By Kriston K. Koepp, MS, & Jeffrey M. Janot, PhD

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TAPERING: SCIENCE AND PRACTICE

Avoid overtraining and enhance athletic performance by using basic tapering principles.

Have you or your clients ever experienced decreased exercise performance; fatigue and muscle soreness; elevated heart rate at rest or during exercise; or unintentional loss of body weight? Collectively, these may be warning signs of overtraining—and subsequent detraining if allowed to continue. It is often difficult to clearly define an individual as "overtrained," because many other factors (medications, disease, stress, etc.) can contribute to the presence of these signs and symptoms. However, one consistent marker for overtraining seems to be a drop in exercise performance during a training period. What is the best strategy to minimize this and other problems that result from overtraining? Research points to **tapering**—the significant reduction of a client's training load—as one good solution (Powers & Howley 2001).

What Is Overtraining?

Overtraining may be more of a problem than undertraining, for many reasons. Overtraining may result in injury or suppress an athlete's immune response. It may also result in psychological staleness, which can be identified as a lack of enthusiasm for exercise training by the athlete or client. General signs and symptoms of overtraining are (1) elevated heart rate and blood lactate levels at rest and during exercise; (2) weight loss due to a reduction in appetite; (3) chronic fatigue; (4) psychological staleness; (5) multiple colds or sore throats; and/or (6) the most prevalent red flag: a decrease in exercise performance. An overtrained client might experience one or all of these markers. It is critical for trainers and coaches to recognize the signs and symptoms of overtraining and respond with a tapering strategy when problems arise (Powers & Howley 2001).

A common misconception about tapering is that to reduce training intensity or volume immediately before a competition may decrease exercise performance through detraining. This is clearly not the case.

Tapering

Tapering is defined as a short-term reduction in training load during a period leading up to a competitive event. This strategy has become very popular; it is common to incorporate a tapering period over several days before a major competition (Shepley et al. 1992). A common misconception about tapering is that to reduce training intensity or volume immediately before a competition may decrease exercise performance through detraining. This is clearly not the case. Coaches, trainers and athletes who make a concerted effort to taper after a period of high-intensity and/or high-volume training may benefit through performance enhancement in both strength and endurance events (Powers & Howley 2001).

In addition to this strategy, many athletes may elect to taper *after* a competitive season to promote recovery from the psychological and physiological stresses associated with in-season competition or intense training (Houmard et al. 1989).

If a tapering period is not administered, overtraining may occur in a competitive athlete. Knowing both your client and the scientific line between tapering and detraining is crucial. Too much of a good thing like tapering is just that: too much! It has been observed that after a reduction in training, athletes can begin to show symptoms of detraining within 14–21 days (Houmard et al. 1989), so plan your athlete's tapering period accordingly.

What Does Tapering Entail?

Tapering can elicit improvements in both physiological and exercise performance factors. A tapering period can increase muscle glycogen concentration, muscle strength and power, VO_2max and muscular endurance, and maximal power output (Neary et al. 2003a). All these factors will improve athletic performance. The goal during a tapering period is to maintain physiological adaptations attained during the training program, and, at the same time, allow the negative impact of training to diminish. Consequently, a precise, controlled training program is needed to ensure that maximal performance is achieved at the right moment of competition (Mujika 1998).

The intention behind a tapering period is to decrease **training load**—the total training stimulus put on the body—to improve an athlete's performance. A 60%–70% reduction in total training load has been shown to improve exercise performance without causing detraining symptoms (Houmard et al. 1989); at least 70% of training load is needed to maintain training-induced increases in VO_2max (Hickson et al. 1985). Training load can be reduced by decreasing training volume; training intensity; training frequency and duration; or a combination of all four.

Training volume, also known as the quantitative component to training, is the amount of work an athlete completes in one workout session or practice. During tapering, training volume needs to be reduced by at least 50% (Neary et al. 2003b). Important reductions in training volume during tapering periods can result in positive physiological and exercise performance responses in highly trained athletes (Mujika 1998).

Training intensity, also known as the qualitative training component, is the intensity at which an athlete performs during a workout session or practice. Training intensity plays an important role in maintaining increases in VO_2max obtained during a training program. A greater training load is needed to increase VO_2max than is needed to maintain it at that same training level (Hickson et al. 1982). Past and recent data suggest that training intensity must be at least 70% of normal and 90%–100% of VO_2max in order to maintain VO_2max (Hickson et al. 1985; Neary et al. 2003b). Training intensity should be slightly reduced to optimize the taper by allowing adequate rest and recovery time. However, maintenance of training intensity in a tapering period appears to be needed to avoid any detraining effects (Mujika 1998). According to Hickson and colleagues (1985), training intensity is critical in maintaining VO_2max and short- and long-term endurance performance, especially during the tapering period.

Training frequency is determined by how many workout sessions or practices occur in 1 week. Highly trained athletes need to keep training frequency high to avoid detraining (Mujika 1998). **Training duration** is measured by how many minutes or hours per workout or practice there are in a day or a single workout session. Short-term endurance performance and VO_2max are maintained when frequency or duration is reduced by one-third or two-thirds (Hickson et al. 1985).

According to research, the best type of exercise program for highly trained individuals to perform during a tapering period is one in which volume is greatly reduced but training intensity remains high. The reduction in training volume allows for ample recovery and "supercompensation," and the brief high-intensity training program gives enough stimuli to prevent detraining (Shepley et al. 1992).

In addition, the best type of exercise modality for tapering involves both upper- and lower-body muscle groups. Research has shown that performance can be lost at a faster rate when training is focused on a smaller muscle mass, as is the case with cycling (Hickson et al. 1985). The tapering period can also be used for focusing on technique work and optimizing nutrition in preparation for the competitive event.

How Long Should an Athlete Taper?

The amount of time to allow for tapering during the in-season is a delicate issue. Most coaches or personal trainers are reluctant to allow too much time off or to take their athletes or clients away from in-season training. Too much time allotted for tapering may cause detraining and affect exercise performance. Issues related to detraining include decreased muscular strength and endurance, an elevated maximal heart rate, and increased lactate production after exercise (Houmard et al. 1989). Reductions in muscular peak power production, muscle size, and neural drive to exercising muscle have also been reported during detraining (Andersen et al. 2005).

What is the proper time to allow for tapering? Research shows that a 7- to 10-day period with no activity does not hinder performance (Houmard et al. 1989; Shepley et al. 1992). Henriksson and Reitman (1977) found that after 6 weeks of detraining there was no decline in VO_2max. However, Houston and colleagues (1983) found an average decrease of 4% in VO_2max after just 2 weeks of detraining.

Tapering also depends on the individual sport and the type of major competition or event that the athlete will participate in post-taper. An athlete may not feel comfortable taking a week off before a major competition. In that case, the individual may want to taper for just a few days with a reduction in activity instead of total inactivity. For example, if the upcoming competition is a marathon, then 4–7 days of tapering would be adequate. In endurance-trained athletes, detraining would cause a rapid decline in VO_2max and exercise heart rate increases to compensate for a decrease in stroke volume; thus, endurance exercise performance would decrease. Frequent exercise is needed to maintain the metabolic benefits of endurance exercise training (Petibois & Déléris 2003). In contrast, if the upcoming major competition is a high-school football championship game, then 1–2 days allotted for tapering would be sufficient.

Detraining also depends on the age of the individual. A child's strength gains and losses are easily reversible. Children-specific maintenance training programs are needed to maintain training-induced strength gains (Mujika & Padilla 2001). Changes in muscular strength for children are mostly attributed to neurological factors rather than muscle hypertrophy. The decreases in strength gains during detraining are due to reduced neuromuscular activation and reduced motor coordination (Tsolakis, Vagenas & Dessypris 2004). In middle-aged and older people, the effects of detraining on muscular strength remain minor compared with the significant decreases seen in younger adults. When older adults reduce training frequency to one session per week, they can maintain their dynamic strength for several months (Hakkinen et al. 2000).

Tapering During Strength Training

Research has shown that tapering allows either maintenance of or significant increases in strength levels. Twitch torque and maximum motor unit activation increase after a tapering period, owing to alterations at the muscle level and within the central nervous system (Shepley et al. 1992). Both these variables are important for maximizing exercise performance. Twitch torque is important because twitch is composed of contraction and relaxation periods and the speed of these periods is reliant on the athlete's muscle fiber type, whether it be slow twitch (type 1 muscle fibers) or fast twitch (type 2 muscle fibers). Motor unit activation is also important to an athlete because stimulation from the motor unit initiates the contraction process in the muscle, leading to maximum muscle contraction (Powers & Howley 2001).

According to Gibala et al. (1994), well-trained strength athletes are able to significantly increase strength performance for at least 8 days as a result of a tapering period. The improvements may stem from an increase in either contractile performance or neural activation (Gibala et al. 1994).

When strength is combined with intensive running training, strength performance might be hindered during the training period but is shown to recover when running training is reduced or discontinued. Twitch torque and maximum motor unit activation have a tendency to increase as a result of tapering (Shepley et al. 1992). Muscular strength can be maintained for up to 12 weeks with a reduced training frequency of only one lifting session per week (Mujika 1998).

When it comes to strength performance and detraining, a 14-day cessation of training does not seem to significantly change one-repetition maximum bench press or squat performance, isometric and isokinetic knee extension force, or vertical jump val-

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ues (Mujika & Padilla 2001). However, after 8 weeks of detraining, decreases in squat and leg force are seen. These losses could be due to muscle atrophy and diminished neural activation (Hakkinen et al. 1981). Trained strength athletes can improve strength performance for at least 8 days during a tapering period by greatly reducing training volume but keeping training intensity high (Gibala et al. 1994). To see an example of a tapering period for strength performance, see Table 1.

Tapering During Sprint Training

Sprint ability is developed by involving brief, maximal-intensity sprint repetitions of varying duration combined with either long or short recovery periods. Sprint performance is usually greatest after a period of rest or reduced training. Research has shown that increases in peak muscular force production and dramatic increases in maximal shortening velocity in type 2 fibers occur with tapered training (Ross & Leveritt 2001). For an example of taper during sprint training, see Table 2.

The detraining effects that appear in sprint training are very limited in the first 2 weeks. Even 7 weeks or longer of detraining does not appear to completely eliminate the effects of the previous sprint training. With prolonged detraining, fast-twitch muscle fibers used to produce forceful muscle contractions during sprinting would be expected to decrease (Ross & Leveritt 2001).

Positive adaptations in sprint training occur in response to reduced training. In addition, the effects of detraining on sprint or power performance are less noticeable. However, detraining may affect exercise performance more during longer sprint events lasting in excess of 15 seconds than during short sprints lasting less than 15 seconds (Ross & Leveritt 2001).

Tapering Middle-Distance Runners

Trained middle-distance runners can significantly improve their running performance by sharply reducing training volume while maintaining or slightly increasing training intensity for 7 days (Shepley et al. 1992). Running times during the 800-meter event can improve after 2–3 weeks of reduced training; 1,600-meter running times can improve after a 2-week taper; and 5,000-meter times can remain the same without suffering a decline during a similar taper (Mujika 1998). The method of greatly reducing training volume while maintaining training intensity is superior to either a taper where both intensity and volume are reduced or a taper where no training is performed for 7 days (Mujika 1998; Shepley et al. 1992).

A tapering period does not affect VO_2max during middle-distance running, but time to fatigue is significantly prolonged due to a high-intensity tapering period. Increased time to fatigue is important to a runner because it allows the body to continue exercising for longer than the time before. Reduced training volume allows for ample recovery and adaptation to occur, and brief, high-intensity training provides an adequate amount of stimulus to prevent detraining (Shepley et al. 1992). For an example of a middle-distance running taper, see Table 3.

Tapering Long-Distance Runners

Research has shown that tapering does not affect VO_2max and, according to some studies, may even increase it slightly in long-distance runners. Therefore, an athlete does not lose the ability to maintain his or her maximal rate of oxygen uptake in the muscles (Shepley et al. 1992). To see an example of a tapering period during endurance running training, see Table 4.

Maintenance of VO_2max is very important to an athlete because VO_2max is an excellent measure of athletic performance. Also, tapering allows time to fatigue to be prolonged; therefore, an athlete can train longer before fatigue begins to affect performance. Both these physiological changes are due to adaptations in the skeletal muscle that occur during training. These adaptations include a rise in the mitochondria's capacity to regenerate ATP (through greater oxygen consumption), and an increase in muscle-buffering capacity, which allows more resistance to metabolic acidosis and prolongs time to fatigue. Hence, tapering may alter the muscle's ability to resist acidosis and significantly increase muscle glycogen concentrations (Shepley et al. 1992).

TABLE 1

Example: Tapering During Strength Training

	Volume	Frequency	Intensity
training period	4x 6RM for each exercise	6 days/week for 3 weeks	100%
tapering period	3x 6RM for each exercise on day 1	5 days/week for 1 week	100%
	2x 6RM on day 2 and day 4		
	1x 6RM on day 6 and day 7		

Tapering Cyclists

Well-trained cyclists who reduce training volume, frequency and intensity can maintain their submaximal and maximal performance for 21 days; VO_2max is maintained for a period of 3 weeks (Rietjens et al. 2001). Cycling time trials and power output improvements are also seen with taper training (Neary et al. 2003b). In a study done by Neary and colleagues (2003a), moderately and progressively reducing training volume (training frequency and duration), while still maintaining high intensity, appeared to enhance cycling performance.

Cycling VO_2max can be maintained at training levels when frequency is reduced from 4–6 days to 2 days of training per week. In addition, training volume and intensity can be reduced to 70% of VO_2max, and duration can be decreased from 40 minutes a day to

TABLE 2

Example: Tapering for a Sprint Runner Prior to Competition

	Volume	Frequency	Intensity
training period	2–3x 30-sec sprints	6 days/week for 6 weeks	100% of VO_2max
	3x 10-sec sprints		
	4x 5-sec sprints		
tapering period	same as above	5 days/week for 1 week	70% of VO_2max

15–25 minutes per day. When training intensity is reduced by one-third or two-thirds, cycling VO_2max is not maintained (Hickson et al. 1985). Table 5 shows an example of a tapering period during cycling training. Table 6 provides a tapering example for individuals who combine running and cycling in their everyday workouts.

Declines in muscular-endurance capacity appear to occur faster during cycling than during running. Exercise performance is usually lost at a faster rate when training is localized to a smaller muscle mass, as seen with cycling (Hickson et al. 1985).

Tapering Swimmers

Most swimmers participate in a year-round training program with only a few rest breaks. During a tapering period, swimmers experience little or no change in VO_2max in the first 5–12 days. However, the effects of swim training may be completely lost within 6–8 weeks of no training (Costill et al. 1985). After 4 weeks of detraining, swimmers are able to maintain muscular strength, but a swimmer's ability to apply force during swimming can decline by 13% (Mujika & Padilla 2001).

After a 21-day taper, type 2 muscle fibers in highly trained swimmers have been found to be larger, produce greater peak forces and possess faster contractile velocities—therefore becoming more powerful (Neary et al. 2003b).

Reducing training volume by 65%–80% and maintaining training intensity and frequency have been shown to maintain a swimmer's VO_2max while improving 100- to 400-meter swimming performances by 4%–8%. A 14-day taper consisting of a progressive reduction in swim training volume from 9,000 to 3,000 meters per day can increase power and improve competition performance times (Mujika 1998). An example of tapering during swim training appears in Table 7.

Variables to Consider

Tapering is an important component of an athlete's training program when preparing for a major competition. The process allows for many physiological changes to occur, such as maintenance of or an increase in VO_2max, prolonged time to fatigue, and maintenance of or an increase in strength (Shepley et al. 1992). Performance can be optimized during periods of taper by significantly reducing training volume, moderately reducing training frequency and slightly reducing or maintaining training intensity. Training intensity and initial performance levels seem to be the most important factors influencing the response to training and exercise performance during competition, provided that proper training volume and frequency are established (Mujika 1998; Neary et al. 2003a; Shepley et al. 1992).

Tapering can be a very beneficial way to suppress the signs and symptoms of overtraining without running the risk of detraining. According to research (Houmard et al. 1989; Shepley et al. 1992), a tapering period lasting 7–10 days will not hinder exercise performance. A 1-week taper is optimal for high-intensity aerobic performance, and a 2-week taper is needed to elicit

TABLE 3

Example: Tapering for a Middle-Distance Runner Prior to Competition

	Volume	Frequency	Intensity
training period	11–13 km/day	6 days/week for 8 weeks 3x 800–1,200 m on day 3 and day 6	90%–100% of VO_2max
tapering period	5x 500 m 800 m jog on day 1	5 days/week for 1 week	115%–120% 50% of VO_2max
	4x 500 m 800 m jog on day 2		115%–120% 50% of VO_2max
	3x 500 m 800 m jog on day 3		115%–120% 50% of VO_2max
	2x 500 m 800 m jog on day 4		115%–120% 50% of VO_2max
	1x 500 m 800 m jog on day 5		115%–120% 50% of VO_2max

TABLE 4

Example: Tapering for a Long-Distance Runner Prior to Competition

	Volume	Frequency	Intensity
training period	11–13 km/day	6–7 days/week for 12 weeks	90%–100% of VO_2max
tapering period	8 km/day	5 days/week for 1 week	70% of VO_2max

TABLE 5

Example: Tapering Prior to a Cycling Competition

	Volume	Frequency	Intensity
training period	60 min/day	4 days/week for 7 weeks	85%–90% of VO_2max
tapering period	45 min/day on day 1	4 days/week for 1 week	85%–90% of VO_2max
	35 min/day on day 2		
	25 min/day on day 3		
	20 min/day on day 4		

TABLE 6

Example: Tapering for Recreational Athletes (Running and Cycling)

	Volume	Frequency	Intensity
training period	**cycling:** interval training: 6x 5 min with 2-min rest in between for 3 days/week;	6 days/week for 10 weeks	100% of VO_2max
	running: continuous running on the alternate days; 30 min/day during week 1; 35 min/day during week 2; 40 min/day during weeks 3–10		
tapering period	same as above, but reduce cycle/run speed by one-third	6 days/week for 3 weeks	70% of VO_2max

greater strength gains. Quantity and quality of training, the individual athlete and the type of sporting event are important variables to consider for tapering (Neary et al. 2003a). In addition, proper tapering is very vital before a major competition, to allow for adequate recovery and to meet the nutrition demands of the body.

Kriston K. Koepp, MS, CSCS, was an assistant strength and conditioning coach at South Dakota State University and Jackrabbit Acceleration. She is currently a sports performance coach at Performance Edge Frappier Acceleration Sports Training in Hayden, Idaho. Kriston specializes in training high-school and college athletes in all sports. Contact her at koepp_k@yahoo.com.

Jeffrey M. Janot, PhD, is an assistant professor of human performance in the department of kinesiology at the University of Wisconsin–Eau Claire. He is the technical editor of IDEA Fitness Journal. *Contact him at janotjm@uwec.edu.*

TABLE 7

Example: Tapering for Swimmers Prior to Competition

	Volume	Frequency	Intensity
training period	11,000 m/day	6 days/week for 5 months	80%–90% of VO_2max
tapering period	7,500 m/day	5 days/week for 2 weeks	70% of VO_2max

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