much the training load can be reduced while retaining these training adaptations (2). A taper that is followed properly can lead to significant performance improvements.

Types of Tapers:

Within endurance sports, four different types of tapers have been described and used in the past (**see Figure 1**) (3). These four tapers can then be divided into two groups: nonprogressive and progressive. A nonprogressive taper is one in which there is only one reduction in the training load. The step taper is the only example of this. A progressive taper involves a multi-step reduction in the training load, and is characteristic of the remaining three tapers. The duration and training load within each taper can be further varied to fit the athlete.

Nonprogressive:

Step Taper - Also known as *reduced training*, a step taper is a nonprogressive reduction of the training duration, frequency and/or intensity by a constant degree (4,5).

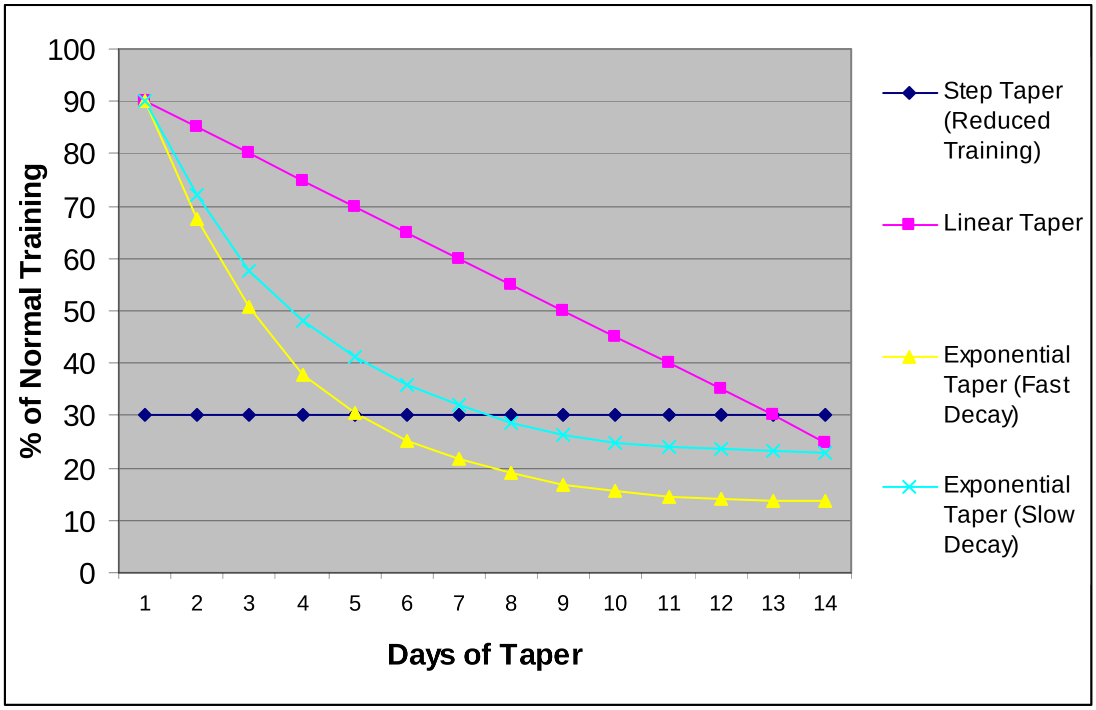
Progressive:

Exponential Decay Taper (Slow Decay) - The training load is reduced in a progressive manner, with a greater reduction near the beginning of the taper. A higher training load is sustained compared to a fast decay taper.

Exponential Decay Taper (Fast Decay) – The training load is reduced in a progressive manner, with a greater reduction near the beginning of the taper. A lower training load is sustained compared to a slow decay taper.

Linear Taper – A progressive, linear reduction in the training load.

Figure 1. Schematic representation of different types of tapers. Redrawn from Mujika and Padilla (2003).



The Physiology Behind Tapering:

Numerous studies have explored the physiological effects of tapering and reduced training. By the time athletes begin to taper, they should have achieved most or all of the expected physiological changes that come with training. The goal of the taper is to therefore get rid of the negative influences of training (i.e. fatigue and stress) thus maximizing the physiological gains made with training (6). **Table 1** summarizes these physiological effects.

Hormonal Changes: Cortisol is a hormone that stimulates protein breakdown (catabolism). Under severe stress situations (e.g. a high training load or emotional stress), greater amounts of cortisol are released into the bloodstream, therefore initiating protein catabolism. Tapering typically causes a decrease in cortisol levels. Another negative side effect of abnormally high cortisol is that is suppresses the immune system, thereby opening the door to illness and injury.

Testosterone, on the other hand, is a hormone that stimulates protein formation (anabolism). In endurance athletes, testosterone levels have been shown to decrease with high training loads but increase with tapering (7). Some studies have investigated the change in the testosterone/cortisol ratio from normal training to a taper. An increase in this ratio with a taper has been found to correlate with a performance improvement in swimmers (3). A decrease in cortisol and/or an increase in testosterone imply increased recovery and reduced fatigue.

Enzyme Changes: Creatine kinase (CK) is an enzyme involved in anaerobic energy production and has been shown to increase with high training loads and then decrease with tapering (8,9).

This makes sense, since the body's energy demands become less when training is cut back. High intensity tapering has also been shown to increase oxidative enzyme activity (1,10-12). In order for a cell to produce energy, oxidative enzymes must be present in sufficient concentrations to make the reactions "go" (7). Unlike CK, these enzymes tend to decrease with high training loads but increase with tapering. In effect, tapering allows these oxidative enzymes to catch up. Finally, myofibrillar ATPase (mATPase) is an enzyme that aids in muscle contraction and has increased activity with tapering (12). This rise in enzyme activity contributes to greater muscular power with tapering.

Energy Supply: Excess carbohydrates are broken down in the body and stored as glycogen in the muscles and liver. During exercise, glycogen is tapped as an extra energy source. When an athlete tapers, muscle glycogen levels increase significantly (1,10,12). The athlete then has a greater source of energy for the final competition, which could translate into improved performance. For more extensive reviews on the topic of carbohydrate supplementation in conjunction with a taper, refer to the articles by Anderson and Fairchild (13,14).

Muscular Power: It has been well documented that a high intensity taper, which will be explained in more detail later, can significantly increase an endurance athlete's power output (1,11,12,15,16). It is believed that maintaining or increasing intensity while tapering improves muscular power, in part, by increasing the size of muscle fibers, particularly fast twitch (Type II) fibers. This, in combination with increased mATPase enzyme activity, contributes to the overall increase in muscular power with tapering (12).

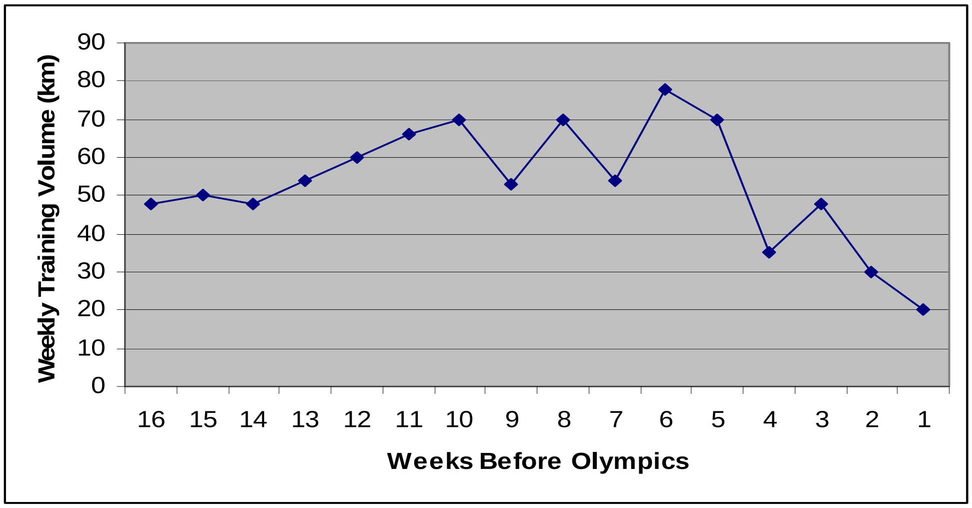
Table 1. Summary of physiological changes that occur with tapering.

HORMONE	**Cortisol**	↓
	Testosterone	↑
	T/C Ratio	↑
ENZYME	**Creatine Kinase**	↓
	Oxidative Enzymes	↑
	mATPase	↑
ENERGY	**Muscle Glycogen**	↑
MUSCULAR POWER	↑	

Tapering and Athletic Performance:

Even though the individual responses to a taper are likely to vary, it is safe to say that most athletes improve or at least maintain performance with tapering (6,10,11,15,17-21). A reasonable estimate of performance improvement after tapering is about 3% (3). Though this percent improvement may seem small, a recent study by Mujika et al. helps to put these numbers into perspective (22). The performance times of 99 swimmers who swam at a meet three weeks before the Sydney 2000 Olympic Games were compared to their Olympic times. The pre-Olympic meet represented the completion of the swimmers' preparatory training and the start of their taper leading to the Olympic Games. **Figure 2** is a schematic representation of the training volume of the swimmers leading up to the Olympics. The main finding of the study was a significant 2.2% improvement in performance, with 91 of the 99 athletes swimming faster at the Olympics. Now, consider that the average difference in time between the gold medalists and fourth placers was only 1.62%! The difference between third and eighth was 2.02%. Tapering alone could account for the difference between last place in the finals and a medal.

Figure 2. Typical weekly training volume (km) for swimmers in the 16-week preparation for the 2000 Olympic Games. Redrawn from Mujika, et al. (2002).



Psychological Considerations:

There is often a fear among athletes that tapering will decrease their levels of fitness. That is why the key to a good tapering program is high intensity. Athletes on a low volume and low intensity taper have actually been shown to have a more negative mood state and slower race times (23). Conversely, athletes on high intensity, low volume tapers had improved mood states, less stress, and improved performance (19,24). Not only does the intensity of a taper need to be high enough to maintain or improve on an athlete's physiological adaptations, but it must also be at a level that makes the athlete feel sharp. Just as an athlete has faith in his/her training program, it is important that the athlete believes in the importance of the taper for it to be effective.

A Tapering Template:

Even though athletes will respond to a taper differently and tapers will vary between sports, researchers have found a general template to tapering that significantly improves performance in a majority of endurance athletes.

Taper Type & Duration: The predominant taper among endurance athletes that has shown the greatest levels of improvement in performance is an exponential decay taper that maintains a high intensity (1,5,10,12,18). Even though both fast and slow exponential decay tapers have proven effective, there is evidence that a fast decay taper may be the best approach. A study by Banister, et al. compared triathletes' responses to four different tapers: step reduction vs. exponential decay and fast vs. slow exponential decay (5). The results of this study showed that the exponential taper group made a greater improvement above a pre-taper standard than the step taper group in cycle ergometry, and was better, but not significantly so, in a 5-km run. **Table 2** summarizes this data. The fast exponential taper group (taper = 4 days) performed significantly better above the pre-taper training standard than the slow exponential taper (taper = 8 days).

Depending on the sport, however, a slow exponential decay taper may be suitable. Swimmers have experienced a great deal of success with longer, slow exponential decay tapers, usually ranging from 5-21 days (15,16). Swimmers have even experienced improvements in performance with tapers lasting up to 28 days, though this seems to be the upper range of taper duration (6). Endurance runners and cyclists, on the other hand, seem to garner the most benefit from shorter, fast exponential decay tapers. Running and cycling performances have been shown to improve significantly following tapers lasting approximately one week (1,6,18). It appears that a quicker reduction in training load may lead to a quicker recovery from and response to the previous training (25).

The bottom line when determining the duration of a taper is to consider the training load of the athlete. The harder the athlete trains, and the longer the distance raced, the longer the taper. A one-week taper should be sufficient for a 5k runner, but a marathoner would probably want to begin cutting back on his/her training load at least two weeks prior to racing (26).

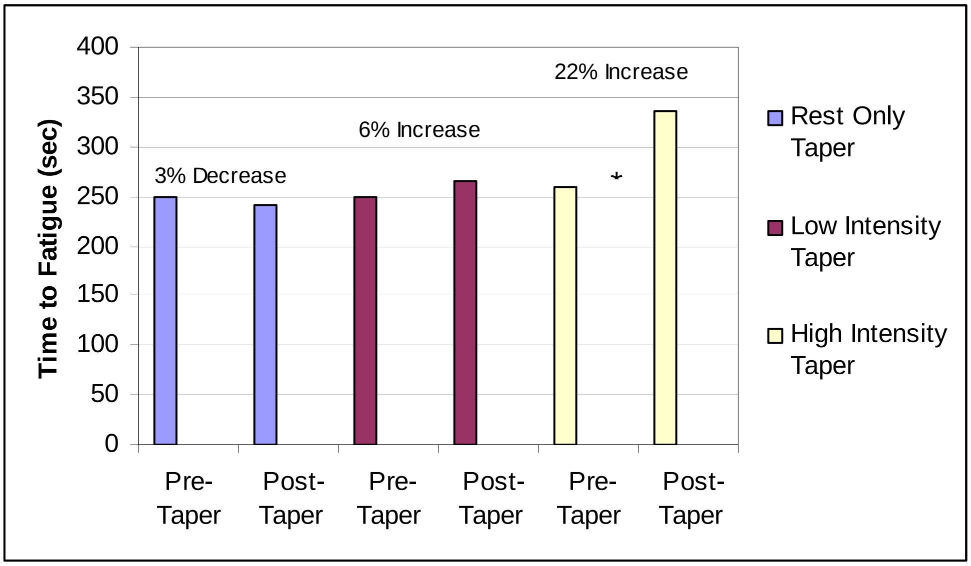
Table 2. Performance results comparing a step taper and exponential decay taper for both a criterion 5-km run and a maximal ramp test on a cycle ergometer. *Significant improvement compared with pre-taper. **Significantly better than step taper. Redrawn from Banister et al. (1999).

Exercise Type		Step Reduction Taper			Exponential Decay Taper		
		Pre-taper	1st week of taper	2nd week of taper	Pre-taper	1st week of taper	2nd week of taper
Run	Time (min:sec)	18:41	18:26	18:28	19:09	18:56	18:23*
Cycle	Power (W)	412	-	418*	423	-	446**

Training Intensity: Among the different training load variables (volume, frequency, and intensity), intensity is the most important to consider when planning a successful taper. A study by Shepley, et al. examined the effectiveness of three different types of tapers, all lasting seven days, on the athletic performance of middle-distance runners (10). The first was a high-intensity low-volume taper (HIT), the second was a low-intensity moderate-volume taper (LIT), and the final strategy was a rest only taper (ROT). The researchers found that the HIT was superior to the other two taper protocols at significantly improving performance on an exhaustive treadmill run and increasing the time to fatigue (**see Figure 3**). The key to a successful taper is intensity; compared to regular training, intensity should at least be maintained if not slightly increased

(1,5,10,12,18). There is a bit more room for variation with taper frequency and volume, but intensity should be high.

Figure 3. Time to fatigue before and after each taper procedure. *Significant pre- to post-taper differences. Redrawn from Shepley et al. (1992).



Training Volume: In conjunction with a high intensity training load, it is important to significantly decrease the volume of training over the course of a taper. A reduction in training volume of 60-85% has been shown to be beneficial in swimming, running, cycling, and triathlon (1,16,18,20,27). There is often a fear among athletes and coaches that such significant decreases in training volume will have a negative impact on aerobic fitness. As long as intensity remains high, these fears are unwarranted. Physiologically speaking, maximal aerobic power (VO_2max) is a quantitative representation of the upper limit of aerobic tolerance. VO_2max is the maximal amount of oxygen that the body is able to use to produce energy, and it is not negatively affected by tapering. (10,16,17,28-30).

Training Frequency: The final component of training load, frequency, should not decrease considerably from regular training- maybe one extra rest day per week. Decreasing the frequency of training during a taper does not appear to provide any performance benefits. In fact, athletes have performed better on high frequency tapers that mirrored their normal training compared to lower frequency tapers (17,27). The better trained the athlete is, the higher the recommended training frequency during a taper; this is especially true in the more "technique-dependent" sports such as swimming (3). If nothing else, maintaining training frequency helps the athlete to stay fresh psychologically.

Practical Implications:

Based on the research and what we now know about tapering, the following conclusions should be taken into consideration when planning a taper (3):

1. The goal of a taper should be to minimize fatigue rather than to attain additional physiological or fitness gains.
2. Progressive, nonlinear tapering techniques seem to have the most positive impact on performance. Exponential decay tapers, fast decay in particular, are superior to nonprogressive step taper strategies.
3. Tapers can last anywhere from 1-4 weeks. The sport and/or racing distance, however, influence the duration of the taper. A general rule of thumb, the longer the distance raced, the longer the taper.
4. Intensity is the key to a successful taper and is necessary to avoid detraining. Training intensity should be maintained if not slightly increased during a taper.
5. Training volume should be reduced by 60-85%.
6. Maintaining a high training frequency is essential to avoid detraining. Training frequency should not decrease by more than 20%.
7. A realistic performance goal for the final taper should be a competition performance improvement of approximately 3%. Tapering is usually effective at improving performance, but it does not always work for everyone. Remember that tapering is an art as well as a science.

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