

Inadequate Sample Sizes in Studies of Athletic Performance at the 2012 ACSM Annual Meeting

David B Pyne¹, Will G Hopkins²

Sportscience 16, 1-11, 2012 (sportsci.org/2012/ACSM.htm)

1 Australian Institute of Sport, Canberra, ACT 2617, Australia; [Email](#). 2 Sport Performance Research institute NZ, AUT University, Auckland 0627, New Zealand; [Email](#). Reviewer: David T Martin, Australian Institute of Sport, Canberra, ACT 2617, Australia.

Featured Highlights with David Pyne: the best athletes, talent ID, exercise for aging, menstrual cycle, monitoring training, marathoners' immune systems, beetroot juice, statistical bloopers, modeling performance, London Olympics and Paralympics, hydration status, central fatigue. **Noteworthy Abstracts** with Will Hopkins: sample sizes, poor abstracts, cool and quirky strategies, accessing and using the abstracts. **Acute Effects**: pre-conditioning ischemia, stretching, post-activation potentiation, pre-cooling, warm-up, Cialis, transcranial stimulation, psych stress, recovery between sprints; clothing. **Correlates of Performance**: underpowered inconclusive studies, performance-enhancing genes. **Injury and Illness**: functional mobility tests, injury-prevention program, β -glucan for colds. **Nutrition**: spinach juice, beetroot juice, arginine and citrulline, garlic, β -alanine and bicarbonate, amylo maize, mouth rinsing, chocolate milk, deep-sea water, Sustamine, nicotine, caffeine, niacin, green tea, echinacea, tart cherry juice, HMB, creatine, betaine, vitamin D, colostrum, whey protein. **Tests and Technology**: Rotor Q-rings, optimum sprint cadence, active drag, shoe accelerometers, volleyball sprint test, rowing ergs, endurance hazard score. **Training and Overtraining**: reciprocal-action resistance, intervals, periodization of resistance, altitude, vision, PNF, heart-rate guided, heart-rate variability, cytokine markers, coach-crew collaboration. **KEYWORDS**: anabolic, elite athletes, ergogenic aids, nutrition, overtraining, tests, training.

[Reprint pdf](#) · [Reprint docx](#)

This year's annual meeting of the American College of Sports Medicine was held in San Francisco, May 29 to June 2. Your usual Sportscience conference reporter, Will Hopkins, did not attend the meeting, but he has summarized the abstracts from the [conference site](#) for this report. A colleague who did attend the meeting, David Pyne, has coauthored the report by providing first-hand accounts of keynote and other featured presentations, none of which have abstracts.

Featured Highlights with David Pyne

Sunny skies but cool conditions greeted delegates at the 59th ACSM Annual Meeting, back in the Bay area of San Francisco for the first time since 2004. The trend towards physical activity and Exercise is Medicine continues, but there is still plenty on offer for those interested in exercise sciences and sports medicine. Another apparent trend is the inclusion of more

feature events, forums, symposia and tutorial lectures rather than long sessions of short free communications. It is nice to hear from the invited experts, even if some recycling of older material and repetition of dogma rather than new insights is inevitable. The newer initiatives in online access to programs and abstracts worked very well, and the free wireless internet at the convention center worked seamlessly. The days of carrying the heavy abstract book appeared to the numbered—just as well with a total of almost 3600 abstracts on offer!

Of key interest to sports scientists was the special event on **Performance: What does it Take to be Better than the Best?** This session was chaired by the inimitable Dave Martin, with a panel of experts in sport science and sports medicine. Some novel ideas were promoted, including single arm and single leg exercise, weight-supported treadmill running and plyometrics (hopping). Illness prevention

was deemed a high priority around competition with strategies centering on eating, hydration, sleep, hygiene and reduced exposure—the notable case of the Norwegian Olympic team being discouraged from shaking hands was highlighted. Dietitians are promoting the need for strategic eating around training and competition, and they are evaluating the true cost-benefit analysis of supplementation programs. In terms of endurance sports there was no getting away from the importance of consistent aerobic training, well targeted high-intensity interval training based on [Seiler's concept](#) of polarized training (Seiler and Tønnessen, 2009), and a high motivation to succeed. In summary, it is crucial for the sport scientist to balance coaching requirements, source and deploy resources, and build coach rapport while focusing on performance outcomes. All these points made common sense although there was still some yearning to identify those interventions and strategies (individually or in combination) that have the biggest impact on competitive performance.

The perennial interest in **What Creates a Sporting Genius—New Concepts in Talent ID** was examined in a tutorial lecture. Some folk characterize elite athletes as very fit obsessive compulsive sociopaths. Jack Raglin contended that self-awareness as both a disposition and a skill can be developed in athletes, and emotions can be used to help performance. Elite athletes push themselves harder than the rest of us, as the natural human condition is for comfort and stability. Zig St Clair Gibson summarized the key requirements for talent as the need for good physique, good physiology, angry spirit and an overachiever. His presentation focused on case studies of top athletes: Cavendish, Armstrong, Wiggins. Whether these attributes hold up in other outstanding performers remains to be established.

Mark Tarnopolsky gave a very impressive president's lecture on **Exercise as a Countermeasure for Aging**. For those who love science and knowledge discovery and appreciate hard work, this was a smorgasbord of high-quality research. Much of his work has used a mouse model to characterize aging and muscle loss as a predominantly mitochondrial disease and to study the effects of exercise in reversing mitochondrial dysfunction. He presented some initial work investigating the optimal sequencing of endurance and resistance exercise: it

appears that resistance training should be undertaken first then endurance training to best maintain mitochondrial function. Although this recommendation is for the broader context of aging and physical activity, it probably tallies with anecdotal reports in the strength and conditioning community on preparing elite athletes.

Despite long-standing interest in the question of **menstrual cycle-based training** there is a paucity of studies. The physiology of the follicular and luteal phases have been well studied and perturbations observed in some highly trained athletes. Petra Platen summarized some of her laboratory's work and practical experience with these recommendations: periodize strength and endurance training during the follicular phase, taking an oral contraceptive should not have a large effect on coordinating different types of training within- and between menstrual cycles, and the ubiquitous take home message that more studies are needed.

One of the father figures in application of rating of perceived exertion (RPE), the indefatigable Carl Foster outlined his thoughts on the popular topic of **monitoring training**. He favors a keep-it-simple approach to monitoring internal and external load, and the benefit of visualizing data by way of figures or plots. The take home messages were "see the pattern of the training load not just the details", and identify and implement effective matching of the prescription and execution of the training plan or program. Oliver Faude indicated the utility of using stress, recovery and total stress scores in managing fatigue in football. High match exposure is tolerable provided training is periodized and recovery methods are implemented. Accumulated fatigue towards the end of the season is more problematic, and other internal and external stressors at an individual player level need to be considered. Maintaining fitness over the whole season was also seen as important.

Nutritional supplementation gets a lot of exposure at the annual meeting. David Nieman gave a spirited account of methods for **protecting the immune system of marathon runners**. Carbohydrate, polyphenols and flavonoids like quercetin have proven efficacy; colostrum, probiotics and β -glucan showing promise; but other supplements including vitamins, minerals, multi-vitamins, glutamine, fish oil, and ginseng lack support in well-controlled studies. A key

message was the interest in potentiation effects using a mixture of flavonoids, the so-called cocktail approach. Nieman also addressed the common concern about interventions interfering with the signaling mechanisms that underpin adaptations to training. He considers that aggressive supplementation might partially block some adaptations by taking the edge off the effectiveness of training, which opens the way for a periodized approach: *loading* blocks with no supplements then *performance* blocks with supplements. But he was still of the view that nutrition targeted at the immune system was an important means of supporting athletes in heavy training.

The contribution of the late Brian Whipp to exercise science (and respiratory physiology in particular) was recognized in a featured science session on the oxygen cost of exercise. The prolific group at Exeter University in the UK delivered a series of presentations on various effects of nitrate-rich **beetroot juice supplementation**. The detrimental effects of hypoxia can be attenuated by dietary nitrate, although the effects of nitrate diminish in healthy older individuals. Pacing, short-term training, nutritional interactions and exercise performance can all be influenced by nitrate supplementation via alterations in oxygen kinetics and cost. Although there is substantial interest in beetroot juice, there is a need for some basic chemistry to assist non-experts navigate their way through the nitrate to nitrite to nitric oxide pathway, and conversion of L- arginine to nitric oxide.

On the statistical front (close to the heart of this journal!), Alan Batterham gave an informative and entertaining tutorial on **statistical bloopers in reviewer comments**. Well, we have all been there. Alan outlined three common reviewer bloopers: confusing measurement error with minimum important difference, calling for the post-hoc observed power, and the perennial "is it significant or not?" The strategies he suggesting for reducing incidence of such bloopers were: improving the training of reviewers and editors; implementing an open review process; implementing a reviewer reward structure; and appointing statistical advisors and editors to journals. Alan recommended that authors include an up-front statement outlining the benefits of a more progressive analytical approach in the methods section and/or cover letter with submission or grant applica-

tion. There are lots of supporting studies of contemporary approaches (and the shortcomings of hypothesis testing) in a range of disciplines from biomedicine, psychology, sports performance, and econometrics. Getting in first with the heavy artillery might be more effective than wrestling with reviewers and editors after the first review.

The balance between **modeling and experimental work** in exercise and sports science was addressed by Jos de Koning using pacing related to speed skating. The concept of the hazard score—the product of perceived exertion and the relative percentage of distance remaining—may be useful for studying pacing. Jos was happy to concede that experienced athletes self-select a pacing strategy close to the theoretical optimum, so perhaps the education and upskilling on pacing is best directed towards the younger and more inexperienced athletes. Although models relating air and ice resistance are useful, more work is needed to quantify the effects of fatigue.

Given the close proximity of the annual meeting to the **London Olympic and Paralympic Games**, it was appropriate to hear about forward planning in a conversational forum chaired by the highly regarded Randy Wilber. The audience heard about the planning and attention to detail of the US Olympic Committee, particularly the work of Bill Moreau and his team in the area of sports medicine. Athlete location for doping control, stem-cell therapy and measles are issues occupying the attention of the US officials and staff. The conversation on the Paralympics was focused, as it often is, on the contentious issue of athlete classification. Some spirited questions from the floor highlighted the challenges facing the Paralympic organization, national teams, as well as individual athletes and their coaches.

New insights in the **assessment of hydration status** were addressed in a tutorial lecture presented by Neil Walsh and Larry Armstrong. Recent experimental work is evaluating the utility of using salivary and tear osmolality as alternative markers to the traditional measures of urine and plasma osmolality. Plasma osmolality is not the gold standard measure of hydration status that many believe it is, owing to substantial error variance. Methodological shortcomings in the saliva collection procedures in many studies may be masking some of the

true effects of interventions. Sample flow rates, swallowing, oral stimulants, and mastication or orofacial movements (including conversation) need to be well controlled. Ocular measures of hydration may be more useful in the research laboratory than the field, but new methods for intraocular pressure, tear osmolality, tear break-up time, and tear secretion might have some application in the future. The presenters finished with the idea that selection of hydration markers should reflect the nature of the activity and setting rather than pinning one's hope on a single marker.

The enigmatic title of *Back to the Soup and Sparks* introduced the issue of **central fatigue**. The leading figures of Romain Meussen and Zig St Clair Gibson did the honors on neurotransmitters and electrical activity respectively. Although studies have described extensively both brain and CNS outputs, the regulation of complex activities such as cognition and emotion is still poorly understood. Current measurement techniques have limitations and multiple definitions of fatigue muddy the waters. A detailed understanding of factors influencing central fatigue and how to measure them is still emerging.

Noteworthy Abstracts with Will Hopkins

My biggest complaint this year is the woefully inadequate sample size in so many studies. No matter what the design, in my view you need a minimum sample of 10 to be confident about applying the effect to other similar subjects. A sample size of 10 in a crossover will also give adequate precision if the effect is big enough or the dependent variable has an error of measurement smaller than the smallest important effect. Most of the time, though, effects are small or trivial, and the error of measurement is large, so you need many more than 10 subjects. And if the design is a parallel-groups controlled trial, you need at least *twice* as many subjects in *both* groups. If the design is cross-sectional (one observation per subject), you will usually need ~10x as many subjects again. Furthermore, these are the sample sizes required for magnitude-based inferences; that is, for adequate precision in relation to smallest important positive and negative (or beneficial and harmful) effects. If instead you stay with the traditional 80% power for 5% significance with the smallest effect, you will need another

three times as many subjects. See my article and spreadsheet on [sample-size estimation](#) (Hopkins, 2006) and the article/slideshow on [research designs](#) (Hopkins, 2008) for more. Little wonder, then, that conference delegates and eventually manuscript reviewers can't be bothered with studies involving groups of less than 10 subjects, especially cross-sectional studies.

Yes, yes, I know: research students are more likely to get funding to attend the conference if they present something, and of course ACSM and other major conferences provide young researchers with valuable inspirational experiences. But what wrong message do these impressionable young people get from poster after poster with small sample sizes? These sample sizes must be OK.

My other complaints about the abstracts are the usual ones...

- Non-significance in grossly underpowered studies is almost always misinterpreted as *no* effect. The correct interpretation depends on the confidence interval in relation to smallest important effects: *unclear* if the interval overlaps substantial positive and negative, *clear* otherwise. That's a start, anyway; a full interpretation depends on probabilities the effect is substantial.
- Conclusions are often incorrectly based on a difference in significance rather than a significant difference. Extreme example: $p=0.04$ in the experimental group vs $p=0.06$ in the control group is misinterpreted as significant! The p value for the comparison would be close to 1.00, very non-significant.
- Use of p -value inequalities is unforgivable these days, but let's get rid of p values and statistical significance entirely.
- Use of confusing author-defined abbreviations seems to be based on the mistaken notion that it's cool and scientific. The word limit is no excuse for writing an incomprehensible abstract.
- Also annoying: typographical errors, missing words, and omission of vital information, including sometimes the complete absence of any effect statistics.

If the conference organizers continue to accept substandard abstracts without feedback for improvement (understandable with such a large conference), perhaps they should include a checklist that the authors have to tick off on-

line before the abstract is able to be submitted. The policy of automatically accepting abstracts co-authored or sponsored by a fellow of ACSM may also need revising, or maybe the fellows need more guidance.

The reviewer (Dave Martin) "wondered if it would be worthwhile to highlight one or two abstracts that get a Will Hopkins gold star—a statement that some competent researchers are out there and there is hope." I checked only my picks in the next two paragraphs, and the best I can award is a bronze star to the study of the effects of [tart cherry juice](#) on sleep. It wasn't done on athletes, baseline data are not reported, and there are no magnitude-based inferences, but it had the acceptable minimum sample size, and outcomes are reported with confidence intervals.

Here is my pick of cool **performance-enhancing strategies** you can apply immediately: the findings in the [meta-analysis of post-activation potentiation](#); use of [precooling](#) after the warm-up; the right [clothing](#) for hot humid conditions; a [warm-up program](#) to reduce injuries in females; [β-alanine plus bicarbonate](#) for anaerobic performance, especially with the arms; [vitamin D](#) supplements for sprint performance of athletes deficient in vitamin D; [whey protein](#) for long-term strength development; [Rotor Q-rings](#) for cyclists; [altitude camps](#) ending no less than 3-4 weeks before a competition; and [collaboration](#) between coach and support crew for reducing injuries and enhancing performance. And don't forget caffeine and the right kinds of carbohydrate!

And here are a few **quirky or promising strategies** to watch closely or research yourself: [pre-conditioning ischemia](#) in both arms prior to leg performance; a [yeast extract](#) to reduce upper-respiratory symptoms; [spinach juice](#) for exercise lasting at least half a minute; [green tea](#) acutely for endurance; [tart cherry juice](#) for sleep; [optimum cadence](#) for sprint cyclists; medium-term [reciprocal-action resistance training](#) for strength; and [PNF stretching](#) for ballet dancers.

You can **access the conference abstracts** in three ways. First, [this page](#) has a menu of links to separate PDFs for the different types of session, and [this link](#) downloads the entire conference proceedings (20 MB). Secondly, register on-line via [this link](#) and use the advanced search form to create and download a PDF of

your own "itinerary". The keyword search is a hit-and-miss affair, because it uses keywords provided by the authors, but you can use the search form to find abstracts featured in this report via the number in brackets [...]. Finally, the abstracts are published in the [May supplement](#) of *Medicine and Science in Sports and Exercise*, where you can browse the sessions from the Table of Contents. Find an abstract by clicking on the Advanced Search link, putting the abstract number into the Keywords box, limiting the search to Titles, entering the volume number (44) and issue number (5), then clicking Search.

Use one or more of the PDFs of abstracts to **review the conference** in the following manner, as recommended in previous conference reports... Get a small group together with an interest in a specific sport or topic, set up the PDF on a big screen, search for the sport or other keyword (using the full Acrobat search form via Shift+Ctrl+F), then skim each resulting hit skeptically. For those abstracts summarized below, see if you agree with the critiques. (I have provided some longer critiques than in previous reports, for this purpose.) You will find this exercise entertaining and valuable if and only if you are a good sport scientist.

Acute Effects

In a seemingly bizarre study prompted by research on heart surgery, **ischemia** (cutting off the blood supply) in one arm before an incremental cycling test with the legs produced a non-significant 2.2% enhancement in peak power in a crossover with 9 highly trained male **cyclists** [2157] at sea level (but a 0.8% impairment at a simulated high altitude). Naturally we got the usual conclusion of no effect, but the authors did suggest trying ischemia in more muscle, presumably *both* arms. Well worth trying, but how can you eliminate the placebo effect (which has a similar magnitude and which is problematic in studies where you can't conceal the treatments)? Tell the athletes you're investigating fatigue signals from hypoxic muscles?

Static stretching and proprioceptive neuromuscular facilitation (PNF) continue to have harmful effects on performance, here on knee peak torque in **female athletes** [997].

In a **meta-analysis** of 141 effects of **post-activation potentiation** in 31 studies, the biggest improvements in explosive or sprint power

came from multiple sets of moderate-intensity conditioning exercise followed by 3-7 min of rest before the performance test [593]. "Biggest" means a standardized change of ~1.0 (i.e., one baseline between-subject standard deviation, which is *moderate* on my scale) compared with some kind of control, presumably generally a steady warm-up. Hopefully the authors will present the effect in percent units in the full paper.

I found two original studies of **post-activation potentiation**. In one, effects of various protocols on various measures of performance had no significant effect with or without vibration [599]. Unfortunately there were no data for me to make a better assessment in this cross-over study of 15 male **athletes**. The protocols looked OK, so some of the effects might have been clinically significant. In the other, there was a 1.5% benefit for sprint speed in a cross-over with 7 collegiate **football** players [3273].

The title states that "**precooling** does not improve 2000-m rowing performance of **females** in hot, humid conditions", but the 8 physically active females went 1.6% faster after 20 min of precooling with a lower body cold-water shower compared with passive rest [1952]. The authors even tried to explain "the lack of performance enhancement" by invoking skin and core temperature changes.

A **warm-up** could offset the benefits of **precooling**, hence this crossover study of effects of precooling+warmup, warmup+precooling (i.e., reversing the order), and control (no precooling or warmup) on performance of 7 trained **runners** in a 5-km time trial in unspecified environmental conditions [995]. Compared with control, subjects ran 1.1% faster with warmup+precooling and 0.3% slower with precooling+warmup. Wow! Obviously you should precool *after* the warmup. Now we need to see whether it's worth even bothering with the warmup when you precool, in a sample size of at least 10 please, and don't show those pointless between-subject standard errors next time.

Don't **warm up** with lighter or heavier softball bats: subsequent swing speed is slower than with normal bats in female varsity **softball** athletes [2267].

Warming up was beneficial for 16 modestly trained **cyclists** completing a 5-km time trial in

a crossover of a short warmup, a long warmup, and a control of no warmup [996]. Both warmups showed similar enhancements of ~4% in time and mean power output. The effects were not significant (" $p>0.05$ "), but they should have been, with a sample of that size in a crossover, especially with a familiarization trial. Something must have been wrong with the ergometer: for $p>0.05$ I calculate a typical error of >5.3%, which is way too high. In any case, the ergometer was not simulating bike riding properly, because the percent effects on time should have been less than half those on mean power.

An enigmatic **cooling product** enhanced mean power in a 30-km time trial by a useful but unsurprisingly non-significant 1.4% (0.4% for time) compared with control in this crossover study of 7 male **cyclists** exercising at 30 °C and 60% humidity [3374]. Given the increasing recognition that perceptions of effort and discomfort of various kinds have on performance, this result is believable, but... blinding for this sort of treatment is impossible, and placebo effects are of similar magnitude.

If anything, the vasodilator **tadalafil** (sold as Cialis, a drug like Viagra) impaired peak power output in an incremental test in a placebo-controlled crossover of 12 **men** [1828], so don't count on it enhancing every kind of physical performance, guys.

Transcranial direct-current stimulation increased incremental peak power by a clear 1% in a crossover with 10 national-level **cyclists** (but peak power was only 300 W) [1896]. I wonder if you can build secret electrodes into a bike helmet.

There were no data in the abstract—not even a sample size—but in this crossover study of **psychological stress** on ball serving in **tennis**, "intriguingly, surveillance by a famous tennis star [compared with a normal spectator] has no effect for elite players but appears to be stimulatory in ball serving performance for ordinary tennis players" [1882]. I would like to see an analysis for individual responses.

Should **swimmers recover** in or out of the water between repeated sprints, if they want to get the best out of each sprint? Unfortunately you can't tell from this abstract, because the researchers reported the mean sprint times only for the group that showed significant changes, and the times (~5 s for 50 m, presumably free-

style) are impossible [1341]. If they had done the study as a crossover, they might have got a clear outcome with a proper inferential comparison.

There were several studies of physiological effects of **cold-water immersion**, but I could find nothing on use of this recovery strategy for performance.

In this crossover study, 8 average **runners** had lower skin temperature during a 45-min submaximal pre-load run at 30°C and 50% humidity with **clothing** designed for low air resistance and high "overall moisture management capacity" than with control clothing (not described). The runners then went 8.3% faster in a 1.5-km time trial [1951]. Note that the gain in a time trial without the pre-load would be a lot less.

Apparently it was double blind, so we have to give some credence to the claim that a T-shirt made from a **"nanobionic" textile**, which apparently reflects far-infrared rays back into the body, enhanced VO₂max by 4.3% in this crossover study of 11 female and 11 male **active subjects** [3377]. There's a substantial proof-reading error in the abstract, adding to my suspicion that this study will be one for the Journal of Irreproducible Results.

Last and definitely least, **EnergyCare bands** worn around the ankles (?) had little apparent effect on various measures of short-term performance in an evidently well-designed but seemingly pointless crossover study of 13 college-age **males** [3378]. From the manufacturer's website: "Our durable Sports Band contains Atraxlite™ technology, [which] facilitates the molecular alignment process..." I wouldn't waste my time researching something so obviously fake.

Correlates of Performance

Several potentially interesting studies of performance predictors were done with sample sizes that were woefully inadequate for their cross-sectional design. If you are going to measure athletes on only one occasion, you need hundreds of them for adequate precision of the inevitably small effects. You *can* get somewhere with 10-20 subjects in *monitoring* studies, in which you have repeated measurements of the athletes and you investigate relationships between *change scores* of predictors and performance using within-subject or mixed-model analyses. The resulting outcomes are

more applicable to individual athletes, too.

Here is a selection of such underpowered inconclusive correlational studies relating parameters and performance: joint **range of motion** and either incremental or 30-s Wingate peak power in 9 **cyclists** [1559]; **aerobic parameters** and 10-km running performance in 31 **subjects** [2895]; an incremental test plus **accelerometry** and running performance in 7 **cross-country runners** [2896, 2897]; **cycling economy** and 3-km track time in 11 **cyclists** [3000]; turn parameters and turn speed in 6 elite free-style **swimmers** [2980]; various novel measures of **within-subject variability** in running speed, stride length and stride frequency measured with an "accelerometric device" during a race and race time in 21 **half-marathon runners** [1438]; **principal components analysis** of various measures and sprint performance in 22 **soccer** players [2262].

The correlational studies of **performance-enhancing genes** were more conclusive, but the differences in frequencies of the allelic variants between athletes and controls are probably not high enough to make testing for such genes a useful component of talent identification, not yet anyway. The I allele of the ALP gene (which codes for a muscle protein that interacts with alpha-actinins in muscle) is relatively less prevalent in controls than in athletes of various sports, especially **track & field, cycling and rowing** [1810]. A polymorphism of one of the actinin genes itself is more prevalent amongst elite Japanese **track and field athletes** specializing in sprint or power, but not endurance [1815, 1821], and there are athlete-related associations with some single nucleotide polymorphisms (SNPs) [1816]. Polymorphisms of the actinin and other genes explained some differences in strength among elite Italian **soccer** players [1819]. Several SNPs are associated with physical performance in **children** [1811].

Injury and Illness

The popular functional movement screen and a novel basketball-specific set of **functional mobility tests** were poor predictors of **injury** risk and performance in 119 collegiate **basketball players** [1216]. The functional movement screen was also ineffective with 122 collegiate **athletes** [2890].

"Pre-season fitness and **musculoskeletal screening measures** were found to be [trivial] predictors of time to **injury**" in 118 male and

143 **female athletes** in various sports, but females had twice the risk (incidence rate) of males in this simple uncontrolled prospective monitoring study [1217].

"Eight sessions of a 20- to 30-min warm-up **injury-prevention program** improved player jumping biomechanics by increasing knee width and flexion when landing" in this uncontrolled underpowered study of 23 young **female soccer players**, but there was a promising absence of injuries over a season [1218].

A **β -glucan supplement** extracted from baker's yeast reduced the number of days of **upper-respiratory symptoms** following a marathon in a randomized placebo-controlled trial of 184 **runners**, but this sample was only 57% of those asked to complete the questionnaire, and no data are shown [1376].

Nutrition

In a placebo-controlled crossover study of 7 **males** inspired by Popeye the Sailor, 6 d of supplementation with **spinach juice** enhanced 30-s Wingate mean power by 6.9%, submaximal work to exhaustion by 42% (about 3% in a time trial, by my estimation), and the last three of a set of five 6-s sprints an unspecified amount, but had little effect of maximum isometric torque [1823]. The researchers suggested **nitrate** as the agent responsible, but made no mention of any Popeye-style acute muscle hypertrophy!

Beetroot juice enhanced performance time in a 50-mile time trial by a statistically non-significant but usefully small 0.8% compared with **nitrate**-depleted placebo juice in 8 trained male **cyclists** [1824]. In a similar study with 14 elite male **rowers**, the effect on mean time for six 500-m sprints was a marginally clear beneficial 0.4%, but much clearer in the last three sprints (1.7%) [1829].

A supplement combining the amino acids **L-arginine** and **L-citrulline** might work via the nitric oxide system like nitrate supplements, but it had trivial effects acutely when 12 student **participants** tried it before an incremental test [1843].

Massive consumption of **garlic** for a week could have enhanced endurance performance in hypoxia (e.g., at altitude) by improving blood oxygenation via dilatation of arterioles in the alveolae of the lungs, but there was little effect in this crossover study of 10 **males** [2147].

Supplementation separately with **β -alanine**

and **bicarbonate** enhances sprint performance (probably via increased intracellular and extracellular buffering), but are their effects additive? They were in this study of 30 **athletes** randomized blindly to either, both or neither (control), with unspecified performance (presumably total work) in four upper-body Wingate sprints assessed pre and post an unspecified period of supplementation [1837]. The effects were much greater than the usual 1-3% seen with lower-body performance: 7% for either treatment and 17% for both, with control only 0.3%. In a similar study of cycling performance with 14 active **students**, the effects weren't nearly as large or clear, but the reporting of results is deficient [1836]. Buffer boosting may be more effective in the arms than in the legs.

Carbohydrate in the form of "**amylomaize-7**" ingested prior to a preloaded ~15-min time trial produced a statistically non-significant enhancement in performance time equivalent to 2.3% in mean power relative to no-carbohydrate placebo, whereas dextrose (glucose) produced a 1.2% impairment in this crossover study of 10 trained **cyclists** [2328]. You guessed it: amylomaize "did not offer an additional performance advantage". I'd use it on the strength of this evidence.

"Consuming a novel, **carbohydrate-free recovery beverage** for 18 days prior to high intensity resistance exercise can significantly reduce muscular fatigue and ratings of perceived exertion" in this parallel groups trial of 40 **subjects** [2348, 2349]. The beverage in this company-funded research is not described.

Mouth rinsing with carbohydrate does [2351] and does not [2352] enhance endurance performance in active **subjects** and **cyclists** respectively. Swallowing it is better, anyway [2352 amongst others].

Serum creatine kinase (a marker of muscle damage) was lower following muscle-damaging exercise in a crossover when the 8 recreational male **athletes** consumed fat-free **chocolate milk** vs a chocolate whey protein drink [1854]. There were "no differences" in performance. The study is notable for the development of an exercise protocol that induced muscle damage reproducibly with an unspecified period between tests.

Chocolate milk was only as good as other non-dairy chocolate drinks and milk for recov-

ery of endurance performance of **cyclists** and active women after glycogen-depleting exercise [2344, 2360, 2362].

With the exception of some extraordinary claims for the effects of deep ocean-based desalted **mineral water** on oxidative damage, rehydration and performance [3013, 3015], I could find nothing unusual in the abstracts on sweating and fluid imbalance.

The authors don't say how **L-alanyl-L-glutamine** ("Sustamine") is supposed to enhance performance when you add it to your water bottle. The company's website claims that this dipeptide enhances water and electrolyte absorption, glycogen synthesis and protein synthesis. Hmm... Anyway, the promising outcomes in this crossover study with 10 female **basketball** players were too inconsistent to get excited about [1841].

In a crossover study of 9 active **males**, **nicotine** chewing gum improved isometric and eccentric leg extensor force, but peak power in a 30-s Wingate test was impaired [3083]. No data, just p-value inequalities.

Relative to decaffeinated coffee and placebo, **coffee** and **caffeine** (5 mg/kg) had similar effects (~4%) on time in a time-trial lasting ~40 min following a 30-min preload in a crossover with 8 trained male **cyclists** [2781]. In other studies coffee has been less effective than caffeine.

In a study of the effects of **caffeine** (6 mg/kg) on diurnal changes in strength of 12 highly **resistance-trained men**, caffeine taken before testing at 10:00 am enhanced performance by 5-6%, effectively equaling the enhancement of 5-8% normally seen at 6:00 pm [2793]. The researchers did not study the effects of caffeine at 6:00 pm.

The proportion of successful **tennis** strokes increased from 89% with placebo to 91% with **caffeine** (6 mg/kg) in this crossover study of 18 female and male collegiate players [2774]. Polymorphism of a particular gene modified the effect of caffeine a little here and in cycling performance [2778].

Caffeine (6 mg/kg) was more effective in AA homozygotes than in those with one or two C alleles of the CYA1P2 gene: 4.6% vs 2.6% in 40-km time-trial time of male **cyclists** [2778].

I guess I have to report a study showing a *harmful* effect of a **caffeinated** commercial energy drink on performance: the 6 **runners**

were 2.3% slower in a 5-km time trial on Organic Energy Shot (140 mg caffeine) than on an unspecified placebo [2788]. Is there something nasty in this drink? The runners were a bit slower on Red Bull (80 mg caffeine), too, although it was ergogenic in another study [2789]. There were several other studies showing positive effects of caffeine [2786, 2787, 2794].

Niacin (vitamin B3) had the opposite effects of caffeine on fatty-acid metabolism and **endurance** performance in this crossover study of 17 untrained **males** [3160]. This finding might make you think twice about taking multivitamin supplements.

Once again statistical non-significance could be hiding a beneficial effect from researchers brain-washed with traditional inferential statistics. Here 14 d of supplementation with **green-tea extract** vs placebo produced a valuable 2.8% enhancement in performance of a 10-km run following 1 h of a preload at 50% of VO₂max in a crossover with 9 reasonably fit competitive **runners**. The authors wrongly reported the outcome as "similar" time-trial times and "no difference in performance" [1368].

Echinacea supplementation didn't act like EPO (as it has in previous studies) in this randomized controlled trial of 24 **males** [1379]. Well, the only result is $p > 0.05$, so who really knows?

Tart cherry juice vs placebo consumed for 7 d resulted in a clear increase of 39 min in sleep time and improvement in a measure of sleep efficiency in a randomized parallel-group trial of 20 **volunteers** [1390]. Melatonin might still be better for acute jet lag.

The potentially anabolic amino-acid **HMB** (β -hydroxy β -methylbutyrate) had mainly non-significant effects (no data shown) on various measures of strength in this parallel-groups randomized controlled trial of only 14 **athletes** (7 in each group is not enough) [1845]. I am worried that the only non-significant effect, on Wingate peak power, was a Type I error. Also, only post-test means are shown in the abstract. Didn't the authors analyze change scores?

Of the two **creatine** studies directly relevant to performance, one was positive [2381] and one was not reported well enough for me to decide [2615].

In my report on the 2007 ACSM meeting I got excited about the amino-acid **betaine**,

which mimicked creatine and had similar positive effects on strength and power following 14 d of loading. Alas, any such ergogenic effect did not translate into an anabolic effect when betaine was consumed during 8 wk of resistance training in a randomized controlled trial with 11 college-age **males** [3552]. At least twice as many subjects next time, please.

In a randomized controlled 4-wk trial with 36 male endurance **cyclists**, half of whom were **vitamin-D** deficient, the 9 cyclists who received the highest dose of vitamin D had the greatest increases in 1RM leg strength and Wingate peak power, but there was apparently little effect on a 1-h time trial [3557]. There aren't enough data in the abstract for me to assess percent effects.

The 12 **males** who received **bovine colostrum** after training sessions for 8 wk edged ahead of the 12 who received isocaloric control for increases in squat strength (40% vs 36%), but there was little difference for other measures of strength, body composition and muscle damage [1856]. Type I error?

In this really tidy parallel-groups study, 41 previously non-resistance-trained **men and women** randomized to **wehey protein** supplementation for 9 months of resistance training gained more lean mass (3.3 kg) than those who received soy protein (1.8 kg) [1853]. It's reasonable to conclude wehey is more anabolic than soy for already trained individuals.

Tests and Technology

The **Rotor Q-ring** is a non-circular chainring that alters the transmission of force to the chain during the pedal cycle. In this uncontrolled study, 8 male **cyclists** were tested with usual cranks before switching to Rotor Q-rings for 4 wk of testing and training. The cyclists performed a 1-km time trial ~2% faster throughout the 4 wk, and performance returned to baseline when they switched back to a circular chain-ring [3579]. Conclusion: switch to Rotor Q-rings!

Does the **pedaling cadence** that produces maximum power output in sprinting depend on whether you sit or stand on the bike? To find out, these researchers modeled the power-cadence relationship with 8 junior elite **cyclists** at a velodrome [1931]. Maximum power output was obviously higher (by 17%) when standing on the pedals, but more importantly, optimum cadence was lower (113 ± 11 vs 120 ± 7 rpm,

mean \pm SD). Now, how closely do top cyclists keep to their optimum?

I can't understand the description, but it looks like a new method of measuring **active drag** with **swimmers** has less error of measurement than the usual method [1907].

There's no need to change the protocol for the 7x 200-m **swimming** incremental **step test** [1908].

The validity of **accelerometers** attached to a **running** shoe (the Adidas Micoach and Nike+ Sports Kit) for monitoring speed and distance was reported in terms only of significance of mean differences from true values [2087, 2088, 2089, 2090]. What about the random errors? These devices may be really noisy.

A **sprint test** specific for **beach volleyball** has good reliability and convergent validity [2275].

In a comparison of performance in an incremental test and a 4-min time trial by 13 male **rowers** on a **Concept II** and **Rowperfect** rowing ergometer, it looks like the ergs display different power output and distance traveled for the same physiological intensity [3477]. No data, just p-value inequalities.

Tweaking perceived effort by multiplying it by the percent of distance remaining made its appearance as the **hazard score** in several studies of **endurance** performance [1433, 1437, 1563].

Neural-net analyses were noteworthy for their absence from studies of athletic performance, but they were applied successfully to categorizing **physical activity** in the stream of data coming from accelerometers [1031,2899].

Training and Overtraining

They were presumably only 29 **untrained young men**, but it's a novel finding about a kind of medium-term potentiation: when they were randomized to three days of control (no training), usual concentric resistance training, and **reciprocal-action resistance training** (legs moving in opposite directions), the reciprocal-action group showed greatest gains in peak torque [594].

How come researchers in a top lab led by Jens Bangsbo are still reporting standard errors rather than standard deviations? What's even worse, the outcomes were reported as a difference in significance in the two groups, not the significance of the difference: 5-km performance time improved by 3% in the 10

male+female **runners** who did **interval training** for 7 wk, whereas "no changes were observed" in the 8 control runners doing normal training [1538]. Sigh... Anyway, we already knew interval training works, here presumably in the build-up, but the new finding is that changes in blood cholesterol appeared to be better in the interval group.

Not surprisingly, 10 wk of **interval training** improved maximum oxygen uptake better than steady running in a controlled trial with 27 recreational endurance **runners** [1107]. But surprisingly, 10 wk of high-intensity **interval training** was only as good as usual training for various measures of performance in high-school **soccer** players [2258]. The findings are inconclusive, because more than half the subjects dropped out.

In a study of weekly **periodization of resistance training**, hypertrophy, power and strength sessions on Monday, Wednesday and Friday might have been better than hypertrophy, strength and power for increasing maximal strength in already well-trained **powerlifters**, but there were only 9 and 6 subjects in the two groups [592].

On Days 9-10 following a 28-d live-high train-low **altitude** camp, performance of 6 elite male distance **runners** over an unspecified distance dipped 0.4% below their pre-altitude best, but on Day 26 they were 0.6% faster, which fits with anecdotal experience of coaches [2158].

Vision training in collegiate female **softball** players "did not appear to translate into enhanced batting capabilities" [2283]. No data.

Eight weeks of **proprioceptive neuromuscular facilitation** (PNF) added to the training sessions of 34 **ballet** dance students produced significantly greater active range of motion than occurred in a control group of 23 dancers [3508]. P values only.

Use of Polar **heart-rate monitors** and software to guide training load apparently reduced training intensity with "no significant differences in any performance marker" in this 8-wk

parallel-groups controlled trial with 11 female and 11 male **cyclists** [1557], but no relevant data are provided.

I was beginning to think that a decrease in resting heart-rate variability might be a reasonable marker of incipient **overtraining** or at least lots of **training stress**, but here's a study of 11 elite **swimmers** showing just the opposite [2990]. Are there any useful markers of overtraining?

In comparison with 24 controls (mainly elite rowers), 24 elite **overtrained athletes** (mainly rowers, runners and soccer players) had plasma concentrations of two inflammatory **cytokines** IL-1 β and TNF α that were moderately elevated (by approximately one between-subject standard deviation) [1132]. Interesting, but is it worth testing for these cytokines in a suspected case of overtraining? Would dietary antioxidants or anti-inflammatories help?

It's only a case study of one collegiate **baseball team**, but the authors attributed a reduction in injuries and increase in wins over a 5-y period to "a **collaborative effort** between sport coaches, sport medicine and sport science departments" [3070]: a great positive note on which to end this report.

Acknowledgements: High Performance Sport NZ commissioned a report from WGH. DBP received an institutional travel grant. Thanks to the reviewer, Dave Martin, for various insightful comments and useful additions to this report.

References

- Hopkins WG (2006). Estimating sample size for magnitude-based inferences. *Sportscience* 10, 63-70
- Hopkins WG (2008). Research designs: choosing and fine-tuning a design for your study. *Sportscience* 12, 12-21
- Seiler S, Tønnessen E (2009). Intervals, thresholds, and long slow distance: the role of intensity and duration in endurance training. *Sportscience* 13, 32-53

Published June 2012. ©2012