Viagra at Altitude and Other Performance-Related Highlights of the ACSM 2006 Annual Meeting

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Sportscience 10, 1-7, 2006 (sportsci.org/2006/wghACSM.htm)
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Acute Strategies: Effects of ibuprofen, pre-tensing, pre-cooling, circadian rhythym, warm-ups, ice-cold recovery, bike fitting, stretching, post-activation potentiation, whole-body vibration, and massage. Altitude: Viagra for performance at high altitude; the live-high train-low mechanism debate; effects of adaptation to artificial altitude. Mechanisms: maximum effort is related to a critical fatigue level in muscle; hard training stimulates EPO; evidence that muscle pH limits intense exercise. Nutrition: training on low carbohydrate; galactose vs other carbs and caffeine; milk protein, amino acids and cherry juice for recovery; colostrum for training; vitamin C and fish oil for asthmatics; echinacea stimulates EPO; caffeine for team-sport and tennis performance; effects of mild hypohydration. Performance Genes: minor findings. Tests and Technology: using modeling to optimize cycling performance; soccer tests; mountain-bike suspensions. Training: big gains with respiratory-muscle, core-stability and high-resistance training; nothing new on overtraining. Reviewer's Comment: a balanced view of train-low compete-high on carbohydrate. KEYWORDS: elite athletes, ergogenic aids, nutrition, tests, training.

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The 53rd annual meeting of the American College of Sports Medicine was held this year in Denver, May 31 through June 3. There were nearly 3000 presentations on health, injury and performance aspects of physical activity and sport in multiple parallel sessions. So many people reported so much good research that I consider it an obligation and privilege to write this report. I have limited it to my own research interest of athletic performance. If your interest is health or injury, I strongly advise you to peruse the relevant abstracts. The book of abstracts was distributed only to attendees, but I explain below how you can access each section of the book as a PDF online.

Even limiting myself to athletic performance, I could only attend a sample of what was on offer. This report is therefore based mainly on the abstracts for the podium and poster presentations of original research. Unfortunately there were no abstracts for the symposia and other special presentations, some of which were outstanding. I have reported on those I attended.

Accessing the abstracts is difficult, so here's a guide. You must be a member of ACSM, or you or your institution must have a subscription to ACSM's journal, Medicine and Science in Sports and Exercise. ACSM members, log in via this link. Enter your username (default is first 3 letters of your family name followed by your member number) and password (your member number). Click on the MEMBER SERVICES tab, then on the link for Member Journals, then the link for MSSE. Otherwise get to this point at the MSSE site via your institution and/or log in with your own subscription info. Now, click on the main Search tab (not the one in the Quick Search box). In the Title field of the search form, type the presentation number shown [in brackets] in this article, select 2006 to 2006 for the date range, then click SEARCH. You should get one hit, the abstract you want.

Some of the hits have a link to a PDF for the entire section of the abstracts. I found it useful to download the PDFs and search keywords within the PDF reader (even though the PDF search form is badly designed). The presentation numbers in each section are: featured sessions, 1-582 (symposia etc, and some original research with abstracts); slides, 583-1124; clinical cases, 1125-1303; thematic posters, 1304-1361; and posters, 1362-2915. I note that the PDF links for the posters have now been removed. You may need to contact ACSM and ask them to make the abstracts available. If all else fails, contact me.

It's possible to find the titles of the podium presentations in Pubmed, but to access the abstracts you get directed to the MSSE site, which you cannot access without a subscription. Disappointingly, the ordinary posters are not indexed in Pubmed–all the more reason to opt for a podium or thematic poster presentation next time.

In my last report on the ACSM conference in 2001, I noted frequent flaws in the abstracts. Five years later there has been a noticeable improvement. For example, there are now more confidence limits, and chances of benefit and harm are even starting to appear. But there is still a long way to go. Here, therefore, is an update of my advice on how to improve the abstracts in future. Not all of this advice is mainstream yet, but it's coming. For more info, click on the link in each of the bullet points below (Batterham and Hopkins, 2005; Curran-Everett and Benos, 2004; Hopkins, 2003; Hopkins, 2004):

- **Show the magnitude of the effect and its confidence limits** so we can see how good or bad the effect might be in reality. Link1.
- **Describe the magnitude probabilistically**, using possible, (un)likely, very (un)likely, almost certainly (not). Link1.
- **Use percent change in performance**, for many reasons. Use power output as the measure of performance, if possible. Link2.
- **Use standardized (Cohen) changes** to gauge qualitative magnitudes of effects, but not for performance of solo athletes. Link2.
- **Show standard deviations**, not standard errors of the mean. Link3, Link4.
- **Avoid abbreviations** and impenetrable thickets of data. Link5. Here's a particularly egregious example from the abstracts: OXY was lower at the E than at the S or M condition in both the G (S: 0.9 (0.0/2.5)µM, M: 0.0 (-1.3/1.3)µM, E: -11.3 (-14.9/-7.1)µM; p= 0.001) and in the NG condition (S: 0.3 (-0.1/1.1)µM, M: -0.7 (-2.7/0.2)µM, E: -6.7(-10.3/-3.0)µM; p=0.001).

I am grateful to the Division of Sport and Recreation of AUT University for providing full funding and leave to attend this conference.

Acute Strategies

The **anti-inflammatory** ibuprofen made markers of inflammation and muscle damage *worse* in an ultramarathon [707]. My guess is that it was because the ibuprofen allowed the athletes to push harder. The sample size was too small (drug, 29; placebo, 25) for quantifying effects on performance with their design (a post-only parallel-groups randomized placebo-controlled trial). The authors made one of those classic wrong inferences about their marker of muscle damage, creatine kinase: there was no significant difference (P=0.16), but the numbers showed much greater damage in the ibuprofen group. Next sentence: "ibuprofen use… did not alter muscle damage". Sigh…

Sprinters are often told to **pre-tense** by pressing backward hard against the blocks, but this strategy apparently made little difference to performance [745]. I would have to see the confidence limits for the effect before I made my decision.

Precooling gave a substantial enhancement of endurance performance in a hot lab, but turning on the fan gave an even bigger enhancement, and precooling plus the fan was no better than the fan alone [827]. So precooling may not be beneficial for performance out on the road, but show me the confidence limits.

In a novel design to assess the effect of **circadian rhythm** on performance, 200-m swim time was worst around the time of lowest body temperature (5 am) and best (by about 3%!) around 11 pm [1543]. It might be possible to take this effect into account when scheduling travel to compete in some time zones.

Optimizing the **warm-up**… A post-warmup recovery time of 10 min is better than a 45-min recovery for 200-m swimming performance [1560]. On the basis of drop-jump performance, the authors of a study of 28 female gymnasts concluded that the best warm-up consisted of running, stretching and practice jumps [1592]. Warming up with a sequence of standard, light and heavy bats might increase bat speed in collegiate baseball players [1617].

It's hard to tell from the abstract, but it looks like a **recovery** strategy of **ice-cold water** immersion for 12 min following a 5-km run had no real effect on 5-km performance next day

[1567]. I can't see any inferential stats for the comparison with control.

There was "no significant effect" of various **bike fitting** methods on steady-state oxygen cost with 15 triathletes [1575], but given the noise in VO_2 measurements, and with no comparison statistics, how can we be sure?

There were numerous posters on **stretching** [1748-1757, 1811], with the usual findings of an increase in range of motion at the expense of some measures of performance. **Proprioceptive neuromuscular facilitation** is OK, though [1816], presumably because it produces some post-activation potentiation.

Post-activation potentiation achieved with an isometric squat enhanced a counter-movement jump 4-5 min later in experience weight trainers but not in novices [1789], although training experience had little effect in another study [1833]. A set of dynamic squats also produced a big enhancement of 30-s cycling sprint power 6 min later in collegiate wrestlers [1803]. The phenomenon is probably responsible for an increase in vertical jump performance during a weights session [1812].

Whole-body vibration had mixed effects on various measures of performance: harmful [1685], trivial or non-significant [1599, 1814, 2129] and beneficial [1599, 2439]. The abstracts didn't show enough data.

A 15-min **massage** had no significant effect (no data provided) on 30-m sprint speed in 37 active males [2428].

Altitude

One of the quirkiest presentations [451] was about the effect of **viagra** (sildenafil) on endurance performance at a simulated moderately high altitude of 3900 m. All 10 of the trained cyclists in the study performed a 6-km time trial worse at altitude than they would have at sea level, as you would expect, but four of them were much worse (15 min to complete the distance instead of 10 min). The extra impairment in these four cyclists disappeared when they consumed sildenafil before the performance test. There was little effect of the sildenafil on the other six cyclists at altitude, and little effect on all 10 cyclists at sea level. How come? By dilating arterioles, sildenafil reversed the excessive hypoxic pulmonary vasoconstriction that limited cardiac output in the four cyclists. See the full paper in J Appl Physiol for more. I doubt whether there would be substantial benefit for any athletes at moderate altitude.

Part of a symposium on **altitude training** dealing with the live-high train-low strategy was a re-run of the point-counterpoint articles last year (J Appl Physiol 99:2053-2057, 2005). Ben Levine explained over-simplistically that the benefit is all due to an increase in red-cell mass, but then Chris Gore made it clear in a more scholarly balanced presentation that the benefit is due at least partly to an improvement in economy.

Highlights of a slide session on **altitude training** [903-909]… It's hard to figure out the abstract, but it looks like 2 h per day of resting and training at an artificial altitude of 3000 m for 28 d was better than sea-level training for performance at sea level [903]. In a related study [908], a group of endurance athletes training in an unspecified way at an artificial 3000 m for 15 sessions over three weeks made gains in peak power at sea level similar to those of a group training at sea level, but the gains made by both groups were too large (~7%) to allow sensible conclusions; on the other hand the altitude group appeared to perform better at altitude. The acutely intermittent variety of hypoxic exposure (5 min on, 5 min off, for 60 min, for 9-14 sessions, over 14 d) had harmful effects on some aspects of performance of rugby players [907].

Highlights of a poster session on **altitude training** [2727-2743]… Sleeping in hypoxia equivalent to altitude of 3000 m for 29 nights improved running economy but not VO2max or hemoglobin mass [2728]. The acutely intermittent variety of exposure to hypoxia did little to prepare rugby players for performance at 1650 m [2731] or at sea level [2732].

Mechanisms

Cycling with different percents of oxygen in the inspired air produced big changes in time-trial time, but there was the same amount of fatigue in the leg muscles (measured by stimulating the motor nerves magnetically) [452]. So it looks like there is a **critical fatigue level** in muscle that signals you to feel maximum effort, just like the critical core temperature does.

At last, someone has found that the plasma volume expansion you get acutely following hard exercise is associated with release of **erythropoietin**, probably via a negative feedback mechanism sensing and offsetting the hemodilution [953]. The resulting increase in red-cell mass would enhance performance via enhanced oxygen transport. It's evidence that endurance athletes have more red cells partly because of training (and no doubt partly because of self-selection into endurance sports).

Evidence that **muscle acidity** (low pH) limits anaerobic performance: supplementing with alanine for 14 d increased isometric endurance time, apparently because this amino acid is converted to carnosine in muscle, where it acts as a hydrogen-ion buffer [1119]. The fact that supplementation with bicarbonate enhances anaerobic performance [1123 is an example] has always been the best evidence of the role of pH in short-term fatigue. Whether pH has a role in endurance fatigue is less clear; evidence from this conference with alanine [1998] and bicarbonate [2237] supplementation indicates no substantial role

Nutrition

A President's Lecture by Bente Pedersen on train-low compete-high was a paradigm-shifter. The "low" and "high" refer to **carbohydrate status**, not altitude. She presented her elegant research on single-leg exercise showing that endurance performance benefits from some training sessions in a glycogen-depleted state (Hansen et al., 2005). Sure, it wasn't sport-specific training in elite athletes, but sport scientists are scurrying to do those experiments. She also made many of us aware of interleukin-6 (Il-6) released by skeletal muscle as a potential mediator of the health benefits of exercise. Supplementation with drinks containing carbohydrate inhibits the release of Il-6, so she was critical about the sale of sports drinks in gyms. Go to her website for more.

A sports drink based on 4% **galactose** produced a bigger enhancement of ~90-min endurance cycling performance than "a pure glucose sports drink, blended carbohydrate sports drinks, one of which included caffeine, and placebo" [736]. Wow! (The sugar in milk--lactose--is digested to galactose and glucose, by the way.)

Protein or amino-acid supplements definitely help **recovery**. Four hours of recovery from 2.5 h of hard cycling with a protein-carbohydrate drink vs carbohydrate alone produced longer time to exhaustion in a subsequent performance test [1066]. A similar drink produced beneficial effects on muscle damage and improved performance following a single hard session with cyclists [1993], and 6 d of supplementation with such a drink between two cross-country races reduced muscle damage and soreness after the second race [1995]. In 8 well-trained athletes, a drink containing carbohydrate and hydrolyzed milk protein consumed in the 4-h recovery period after 2 h of hard exercise gave a 1.5% enhancement in speed in a subsequent 10-km cycle test in comparison with an isocaloric drink containing only the carbohydrate [1118]. Coupled with the effects of galactose, could milk be the best training drink? Training with supplements of branched-chain amino acids five times a day for 3 d reduced muscle soreness and blood markers of inflammation and muscle damage in a double-blind crossover study of 6 female and 6 male distance runners [1988].

But **protein supplements** aren't so good for **acute performance**. Consumption of a protein-carbohydrate drink at half time in a simulated football game wasn't as good as a straight carbohydrate drink for performance in the second half [1991]. Similarly, adding 1.6% protein to a 6% carbohydrate drink if anything impaired performance in a ~40-min time trial following a 120-min pre-load in 10 fairly ordinary cyclists [1392]. And athletes drink less when the drink has protein in it [1514].

Acute supplementation with the amino-acid **alanine** didn't do much for endurance performance (in a 15-min time trial after a 45-min pre-load) in trained cyclists: if anything the placebo was better than the various combinations of alanine and carbohydrate [1998].

At last, a believable positive outcome with **colostrum**! The athletes did a 40-km cycling time trial before and after 5 wk of supplementing with colostrum (n=14) or whey-protein placebo (n=15), then another 40-km time trial after an additional 5 d of hard training. The colostrum group had several apparently beneficial differences in immune markers, reduced incidence of upper respiratory symptoms (3/14 vs 8/15), much more saliva (!), and what looks like about 1.5% better time-trial time after the hard training [896].

Although it's not directly related to performance, it’s worth knowing that supplementing with **vitamin C** reduced the severity of exercise-induced asthma [2158]. Supplementing with **fish oil** had a similar effect [2160].

Tart cherry juice twice a day for 8 d reduced strength loss and pain in arm muscles resulting from a bout of eccentric exercise on Day 4 in a crossover study of 14 college students [2243]. Again, not exactly sport-specific exercise in competitive athletes, but it's pretty clear that natural foods rich in antioxidants and anti-inflammatories will help athletes train harder.

Echinacea supplementation raised erythropoietin by more than 50% over a 21-d period in a randomized controlled trial with 24 recreationally active males [2256]. There were no blood measures that would properly indicate erythropoiesis, and no measures of performance. I'd be surprised if it didn't work.

I'm skeptical about the claim in a Taiwanese study that **ciwujia** (Siberian ginseng) supplementation for 28 d enhanced time to exhaustion significantly by what amounts to 2.8% (which would be negligible if it's a constant-speed test) and increased maximum heart rate by an unheard of 13 beats/min [2232].

Sodium bicarbonate enhanced performance in each of three series of judo throws, each separated by 5 min of recovery [1123]. This finding shows that the extra bicarbonate is not "used up" in a bout of intense exercise: it regenerates for the next bout. Two protocols of sodium bicarbonate ingestion vs placebo produced "no significant differences" in time to exhaustion at 1500-m pace in elite middle-distance runners [2237], but there were only 6 of them and no performance data whatsoever, so who knows?

Caffeine doses of 80, 120 and 400 mg enhanced physical and mental performance in a team-sport simulation [731]. The sample size was probably too small (11, admittedly in a crossover) to conclude confidently that the effects were independent of dose. Confidence limits, please! In a thematic poster session on caffeine [1330-1335], there was no worthwhile effect of low-dose caffeine (2 mg/kg) on 100-m sprint performance of 15 elite swimmers [1330] or on 50-m sprint performance of 8 elite swimmers [1334]. Sleep quality suffered in the former study. Caffeine enhanced anaerobic performance represented by 30-s sprints and total weight lifted in a set of chest presses [1331]. It also reduced muscle pain during maximum voluntary activation of muscles already damaged by eccentric exercise [1332]. Finally, it enhanced forehand skill during a 60-min tennis simulation in 10 collegiate players, and if I read the faulty table correctly, it looks like backhand skill might have been better, too [1335].

Bad news for WADA, and good news for drug cheats: small doses of **testosterone** can enhance performance without producing a positive urine test in some athletes [2249].

Highlights of a thematic poster session on **hypohydration** and performance [1337-1341]… Mild hypohydration (3% loss of body mass) produced small detrimental effects on a resistance-training workout [1338]. Performance in a 2-h cycling time trial in the heat with a fan blowing was a little worse when the athletes drank too little (less than two-thirds of fluid lost) [1340]. Basketballers showed a substantial decline in sprinting and shooting performance with dehydration above 2% [1341].

Hyperhydration with **glycerol** produced what seems like a substantial increase (8%) in performance time in an incremental test following a 2-h preload in a temperate environment with some fluid ingestion during exercise [1513]. But with $P>0.05$, the authors concluded no effect.

Performance Genes

Variation in a gene related to **fat metabolism** and endurance performance (because its expression changes with training) was associated with marathon running performance [779]. The **ACE genotype** didn't predict performance level of Mexican marathoners [2089]. The **alpha-actinin** genotype didn't have much of an effect on strength of non-athletes [2084, 2090].

Tests and Technology

A symposium on the **science of cycling** was noteworthy for the practical application of modeling to performance enhancement. Jim Martin explained how you need only a mobile ergometer (SRM or PowerTap), an anemometer, and a test surface with a known gradient. You then perform several trials to get an estimate of the drag coefficient (effect of wind resistance). Put the numbers into the model and you can predict how changes in body mass, power output, drag, and pacing profile will affect time-trial time (Martin et al., 2006). Andy Coggan also explained his approach to condensing down the stream of data from a mobile ergometer in training or competition rides. He smoothes the data with a 30-s moving average, raises the resulting numbers to the 4th power, then averages the lot and back-transforms to a "normalized" mean power. (Download a chapter from USA Cycling's coaches' manual for details.) This number from a road race is similar to lactate-threshold power and time-trial power. But the 30 s and 4th power are arbitrary, and changing their values over reasonable ranges results in substantial changes (~5%) in normalized power. Maybe they need to be individualized.

A **soccer-specific running test** had a high correlation with VO_2max [1559], as did a test for **figure skaters** [1590]. More interesting were performance measures from a **soccer simulation** that had small errors of measurement and showed clear effects of supplementation with carbohydrate vs placebo [1588].

E-3 Fitness Grips don't do anything to improve **running biomechanics** [2207].

Front-only suspension is better than front and rear for **mountain bikes**, because of the difference in weight [2239].

We're always concerned that athletes don't put the same effort into lab tests as into real competitive performance, but maybe we don't have to worry so much: an unanticipated **monetary incentive** in the last of four 1500-m cycling time trials in the lab made little difference to performance in seven recreational cyclists [2696], but what about confidence limits?

There were the usual cross-sectional studies of **performance predictors**, for example in pole-vaulting [1565], mountain biking [1570], soccer [1580, 1585], cross-country skiing [1589], kayaking [1593], and football [1595]. Useful for talent identification?

Training

Training respiratory muscles by hyperventilating isocapnically (to prevent lightheadedness from loss of CO_2) improved endurance in 15 runners, although they needed a few days for their respiratory muscles to recover [740]. There was no information whatsoever about the training protocol, and was there even a control? Contact the author. Or use a device for **inspiratory muscle training**, 8 weeks of which improved mean power in a 6-min rowing test by 12% in an apparently uncontrolled study of 13 collegiate rowers, presumably in the base phase of training [1586]. There was a similar spectacular gain in intermittent sprinting with collegiate soccer players using a device that trains inspiratory and expiratory muscles [2152], although there were big individual responses. But beware: training only the expiratory muscles doesn't work, and combined inspiratory-expiratory training might not be as good as inspiratory only [2167].

There were no new insights into **overtraining** [1547-1549, 2148] or **tapering** [1574, 1584], although a taper of 3 wk might be better than 4 wk in swimmers [1622].

Use of an adjustable sling in a **core-stability training** program produced beneficial effects on performance in elite soccer players [1611] and junior golfers [1781].

Strength of college football players following an unspecified period of **complex training** differed little from that of players doing usual gym training [1613].

Here's something novel: do some sessions with a cuff to **restrict blood flow** to the legs. It raised the antioxidant markers in blood after 10 wk in speed skaters [1625]. No measures of performance.

This is cool too: in a case study of a nationally ranked powerlifter who had reached a plateau, two sessions of **forced-assisted reps** with a supra-1RM load increased 1RM bench press by 5% [1837].

An attempt to **model** (predict) changes in performance using measures of **fitness and fatigue** in swimmers wasn't successful [2585].

Low-cadence all-out **interval training** against high resistance is probably more effective than high-cadence interval training (gains in power output of 6-11% vs 2-3%) in highly trained road cyclists in their competitive season [2588].

Reviewer's Comment

Some further comments on the "train-low compete-high" President's Lecture… Dr Pedersen was reasonably certain about the health benefits of exercising on low carbohydrate for those at risk of the metabolic syndrome (obesity, insulin resistance, diabetes, cardiovascular disease…). But she included a question mark in the title of her talk to express caution in the application of her recent findings (Hansen et al., 2005) to athletes. This theme was taken further in a symposium on nutritional strategies by this reviewer (Louise Burke), John Hawley and Ron Maughan. Both John and I looked at the pros and cons of training in a carbohydrate-deprived state (low glycogen status, no carbohydrate intake during exercise) and concluded that there were more cons than pros, both in the effect on ability to train and the effect of the training stimulus on signaling pathways. Although the study by Pedersen's group has a cool design, John pointed out that it was "train 50% of the time low, compete high". Importantly, elite athletes periodize their nutrition: some sessions are done with good carbohydrate availability (usually athletes practice these strategies for the key sessions of the week), while it is more practical to do others after an overnight fast or without the benefit of aid stations. This mix may be important in optimizing the overall outcome.

See also commentary by Stephen Seiler.

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Published June 2006.