Bicycle Medicine & Science 2000

The true method of knowledge is experiment.
William Blake, 1788

What's New This Past Year

What's the latest medical and scientific info about bicycling?

Do you read the ad copy in the magazines to figure out what might be worth trying? Do you look to the pro athletes, who are sponsored, and figure that if they do it or use it, it must be great? Do you rely on coaches, some of whom receive kickbacks if you buy on their recommendation? Do you ask your friends? Or do you just spend your time, effort, or money and try everything yourself?

For most of us, it's a combination of all of the above, plus a little hope. And, unfortunately, that little hope is what lots of companies cash in on when they manage, for example, to sell us plain old water at a couple of bucks a gallon or more.

Scientific method: There's another way—the scientific way. Looking at what studies or experiments really show. The scientific way is the best way to evaluate what works and what doesn't. The scientific way is better than opinion or guessing, but it's not foolproof. Good sport science studies are hard to come by. Worse, unfortunately, there is sometimes bad science.

A complete review of what makes good science isn't possible in this article, but here are a few examples of "science" problems.

(For a more complete review of the subject read: Ergogenic Quackery: Maxxta Makes You Fasta, in Bicycling Medicine, published by Simon & Schuster, 1998.)

Initially, only studies showing an effect tend to be published: Few publications are interested in reporting, for example, that Vitamin X doesn't cure cancer. Once something has been accepted as working, then it's fair game for challenge. So it's common for some substance or training method to burst on the scene for a few years, and then have its bubble burst—by being shown not to work or having undesirable side effects. Androstenediol, androstenedione, bee pollen, chromium, medium chain triglycerides, nasal dilators, and royal jelly are now out of favor.

An interested party pays for some studies. Last year, for example, peanuts were reported to help ballet dancers' performance (presumably by increasing their deficient caloric intake) in a study paid for by a consulting company. A company I'd guess was representing a peanut company. Peanuts may well help calorically deficient ballet dancers, but so might Häagen-Dazs ice-cream or Pop-Tarts.

Worse, imagine a company that pays for ten studies from ten different sets of researchers and advertises only the findings, perhaps obtained by chance, that promote the company's products.

Some studies appear to provide important or new information but the wrong question is being asked or answered. The recovery drink R4 was shown to provide better recovery than Gatorade when 24 ounces of either was consumed between taxing exercise bouts. Sounds promising, doesn't it? But the R4 provided almost four times as many calories. Would a couple of donuts with the Gatorade have been as good?

A problem with sport science, unlike general medicine, is that studies tend to use small groups—less than 20 subjects. Small groups require relatively large differences to find statistical significance.

Studies often initially appear as abstracts. These present preliminary data, are less subject to peer or other review, may be withdrawn, and are often cited in promotions by sponsoring commercial companies.

Keep in mind that it's common for studies to show apparently conflicting results. For example, over the years bicarbonate loading and caffeine have been accepted as improving human performance. Newer studies have questioned that conventional wisdom.

Each study often adds just a little piece to the puzzle. It's important not to put too much faith in any one study.

I've written similar articles for the past six years. I've culled over 2,000 reports and studies during the last year. Here's my synopsis and spin on some of the published information on bicycling-related medicine and science that came out in 2000.

Each new paragraph represents a different study.

Nutrition

Calories

General nutrient mix: It is commonly accepted that most aerobic endurance athletes should consume a diet relatively high in carbohydrates—65-70% of total caloric intake.

Many find this approach simplistic, and say what is more important is that enough carb calories should be ingested to replace those lost through exercise. This often amounts to the same thing, but reflects an approach to the reasoning underlying the simplification. For example, it's not that an athlete consuming 3,000 calories per day needs 65% of calories from carbs, it's that 2,000 carb calories are needed to replace those lost during exercise.

Increasing calories from 57% carbs to 68% or 88% carbs was shown to result in more muscle glycogen after repeated bouts of exercise, in proportion to the amount of carbs ingested. However the 88% carb diet led to decreased muscle triglyceride concentrations.

One week of carbs 6gm/kg/d vs.4 mg/kg/d made no difference in blood lactates during a graded exercise test.

As might be expected, 40-30-30 (carb/protein/fat) products were shown to have a lower glycemic index than high-carb energy products.

Pre-event nutrition: Subjects who consumed a carb-plus-protein drink before exercise were more likely to experience low blood sugar during exercise than subjects who drank a carb drink alone. Carb solutions, gels, and bars all improved performance about equally when each was compared with placebo.

During-event nutrition: In previous research, it's been shown that about 25% of carbohydrate needs can come from glucose ingested during exercise. This translates to roughly 1 gm/kg/h.

A study found no difference between formulations of maltodextrins in liquid vs. gel form.

Some have speculated that delaying feedings until 90 minutes after the start of a 3-hour exercise bout might improve performance by preventing an insulin-mediated inhibition of fat oxidation. "No!" said a study that examined performance in a 3.5-hour cycling event.

A study found that carb ingestion during resistance (weight) training spared glycogen.

Post-event nutrition: Carbohydrate-protein supplements continue to be promoted for muscle glycogen recovery after exercise. Another study this year demonstrated that such supplements do a better job than simple carb solutions. Once again, this manufacturer-supported research tells a half-truth. Although 12 ounces of *R4* does do a better job than *Gatorade*, the R4 contained 270 calories, the Gatorade product only 80 calories. If 12 ounces of either product is all an athlete consumes, R4 is better. But if the athlete adds a sandwich, muffin, cookie, donut, or ice cream to Gatorade, the conclusion might be different: Previous studies have shown that it's not the protein or protein-carb ratio in recovery drinks that is important—it's (first) the total calories ingested and then (second) the percentage of calories supplied by carbohydrates. Another study this year again confirmed that muscle glycogen is not improved by eucaloric (same total calorie) carb-protein feedings compared with carb alone.

There is some evidence that post-exercise mood may be better with whole food or mixed-source caloric drinks (carbs, protein, and fat) than with carb-only fluids.

Hydration

Solutions with higher than 6% carbohydrates may delay stomach emptying. Weaker solutions don't improve it.

Carbs and electrolytes in solution improve exercise-induced dehydration.

Beer worsens it.

Does concentrated urine mean that one is not well hydrated? That's the common view. In fact, NCAA wrestlers cannot have their body composition measured for the wrestling season if specific gravity is >1.020. But a study following well-hydrated volunteers found urine specific gravity was often more concentrated than that level.

Hyperhydrate with glycerol products? Maybe. Studies have shown that glycerol can help reduce sweat rates and improve hydration. But adding common salt to the diet may do the same.

The manufacturer of Revenge claims it may improve performance by decreasing blood viscosity. Not so in a study that examined ingestion of 20 ounces of the product.

By the way, companies promote their products to many different markets. Cycling-centric readers take a wider view: A study this year sponsored by Gatorade found that dehydrated bowlers had the same ball speed but less accuracy than their Gatorade hydrated partners.

Vitamins and Minerals

Vitamin C: Did not have an effect on cardiovascular endurance.

Iron: Please read more about iron in "Physiology—Blood," below.

Zinc: Physically active vegetarian women did not show lower blood levels of zinc than non-vegetarian women.

Antioxidants: These have again been shown in some studies to improve some measures of immune function. Whether this translates to a health or performance benefit is a leap.

Ergogenics

Performance-enhancing substances and devices.

Should these be banned? Should one be allowed to take something to make one stronger or go faster? It's not a black and white issue, and not a question that I'll discuss here. But many researchers are looking at these substances.

Supplements are used by over 90% of athletes in some sports. Intakes are higher in men than in women. In high school and college, progressively more athletes use supplements as academic class (freshman through senior) advances. The most popular supplements are vitamins and minerals, creatine, and protein powders.

Many studies of athletes have shown that they have important deficiencies in knowledge about supplements. In the case of vitamins and minerals, intakes over 10 times the RDA are common. (As I point out in my book *Bicycling Medicine*, studies have shown that such excessive RDA intakes are more likely to hurt, rather than help, performance.)

Supplements, unlike drugs, do not have to be proven to be safe and effective before they are marketed. There are no governmental regulatory processes unless a substance is shown to be dangerous. The FDA issued warnings over the last few years about a number of supplements, marketed as sleep aids, aphrodisiacs, and muscle builders that have caused at lease three deaths and hundreds of severe reactions. Some of the brand names include Revitalize Plus, Serenity, Enliven, GHRE, SomatoPro, NRG3, Thunder Nectar, and Weight Belt Cleaner. The diet-pill company Metabolife was sued for its (legal, unregulated) use of ephedrine in its products—a substance linked to seizures, brain damage, stroke, and as many as 17 deaths.

A study this year found that in one high school about 20% of male and 1% of female athletes used performance enhancing substances. When asked whether they would take such substances if they would guarantee a college scholarship but take 20 years off of their lives, 6% said "yes."

Aspirin: 650 mg one hour before exercise improved blood flow velocity.

Androstenediol, Androstenedione: Bad news for those using these supplements in an attempt to improve anabolic effect or testosterone levels.

Studies trying to find an anaerobic, strength training, or body composition (fat) benefit in men failed to do so.

After a few months of use, studies found no significant increase in testosterone levels ("anabolic" or "male" hormone levels) but a significant conversion to estrogen ("female") hormones. Further, these "andros" may have an adverse effect on blood lipids including cholesterol.

Andro products also commonly contain trace contaminants that may result in urine test results positive for nandrolone.

Beta-hydroxy-beta-methybutyrate (HMB): No help in strength training. Decreased percent body fat in football players in a study funded by the manufacturer.

Branched chain amino acids: Did not improve muscle strength or muscle size in older men.

Did not improve static muscular endurance in mountaineers.

Bovine Colostrum: That's the first milk of cows beginning lactation. Increases some immune markers in blood. Whether this translates to improved human performance or health may be a great leap for scientists—though not for marketing executives.

Caffeine: Caffeine's generally accepted ergogenic effect is thought to be, at least partially, central (brain) in origin. Supporting this view, a study showed caffeine reduced the sensation of force (perceived exertion) produced.

Coffee drinking athletes often stay away from caffeine for days before competition, hoping for an improved ergogenic effect with ingestion at the time of competition. A study of the length of time needed to produce an ergogenic effect in a habitual coffee drinkers found 12 hours as effective as 4 days.

Caffeine improved 2000-meter rowing performance in men and in women.

Caffeine increased fat utilization and reduced perceived exertion in a step aerobics study.

L-Carnitine: Did not improve lactate/pyruvate ratios or improve sprint performance in elite male cyclists.

Creatine: For the last few years creatine has been one of the hottest ergogenic aids. Over the years, the consensus has been that it will not help aerobic performance activities such as most cycling events. It may or may not work for sports with repeated anaerobic efforts such as track cycling, hockey, or football. It may be helpful for resistance (weight) training. This year a meta-analysis (statistical summary review) of creatine and anaerobic performance concluded that creatine supplementation does not improved anaerobic performance.

The current consensus is that if taken, creatine should be ingested along with glucose. Some studies seem to indicate that carbohydrate supplementation alone may increase performance as much as creatine.

Creatine is not without potential side effects:

- Creatine may be a problem in the heat—it may be related to cramping and injury. Some studies show this, others don't.
- It may increase blood pressure.
- It may increase compartment pressure.
- Creatine seems to increase body weight—probably not good for climbers.

Some studies have also suggested that coaches, sport scientists, and physicians should discourage use creatine because it is associated with more potentially dangerous ergogenics (i.e. "may lead to harder stuff"),

Studies this year also showed that creatine:

- Did not increase core body temperature in 16 volunteers marching in the military.
- Was used by 8% of high school athletes (both males and females). More than one half of these athletes didn't know the dose they were taking, and 20% attributed side effects to the supplement.
- Was associated with high blood pressure.
- Was not associated with kidney or liver damage in two studies.
- Was not associated with cramping in four studies. The longest follow-up was one year.
- Was not associated with changes in total body fluids.
- Was not associated with injuries or biochemical changes in athletes monitored one year.
- Did not reduce delayed onset muscle soreness.
- Was associated with gastrointestinal distress and muscle cramping.
- Helped gain muscle in younger, but not older men.
- Did not help rowers
- Two studies suggested that creatine helps older men achieve stretch and power gains.
- A follow-up study of strength gains attributed to creatine use found that creatine cessation was not associated with strength loss.
- Did not improve sprint performance at the end of a simulated cycling endurance exercise.
- Increased fat, but not muscle mass, in army rangers.

Cycling summary: Creatine may or may not help track sprinters. It probably won't help anybody else.

Ephedrine: Improved running times in a study of 10K times. Note: Ephedrine has been associated with serious side effects, including death.

Ginseng: Studies I have reviewed over the past few years have not shown any ergogenic benefit of ginseng or Siberian ginseng. Another study this year similarly found no benefit on metabolic and performance variables.

Pyruvate: No improvement in muscle strength or treadmill time to exhaustion.

Ribose: In a manufacturer-supported study, sprint performance was occasionally improved. (And more than occasionally, not.)

Tribulus: No change in biochemical markers of liver function. No effect on testosterone or LH in one study.

No change in testosterone, but a change in cortisol levels in another.

No change in average power or VO2, though time to completion of a 12.5 km time trial was improved in one study.

Equipment

Sport bras are not created equal. A study showed significant differences in terms of comfort, support, displacement, and psychological fit. Encapsulated designs work better than compression or combination designs. This report, from a poster session, did not mention whether a particular manufacturer funded the study.

Bicycle position change results in different muscle recruitment. This was documented in a study that showed the primary muscles used on *recumbent* bicycles to be gluteus maximus, biceps femoris, and soleus; and the primary muscles used on *supine* bicycles to be rectus femoris, adductor longus, and gastrocnemius.

Subjects who self-selected workout intensity didn't work at as high intensity on *semi-recumbent* bicycle ergometers as they did on upright ones.

Cyclists riding in a supine position worked at lower heart rates than those semi-recumbent. Their mood at the start of exercise was lower, but was higher at the completion of 30 minutes of cycling.

Hand-cycle racing has become increasingly popular due to its increased efficiency and performance over traditional wheel-chair racing.

Bicycle light generators increase the oxygen metabolic cost of riding almost 10%.

Those *Breathe-Right* nasal dilator strips are still being studied several years after almost all studies have discounted any benefit for athletes. Yet another study this year found no impact on performance.

Climate

How do we acclimatize to the heat? A study this year showed that with exposures over five days, there is progressively more blood flow to the skin.

Are there gender differences in sweat rates? A study showed that women sweat less than men do when exercise intensity is at the same percentage of VO2 max.

Those with a smaller body mass were shown to have a thermal advantage compared with heavier runners.

A study suggested that sweating in hairy areas was increased in the evening compared with the morning.

Does heat help clear blood lactate? Is lactate cleared through the sweat glands? Not in a group examined this year.

Precooling with water immersion (17°C, 67°F) for 30 minutes lowered sweat loss during 60 minutes of exercise.

A study of runners found that increased humidity in the air, independent of temperature, increased running times.

A study of runners showed regardless of temperature, fluid replacement falls behind sweat losses—though the deficit is larger when it’s hotter.

Physiology—General

A cycling study again showed that blood lactates while time trialing are between 5 and 12 mmol/L, well above the so-called anaerobic threshold.

A rowing study also confirmed this: 30-minute blood lactates were significantly higher than all “lab” thresholds commonly accepted.

In another study, 40K maximum lactate steady state levels were found to average 6.9 mM/l. .

Keep riding and cool down if you are planning to race a second crit: blood lactate was cleared more rapidly by 20 minutes of low-intensity riding than by complete rest, or partial rest/recovery.

In conflict with the preceding, another study found that active recovery between 30-second anaerobic efforts did not promote the greater disappearance of blood lactate than did passive recovery.

Neither did cold-water immersion.

A large study (almost 7,500 people) showed that although resting blood lactate tends to remain constant with advancing age, maximum levels tend to peak at age 20-25 and then decline. Power-trained individuals tended to show less loss with age when compared with sedentary individuals.

Cyclists in a 12-hour endurance mountain bike event averaged 70% of maximum heart rate.

Physiology—Testing

It has been know for some time that testing is sport specific. A study this year reconfirmed that VO2 max and anaerobic threshold values for cycling are about 10% lower than those obtained for running.

A study this year validated a formula for predictingVO2max from maximum ramped cycling power.

VO2 max can be predicted from maximum power output during various ramping protocols. Of three protocols tested in one study—5 watts every 20 seconds; 15 watts every minute; and 5 watts every 20 seconds until a set value, and then 6 minutes at constant load—the 5 watts per 20 second protocol proved best, and the constant load protocol the worst.

Another study suggested that ramping cadence provides another method of predicting VO2 max.

Testing power output in the lab predicts power output, but not finishing times, in time trials. Aerodynamics and frontal surface area affect the times.

In case you were wondering, a study looked at max power production over 30 seconds produced by forward as well as by backward pedaling. Forward direction produced 25% to 30% more power.

Physiology—Muscle

Percent slow-twitch muscles, ramped power output, and aerobic (but not anaerobic) capacity, were found to be related.

Physiology—Nerve

Leg-length discrepancy (a difference in leg lengths) causes a number of overuse injuries. A study of Mexican adolescents found electromyographic differences.

Physiology—Blood

Reticulocyte (red blood cell) parameters include the following: *Hematocrit* is the percentage of red cells in a given volume of blood. *Hemoglobin* is the amount of that oxygen-carrying protein in a given volume of blood. The *total blood volume* is made of cells (red and white) and *plasma*—the cell-free fluid. *Red cell mass* is the total amount of red cells in *all* the blood of a person. Hemoglobin manufacture is dependent upon many factors, including *iron*, *folate*, and *vitamin B12*.

Reticulocyte parameters may be measured as a method of detecting EPO abuse in athletes. Although a recent study confirmed this fact, this is old news. A paper co-authored by F. Conconi almost a decade ago came to the same conclusion.

Although testing for EPO directly is on the horizon, it remains problematic. It may require out-of-competition testing, since current tests don't appear to be able to uncover its use after a few days.

Although at least one cyclist has claimed that his high hematocrit was due to physiologic changes that occurred during a stage race, another study this year showed that stage racing is likely to reduce, not increase, morning hematocrit. (Dehydration *during* an event may lead to increased viscosity and hemoglobin/hematocrit values immediately after an event.)

The EPO era has many sport scientists examining the role of increased hematocrit in improving human performance. A study this year suggested that reducing blood viscosity (thereby improving blood flow) offers as great a potential to improve human performance.

Various international sport federations exclude participants from competing when hemoglobin or hematocrit values exceed certain thresholds. Athletes are reported to evade detection by injecting saline solutions intravenously just prior to testing. A study supported by the International Ski Federation found that one liter of saline solution lowered hematocrit by about 3 percentage units (from 46 to 43).

Although physicians have traditionally been taught that men are not subject to iron deficiency, both male and female athletes can lose significant quantities of iron in sweat. Sweat iron loses may be 0.1 to 0.2 mg/l. Since on hot days aerobic endurance athletes may lose more than 10 liters (quarts) of sweat, iron loses may be more than 2 mg daily. To replace this loss, athletes may need to ingest more than 100% of the RDA.

A study of 19 female Swedish national-team soccer players found that half had evidence of iron deficiency anemia and that 30% had anemia. Hemoglobin rose from 12.0 to 13.3 with iron supplementation.

Another study found that iron-deficient non-anemic women improved performance with supplementation. The explanation may be that normal hematocrit or hemoglobin levels represent a population range; population normal values may be low for the individual.

Plasma volume expansion with dextran did not improve anaerobic Wingate performance.

Physiology—Heart

Athletes are known to have big hearts. A study of almost 2,000 athletes in Spain showed cardiac muscle thickness adaptations generally within the normal range, but changes in the volume of left ventricle cavity that often fell into disease-range. The prognostic health significance of this is uncertain.

Physiology—Lung

In some cold weather sports more than 50% of National and Olympic teams have been found to have exercise-induced bronchospasm or asthma. Last year a study found that almost 75% of those with competition exercise-induced bronchospasm/asthma could not be diagnosed with standard lab tests and required in-the-field evaluation.

Consistent with past reports, a United Sates Olympic Committee study this year found roughly one-half of 158 elite-level athletes had one or more symptoms of exercise-induced asthma, but only one-quarter could be confirmed by standard lab post-exercise spirometry. Perhaps in-the-field testing would have confirmed what the other 25% of athletes reported but did not show in the lab.

A study found that even in non-asthmatics, anti-inflammatory lung medicines might improve lung function.

Studies have suggested that exercise alters pulmonary function *whether disease is present or not*. Perhaps it would be more correct to say *whether disease is previously known to exist or not*.

Both sodium and chloride (the two components of common table salt) have been found to be associated with worsening of exercise-induced asthma.

A study found that airflow is limited in athletes. Almost 10% more helium/oxygen air could be breathed than standard air nitrogen/oxygen. (Helium, lighter than nitrogen, flows more easily.) .

Physiology—Women

Hormone replacement therapy did not change watts power output, oxygen consumption, lean body mass, or resting metabolic rate in post-menopausal women.

The frequency of stress incontinence (loss of urinary bladder control) was relatively more common in athletes (about one-third) than in the general female population (about one-quarter)

Physiology—Aging

Past studies have shown that although there are declines in VO2 max and max HR with age, much of the difference is related to training differences rather than age per se. A study this year showed that when expressed as a percentage of maximal, ventilatory and heart rate thresholds did not differ significantly in older subjects when compared with younger ones.

Training/Racing

Cadence: Optimal pedal cadence remains a subject of much debate. The prevailing consensus is that perceived exertion is lower at low pedal cadences for low workloads, and lower at high pedal cadences for high workloads.

What is responsible for this difference? Heart rate is high at given workouts and higher cadence. Economy worsens. A study this year showed that at ventilatory threshold, neuromuscular fatigue is not a factor. Some feel the answer is muscular tension, which is greater at lower cadences.

Pacing: Even power output pacing probably produces the lowest overall time in time trials. Riders err when they rely on a constant heart rate to pace. A constant heart rate time trial is usually associated with declining power. A better pacing strategy is to plan for heart rate to rise slightly throughout the time trial.

Power vs. heart rate was also studied in pro cyclists. At high heart rates, correlation to power output was poor. Heart rates were thought to reflect whole body metabolic stress rather than power output.

RAAM athlete: A report on a 1999 competitor who completed the event in 10.1 days showed an average daily caloric expenditure of 7,946 calories, a daily average intake of 6,812 calories, a mean power output of 97 watts, and an average racing heart rate of 99 bpm.

Exercise intensity can be objectively monitored by oxygen consumption, heart rate or power. Perceived exertion and the "talk test" are more subjective methods. The point at which one can no longer carry on a comfortable conversation (talk test) was found to be at 75% VO2 max, 85% max HR, 78% HRR (heart rate reserve), or RPE (rating of perceived exertion) 5.2 ("hard").

Some propose using serum urea concentration as a method of setting training intensity. A study this year concluded that values have too wide a range to be useful.

Spinning classes were shown to improve aerobic capacity, but not muscle strength or endurance.

Strength training: Does reducing blood flow to the arm with a pressure cuff, followed by increasing flow with the cuff's release immediately before exercise improve strength? A pilot study found it did.

A study examined power output in a 30-second sprint when preceded by relative rest or 10 minutes at 90% of maximum heart rate. It found no difference. This is an example of how lab science can be completely off the real-world mark: Who among us sprints as well when ramped out in the last 10 minutes of a crit as when fresh?

Intervals twice a week for three weeks improved TT performance two and three weeks later.

For relatively sedentary females who have the time, adding strength training to endurance training may improve both endurance and anaerobic power.

Stretching and strength training improved strength roughly three times more than strength training alone.

Ten weeks of strength training did not improve 5K running performance.

How hard should a warm-up be? In strength training, warming up with 50% of one repetition maximum was not as effective as with heavier weights representing 80% of 1RM.

Altitude Training and Competition—Manipulation of Oxygen Content of Air

For an overview of this subject see my review in the Sport Science Webjournal, July 1998 issue, in the training and technology section. The web site is: www.sportsci.org.

At altitude, the reduced oxygen content of air or hypoxia, results in a decrease in VO_2 max, cardiac output, maximum heart rate, stroke volume, and power.

There is considerable variation between athletes, however, in the degree of drop. VO2 max, for example, may fall by about 0.5% to about 1.0% per 100 meters above 1,000 meters.

VO2 max, cardiac output, and max HR are increased with supplemental or hyperbaric oxygen.

Training under either of these opposing conditions (hypoxia or hyperoxia) may stimulate different body systems to adapt and perhaps result in improved performance.

Living-high training-low currently appears to be the best overall strategy.

A study of Olympic distance triathletes showed living approximately 12 hours per day at 6,500 feet for one month increased VO2 max at sea level by about 8%. Changes in blood indices, rather than improved lean muscle mass, accounted for the change. One individual improved VO2 max by more than 25%. Responders outnumbered nonresponders 12 to 2.

Intermittent training in hypoxia was shown to improve both aerobic and anaerobic performance in 16 elite male triathletes followed for two years in one study.

Intermittent training in hypoxia was not shown to improve performance in another study. Researchers looked to see whether 12 or 16 hours of “altitude house” exposure was better than 8 hours in stimulating EPO response during 3 days at about 8,000 feet. The shortest (8 hour) exposure was as effective as the others.

Another found improved anaerobic, but not aerobic performance in athletes after 12 nights in an altitude chamber.

How much altitude is necessary? 8,000 feet was shown to result in higher and more sustained EPO increases than 6,000 and 7,000 feet. 9,000 was not better, though previous studies have shown that after a few days to a week at altitude, even higher elevations tend to maintain high levels of EPO which otherwise may fall.

Although one might intuitively think otherwise, hypoxia decreased submax and maximum blood flow rates during exercise.

Hyperoxic training was found to improve performance, perhaps by improving lactate kinetics.

Delayed Onset Muscle Soreness (DOMS)

Researchers spend a lot of time investigating this problem because sore muscles—sore especially from eccentric exercise (muscle fibers lengthening while under tension)—prevent high-level performance in athletes.

Studies this year showed a significant placebo effect—sham treatment was associated with significant improvement in symptoms.

As in previous years, studies this year showed that icing and stretching may help. Magnets again had no effect.

Additional damage to muscle did not result from repeated exercise while still sore in two studies, although muscles could not generate as much force as initially.

A study looked at whether decreased muscle strength was due to a central (brain) effect. It did not find one.

The anti-inflammatory drug ketoprofen helped reduce DOMS in one study this year.

Deep heat did not help in another.

Vitamin C trended to show a helpful effect in one study.

Summary: Over the past few years studies have been inconclusive about the usefulness of almost everything for DOMS. They have shown that anti-inflammatory medicines, massage, stretching, ice, or heat may or may not help. The effectiveness of placebo for DOMS makes meaningful investigation more difficult.

Prevention is key: When beginning new activities, ease into them. Don’t start weight training, plyometrics, hill climbing, hard time trialing, intervals, or sprinting without base and transitional training. Allow the body time to adapt.

Psychology

Music did not change maximum work, but did lower heart rate in a max power output test.

Conclusions

As I usually find, there’s a lot of interesting science out there, but only a limited amount of information that will prove helpful to improving performance. Knowledge is modestly incremental.

Key points: Hydrate. Have carbohydrates before, during, and after exercise. Be cautious about supplements, ergogenics, new techniques, and fads. Work on pacing during time trial type events. If you want to have good luck, train.