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Cycling Research News

OPTIMAL TAPERING FOR CYCLISTS: DOES MUSCLE-FIBER COMPOSITION MATTER?

Almost all cyclists recognize the need for tapering before performances, but few are certain about exactly *how* to taper. Making matters complicated, research suggests that various tapering plans can have different effects on fast-twitch muscle fibers, in comparison to slow-twitch cells. However, the existing data indicate that high-intensity tapers have the broadest impact on fitness, suggesting that they can be used by cyclists with both "fast" and "slow" legs. In addition, steep-decay tapers seem to have uniquely beneficial effects which may make them preferable to step-reduction plans.

Most cyclists accept the idea that tapering can enhance performance; what is less certain is how tapering actually works and what *form* of tapering is optimal.

By definition, tapering is considered to be a training technique which strives to eliminate training-induced fatigue while maintaining – or even upgrading – training-associated adaptations (1). In practical terms, tapering usually involves a diminishment of training volume, intensity, and/or frequency over a period of two to 28 days before an important competition. It is clear from the available scientific research that tapering can promote improvements in performance-related physiological variables such as VO_2max and lactate-threshold speed, as well as in race times (2).

Why does tapering work so effectively? Exercise scientists have noticed that tapering tends *to magnify* many of the physiological changes observed during systematic endurance training. For example, several studies have shown that tapering bolsters glycogen levels in muscles and updates muscular concentrations and activities of oxidative enzymes. The surplus glycogen accruing as a result of a tapering period increases fuel availability during prolonged exercise, and the

Please continue on page 2.

HERBAL STUDY PLANTS DOUBTS

Two herbal supplements, *Cordyceps sinensis* and *Rhodiola rosea*, are becoming increasingly popular with endurance athletes. Traditionally used in Chinese and Ayurvedic medicine, the supplements are sold to athletes as "energy-boosters" and oxygen-utilization enhancers. There is some scientific evidence, as well as a wealth of anecdotal information, to support their use in the athletic world.

Cordyceps sinensis has been a popular herbal medicine in China for hundreds of years (1). As I am sure you realize, *Cordyceps sinensis* is not actually a plant but a fungus; its presumed-to-be-physiologically

Please continue on page 10.

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hoisted enzyme concentrations allow usable energy to be created at higher rates during exertion, fostering higher-intensity effort during competition.

Although there is little doubt that tapering is beneficial, there continues to be debate about *what kind* of taper produces the greatest overall adaptations. Some athletes think of a tapering period as a time for easy training; they don't change their volume or frequency of training very much but do cut out most of the intense work they have been doing. Others take several days off during their tapering phase but otherwise train in a fairly routine manner. Finally, some competitors cut back drastically on overall volume of work (by eliminating and/or shortening workouts) while maintaining a solid core of intense training (although there is a concern that intense effort may increase fatigue, it is believed that the retained high-quality work provides an added upward push to competitive fitness).

Muddying the taper debate a bit is the notion that tapering might influence different *types* of muscle fibers in discrete ways. There is not much information available in this important area, but in a recent study researchers were able to show that the Type-IIA muscle cells of highly trained swimmers produced greater peak forces and were significantly larger after a 21-day taper; in contrast, the Type-I ("slow-twitch") fibers of the natatorians were not larger but probably were able to contract at a higher rate, compared to before the tapering period (3). Since tapering seems to be able to produce fiber-specific effects, it is possible that a tapering program which revolved around cutbacks in volume might have a different effect on performance and on the three key muscle-fiber types (I, IIA, and IIB), compared with a tapering period which focused on paring away intensity. It is not beyond the realm of possibility that an athlete with a preponderance of one type of muscle cell might need an entirely different kind of taper, compared to a competitor with a different muscle-fiber composition.

To find out more about the utility of various tapering programs and the effects of commonly used tapers on the different muscle-fiber types, Patrick Neary and his colleagues at the University of New Brunswick and the University of Alberta in Canada recently divided 22 well-trained, male endurance cyclists into three groups (4). After seven weeks of intensive training, a control group (N = 7) simply continued training rigorously. Meanwhile, one of the two experimental groups maintained training intensity while lowering overall volume (N = 7), and the second experimental group held volume steady but trimmed exercise intensity (N = 8). A simulated 40-K time trial was completed by all cyclists before and after the one-week tapering periods.

Going into the tapering period, the cyclists were fit, with an average VO_2max of 60.9 $ml \cdot kg^{-1} \cdot min^{-1}$. The seven-week training period leading up to the taper had been rugged for all of the cyclists, with the program featuring four 60-minute workouts per week at an intensity of 85 to 90 percent of maximal heart rate. The control group continued to train in this way during the tapering period, whereas the first experimental group kept up the 85-90 intensity but backed down to workouts lasting for 45, 35, 25, and then 20 minutes during the tapering week. The second experimental group preserved the 60-minute workouts but lowered intensity from 85 percent of max heart rate to 75 percent, 65 percent, and then 55 percent of max over the course of the four workouts. Members of both of these experimental groups rested completely for one day at the end of the tapering period before embarking on the 40-K time trials. For these tests, the cyclists used their own bicycles, mounted on wind-loaded cycling rollers fitted with a stabilizing bar attached to the handle bar for safety. The air pressure of the bicycle tires was checked before and after each ride and also before and after the taper to make certain that maximum pressure was maintained throughout.

Compared to before the beginning of the seven-day taper, the cyclists who preserved training intensity (while carving into volume by reducing workout duration to as little as 20 minutes) during the tapering period improved 40-K performance by an average of 170 seconds, a close-to-three-minute (4.3-percent) upgrade which was statistically significant. Meanwhile, the athletes who maintained their 60-minute sessions (their volume of training) while reducing their intensity of work failed to improve at all during the tapering period. As you might expect, control cyclists also did not get better (they were simply too fatigued and non-recovered to perform well).

Along similar lines, VO_2max climbed upward during the seven-day taper by 2.5 percent for the cyclists who preserved intensity - but stagnated among athletes who decreased intensity or who trained in the usual way. However, "power output at the ventilation threshold" (a surrogate for lactate-threshold speed) jumped significantly for both the intensity and volume preservers, from roughly 235 to 259 Watts. In addition, muscle-glycogen concentrations rose by around 25 percent in both groups.

The analysis of muscle-fiber types yielded some interesting results. Basically, average muscle-cell cross-sectional area advanced only in the Type-II (fast-twitch) fibers of the *intensity-preserving cyclists*, an indication that the fast-twitch cells of these preservers could contract more powerfully after the taper. There were some differences between the groups in terms of the fiber-related changes in enzyme levels, too. Specifically, the intensity preservers enjoyed increases in SDH activity in their slow-twitch fibers as a result of tapering; SDH *(aka* succinate dehydrogenase) is a key enzyme of aerobic metabolism. Meanwhile, the volume preservers couldn't knock SDH up a notch or two, but they did manage to increase both CYTOX and B-HOAD in their slow-twitch cells. This is rather interesting, because B-HOAD is an enzyme which is important for the metabolism of fats, which of course would be relied on to supply a fair amount of the energy required for the low-intensity workouts carried out by the volume-preservers during their taper week (during high-intensity workouts, fat would be a much-less important source of fuel). CYTOX is a key oxidative enzyme. Clearly, the different tapers had varying effects on the athletes' slow-twitch muscle fibers!

What happened with the fast-twitch fibers? Thought you would never ask: Among the intensity-preserving cyclists, activities of mATPase, CYTOX, B-HOAD, and SDH all swelled upward; mATPase is an enzyme which facilitates the mechanical contraction of muscle cells (you are already familiar with the other three). For the volume preservers, only poor-old B-HOAD increased its activity.

What should we make of this fiber analysis? Are the fiber differences related to the disparity in performance between the two groups of cyclists? There are various ways to look at this. One legitimate dissection would be simply to note that the intensity preservers boosted the activities of five important enzymes in their two muscle-fiber types during tapering, while the volume people increased just three. It makes sense that this contrast could lead to better performances in the intensity-loving cyclists.

Innovative Tapering Researcher Patrick Neary

But it gets better than that. When Neary and his Canadian colleagues took a look at which enzyme-level changes were highly correlated with improvements in 40-K time-trial time, they found that upswings in CYTOX and SDH activities *in both muscle-cell types* were neatly linked with performance upgrades; no other enzymes made the grade. This certainly makes sense when it comes to B-HOAD, which – although it is certainly a wonderful enzyme - plies its trade in the metabolism of fat. During an intense, 40-K time trial lasting for just over an hour, fat metabolism would be at a relative minimum, with carbohydrate carrying the day (especially since glycogen concentrations had soared by 25 percent prior to the post-taper trial), and thus having extra B-HOAD loitering in the muscle cells would be as helpful as having an extra pound or two of suet lingering in the athletes' loins. When we remove B-HOAD from the scoreboard, the enzyme advantage reads four to one, high-intensity taper over volume-maintenance cutback.

Only the high-intensity taper produced an advancement in the size of fast-twitch muscle cells, the ones which can contract most quickly during cycling.

If you are somewhat unconvinced by this, don't forget that the high-intensity taper was the only one which led to an increase in diameter of the fast-twitch muscle cells, a change which can by synonymous with advances in raw muscle power (and thus faster 40-K times).

So what does all of this tell us? Should you shape your taper to fit your unique muscle-fiber composition?

It's too early to say. If this Canadian study offers the final word on the subject, then one might argue that individuals with a predominance of slow-twitch fibers might do best with a volume-preserving (low-intensity) taper, since such an affair doubled the number of enzymes with upgraded activity profiles, compared with a high-intensity taper. However, the problem with this reasoning is that one of the volume-preservers' augmented enzymes (B-HOAD) had nothing whatsoever to do with enhanced performance, leaving the score knotted between the two techniques. The intensity cyclists had their SDH, and the volume athletes had their CYTOX; upticks in both enzymes were linked with better performances.

When it came to the fast-twitch fibers, the competition wasn't even fair. The intensity preservers boosted the activities of four enzymes in their fast-twitch cells, versus just two enzyme lift-offs for the volume preservers. If we focus on only the enzymes correlated with performance, the score was two to zip, intensity over volume. So, we might argue that high-intensity tapers would be best for athletes with a hefty number of fast-twitch fibers in their muscle cells, and that argument would certainly make sense, not only from the enzyme standpoint but also from the neural watchtower (one would want to practice the high-intensity movements required for competition during the tapering week to improve coordination of those movements; loafing along would be unlikely to touch up efficiency of motion at high speeds).

Don't forget, too, that although both the high-intensity and low-intensity (volume-maintenance) tapers improved ventilation threshold by similar degrees, only the high-intensity taper significantly improved VO_2max, and only the high-intensity taper refurbished performance. One can assume that the athletes in the two groups possessed an array of different muscle-fiber compositions, although muscle-make-up information was not provided by the researchers.

It is possible that there is *one type of competitive event* for which low-intensity, volume-maintaining tapers might be preferable. For example, if you are planning to participate in an all-day ultramarathon of some sort or even in a multi-day test of endurance which involves prolonged riding/running on each day, a low-intensity taper, with its apparently broader influence on B-HOAD activity, *might* be the way to go. During such competitions, it would be difficult to keep muscle-glycogen levels high, and the lowered intensity associated with the stretched-out exertions would increase the importance of fat oxidation, which is B-HOAD's specialty. However, it should be noted that reduced B-HOAD activity has never been shown to be a limiting factor in ultra-endurance competition, nor has spiked B-HOAD action been linked with upswings in ultra performance.

Overall, Neary's study suggested that keeping the intensity of exercise high while steadily reducing training volume could be an excellent tapering strategy. What clues does other research provide about how to put together an optimal taper?

Of course, one of the key debates about optimal tapering has centered on the question of whether tapers should contain "step reductions" in training or "exponential decays" in workload. In a step reduction, total training is reduced by a certain amount, and the new volume of training is sustained throughout the tapering period. In an exponential-decay situation, the quantity of training decreases steadily over the course of the taper (there is no step-down in volume but rather a continuous slide, usually quite steep at first, as was the case for Neary's intensity preservers), reaching bare-bones levels at the end of the tapering period. One popular step-down strategy is to clip training by 65 to 70 percent and then maintain the new, lower volume of work for one to three weeks or so. Traditionally, exponential decays have been linked with shorter durations of time, often four to eight days (Neary's athletes used a seven-day decay), although it is possible to extend the volume atrophy to longer periods.

Several years ago, outstanding tapering theorist Joe Houmard asked a group of endurance athletes to cut training volume by 70 percent for three weeks (a step reduction). At the end of the 21-day period, the athletes' performances were not significantly better, nor were the athletes able to display greater muscular power (5). In contrast, a seven-day exponential decay carried out by similar athletes in which training volume was reduced each day and overall weekly volume dropped by 85 percent produced dramatic improvements in race times and muscular power (6).

Houmard's research has led some exponential-decay paracletes to argue that when training volume is reduced progressively and aggressively to an extremely low level, performance is improved to a greater extent, compared with situations in which a single step reduction in training is enforced over a longer period of time. Some "anti-step" exercise scientists even argue that step reductions generally maintain performances but usually do not enhance them.

Such arguments are not correct: step-reduction tapering *has* been linked with some fairly impressive gains in physical capacity. In a classic study carried out by renowned exercise physiologist David Costill of Ball State University, collegiate swimmers reduced average training volume from 10,000 to 3,200 yards per day for a 15-day period (7). After this 15-day, step-reduction taper, the swimmers' performance times improved by 3.6 percent. Physiologically, the tapered swimmers had lower blood-lactate levels during fast swimming, a sign that lactate threshold-speed had improved, but it was not clear what had actually caused the upgrade in threshold.

Did the swimmers' muscles have more time (during the tapering period) to create more mitochondria (intramuscular sites of lactate breakdown) and MCT1s (carrier molecules which transport lactate into muscle cells), so that more lactate could be cleared from the blood and broken down for energy? Or had the swimmers somehow gotten stronger (even though they had carried out less training), perhaps because their muscles had more energy and substrate available for protein synthesis once training was reduced? Gains in functional strength usually improve lactate threshold, because as muscle cells get stronger fewer of them need to be activated to cycle (or run or swim) at a particular pace, which in turn leads to a lower lactate output (there are simply fewer cells pushing lactate through their membranes into the blood).

When constructed properly, tapering periods should produce dramatic improvements in muscular strength.

As it turned out, the swimmers' arm strength and power swelled by up to 25 percent during the tapering period, suggesting that gains in strength played a key role in advancing performance and lactate threshold. These results led Costill to recommend tapering periods of approximately two weeks in duration, with volume set at about one-third of usual levels (a 67-percent step reduction).

In subsequent research, Raymond Kenitzer and Catherine Jackson asked 15 female collegiate swimmers to pare training volume by about 60 percent over a four-week period (8). For the long-distance swimmers involved in this study, daily training volume dropped from 8000 to 3500 yards. During this step-reduction taper, blood-lactate levels fell steadily during exertion over a period of about two and one-half weeks, and performances increased progressively over the same time frame. After two and one-half weeks, however, lactate concentrations began to increase and performances worsened. Logically enough, Kenitzer and Jackson recommended a tapering strategy consisting of a 60-percent step reduction over 17 to 18 days.

So, it is clear that step-reduction tapers can do more than merely maintain performance capacities. However, the exponential cause was advanced dramatically shortly after the publication of the Kenitzer-Jackson work. Another scientist with a strong interest in tapering, Duncan MacDougall of McMaster University in Hamilton, Ontario (Canada), asked a group of well-conditioned runners who were averaging 45 to 50 miles of running per week to try out three different kinds of one-week tapers (9). The three strategies were:

(1) Doing nothing at all during the week (a 100-percent step reduction),

(2) Running about 18 miles during the week at a leisurely pace, with a complete-rest day at the end of the week (a 64-percent step reduction), and

(3) Undergoing a drastic, "exponential" decay in training over the course of the week, with an emphasis on quality running. Using this strategy, the runners completed five hard 500-meter intervals on the first day of decay, four 500-meter blasts on the second day, 3 X 500 on day three, just 2 X 500 on day four, and a single 500-meter surge on day five. After a rest on day six, they were ready to be tested on day seven (as were the employers of strategies one and two). Importantly, each 500-meter interval was performed at about one-mile race pace, and since the runners warmed up with 500 meters of inchmeal jogging before the high-quality intervals were undertaken, the total training volume for the week was about 10K, or just over six miles. Thus, this decay involved an overall 87- to 88-percent reduction in training volume (note that the decay in this case was actually linear rather than exponential). Cyclists wanting to utilize this tapering scheme before a 20-K time trial might carry out something like 5 X 1000, 4 X 1000, 3 X 1000, 2 X 1000, and 1 X 1000 meters on successive days during a taper week, with a rest day intervening between the 1 X 1000 and the trial.

Tapers during which the volume of training decays rapidly over the course of the tapering period seem to have a strongly positive impact on performance.

For MacDougall's athletes, the performance test on day seven involved running as far as possible at one-mile race pace, the tempo which was so well-rehearsed by the exponential-decay runners. The 64-percent-step-reduction runners (who covered 18 soft miles during the week) actually performed pretty well, advancing endurance time at one-mile speed by 6 percent. The 100-percent step reductionists, who did no training at all during the week, failed to improve one-mile-race-pace endurance at all (notably, they didn't get worse, either).

In contrast, the "exponential" runners blew the roof off MacDougall's lab, raising endurance time at one-mile pace by a full 22 percent! The expo athletes also possessed enhanced leg-muscle enzyme activity, augmented total blood volume, increased red-blood-cell density, and greater muscle-glycogen storage, compared to the step-reducing runners of both types.

What was behind this surfeit of positive changes? The greater glycogen storage was no doubt at least partially a result of the lower volume of training carried out by the decaying athletes, compared to the step-reduction runners (six vs. 18 miles). To put it simply, more ingested carbohydrate could be funneled into storage, instead of being used to provide the energy for exercise.

On the other hand, the simultaneous occurrence of heightened red-blood-cell density *and* expanded blood plasma (as a result of the steep-decay taper) may seem a bit contradictory. Usually, red-cell concentrations increase when blood plasma decreases and decrease as plasma advances; the two do not usually march upward together. These congruent phenomena suggest that the steep-decay tapering produced a "kidney effect" on performance. It is possible that when training is cut drastically down to an intense, fiery core the kidneys produce more EPO (yes, this is a natural compound produced by the kidneys, in addition to being an ergogenic substance which, when introduced into the body via needle, can get one banished from competition by the governing bodies of cycling) to spike red-cell density and to exhort hormones which help retain blood plasma to swing into action. The kidneys play a very strong role in regulating blood plasma.

Other studies definitely indicate that plasma upswings tend to be more associated with high-intensity training rather than easy work, which is probably why the steep-decay athletes fared better with their plasma than the slowpoking 18-mile per week individuals. Possessing perfect plasma can potentially push performance up by giving the blood a chance to satisfy the twin demands made on it during strenuous exercise – greater flow to the skin to promote cooling and enhanced movement to the muscles to provide more oxygen and energy. Thus, the Canadian research teaches us that training volume should drop down drastically (and intensity should go up) so that blood volume can climb.

MacDougall's results certainly made decay tapering look better than step-reduction plans, but a few comments are in order here. First, note that MacDougall's decaying runners employed a relatively high quantity of quality work during their taper – about 7.5 kilometers out of a total training volume of 10K (75 percent). It is quite possible that the 64-percent step-reduction athletes would have performed much better (and perhaps as well as the decay folks) if they had been able to include quality work in their training as well.

In addition, the decay athletes trained during their taper week at exactly the pace which was utilized for testing. Thus, their tapering period was highly "neural," i. e., it "tuned up" their nervous systems and prepared their neuromuscular set-ups for the exact intensities and patterns of coordination and overall movement which would be used in the test. As you can see, MacDougall's work did not really compare step-reduction tapering with decay cutbacks but instead merely contrasted two widely disparate tapering stratagems (a true comparison between decay and step-reduction would have placed equal amounts of intense work within the two plans over the course of the tapering week, for example).

Research carried out by Joe Houmard supported the use of the "MacDougall Tapering Plan."

Nonetheless, MacDougall's unique plan for training decay within a one-week taper looked mighty good, and further work by Joe Houmard and his colleagues added weight to the idea that tapering should proceed along a "steep-slide" course. Inspired by MacDougall (Houmard had personally used MacDougall's taper to prepare very successfully for a marathon), Houmard asked eight experienced runners (six males and two females) who had been running about 43 miles per week to abbreviate their running to 6.2 miles of interval training and seven miles of jogging over the course of a week. Almost all of the interval training consisted of high-intensity, 400-meter intervals at about 5-K race pace or slightly faster.

The taper designed by Houmard for his runners bore a strong resemblance to MacDougall's. On the first day of the taper, Houmard's athletes completed eight 400-meter intervals, on the second day they clipped off 5 X 400, on day three they hit 4 X 400, and on day four they tried 3 X 400, followed by 2 X 400 on days five and six and 1 X 400 on day seven. During these workouts, recovery intervals (composed of walking or resting) lasted just long enough to let heart rates drop to 100 to 110 beats per minute, and an 800-meter easy jog was performed both as a pre-workout warm-up and a post-training-session cool-down (these jogs accounted for the seven miles of jogging for the week). A control group of eight runners maintained their usual training volume of 43 miles per week.

All eight of Houmard's runners were able to improve 5-K race performances following the use of the steep-slide-decay tapering plan.

When a 5-K race was held on the eighth day of the study (the day immediately following the one-week taper), Houmard's slide-decay runners trimmed average 5-K time by a statistically significant 29 seconds, from 17:16 to 16:47; remarkably, all eight runners were able to improve their performances. The decayed runners also improved running economy by a rather dramatic 6 percent, while the control runners improved neither economy nor 5-K time.

While the MacDougall-Houmard investigation combo certainly suggests that a one-week, steep-slide taper which contains a heavy bias toward quality training leads to outstanding improvements in physiological variables and performance, further disputations about tapering are inevitable. For one thing, many cyclists and runners have tried tapers similar to those recommended by MacDougall and Houmard and have ended up with very sore legs on race day (because of the demanding, back-to-back-to-back…..quality work), as well as sub-par performances. Some athletes seem to handle the daily regimen of quality work very poorly (this is a good reason why athletes who intend to utilize the MacDougall-Houmard plan should try it out at least once during the course of the training year, instead of waiting until the week before the biggest competition of the season to carry it out for the very first time).

In addition, even if one accepts the idea that steep-slide-decay tapers are best, questions remain about *how long* such tapers should really last. Is one week really the best taper duration? It seems reasonable to think that in cases in which training has been extraordinarily heavy it would be nearly impossible to recover adequately in a one-week time frame, especially if daily or nearly daily nuggets of quality work were present. As the demands of training increase, the length of the tapering period must also advance.

Here are the bottom lines:

(1) Tapering can lead to incredibly large improvements in performance. If you are not tapering properly before your major competitions, it is unlikely that you are performing at your true potential.

(2) Tapering does produce unique physiological changes at the level of the muscle fiber, and these alterations appear to be different between fast- and slow-twitch muscle cells. From what we know so far, it seems that high-intensity tapers produce a superior array of positive changes in fast-twitch fibers, compared with low-intensity, volume-maintaining tapers. These alterations include increased size and heightened enzyme activities in the fast-twitch cells.

(3) Taper periods should be highly neural. Much of the quality work carried out within the taper should mimic the intensity which will be utilized during the impending competitions. This should improve efficiency and confidence at race pace and expand the ability to sustain the desired velocity for the entire duration of the competition.

(4) We do not know whether decay tapers are inherently better than step-reduction tapers, or vice-versa. It is likely, however, that decay tapers work in a superior way when tapering periods become significantly elongated. During a four-week taper before a long-distance cycling competition, for example (such lengthy tapers might be required due to the heavy nature of the preceding training), a cyclist might profit by reducing training volume by 30 percent, 25 percent, 20 percent, and 15 percent,

respectively, over the course of the four weeks. Bear in mind that research carried out with swimmers suggests that a 60-percent *step reduction* helps performances for no longer than two and one-half weeks. When tapering periods are extended for more than 17 days, a decay taper might give a cyclist a better chance of holding on to (and expanding) the physiological adaptations achieved during the training year. Note, though, that no one has ever looked carefully at what a small step reduction in training (say, 20 percent) might do to performance when continued for a four-week period.

Each taper that you carry out requires a solid "core" of intense work, without which the taper can not elicit maximal gains in performance.

(5) While the optimal balance of quality and easy training during a tapering period is unknown (and probably depends on the prior training and actual race distance), it is clear that a solid core of high-quality work should be carried out during the taper. The inclusion of intense effort seems to magnify the physiological gains made while tapering, more than offsetting the potentially reduced recoveries associated with high-quality training. Remember, too, that Neary's careful scrutiny of fiber-related changes associated with reduced training suggests that any fast-twitch fibers hanging out in your leg muscles will be significantly upgraded (in terms of size, power, and enzyme levels) by high-quality tapering. It is logical to assume that you do not have to train at a high intensity *every day* during your taper, however, even though that is what the MacDougall-Houmard athletes did. Every-other-day quality training, not overly prolonged in nature (the kind of session which leaves you fresh the following morning, rather than exhausted), would probably provide enough intensity to optimize your enzymes and competitive energy.

(6) Don't forget that the optimal length of a taper depends a lot on the training which has been carried out leading up to a competition. If you find yourself – in the weeks leading up to a major competition – significantly fatigued and experiencing troubles carrying out your high-quality workouts, that's a good sign that you need an extended taper, something longer than just a week. On the other hand, if you are recovering extremely well from the training you are doing and you are raging through your high-effort sessions without much trouble, you will probably benefit most from a taper which lasts about seven to 10 days. It is hard to provide hard-and-fast rules linking training volume with tapering-period length, especially since there is such variation between cyclists in the response to a specific volume of training (some thrive on 300-K weeks, for example, while others wilt). Rather, it is best to study the way you individually respond to reduced-training periods in order to get a feeling for what you really need. Note that it is always possible to carry out a one- or even two-week tapering period during your training year (even when there is no major competition looming) to see what happens to your performances; you could carry out a vVO_2max test (riding as far as possible in six minutes) or a 20-K time trial after your test taper and compare it with previous self-exams to determine your response to the taper you have created. ©

References

(1) "The Effects of Reduced Exercise Duration Taper Programme on Performance and Muscle Enzymes of Endurance Cyclists," *European Journal of Applied Physiology*, Vol. 65, pp. 30-36, 1992

(2) "Physiological Effects of Tapering in Highly Trained Athletes," *Journal of Applied Physiology*, Vol. 72, pp. 706-711, 1992

(3) "Effect of Swim Taper on Whole Muscle and Single Muscle Fiber Contractile Properties," *Medicine & Science in Sports & Exercise*, Vol. 33, pp. 48-56, 2001

(4) "Effects of Taper on Endurance Cycling Capacity and Single Muscle Fiber Properties," *Medicine & Science in Sports & Exercise*, Vol. 35(11), pp. 1875-1881, 2003

(5) "Testosterone, Cortisol, and Creatine Kinase Levels in Male Distance Runners during Reduced Training," *International Journal of Sports Medicine*, Vol. 11, pp. 41-45, 1990

(6) "The Effects of Taper on Performance in Distance Runners," *Medicine and Science in Sports and Exercise*,

Vol. 26, pp. 624-631, 1994

(7) "Effects of Reduced Training on Muscular Power in Swimmers," *Physician and Sportsmedicine,* Vol. 13, pp. 94-100, 1985

(8) "Blood Lactate Concentration in Female Competitive Collegiate Swimmers during End Season Taper," *Medicine and Science in Sports and Exercise,* Vol. 21(2), p. S23, 1989

(9) "Physiologic Effects of Tapering in Highly Trained Athletes," *Medicine and Science in Sports and Exercise,* Vol. 22(2), Supplement, #801, 1990

Herbal Supplements for Cyclists continued:

active component is in its mycelium, the collection of threadlike structures which penetrate its "host" and draw out nutrients (since most fungi can not engage in photosynthesis, they must act as parasites on other living things to obtain energy). For *Cordyceps sinensis,* the hosts happen to be moth larvae, and the *C.-sinensis* mycelium which cob-webs its way through the unsuspecting moth babies produces a unique chemical called CS-4 which has been the focus of a fair amount of scientific investigating.

One study utilized PNMR spectroscopy to learn that the administration of CS-4 swelled the concentration of ATP (a high-energy compound which cells use to fuel their activities) in the *liver cells* of mice by 18 percent (2). Unfortunately, this research did not measure ATP levels in muscle cells; spikes in muscular ATP might indeed be conducive to higher athletic performance, especially in short-term, high-intensity events. A separate investigation found that CS-4 significantly reduced the risk of death and the rate of oxygen consumption in mice exposed to low-oxygen conditions (3). Yet another exploration suggested – somewhat paradoxically - that *Cordyceps-sinensis* supplementation could augment maximal aerobic capacity (VO_2max) in elderly humans by about 5 percent (4). Maybe those mycelium-muddled moth infants are lucky after all!

None of this scientific research would suggest that *Cordyceps sinensis* is specifically good for athletes, but the "rumor mill" which prevails in the athletic community has intimated that Olympic teams from several different countries have employed *Cordyceps sinensis* as an "adaptogen" (a compound which helps athletes maintain good health and enhances the adaptive response to training) over the last 12 years or so. *Cordyceps sinensis* first took root in the minds of athletes in the early 1990s, when Chinese athletes such as Yunxia Qu, Junxia Wang, and Bo Jian began setting incredible world records while supplementing their diets with the ancient herb. Qu's 3:50.46 for 1500 meters, Wang's 8:06.11 for 3000, and Jian's not-shabby 14:28.09 for 5K, all completed in 1993, still stand as world records nearly 11 years later. Note that it is not clear why subsequent Chinese runners, who presumably have also supplemented their diets with *Cordyceps sinensis,* have been unable to establish new world marks.

Rhodolia rosea also has a very interesting history. It has a general reputation for stimulating the nervous system, decreasing depression, boosting work performance, cutting fatigue, and minimizing high-altitude sickness (5). Like *Cordyceps sinensis, Rhodolia rosea* has been called an adaptogen; some fans of the herb believe it can increase resistance to an array of biological, chemical, and physical stressors (by means of protection of cardiovascular function and enhancement of nervous-system functioning). That's not all: Various reports link *Rhodolia rosea* supplementation with the alleviation of sleep problems, poor appetites, irritability, headaches, fatigue, and the inability to perform vigorous work. Supposedly, *Rhodolia rosea* can act directly on the nervous system, influencing the concentrations of key neurotransmitters such as the beta-endorphins. Reading some of these claims can make one suspect that *Rhodolia rosea* is a kind of wonder drug, but it is important to bear in mind that very few of these asseverations are backed up by solid, well-controlled, randomized scientific research. In fact, most references to *Rhodiola rosea* show up in journals as conference abstracts (which have not undergone the full peer-review process) or else as reviews which cite articles which may not contain world-beating methodologies.

In fact, a careful combing of the Western scientific literature unearths just one full-fledged study which connects *Rhodiola* with a benefit to human subjects – an investigation carried out with professional Chinese athletes with linked 75 days of supplementation with heightened VO_2max (6). In this study, a "cousin" of *Rhodiola rosea* – *Rhodiola crenulata* – was actually utilized as the supplement.

To find out whether *Cordyceps-Rhodiola* supplementation could really be beneficial to athletes, researchers at the Cooper Institute Center for Human Performance and Nutrition Research in Dallas, Louisiana Tech University, Baylor University, and the European University of Madrid recently divided 17 male competitive cyclists into two groups; nine of the athletes embarked on a 14-day supplementation program with the two substances, while the other eight subjects served as controls (7). The athletes were about 31 years old; their mean maximal aerobic capacity was approximately 54 $ml \cdot kg^{-1} \cdot min^{-1}$.

Before and after the 14-day supplementation period, all athletes took part in a cycling test which began with a 10-minute warm-up at an intensity of just 50 Watts and then progressed to 75 Watts for two minutes. The power output was then increased to 100 Watts, and the intensity increased by 25 Watts every four minutes until a subject could no longer continue working at the progressed intensity. Each rider was allowed to choose his preferred cadence within the range of 70 to 90 rpm.

The supplement chosen for the study was a commercially available one – Optygen™, a product sold by First Endurance of Salt Lake City, Utah (visit them on the web at http://www.firstendurance.com). The supplementing athletes consumed their Optygen™ according to the manufacturer's recommendations, ingesting their supplements in two phases: A loading phase (six capsules per day for four days), followed by a maintenance phase (three caps a day for 11 days). The placebo capsules looked exactly like the Optygen™ pellets but contained only inert methycellulose. Each three capsules of the Optygen™ product were said to contain 1000 mg of CS-4 from *Cordyceps sinensis*, 300 mg of *Rhodiola rosea* root, and 200 mcg of chromium. The supplement also packed a blend of 800 mg of combined calcium pyruvate, sodium phosphate, potassium phosphate, ribose, and adenosine (the exact weight of each component was not know by the researchers – nor provided by the manufacturer).

The researchers uncovered little evidence to support the idea that Optygen supplementation improved performance variables—or performance.

As it turned out, the supplementation with *Cordyceps sinensis* and *Rhodiola rosea* (along with the "proprietary blend" of other substances) had no effect at all on performance; there was no difference in peak oxygen-consumption rate, maximal power output, or time to exhaustion between the two groups. Peak heart rate was also similar between the groups, and power outputs at lactate threshold and ventilatory threshold were equivalent.

Although supplementation with *Rhodiola rosea* is alleged to enhance the oxygen-carrying capacity of the cardiovascular system, another recent trial found that seven days of *Rhodiola-rosea* supplementation (447 mg per day) had no effect on the saturation of red-blood-cell hemoglobin with oxygen during 60 minutes of acute exposure to low-oxygen conditions (13.5 percent oxygen) (8).

The "proprietary blend" included with the two herbal preparations in the Optygen™ contained some interesting compounds, including pyruvate, sodium phosphate, and potassium phosphate, which have been linked with improved athletic performance or at least indices of upgraded athletic performance – such as maximal leg power and oxygen consumption. However, note that the "blend" of various ingredients added up to a dose of no more than .8 grams per day, whereas the possibly ergogenic dose of pyruvate is believed to be in the area of 30 grams per day and the possibly helpful intake of phosphates would have to be around four grams per day or more. In other words, while the blend contains some intriguing ingredients, it probably does not possess enough of these ingredients to make a difference to oxygen utilization or performance.

Would a longer supplementation period with *Cordyceps sinensis* and *Rhodiola rosea* make a difference? That is possible (remember that this Cooper-Baylor-LaTech-European-University-of-Madrid study went on for just 14 days). However, we won't hold our breath while waiting for such research to appear, and if we do we won't rely on either of these herbal choices to help us survive the resulting hypoxia. ©

References

(1) "The Scientific Rediscovery of an Ancient Chinese Herbal Medicine: *Cordyceps sinensis:* Part I, *Journal of Alternative and Complementary Medicine,* Vol. 4, pp. 289-303, 1998

(2) "CordyMax Cs-4 Improves Steady-State Bioenergy Status in Mouse Liver," *Journal of Alternative and Complementary Medicine,* Vol. 7, pp. 231-240, 2001

(3) "Cardiovascular Pharmacological Studies of Ethanol Extracts of *Cordyceps* Mycelia and *Cordyceps* fermentation Solution," *Chinese Traditional and Herbal Drugs,* Vol. 17, pp. 209-213, 1986

(4) "Increased Aerobic Capacity in Healthy Elderly Humans Given a Fermentation Product of *Cordyceps* Cs-4," *Medicine & Science in Sports & Exercise,* Vol. 31:S174, 1999

(5) "Selected Herbals and Human Exercise Performance," *American Journal of Clinical Nutrition,* Vol. 72, pp. 624S-636S, 2000

(6) "Protective Effects of *Rhodolia crenulata* on Rats under Antiorthostatic Position and Professional Athletes," *Space Medicine and Medical Engineering,* Vol. 6, pp. 6-11, 1993

(7) "Effects of a Commercial Herbal-Based Formula on Exercise Performance in Cyclists," *Medicine & Science in Sports & Exercise,* Vol. 36(3), pp. 504-509, 2004

(8) "The Effects of Reduced Atmospheric Oxygen and Dietary Supplements on Blood Oxygenation." In: Sixth IOC Congress on Sports, p. 15, 2001

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