# Novel Training and Other Strategies for Sport Performance at the 2011 ACSM Annual Meeting

Will G Hopkins[1], David T Martin[2], Martin C Knight[3]

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1 Sport Performance Research institute NZ, AUT University, Auckland 0627, New Zealand; Email. 2 Australian Institute of Sport, Canberra, ACT 2617, Australia; Email. 3 Hamline University, St. Paul, Minnesota 55104; Email.
Reviewer: David Rowlands, Massey University, Wellington, NZ.

The annual conference of the American College of Sports Medicine was noteworthy for its variety of novel performance-enhancing strategies based on training and post-activation potentiation. **Denver Highlights** with Dave Martin: pacing, US Olympic Training Center, altitude, central governor, models, US military, energy balance, networking. **Take-home Messages** from Marty Knight: creatine, footwear injuries, barefoot running, Vitamin D, genetic testing, older adults, evidence-based education, alternative learning. **Abstracting No Effect** by Will Hopkins: The meaning of non-significance in underpowered studies is misunderstood. Acute Effects: Compression socks, ionized compression garments, ibuprofen, warm-ups with post-activation potentiation, hyperoxemia, cold-water immersion. Nutrition: acute and chronic antioxidants, iron, bananas, coconut water, chicken essence and ginseng, fructose:maltodextrin ratio, caffeine, charge-stabilized nanostructures, leucine, creatine, bicarbonate, sodium lactate, combinations of ergogenics, pseudoephedrine, beetroot. Tests, Technology and Modeling: poorly designed cross-sectional studies, new running shoe, modeling power output, oxygen cost. Training: functional vs traditional resistance, linear vs undulating periodized resistance, unstable vs stable surface resistance, hypoxia vs normoxia resistance, effects of step frequency on economy, traditional strength on endurance, underweight softball bats, core strength on endurance, snorkel on endurance, traditional altitude on competitions.
KEYWORDS: elite athletes, ergogenic aids, nutrition, tests, training.

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Your usual Sportscience conference reporter, Will Hopkins, did not attend this year's meeting of the American College of Sports Medicine in Denver, but he has downloaded abstracts from the conference site and produced his usual report. Two colleagues who did attend the meeting have coauthored this article by providing first-hand accounts of memorable research and of the special presentations that lack abstracts. Dave Martin has focused on sport performance, while Marty Knight has reported on a wider range of sessions.

As with previous ACSM meetings, it is possible to access the abstracts of the original research presentations on line. Will got his by registering at the conference site (it's free), then systematically reviewing all sessions relevant to sport performance. If the conference site is closed off by the time you read this, the abstracts will also be presented in the May supplement of Medicine and Science in Sports and Exercise, where you can browse the sessions from the Table of Contents. Find a specific abstract from the number in brackets […] in this report by clicking on the Advanced Search link, putting the abstract number into the Keywords box, limiting the search to Titles, entering the volume number (43) and issue number (5), then clicking Search. You can also email Will for a PDF of all the 600+ abstracts containing the word *performance*. Use this PDF in the manner he has previously recommended to review this and other conferences: get a small group together (no more than five) with an interest in a specific sport or topic, set up the PDF on a big screen, then search for the sport or other keyword and skim each abstract containing the keyword. If you don't find this exercise entertaining and instructive, you should consider a different career or early retirement.

### Denver Highlights
with Dave Martin

**Pacing** continued to be a popular theme this year. The approach taken by Carl Foster's group whereby real world-class performances were examined to investigate whether Olympic performances are paced differently from world record performances was insightful [1021].

For those of us who are keen on Olympic sport and elite athletes, it was great to see Randy Wilber's contributions from the **US Olympic Training Center**. Randy described the various ways sport science at the USOTC has contributed to success in winter sport. He also organized an **altitude-training** symposium that included reviews of the past by Jim Stray-Gundersen and summaries of contemporary altitude-training research by Philo Saunders from the AIS. Philo won the ACSM Gisolfi 5-km fun run five days after coming down from an altitude camp in Spain, making his presentation particularly authentic. Ben Levine, well known for his popular live-high/train-low research, explored the important aspect of the time course of the performance benefit after altitude training. He reviewed the phenomenon of neocytolysis–the rapid destruction of new red blood cells in response to dramatic decreases in serum EPO post altitude–and raised the interesting question of whether performance gains post-altitude training coincide with elevated hemoglobin mass. Despite limited data in this area, Ben suggested best performances will occur 3-4 wk post altitude training.

I really enjoyed Alan St Clare (Zig) Gibson's introduction of "strong" and "weak" **central governor** concepts as a timely refinement to the traditional central-governor model. Researchers are using clever experimental models to better understand the central component of whole-body fatigue. In particular, Jim Martin's lab at the University of Utah has introduced a provocative cycling performance model for examining peripheral and central fatigue [642, 643]. I was also impressed with the many elaborate **mathematical models** that are finding their way into competitive cycling [838, 967].

The presence of the **US military** was hard to miss [671, 1605, 1607]. Numerous presentations addressed performance aspects of the soldier, sometimes in collaborative projects with elite sport [1382].

Finally, the topic may not initially seem relevant to top athletes, but I'm glad I was one of the many who attended the expertly presented symposium on *Food, Exercise, and Appetite: Implications for Energy Balance and* **Weight Management**. Barbara Rolls gave a world-class performance as she reviewed more than 20 years of her own research examining factors influencing how we eat: great science with clear questions and elegant experimental designs. Inspirational!

As per usual at ACSM and other international conferences, conversations during breaks between sessions and over dinner were often as valuable as the sessions themselves. I find researchers stop defending their data and start thinking more critically after a beer or two. Make sure you take every opportunity to **mingle and network** at your next conference.

### Take-home Messages
from Marty Knight

Here is what I managed to take home from the symposia, tutorial lectures and other special presentations at the meeting. The sessions I attended reflect my diverse interests in exercise science. I have added contributor names so you can find the sessions in the program, but there are no abstracts or email addresses for these sessions.

**Creatine Update**. This session was a summary of a conference on creatine in 2010. Creatine supplementation has beneficial effects in several neuropathologies: muscular dystrophy, Huntington's disease, and mini-stroke patients. It is inexpensive and safe: even patients with one kidney have shown no ill-effects while taking creatine. The concerns over creatine administration and safety likely stem from the media reports that athletes suffering from rhabdomyolysis were taking creatine, but the rhabdo was likely a result of over-exertion and dehydration. [Rawson, Tarnopolsky]

**Biomechanics of Footwear**. We need a new model to predict injury, according to Hamill. The previous model assumed that biomechanical factors caused injury, while footwear reduced injury. This model was likened to Kepler's model of the solar system: it worked for a while. A new model is needed, one that incorporates the idea of shoes designed to compensate for the differences among runners that might lead to injury in one but not another. [Torry, Hamill, DeFrate]

*Note added by reviewer (Dave Rowlands).*

There was also a symposium on **barefoot running**, and I managed to attend Dan Liebermann's interesting presentation. His message was that *Homo sapiens* has several anatomical features that evolved to accommodate long distance running that are not relevant for walking (see Bramble and Liebermann, Nature, 2004). Barefoot running is toe-heel-toe, which substantially lowers ground reaction forces vs shod heel-toe. Unfortunately for most of us, evidence so far is that barefoot running in adults after a lifetime of shoes does not reduce injury risk. More research is needed on this current popular US trend/fad.

**Vitamin D** has become a hot topic in sport since low blood concentrations of this vitamin have been associated with poor physical performance in some populations. The dietary plant-based form, D2, is less potent than the D3 we get from exposing skin to ultraviolet light. For those who live north or south of 35° from the Equator, oral supplementation is advisable in winter months. Blood levels of Vitamin D we currently regard as normal may be too low: the Massai, whose outdoor lifestyle is probably close to what *H. sapiens* adapted to over the last few million years, average 104 nmole/L, which is considerably higher than the US average of ~70. [Larson-Meyer (chair)]

*Reviewer's note*. Many athletes and normal people are deficient because we spend too many hours indoors on the computer and not enough time outdoors riding our bikes. The recommended daily allowance has just gone up. Indoor sports athletes are more at risk that others. Tanning beds could be an option for winter months. There were several presentations on Vitamin D in athletes, but none on its effect on performance.

**Genetic Testing of Athletes**. Advertisements for genetic testing to screen for athletic prowess are now easily found on line. It is highly unlikely that such testing provides any useful information for aspiring athletes: too many factors associated with elite athletic performance, among them dedication and hard work, appear to be dependent on experience rather than any known genes. One world-class long jumper's genetic profile from such a testing service found him to be lacking in speed and power capability A world-class cross country skier who was studied by sport scientists (not an on-line testing service) was found to have a genotype that facilitates oxygen transport through high levels of hemoglobin, but this genetic characteristic was specific to his family and would not have been discovered through on-line testing services. Would such examples of false negatives be rare with these tests? And what about false positives? The diagnostic power of these tests needs to be investigated. If the service doesn't provide such information in plain language, don't use it. [Roth] *Reviewer's note*. I believe genetic testing will be a useful tool in the near future, but meantime we still can't go past simple performance tests.

**Exercise in Older Adults**. The site easyforyou.info has a new approach for screening older adults before exercise. It is superior to the PAR-Q, because it doesn't overtly screen future participants out of physical activity programs; rather, it screens them in. [Chodzko-Zajko, Hoffmann]

**Evidence-Based Education in Exercise Science**, Active learning is superior to conventional lecturing for student outcomes (a standardized mean difference of ~2, or large to very large). Of the various active learning methods studied, reciprocal teaching (students teaching students) is the best. The good teacher provides feedback, structure and variety, incorporates rest to allow for reflection and encourages interaction. When information must be given, use the 10/20/10/20 model: present new content for 10 minutes, allow for 20 minutes of active learning, then repeat (for a typical one-hour class). It sounds like the hype of advertising, but asking questions and setting quizzes really can improve student performance by up to 70%. [Persky]

**Alternative Learning**. In 2009 the Association of American Colleges and Universities adopted the following essential learning outcomes: knowledge of human cultures and the physical and natural world, intellectual and practical skills (especially forms of critical thinking), personal and social responsibility, and acquisition of integrative and applied knowledge. We should not think of teachers as bankers who deposit knowledge in the brains of students. (Read: *Pedagogy of the Oppressed* by Paulo Freire.) Problem-based learning, which incorporates an active learning strategy with discipline-specific problem solving, is a particularly successful strategy. [Ode, Battista]

## Abstracting No Effect

by Will Hopkins

If you were to believe the claims in many of the abstracts, even tried-and-true strategies to enhance performance have apparently stopped working. The subheading for my report calls attention to this lamentable fact–lamentable, not because the strategies are useless, but because the authors still haven't come to terms with the basics of inferential statistics. The main problem is a specious and apparently irreversible brainwashing they received in graduate school, where they learned that p>0.05 means "no effect". According to this logic, studies on a handful of subjects will result in no effect up to 95% of the time. Once and for all, get it right: failure to reject the null does not necessarily mean you accept the null! For some abstracts I've provided explanations as to why the effects may not have gone away after all, but I have omitted all mention of grossly underpowered studies (<10 subjects tested once or twice) when no data are shown and the only inferential information is "not significant". And as usual, I have skipped many studies of non-athletes.

My report is a page shorter than in previous years. Is it my imagination, or is ACSM's new poster child Exercise is Medicine™ responsible for displacing a substantial amount of sport performance research from this year's meeting? EIM™ might also explain why the program committee appears to be accepting less special presentations related directly to elite sport.

It was great to see so many contenders for successful training-based strategies this year. My choices: training the step frequency of runners, training with underweight baseball bats, core training, and snorkel training. One with an outside chance is hypoxic resistance training: it doesn't work for strength, but more research might show that it adds to the beneficial effect that high-resistance interval training already has on endurance performance. Warm-ups involving post-activation potentiation also deserve special mention as acute strategies.

The booby prize (for the product, not the research) goes to ionized compression garments. I can't award a booby to the drink containing "charge-stabilized nanostructures" until, as seems most likely to me, the apparent beneficial effects fail replication.

The prize for the most annoying use of pointless abbreviations goes to a study on running mechanics and economy of runners and triathletes: "All HRA parameters (RMS, EC, RA) were significantly greater for XC vs. TRI in VT, and lower (p<.05) for XC vs. TRI in ML and AP, except MLRA."

### Acute Effects

**Compression socks**, if anything, impaired running economy (by 3.2%) in seven **triathletes** following the cycle phase of a simulated race [859]. You can also forget about using compression socks for recovery of running performance in collegiate **distance runners** [2767].

I googled "**ionized compression garments**" and found this gem: "IonX™ - Ionised Energy Fabric™ performance apparel and compression support delivers ionic energy to the body through a negatively charged electromagnetic field." Yeah, right. No surprise, then, that there was little effect on endurance performance in **cyclists** [2755].

The anti-inflammatory **ibuprofen** significantly *impaired* 10-km run time in a blind crossover of 13 experienced **runners** [2773]. P values only, so I can't provide the percent effect.

A **high-intensity warm-up** enhanced shot-put release speed clearly by 5.3% in a crossover study of 10 collegiate **shotputters** [3020]. It would be nice to convert this effect into distance in a shotput with a good trajectory, but a more important concern is the control: stretching impairs some kinds of performance. Whatever, strategies aimed at optimizing so-called **post-activation potentiation**, which is the basis of this and other special warm-ups, are a good source of projects for graduate students. Other warm-ups that worked: an **overload** for sprint **cycling** [3021], and an **overspeed** for sprint **running** [3023], Some that didn't work or even had a negative effect: a **weighted vest** for a counter-movement **jump** [3020]; **sub-maximal exercises** for a 30-min **run**; and **over- and under-weight baseball** bats for bat swing speed (although there might be individual differences worth further investigation) [3032].

It's not surprising that breathing oxygen between bouts of high-intensity exercise to induce **hyperoxemia** will enhance performance of that exercise [3035]. We surely can't have athletes using oxygen bottles before their event, but Randy Wilber apparently reported that US Olympic athletes enjoy the use of bottled oxygen when exercising at altitude.

In a **meta-analysis** of 14 studies comparing **cold-water immersion** with presumably no special treatment, there were mainly moderate benefits on recovery from fatiguing exercise [3036]. A pity the authors didn't covary for the different types of cold-water immersion; maybe there weren't enough studies.

Anyone who has watched Olympic finals in **track events** will know that the **pace** is often slow initially and winds up to a dash for the line amongst the front-runners. Researchers in the pacing study Dave Martin referred to put numbers on this phenomenon and compared pacing in Olympics with the more even pacing that results in world records [1021].

## Nutrition

**Antioxidant** supplements and foods continued to show generally benefical effects on pain, inflammation and/or performance following a bout of unaccustomed hard exercise, including tart cherry juice (non-significant trend) [584], cherry extract [585], pine-bark extract [586], blueberries [587], non-alcoholic beer [588], oats [589], purple sweet potato leaves [1784], and a proprietary supplement containing phytonutrients [1800].

Acute effects of **antioxidants** *directly* on performance rather than on *recovery* from performance are more interesting. Surprisingly, 7 d of **quercetin** had little effect on performance and blood markers of inflammation in 16 **soldiers** [1779, 1780], and a **meta-analysis** of 10 studies concluded with "quercetin supplementation (1000 mg/day) for 18-21 days is very unlikely to provide an endurance performance advantage or incur a meaningful physiological change in $VO_2max$" [1783]. But the meta-analyzed effects were 0.7% on power output and 2.1% on $VO_2max$, which *would* be beneficial to top competitive runners, if not cyclists. My name was on a review of antioxidants in the same session in which we thought quercetin was looking promising [1793], so I think it's wait and see for this antioxidant. We also concluded that **Vitamin E** has little effect, **N-acetylecysteine** improves performance but with too much risk of side effects, and **beetroot** juice is also beneficial, but probably because of nitrate rather than antioxidants.

Even more interesting are the longer-term effects on performance when **antioxidant** and similar supplements are combined with **training**, because there are concerns that antioxidants might impair adaptations by blocking the signaling action of the reactive species released in hard exercise. (See last year's ACSM report for more.) So, an antioxidant could enhance performance with acute use but impair performance with chronic use. The duration of supplementation and the nature of the training are therefore important issues in studies of longer-term effects. In the above review [1793], chronic **Vitamin C** was harmful, but the durations of supplementation and exercise tests were not stated. **Astaxanthin** is an antioxidant found in salmon and other edible red marine animals, which get it originally from algae. A randomized placebo-controlled trial of the effects of 28 d of astaxanthin supplementation by 14 competitive amateur **cyclists** resulted in a net 6% improvement in 20-km time-trial time in the astaxanthin group following a 2-h submaximal ride [1792]. There was no statement about training or red urine! A "proprietary **nutritional blend**" (containing lipoic acid, acetyl L-carnitine, quercetin, and "SerraPeptase") taken during 6 wk of resistance training by 29 **college-age males** randomized to supplement and placebo produced no significant difference in changes in strength, although the supplement group improved in anabolic status (testosterone/cortisol ratio) [1781].

In a randomized placebo-controlled trial of 31 non-anemic collegiate **female rowers**, those supplementing with **iron** for 6 wk had perceptions of improved training quality [2004]. Effects on time-trial performance were not reported. There was "no effect" (and no data) on an incremental test in a crossover study of 10 **active females** who supplemented with iron for 7 d during menses [2005].

The authors claimed that "ingestion of **bananas** during a 75-km **cycling** trial supported performance in a similar fashion to a 6% sports drink when carbohydrate intake was equated", but actually the times were a substantial 2.1% slower on bananas [1537]. A magnitude-based inference on this outcome would indicate a high risk of performance impairment, probably arising from high potassium and low sodium in the bananas. Do not consume bananas for time trials lasting several hours!

Given that bananas are likely harmful, I was expecting a similar result for **coconut** water (isn't it coconut *milk*?), but there was negligible difference between its effect and those of water and water+electrolytes on a 10-km run following a 2-h pre-load run in a powerful crossover study of 17 **endurance-trained men** [1957]. I guess there isn't enough carbohydrate in the coconut water.

Compared with placebo, a brew of **chicken essence** and **ginseng** extract consumed for 2 wk increased time to exhaustion at 75% VO2max by 12% (equivalent to ~1% in a time trial) in a crossover with 14 healthy **males** [1789]. I am skeptical: the placebo effect could be responsible, if there was any loss of blinding through changes in gastro symptoms or urine.

**Carbohydrate** research seems to be on the wane at last, but there was one good crossover study of 10 **male cyclists** showing that peak power in an incremental test following a 2-h preload was ~3% higher with consumption of drinks containing fructose:maltodextrin ratios of 0.8 and 1.25 than with a ratio of 0.5 or with water placebo [2249].

Ho hum, the usual confusion of non-significance with null effects reigned in a clutch of **caffeine** studies. Caffeine dosage had "no effect" on repeated **cycle** sprints by 17 well-trained males [2367]. The exact p values (thanks for that, at least) were probably low enough for the effects to be practically clear and important via magnitude-based inferences, but unfortunately the authors did not report the magnitude or direction of the observed effects for me to tell. We weren't even given exact p values in another caffeine study, this time on strength in **weightlifters** [2368]. Caffeine plus carbohydrate gave a significant 3.4% improvement in a 20-km **cycling** time trial, but caffeine and carbohydrate each alone were deemed not to work, so illogically no data were shown [2370]. I'd bet on the effects being about 1.5%, and clinically clear. Caffeine worked significantly for repeated cycle sprints in **team-sport athletes** with long (90-s) recovery intervals [2377], but I'd like to see data and p values before I could believe the effects for short intervals (21 s) were "negligible".

It looks like it's better to chew **caffeinated gum** 5 min before rather than 60 or more min before a **cycle** time trial [2373]. I can almost believe that, but I would still like to see the confidence limits for the comparison of the three time points, not just the 5 min vs placebo.

**Caffeine** produced a mean increase in repetitions of **resistance exercise** to failure [2375]. The authors were convinced there were substantial individual responses, but these may simply reflect the notorious noise in time or reps to exhaustion. You need a control group or retests in a crossover to estimate the magnitude of individual responses.

I visited the website of the company promoting a sports drink containing "**charge-stabilized nanostructures**", but there was no believable description of what the nanostructures are, the on-site video didn't work, and the language is consistent with quackery. So I'm skeptical about what looks like fishing for an effect of the drink on VO2max in a fitter subgroup of 25 already **fit males** without data on a comparison with the less fit or even with placebo [2383]. Uh oh, two of the researchers are in the company!

In a crossover study of 12 **cyclists**, adding the branched-chain amino-acid **leucine** to a protein recovery supplement produced clear trivial changes in sprint power in the days following an unspecified bout of fatiguing exercise [949]. Previous research by the same group had shown a beneficial effect with addition of leucine, but the athletes had been in mild negative nitrogen balance. Protein alone is enough, apparently, if you are already in positive nitrogen balance.

**Creatine** still works with a usual 7-d supplementation protocol, thank goodness, but the authors found it also improved antioxidant capacity in 5 (!) male **cyclists**, reporting it as evidence that creatine might not be harmful with long-term use [2961]. Taken only one hour before repeated sprints, creatine if anything tended to *impair* performance [2962], but you wouldn't have used it that way anyway.

**Bicarbonate** acute supplementation produced a massive enhancement of 9.4% in overall mean power in repeated sprints on a cycle erg, but *peak* power averaged across the sprints was actually impaired by 5.9% [2966]. Mind you, it was only eight **rugby** players and they were tested on a cycle erg, so it's hard to know how much of these effects would apply to running in team sports. I almost can't see the point of any more studies of effects of bicarbonate on short-term (~2.5 min) maximal performance [2969], but it's good to see use of the trusty old time to exhaustion at constant pace, and an attempt to account for individual responses.

It's no surprise that consumption of **sodium**

**lactate** raises blood bicarbonate and enhances high intensity performance [2990]. Strange that there was "no effect" on blood pH, but don't worry, you can bet a substantial increase was not excluded by their data. More importantly, what about gut symptoms compared with published findings for bicarbonate?

We're starting to see studies of combinations of ergogenic substances: **bicarbonate** plus **caffeine** [2968] and **bicarbonate** plus **creatine** [2964]. These studies are worth doing, not only to check that the effects add constructively, but also to provide research students with original topics for their projects. The downside is that such studies need three groups (A, B, AB) and large sample sizes for acceptable uncertainty in what will usually be a trivial difference between Group AB and Group A plus Group B.

Fifteen female **runners** in a crossover makes a reasonably powerful study for investigating the effect of the banned substance **pseudoephedrine** on 800-m time-trial time, and when the authors got p=0.92 and next to no difference between ephedrine and placebo, you would think their claim of "no effect" was reasonable [2986]. Sorry, guys, no: a p value can be misleading, whatever its value. Put your data into the spreadsheet for confidence limits and clinical chances (Hopkins, 2007) and you will find 90% confidence limits of -0.8% to 0.9%. Given the smallest important change in 800-m time is 0.3×0.8% or ~0.25% (Hopkins, 2005; Hopkins et al., 2009), you have to conclude that pseudoephedrine is possibly beneficial *and* possibly harmful–the outcome is unclear, in other words.

Six days of **beetroot** juice unexpectedly resulted in an *impairment* of 1.2% in 16-km time-trial time following a 30-min pre-load in a crossover with eight male **cyclists** [2989]. As usual, the claim "did not enhance… performance" is not justified: their observed effect and p value give 90% confidence limits of -0.9% to 3.4%, which extend way beyond the smallest important effects on cycling time of 0.3×1.3%=0.4% (Hopkins et al., 2009; Paton and Hopkins, 2006).

### Tests, Technology and Modeling

Was there any point in finding out which of eight tests in a **test battery** had the highest correlations with performance in a cross-sectional study of only **seven female** or **nine male athletes** (on-snow skate skiers) [557]? Definitely not. Students have to present something to justify attending a conference, sure, but in my view this presentation and others like it reflect badly on the students, the supervisors, and the conference committee. Come on, guys, lift the quality.

A **running shoe** that mimics the foot-strike pattern in barefoot running made running economy *worse* by 1.1% compared with normal shoes in 18 slow-ish **distance runners** [1455].

In a case study of a 4-km **pursuit cyclist**, the effect of duration of exercise on torque, cadence, aerobic power and anaerobic power were **modeled** in various semi-theoretical and empirical ways, then combined into a single model to predict 4-km time under various conditions [838]. Actually it's not entirely clear that that's what the study was about, but apparently the model predicted performance time with a residual error of only 1%. A useful approach to optimize pacing?

In another modeling study of the **power-duration relationship**, sport scientists at the Australian Institute of Sport were interested in predicting power output of 12 female and 12 male national-level **cyclists** in a 1-min effort using power output in shorter (5 s) and longer (4 min) tests, which are less stressful [810]. Alas, there was too much random error (6%) for the prediction to be of any practical use, given the smallest important change in a cyclist's mean power output over 1 min is ~2.5×0.3×1.2%=0.9% (Hopkins et al., 2009; Paton and Hopkins, 2006). The noise in mean power in performance tests like these is usually ~2%, so the modeling is the problem.

There appeared to be a phenomenal difference in **oxygen cost** for the same running speed between **triathletes** and **runners** (47 vs 41 ml/min/kg, or 16%) [856], and the authors used high-resolution accelerometers to associate the difference with differences in running kinetics. I can't believe the difference in cost is that great, but there is obviously some difference, so it might be worthwhile to focus on improving the running economy of your triathletes, possibly via those kinetics.

### Training

There were little differences in the effects in the following controlled trials of resistance training: **functional vs traditional** pre-season resistance in **baseball** players [2935]; **linear vs undulating** periodization of resistance in college **students** [2936]; three **baseball**-specific resistance programs in high-school players [2938]; and **unstable vs stable surface** resistance in female **soccer** players (unstable was possibly even harmful) [2947].

Resistance training in **hypoxia vs normoxia** (14% $O_2$) with 16 **males** resulted in similar or slightly lower gains in strength but much greater gains in endurance (load×repetitions): 158% vs 101% [2955]. Wow, but before you get too excited, this measure is another time or reps to exhaustion, so the net effect of the hypoxic training on mean power in a time trial is more like 3%. Also, this strategy amounts to live-low train-high altitude training, which hasn't been successful in other studies. Be that as it may, someone should try hypoxia with the high-intensity resistance training that already works well in endurance athletes.

An unstated number of female **runners** with an apparently relatively low **step frequency** (<176 per min at an unstated speed) improved their running economy by 3% and their self-selected step frequency by 4% after 15 min per day of training at 180 steps per min for 10 d [857]. But the study lacked a control group, and would it have shown the same gain in economy? Stranger things have happened.

A meta-analysis of the effect of traditional **strength training** on **cycling endurance** used standardized effects from each study [2946], which represent a metric inferior to percent changes in mean power (Hopkins, 2004). There were moderate effects overall, but how do they translate into medal prospects for top riders? Also, I don't trust estimates of effects of covariates (moderators) with the standardized metric.

The sample size was too small (13) in a controlled trial of what looks like possibly beneficial effects on ball speed of training with **underweight softball bats** in female **softball** players [3003].

Adding 4 wk of **core strength training** to usual training resulted in a 3.8% improvement in 800-m time in a controlled trial of 15 **runners** [2764]. Cool.

Here's a quirky idea: combine respiratory muscle training by working out with a **snorkel** to restrict airflow. In the randomized controlled trial of 12 **recreational runners** (six females and six males–don't mix sexes with such a small sample size!), 6 wk of an unspecified frequency and duration of sessions at 65% of $VO_2max$ on a treadmill resulted in no significant differences within or between groups [2771]. The snorkel group did better than the control group, but only their data were reported (amounting to a 2.5% improvement in 5-km run performance). Is it worth another study with serious competitive runners adding a few weekly snorkel sessions to their program? Maybe.

Among the six authors, some of them grey beards, apparently not one drew the line at randomizing 11 athletes to three groups for a study of **resisted-assisted training** with **runners** [2830]. Next time make it two groups (experimental and best-practice control) and increase the sample size to a minimum of 20.

Here's some evidence from real competitions that traditional live-high train-high **altitude training** improves performance: 14 elite female and male endurance **runners** who spent 4 wk at an altitude camp prior to the 2010 season achieved 24 personal bests, compared with 15 and 16 in the previous two seasons, and their improvements in times were 1.4% vs 0.8% and 0.9% [787]. Or maybe not. The effects of altitude wear off too quickly for any enhancement to be sustained over a season, whereas the training-camp effect might have carried through the season. Anyway, this is a good study to finish my report: what matters in the end is effects in competitions. Studies like this one, with better control, are the way to go.

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