The Triumph of Technology for Athletes at the 21st Annual Meeting of the European College of Sport Science

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The conference, if not Vienna, lived up to expectations. Sport technology was a highlight. Accessing Abstracts and Videos: links to the downloads. Presentations with the Wow Factor: fiber typing, injury prevention, diets, ethics, technologies, and training. Acute Effects: fiber typing; post-activation potentiation; vibration; re-warmup; stretching; coasting downhill; recovery; foam rolling; fatigue; visual search strategy; blue light; sprinters' blocks; anxiety; testosterone patches. Injury: FIFA 11+ Kids; ACL in football, basketball, floorball; ulnar ligament in baseball; rates and prevention in skiing; shoulder in tennis. Nutrition: high carb vs high fat; periodized carb; beetroot juice and nitrate; hypotonic drinks; fish-oil recovery drink; hydrogen-rich water; low food-acid diet; caffeine; β2-agonist; paracetamol; zeolite; creatine; beta-alanine; beef protein; NAC; polyphenols; anti-oxidants; vitamin D. Performance Analysis and Monitoring: tools for big data; football; rugby union; rugby league; heart-rate variability; volleyball; basketball; tennis; swimmers; kayakers; bobsleigh; decathlon; hammer throw; fencing; taekwando; Frisbee. Talent Identification and Development: policy transfer; Aspire Football Dreams; rugby union draft camp; Russian genes. Tests and Technology: ethics; innovative technologies; deep learning; new GPD unit; functional movement screen; soccer passing test; acceleration; heart-rate variability; visual simulator; volleyball test; 1RM estimation; jump mat; cell-free DNA. Training: genotype-enhanced in soccer; muscle stimulation; mindfulness and load in basketball; small-sided games and core training in handball; meta-analysis of complex training; high-intensity interval and repeated sprint in youth soccer; intermittent hypoxic in team sports; hypoxia/heat in football; altitude in race walkers; hypoxic swimming in triathletes; meta-

analysis of strength for endurance; strength for ultra-marathon; interval for cyclists; blood-flow restriction. KEYWORDS: competition, elite athletes, ergogenic aids, nutrition, performance, talent identification, tests, training.

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Vienna is usually on the podium when the contest is the best city in the world, so it was inevitable that my expectations for the city were unrealistically high. The Danube wasn't blue, I don't really like Mozart or Johann Strauss, and my apartment and the area it was in were a tad on the shabby side of chic. But the underground was incredibly efficient, the first-hour-free bikes were conveniently sited nearly everywhere, and there were heaps of grand old buildings. With no expectations for the setting of next year's Metropolis Ruhr conference in Essen, I am hoping to be pleasantly surprised. Mark the date now: July 5-8.

My expectations for the conference itself (July 6-9 in the Austria Centre Vienna) were also high, but I wasn't disappointed: the venue and organization couldn't be faulted; the opening and closing ceremonies were entertaining without being over the top; the Friday stylish night out in a classy bar overlooking the city was a nice touch; the program was diverse, including a plenary and symposium on sport technology that were highlights of the conference; the usual ~5% of presentations summarized here were of value to more than just the presenter; and there was the usual handful of exceptional presentations with the Wow factor that made the time, effort and expense of attending the conference very worthwhile. Many thanks to Arnold Baca, Harald Tschan, Barbara Wessner, Rosa Diketmüller and the team of volunteers, as well as to Tim Cable and the various ECSS committees for all the work and stress.

Check out the statistics and logistics in the official debrief. There's an extensive picture gallery (login: ECSS2016; next time it needs editing into a slideshow of highlights, please guys). See also who won the young-investigator awards, the GSSI nutrition awards and the Aspetar football awards.

As in all my reports, I have focused on performance of competitive athletes. If you put too many abbreviations into your abstract, I gave up on it. I also didn't bother with cross-sectional comparisons of different groups with only ~10 in each group or with "athletes I have tested" (descriptive or correlational studies of a squad or team with no useful outcome). Even so, writing this report took well in excess of a full working week of doing nothing else, so I hope you will forgive me for not reviewing the following topics: athletes with disabilities; the relative-age effect; mechanisms of fatigue; any physiology, biochemistry or "omics" of exercise that did not involve a measure of performance relevant to athletes; and most questionnaire-based injury-

prevalence studies. If you have an interest in these topics, do a key-word search of the abstracts (see below). Anyone with an interest in exercise in non-athletic population groups should do similar searching, because this year I did not get any volunteers for a separate review of such presentations.

Accessing Abstracts and Videos

Go to the Vienna conference site, hover the cursor over the Programme drop-down and select Scientific Program (or just click on this link), from where you can link to pages for each tier of presentation. Or download PDFs of the full program and the full book of abstracts. Access all abstracts, mini-oral slides and e-posters via the search form or eventually via the E***D***SS database (for ECSS members only). To find the presentations I have reviewed, copy the presenter's name and initial shown in brackets […] into the search form at the ECSS site, or if you have downloaded the PDF of the abstracts, copy into the advanced search form (Ctrl-Shift-F) in the Adobe Acrobat PDF reader. ECSS members can also access videos of plenaries and some invited symposia via the ECSS.tv page.

See the 2014 report for an explanation of the structure of the ECSS conference. This year they brought back conventional posters in chaired sessions, in addition to the un-chaired ("not debated") e-posters. The oral podium presentations, invited symposia and conventional posters have no downloadable content other than their abstracts, while the e-posters and the slides for mini-orals are available as PDFs via the ECSS search form.

The Wow Factor

Here's my pick of the most exciting presentations, in order of appearance under the headings below: fiber type, determined non-invasively by magnetic resonance spectroscopy, depends on cyclic movement frequency; very large reductions in severe injury with the FIFA 11+ Kids warm-up; a high-carbohydrate diet for elite race walkers is better than high-fat; thin and thick theories for understanding the ethics of sport technology; innovative technologies for sport performance; individualize training with the athlete's genotype; and direct muscle stimulation augments resistance training. Each of these is preceded by Wow! and a direct link to any video or PDF.

I missed the ECSS-ACSM exchange symposium: Preparing for the Olympics–a European and American viewpoint, with speakers Kamiel Maase and Randy Wilber. Their abstracts are uninformative, and the symposium was not recorded for ECSS.tv, but I presume the content was not substantially different from what they presented at the ACSM meeting a month earlier. This link takes you to a summary by David Pyne and Marc Portus in the ACSM report.

In an interesting mini-oral that doesn't fit into under any of the headings below, the author hoped to "inject the philosophy of Lao-tzu and Chuang-tzu

into sports games, focusing on only the game itself, not the winning." [Kwon, O]. This hope could be realized at the level of some individual athletes and spectators, but at the national level it has about as much chance as world peace.

Acute Effects

Wow! Muscle carnosine content, a surrogate for fast-twitch fibers measured non-invasively with magnetic resonance spectroscopy (and probably better than with biopsies), showed a higher positive correlation with "**cyclic movement frequency**" than the expected negative correlation with performance duration in a study of 111 elite **runners**, **triathletes**, **swimmers**, **swimmers**, **cyclists** and **kayakers**. [Lievens, E]. A few more athletes and sports will make this finding valuable for talent identification and event selection. Modifiability of carnosine content also needs to be included.

Adding balance exercises before a conditioning series of leg extensions produced an additional 3% **potentiation** of countermovement-jump height in a crossover with 12 elite female youth **soccer** players. [Prieske, O]. How long will the effect last?

I can't make complete sense of the design from the abstract or the e-poster, but it's probably more than good enough to conclude that four plyometric push-ups were practically as effective as 6 s of an isometric push-up at **potentiating** the **shot put** of 10 female collegiate throwers 2 min later (by 1.5% and 1.8% respectively). [Kontou, E]

For eliciting post-activation **potentiation** of jump performance, this crossover study of 10 professional and 10 amateur **rugby league** players showed that "a hexbar deadlift is an effective alternative to a backsquat, as it is a safer, less technically demanding exercise that enables greater loads to be lifted." [Scott, D]

Two kinds of **plyometric** exercise had apparently equal positive **potentiating** effects (no data shown) on drop-jump performance in this cross-over study of 35 well-trained female and male **gymnasts**. [Dallas, G]

The best of a range of frequencies and amplitudes of **whole-body vibration** (35 Hz, 4-6 mm) produced an immediate 9.4% enhancement of jump height in 27 male club-level **volleyball** players. [Naidoo, R]. How long does the effect last, and what about other aspects of performance?

Twenty-two elite under-19 **football** players tried four **re-warmup** exercises before performing jump and sprint tests 6 min later. The conclusion: "eccentric exercise prior to football match may be harmful for physical performance, but plyometric and repeated changes-of-direction exercises seem to be efficient active strategies to attenuate losses in vertical jump and sprint capacity after warmup." [Abade, E]

In this well-designed crossover of 20 men competing in **running-based sports**, static and dynamic **stretching** during a full warm-up "showed a high likelihood of trivial changes" in sprint, jumping and agility tests, a finding that is "contradictory to (some) current recommendations". [Blazevich, A]

The eight nationally competitive **mountain bikers** in this cross-over study **pedaled or coasted** the downhill part of a course. "Pedaling did not elicit a performance benefit", but they actually went 2.6 s (1.8%) faster when pedaling. Allowing for uncertainty in the estimate, and considering the negligible increase in energy cost, the recommendation not to use pedaling seems premature to me. [Miller, M]

The changes were not significant, but a combined **recovery** intervention consisting of active recovery, stretching, cold-water immersion and massage resulted in 1.3% *less* running distance, 18% *fewer* sprints, and 15% *less* sprinting distance compared with passive recovery between matches in this crossover study of nine national-level **tennis** players taking part in two 5-day tournaments. [Wiewelhove, T]. Goodness me! The findings are important, considering this is one of the few studies investigating effects of recovery interventions on competitive performance, where there is likely to be less contribution from any placebo effects. The authors stopped short of advising players to just sit it out between matches.

Three studies showed little effect of **foam rolling** on performance. [Baumgart, C; Damico, A; Doeweling, A]

Male under-17 **basketball** players missed an extra ~3 shots in every 10 attempts when their heart rate was 80% of max compared with when it was 50%, which helps explain why players "aim always at **resting** as much as possible between game-play pauses". [Padulo, J]

You wouldn't think there'd be much difference between European-cup and world-championship **alpine skiers** in a 90-s isokinetic leg press, but magnitude-based inference showed "sizable differences between the two groups, suggesting lower levels of **fatigability** in both male and female world-championship skiers". Implications for training are obvious. [Bosio, A]

"**Football** players were defined as fatigued after performing >30 match-day minutes and as recovered when they had >1 post-match rest/recovery day." I can't see how this definition will lead to any insights into individual differences in **fatigue** and factors affecting it. As emerged in discussion of this and other presentations in this podium session, what we need is an objective criterion measure of the extent of an athlete's fatigue. I don't think creatine kinase, urea, or measures from a counter-movement jump provide it [Noor, D; Skorski, S; Hecksteden, A], but some of the vectors of PlayerLoad from an accelerometer in an agility test look promising [Marques, J].

Here's a great example of investigation of an objective measure of **fatigue**: the change in the rate of increase in heart rate in a submaximal **running** test, which correlated with change in 5-km time-trial time when the test and time

trial were performed before and after a bout of heavy, fatigue-inducing running. The correlations were not promising (<0.50), but correlations between change scores are hard to interpret. These authors should express the effect as percent error in the predicted change in performance, adjusted somehow for the error of measurement in the time trial. [Nelson, M]

Mental fatigue (from 30 min of the Stroop color-word test) did not significantly impair 15-m sprint performance in a cross-over with 10 internationally competitive **cyclists**. No data other than p values. [Staiano, W]

Mental fatigue was more of an issue in **football**. In a crossover with 10 under-15 football players playing 5-vs-5 (plus goalkeeper) small-sided games, prior physical fatigue had substantial effects on many performance indicators, but prior mental fatigue (the Stroop again) reduced only "team dispersion and the time that players spent synchronized in longitudinal displacements". [Coutinho, D]. The Stroop also produced unclear effects on physical performance but moderate impairment in technical performance in small-sided games in a crossover study of 20 well-trained soccer players. There was also a small impairment in response time in a soccer-specific video task. "Ensure players are not mentally fatigued prior to competition." [Smith, M]

In an experimental field setting with 30 amateur **soccer** players, when **penalties** were saved, "players disengaged (fixated away) from the ball earlier prior to kicking the ball". Shorter quiet-eye periods prior to the end of the kick were also associated with saves. [Timmis, M]. These aspects of **visual search strategy** can presumably be trained.

Exposure to **blue light** for 60 min with 21 **healthy volunteers**, made "no difference" (no data) to Wingate mean or peak power in a crossover with white light, but *minimum* power was 11% higher. [Beaven, C]. Does this represent a performance benefit, if mean power isn't any higher? In any case, we need to see effects on athletic performance.

"Our results indicate that a **sprinter's block setting** based on the individual's leg length [vs the usual block setting] improves sprint start performance by enabling larger rear block forces and impulse." Unfortunately all they showed is p=0.005 for time at 5 m, and with 27 sprinters in this crossover, it's possible that the effect was significantly trivial. [Milanese, C]

"Short serve performance was significantly poorer in competition compared to practice" in a crossover with 19 competitive **badminton** players. No data on magnitudes were provided. **Anxiety** was assayed but apparently not covaried with the change in performance. [Duncan, M]

"After removal of a **testosterone** patch, all testosterone levels in blood, saliva, and urine returned to baseline within 24 h" in this study of an unspecified number of **unspecified subjects**. [Schönfelder, M]. Does this

mean that athletes training with testosterone patches in remote locations could escape detection?

Injury

Wow! The **FIFA 11+ Kids** warm-up program more than halved **overall injury** rates and reduced **severe-injury** rate to one-quarter in a large multinational controlled trial of children's **football**. [Rössler, R]. These are large and very large effects respectively.

"A 10-year effort to collect and analyze videos of 10 ACL injury situations (in **football**) that were filmed with at least two cameras… led us to propose a new hypothesis for the **mechanism of ACL injuries**." [Krosshaug, T]

In this study the researchers attempted to identify biomechanical variables measured at baseline in a **drop jump** that would predict subsequent **ACL injury** in 171 female **basketball** and **floorball** players. The problem is that there were only 15 new injuries, so the effects would have to be moderate to large for clear outcomes. One such was a 10-unit bigger knee flexion angle, which more than halved the risk (hazard ratio 0.47), but this and the other effects need to be expressed per two standard deviations for proper evaluation of magnitude and clarity. Also, with such a small count of injuries, there are almost certainly some Type-I errors or over-estimation of magnitude arising from fishing for multiple effects. Consider it a pilot study with promising results for "preventive neuromuscular training, not only to avoid valgus movement but also to avoid stiff landings". [Leppänen, M]

Faster pitchers and those with **fewer days between games** of major league **baseball** had higher risk of catastrophic **ulnar collateral ligament injury** in this retrospective case-control study of 75 cases, "a finding with obvious implications for franchise-level roster management and league-wide policies". [Whiteside, D]

See the abstracts of the symposium on **injury prevention** in elite **alpine skiing** for injury rates and prevention strategies [Steenstrup, S; Kröll, J; Spörri, J; Haaland, B]. Alas, no videos.

Several **musculoskeletal screening** measures had apparently marginally small associations with subsequent **shoulder injuries** in this retrospective study of 88 male and 76 female junior and professional ranked **tennis** players. [Gescheit, D]

Nutrition

Wow! Does adapting to a **high-fat diet** enhance endurance performance? Not for the 29 world-class **race walkers** in the AIS Supernova study, who were randomized for 3 wk to either high fat (3% of energy intake), continuous high carbohydrate (63%), or periodized high carbohydrate (63%), in which some

training sessions were performed with depleted muscle glycogen. Compared with the high-carbohydrate groups, the high-fat group performed "significantly" worse either while still on high fat or after acute return to high carbohydrate. The continuous carbohydrate group made substantially but not significantly greater improvement than the periodized group. The abstract contains no mention of this study. [Hawley, J]. It would have been nice to see magnitude-based inference for the comparison of the carbohydrate groups, but in my experience these researchers have more faith in p values, if it means getting the work into a high-impact journal. They might also prefer to have no (significant) difference, rather than a possible or likely relative impairment with periodized vs continuous carbohydrate (if the difference was clear). A follow-up analysis of the changes in competitive performance is needed to address the question of whether the high-fat group experienced super-compensation weeks or months later, which apparently some of the athletes believed might happen.

In another study of the effect of a **high-fat diet**, this time on ultra-endurance performance, eight highly trained male endurance athletes (apparently **cyclists**) performed a ~5-h time trial in a crossover after 4 wk on a moderate and low carbohydrate diet (>5 g and <2 g carbohydrate per day). "A carbohydrate load was allowed on both diets from the day before the time trial." The athletes were 1.0% slower following low carbohydrate "(p=0.888)". [O'Connor, W]. The p value represents 90% confidence limits of ±13%, so assuming a smallest important of ~1%, we can conclude nothing useful from this study, other than the obvious need for a much bigger sample size and more reliable performance test.

In a randomized controlled 1-wk trial of **periodized carbohydrate** intake with 22 trained **cyclists**, the "sleep-low" group (low-carbohydrate recovery after a high-intensity training session in the late afternoon, followed by a low-intensity session after an overnight fast) improved 20-km time-trial time after a fatiguing preload by ~3%, whereas the control sleep-high group (usual carbohydrate intake during and after the high-intensity session, with the same total intake of carbohydrate) improved by ~1%. These effects were reported as times and as a difference of significance, the control being, of course, "no change", and the authors claimed "improvement in performance". [Marquet, L]. Doesn't everyone know by now that a difference in significance is not necessarily a significant difference? I calculated a non-significant difference for the comparison, and it was even unclear with magnitude-based inference. Allowing for the curse of the decline in magnitude when studies are replicated, the outcome with periodized carbohydrate in the Supernova study above, and of course the dreaded placebo effect, it may be premature to adopt a sleep-low strategy.

Consuming **beetroot juice** for 6 d enhanced intermittent high-intensity performance (in the Yo-yo test) by 3.4% compared with nitrate-depleted juice in a crossover with 32 trained **soccer** players. [Nyakayiru, J]

Two studies addressed the question of whether supplementation with **nitrate** (via **beetroot**) improves the effect of high-intensity interval training. In the

first study, a phenomenal sample size ("24 men and 24 women") was wasted by assigning half the subjects to two unnecessary groups (beetroot + no training, training + no placebo) instead of assigning all subjects to training + beetroot and training + placebo. Beetroot produced improvements in submaximal exercise economy, but "the improvement in severe-intensity exercise performance was not different [significantly, presumably] between training interventions". The modality of the exercise tests was not stated. [Thompson, C] The second study had the usual inadequate sample size ("17 subjects") assigned more sensibly to two groups, and not surprisingly "endurance time [on a cycle ergometer] was not significantly different." [Maassen, N]. No performance data were provided in either abstract, and anyway, the subjects weren't highly trained athletes, so we're none the wiser. Why did they do these studies on **non-athletes**?

Changes in plasma volume show that "hydration rate is almost certainly greater with **hypotonic vs isotonic sport beverages**" in this meta-analysis of 12 studies. [Rowlands, D]. If rapid rehydration is an issue in tournaments or endurance competitions, use hypotonic drinks.

The 27 competitive **soccer** players in this controlled trial were assigned (blind?) to one of three groups for 6 wk of supplementation with a Smartfish **recovery drink** (carbohydrate, protein, vitamin D, **fish oil**), a similar drink without the fish oil, or an isocaloric drink containing carbohydrate only. The fish oil reduced muscle pain 72 h after a bout of eccentric exercise by a moderate amount compared with the other two drinks (if the strange pain units in the abstract are correct), and it also produced a likely or very likely beneficial effect on an agility test (no data provided). [Philpott, J]

The effects on multiple sprint performance seem to me to be unclear when nine middle-aged trained male **cyclists** consumed 2 L per day of "**hydrogen-rich water**" for two weeks in a crossover. [Da Ponte, A]. Wait for more evidence.

They were only recreationally **active subjects**, but the 18 women in this crossover went for 23% longer at VO2max intensity when they were on a 7-d **low food-acid diet** compared with a high-acid diet. This effect would translate into 1-2% in a time trial. The effect on 15 men was not reported, apparently because it was not significant and therefore didn't exist! [Hietavala, E]. At this stage it would be prudent for high-performance athletes to avoid high-acid diets, pending further research.

Two studies with parallel-group designs addressed the issue of de-sensitization or tolerance with chronic use of **caffeine**. In the first, "18 low habitual caffeine consumers" (presumably **non-athletes**) performed an endurance test of work output (with a preload) before and after 28 d of daily caffeine or placebo supplements. The initial acute effect of caffeine was 11% in the caffeine group, but after 28 d the effect had dropped to 3.8%, whereas in the placebo group the effects of caffeine before and after the 28-d period were 6.4% and 5.6%. [Ross, B]. The second study had a similar design for the effects on high-intensity interval training with 20 recreational male

endurance athletes, but there was no significant tolerance effect and no data were provided. [Salam, H]. It's safe to assume tolerance occurs with caffeine and that you should eliminate it from your diet for what, a week before competing?

Time to fatigue was "significantly higher" (no data provided) in a "simulated treadmill soccer-game protocol" when 20 well-trained **soccer** players consumed **caffeine** compared with placebo. [Hadjicharalambous, M]

Five weeks of whole-body strength and power training on **β2-agonist** asthma drug Salmeterol at apparently one-quarter the WADA-permitted daily dose improved 30-m **sprint** performance by ~5% compared with placebo (which oddly showed no improvement) in this randomized controlled trial of 24 male and 15 female non-asthmatic and "**active participants**". A third group on double the permitted dose of another β2-agonist, Formoterol, showed similar gains as with Salmeterol. "A review of the use of inhaled doses of β2-agonists by athletes in training and official competition may be necessary." [Merlini, M]

Acetaminophen (Paracetamol) continues to produce small enhancements of performance acutely, this time with 60 isometric maximum voluntary contractions (why this unrealistic test?) of the knee extensors in a double-blind crossover with 13 **active males**. [Morgan, P]

Panaceo Sport, a dietary supplement based on **zeolite**, had little effect on incremental peak power in a crossover with 16 trained male **cyclists**. [Wallner, D]

The study of male academy (age 16-18 y) **football** players was under-powered (15 subjects randomized to two groups), so you can't really conclude much from the observed greater but non-significant improvement in repeated sprint time in the group who trained for 8 wk with placebo supplementation compared with the group who received **creatine** (2.8% vs 0.7% respectively. Magnitude-based inference would show unacceptable likelihood of harm, pending more data. The effects on high-speed running in actual matches would have been more interesting, but data were available for only four and six players in the creatine and placebo groups. [Horne, S]

The 14 trained **cyclists** in this randomized controlled trial loaded with either **beta-alanine** or placebo for 4 wk, then continued supplementation for 5 wk of sprint-interval training. The initial period of loading with beta-alanine produced minor and possibly unclear benefits for performance, but effects were clearer following training: 12.9 vs 6.6% for 4×1-km cycling sprints, and 4.0 vs 2.9% for a 4-km time trial. [Bellinger, P]

Supplementation with **beta-alanine** increased the number of throws in a simulated fight and **judo** fitness test in a randomized controlled trial with 23 highly trained judo athletes. Comparisons of p values only. [Kratz, C]

A group of already 12 **resistance-trained males** consuming a **beef-protein** supplement experienced the greatest gains in fat-free mass (1.8%) in a resistance-training study of unstated duration. Surprisingly, a group of 12 consuming only carbohydrate were not far behind (1.5%) and did better than a group of nine consuming whey protein (0.9%). [Seijo, M]. None of the differences would be clear, so the take-home message is to use a bigger sample size.

Acute supplementation with the anti-oxidant **N-acetylcysteine** (NAC) had an unclear 0.5% effect on mean power in **athletes** (?) performing time trials of unspecified duration in this meta-analysis of five studies. [Braakhuis, A]

"Fruit-derived **polyphenol** supplementation enhances recovery from muscle damage", but we still don't know whether cherries and berries enhance or impair training adaptation in **athletes**. However, the indications are that they "may truly provide a tasty panacea for healthy aging." [Bowtell, J]

Antioxidant-rich snacks vs placebo made "no significant difference" (and no data shown) to the outcomes of training at moderate altitude (hemoglobin mass; VO2max in a subset of 16 athletes) in this randomized controlled trial of 8 female and 23 male national-level **team endurance athletes**. [Koivisto, A]. Magnitude-based inference might have helped here.

A review of literature on **vitamin D** and performance provided nothing more than the references for two studies showing "beneficial effects" and three studies showing "no effect", even in the poster. [Grivas, G]

Performance Analysis and Monitoring

With the advent of sophisticated technologies to monitor player actions in **games**, "performance analysts are struggling with large amounts of data… and there is a need to develop **methods and tools** to enhance the usability of such '**big data**'". Promising approaches include social networks analysis, cluster phase analysis and dominant region diagrams [Duarte, R]. No details in the abstract, unfortunately.

In matches they won, 65 forwards in 306 matches of the German **football** league had "significantly" greater **total distance** covered at various speeds, more sprints, longer sprints, more ball touches, higher percent of accurate passes, and higher percent of won one-on-one plays than in drawn and lost matches (all determined with the Impire motion analysis system) [Chmura, P]. Disappointingly, only p values were reported, with no indication of how the differences affected the chances of winning. If the analysis included proper attention to repeated measurement, some of these effects might be significantly trivial.

A neural-network model that takes into account **temporal sequence of actions** showed that two specific players had most influence in their team gaining advantage in an analysis of five games in the Japanese professional **football** league. But does it perform any better than traditional analysis of performance indicators? [Saito, Y]

Machine (neural-net) learning was used to identify patterns of play preceding **shots at goal** from continuous positional data of players in 3 vs 2 small-sided **soccer** games. The findings on the most successful assists and shots, detailed in the abstract, "are likely valid also for the 11-a-side game." [Hoch, T; Leser, R]

Top ranked teams at two international youth **football** tournaments performed more **shots**, more shots on target and more **tackles**, but effects of ranking on other performance indicators were unclear. [Varley, M]

Using a moving window of various durations (5 s through 10 min) to determine the "**maximum mean**" values of various measures of **player load** (measured with GPS-accelerometer units) has been applied to various sports, including now **rugby union** for a team at the national level. [Howe, S]

In an analysis of **maximum demands** in adolescent **rugby union** training and games with GPS-accelerometry, "academy players were exposed to external loads and movement demands during their training week comparable to the demands of match play, but within schools, training sessions may under-prepare backs and over-prepare forwards." [Phibbs, P]

In international **rugby-union** matches, **tackling** the ball-carrier by the jersey rather than the shoulder increased the chances of a tackle break occurring by nearly 3×. The defensive team was also nearly 3× more likely to win possession of the ball at the **ruck** when committing more players at the ruck (3-5 players vs 0-2). [Hendricks, S]

Composition of teams based on "shared selections" in the four years leading up to the **rugby-union** world cup was much more stable for the All Blacks (the winners) than for the XV de France (eliminated in the quarter final). [Saulière, G]. It's just a case study, but the researchers have developed a potentially valuable team-performance indicator.

Organizational differences that could explain the dominance of southern-hemisphere nations in **rugby union** are summarized in this mini-oral. [Alpuim, J]

Recordings of resting heart rate of 32 players ~4 d before matches during a season of national-level **rugby league** showed that "prior to successful matches, players exhibited enhanced short-term **heart-rate variability**, with specific frequency-domain and non-linear measures of variability successfully predicting match outcome." [Leicht, A]. The effect appears to be

small. This finding will be useful when we know what was responsible for the changes in heart-rate variability.

Monitoring of resting **heart-rate variability** in "12 **intermittent sport** athletes" during and following a 4-wk period of high-intensity interval training was "unable to track fatigue, recovery and performance adaptations at the group level… The monitoring seems to provide valuable information on individual responses and adaptations… However, the enormous amount of effort required seems not to be justifiable regarding the possible benefits." [Schneider, C]

"In the 2015 Asian men's club **volleyball** championship, winning may be particularly related to the adoption of **spiking strategy** at the position 1." [Huang, H]

An analysis of **blocking** in the 2014 women's **volleyball** world championship "can be employed to improve the block technical/tactical and the attack strategies, knowing the best attack direction." [Gubellini, L]

In **basketball**, the "Technique for Order Preference by Similarity to the Ideal Solution" (the TOPSIS method) is effective for assessing the **offensive ability** and overall strength of teams. but it is less effective for **defensive ability**, apparently because of low reliability of the defensive measures. [Shaoliang, Z]

I thought at first that 625 junior male **tennis** players was an excessive sample size to investigate anthropometric and performance-test **correlates of speed of serves**, but there were separate analyses for each of four age groups, and ~155 is well short of the optimal sample sizes of ~270 and ~780 for magnitude-based inference and null-hypothesis testing, respectively. With multiple or stepwise regressions, sample sizes need to be even larger to reduce the inflation of Type I error. Nevertheless, useful correlates were identified. In summary, "upper body power/strength and the transfer of power from the lower to the upper body in proper timed sequences [are important] for the junior player's service, while purely lower body power seems to be less important. Intervention programs focusing on the specific requirements are recommended to increase serve performance." [Fett, J]

The root mean-square error (representing the usual error of the estimate) would have been better than the mean absolute error to assess the three models relating **training load** to performance in a twice-weekly semi-tethered swimming test in five elite **swimmers**. The errors were 2.6%, 2.9% and 3.1% for the performance-potential-double, performance-potential and Banister fitness-fatigue models respectively. [Rasche, C]. Assuming the performance measure relates directly to time-trial time, these errors are too large for the models to be useful, considering the smallest important effect is ~0.3%.

A correlational analysis of **stroke variables** of 52 junior male sprint **kayakers** led to the conclusion that to improve 200-m sprint performance,

kayakers should "increase the stroke rate without loss of the displacement per stroke." [Hirano, T]

From a **kinematic analysis** of **bobsleigh** team **starts** of unstated athletes or data, "we illustrate how just the change of run-up length by the driver could deliver 2.5% increase of the initial velocity, which could result in more than 5% reduction in the total time." [Dabnichki, P]

Analysis of the 100 world top (all-time) **decathlon** performances showed that "**sprint events** influence the decathlon performance more than other events. This outcome may be taken into account to select talents and develop more effective training programs." [Ciacci, S]

A cluster analysis revealed **three types** of **hammer throw** for 116 athletes from Olympics down to local championships: fast start, slow start and "middle". "There were no significant differences in the throwing record between the three types… In addition, decreasing the total time of turn leads to a longer throwing distance for all types" [Hiorse, K], presumably reflecting simply a faster throw.

The jargon will make sense to those who study **fencing** in this analysis of **tactical actions** in two world championships. Main finding: "counteroffensive actions were performed less but were more effective." [Iglesias, X]. See also an analysis of work-to-rest ratios. [Tarrago, R]

Analysis of video files of the 2015 **taekwondo** Grand Prix final showed that "champions exploit the front-leg **roundhouse kick** tactic to a fuller extent." [Wu, Y]

If **ultimate frisbee** becomes an Olympic sport, these abstracts on the **physical demands** and **performance indicators** in world championships will be even more useful. [Di Michele, R; Russomanno, T]

Talent Identification and Development

China's success in **swimming** in the last two Olympics was apparently due to "**policy transfer**": copying other successful countries. [Tien-Chin, T]

From a total of 4.6 million boys in developing countries who registered for the Aspire **Football** Dreams project, 1823 reached their country finals, and of these, 64 won an educational and sports development scholarship. The **scholarship winners** were taller, heavier, faster in a sprint and had more endurance in a shuttle run than the country finalists. [Price, A]

Percent body fat and 15-m sprint speed of 531 male under-16 **rugby-union** players in Italian national **draft camps** were the strongest predictors of subsequent success at age 21-24 y. [Colosio, A]

The latest **genetic markers** of athletic performance in Russian **athletes** are summarized in two presentations. [Ahmetov, I; Khabibova, S]

Tests and Technology

Wow! Sigmund Loland gave a magisterial overview of the **ethical issues of technology** in **sport**, first by defining technology, then by contrasting two normative ethics theories that guide our attitudes. In the "thin" theory, sport is an opportunity to maximize performance, technology helps transcend physical limitations, and beyond fairness in competition, there should be no regulation. Sigmund described this theory as sociologically naïve, leading to a "negative equilibrium," where there are more costs than benefits. The "thick" theory views sport in the context of social issues and moral values, emphasizing talent and effort, where athletes are responsible for their performance, and fairness and avoidance of harm are the overriding considerations. He noted that there will be difficult ethical issues for sport when genetic modification leads to the advent of "Humans 2.0". He concluded that technology could represent enslavement or liberation, perspectives that (it seems to me) apply to the thin and thick theories respectively. His abstract [Loland, S] is uninformative, but ECSS members can view the talk here.

Wow! A symposium on **innovative technology** for athletic performance was a high point in the conference: some cool stuff really is being done by experts in the field. Unfortunately the symposium was not recorded for the ECSS.tv site, my notes are sketchy, and the abstracts don't convey the excitement or the detail. Oh well, in summary… "Virtual reality technology offers an exciting new way of studying decision making in sport where the perception/action cycle is maintained" [Craig, C]. "Innovative technologies [in **snow sports**] offer a chance to improve protection by new and better safety gear" [Senner, V]. Most inspirational of all was Uwe Kirsting's examples of the use of field-based technologies to enhance performance in a range of sports, including even the use of movement-related cortical potentials to get an earlier start in **skiing**, and his concluding "reflection" on the complementary roles of athlete, coach, sport scientist and society in competitive sport [Kirsting, U].

"**Deep learning** is a game changer" was the take-home message in Thomas Moeslund's plenary address on computer vision in sport. It has become possible to track players in **games** without the need for wearable technology. [Moeslund, T]. ECSS members can view the talk here.

The increased sampling frequency (16 Hz) of a new **GPS unit** "seems to overcome limitations suggested concerning both high-velocity and acceleration monitoring in **athletes**." [Peeters, A]

Increasing the gradations on each of the tests of the **functional movement screen** to yield a 100-point scale did not change the almost perfect inter-rater (only two raters) and intra-rater (6 wk later) reliability of scoring of videotaped movements of 110 **physically active collegiate males**. "The 100-point scoring system may help distinguish athletes of different movement abilities more effectively than the 21 point scoring system." [Everard, E]

The **Loughborough soccer passing test** did not accurately represent in-game passing performance in this study of 25 under-18 state representative players, who performed the test and then had their passing analyzed in the first eight games of the competitive season. [Serpiello, F]

These authors have suggested coding **accelerations** of **team-sport players** as percentages of maximum acceleration possible at the given speed of the player. [Sonderegger, K]. In their investigation the players performed a graded test to determine the maxima at different speeds, but it seems to me the maxima achieved in a game would be good enough. Whether the measure adds anything to existing performance indicators needs further research.

The return of **heart-rate variability** with the fall in heart rate (parasympathetic reactivation) after a standardized exercise bout had almost as strong a correlation (0.85) with peak power output in 20 trained female **cyclists** as that previously observed in 50 trained male cyclists. The correlation with time-trial time was somewhat less in the females (-0.63 vs -0. 83) [Lamberts, R]. Now we need to see if this measure of heart-rate variability is better for monitoring training status than one presented above. Reviewer's comment: "I totally agree and will present something hopefully next year."

"Cognifoot, a **visual environment simulator** fully synchronized with a motion capture system" appears to be more accurate than coaches for assessing kicking accuracy of 46 youth elite **soccer** players. It will be expensive! [Taube, W]

Volleyball spike actions recorded from the defender's perspective were presented to female volleyball players of various levels for an analysis of **reaction time and accuracy**. Experts reacted faster but used almost the same gaze strategies as novices. [Velentzas, K]. Maybe movement-related cortical potentials (see the symposium on innovative technologies) could be used to train reaction time?

Force-velocity curves with three loads gave highly accurate estimates (mean absolute error 1-2%) of **1RM strength** in leg and chest presses of 27 **males**. "The proposed methodology is an accurate and safer alternative to the direct determination of 1RM." [Picerno, P]

A **jump mat** has less random error than a criterion motion-capture system for measuring jump height. Mean difference in height between the two systems can be explained by the effect of the length of the athlete's foot on jump height estimated from flight time off the mat. [Lipinska, P]

Circulating cell-free DNA is still a work in progress as a marker for exercise load. [Haller, N; Ochmann, D; Schmidt, S]

Training

Wow! I missed this podium presentation, but the abstract says it all. A **power/endurance genotype score** based on 15 performance-associated gene polymorphisms was first determined for 39 **soccer** players. They were then assigned to an 8-wk high- or low-intensity resistance training program, either matched or mismatched to their genotype score. In the matched group (power genotype trained with high intensity, endurance genotype trained with low intensity), jump height improved by 7.1% compared to 2.4% in the mismatched group, and power (?) in a 3-min cycle test improved by 7.7% vs 1.9%. "Matching the individual's genotype with the appropriate training modality leads to more effective resistance training." [Suraci, B]

Wow! Applying **direct magnetic stimulation** to the gastroc muscle during a daily set of 10× 5-s voluntary activations at 80% of maximum torque increased voluntary maximum torque by 15% after 5 d and 19% after 15 d compared with a group doing control training in this controlled trial of 18 **male athletes**. Changes in H and M responses and EMGs showed that the improvement was due to "increase of a descending nerve drive to the spinal motor neurons and increase of gastrocnemius motor neuron pool reflex excitability." [Gorodnichev, R]. Here's the link to this e-poster gem, which I hope can be replicated one way or another.

Amazingly (but not quite a Wow!), in this random controlled trial of 16 wheelchair-**basketball** players, **mindfulness training** prior to and during a 7-wk competition period resulted in non-significant changes in cortisol, whereas the control group showed significant increases. P values only, I'm afraid, and once again, a difference in significance is not necessarily a significant difference. In conclusion, "mindfulness training may be a beneficial tool for athletes to manage the onset of physiological stress during intense competition." [MacDonald, L]. Maybe, but what are the effects on performance?

Training load in the pre-season had a negative effect on change in jump height and unclear effects on change in repeated sprint and endurance tests in 14 professional and 18 semi-professional (male?) **basketball** players. [Ferioli, D]. I guess they need more data before they decide to reduce training load.

Addition of **small-sided games** (3 vs 3) for 12 wk improved aerobic and anaerobic performance in this randomized controlled trial of 24 male **handball** players. Incomplete reporting of data. [Chittibabu, B]

Addition of **core-training** exercises to usual training for 10 wk resulted in "statistically significant differences" in changes in throwing velocity in comparison with changes in a usual-training group in a randomized controlled trial of 16 junior and 14 senior **handball** players. In the e-poster the differences were ~4%, which amount to small standardized effects. [Manchado, C]

In a meta-analysis of the effects of **complex training** (alternating heavy resistance with plyometrics/power exercises) on **trained athletes**, longer durations of intervention (>6 wk) were possibly more effective for sprinting, while intervals of longer than 3 min between sets resulted in higher gains in jump height. [Freitas, T]. Comparisons with conventional resistance training weren't presented.

Three sessions of **high-intensity interval training** worked better than endurance training in the winter-transition week in this controlled trial of 10 under-19 **football** players. [Romero Moraleda, B]

Repeated-sprint and agility training enhances performance of repeated sprints and agility in youth **soccer** players, not surprisingly. [Mathisen, G]

"A comprehensive analysis of **intermittent hypoxic-training** studies highlights only poor extra benefits of adding a hypoxic stimulus for sea-level performance… [but] repeated sprint training in hypoxia for **team sports** may boost players' physical performance, prepare their organism to subsequent more sports-specific training and potentially delay premature in-match fatigue." [Faiss, R]. References supporting these assertions are cited in the abstract.

I missed the symposium, so I don't know if there is still only one study (cited in the abstract) supporting the notion of combining "the short-term muscle adaptations obtained by high-intensity **training in hypoxia**, with the short-term cardiovascular adaptations acquired by **training in the heat**" in **football** players. [Racinais, S]

Race-walking performance at moderate altitude (1400 m) showed a likely improvement for a group who trained at that **altitude** than for a group who trained at 600 m. Comparisons of the effects in a live-high train-low group were apparently unclear. With only seven race walkers in each of the three groups, it's not surprising that the effects were all non-significant. [Carr, A]. If you use magnitude-based inference *and* statistical significance, what do you conclude when a clear likely improvement is not significant? That it is less likely to be an improvement? And if it *is* significant, does that make it definitely likely? These authors concluded that "natural altitude training at or near the race altitude remains the likely most beneficial option for athletes

competing at altitude", so they apparently ignored the p values. Cool! Why show them at all?

Eight well-trained **triathletes** who added two supramaximal sets per week of "exhale-hold" **hypoxic swim training** for 5 wk showed 3-4% improvements in 100- to 400-m swimming time trials, whereas eight triathletes in the control group showed "no change" and no data, not even a p value. [Woorons, X]. You can bet there was no significant difference between the groups. Magnitude-based inference would provide a realistic probabilistic assessment of benefit and harm, but even so, taking into account the placebo effect, I advise wait and see.

This meta-analysis "supports the implementation of **strength training** in addition to normal aerobic training to improve **middle and long-distance performance**" in various sports. [Berryman, N]. The effects are shown in standardized units, which are inappropriate for solo competitive athletes. Next time show percent effects, please, and take into account the smallest important effect.

Adding **strength, explosive and plyometric sets** to the usual training for 12 wk improved running economy by ~4%, whereas a control group showed "no differences" and no data in this controlled trial of 25 **ultra-marathon runners**. [Giovanelli, N]. But what if there were compensatory negative changes in fractional utilization and VO2max? You need a performance test to be sure.

"A combined 16-wk **endurance and interval-training protocol** is more effective in increasing work output in repeated sprint exercise than conventional endurance training alone in athletes with several years training experience," the athletes being 20 **cyclists** randomized to the two groups. [Hebisz, P]

Interval training on a treadmill with **blood-flow restriction** to the lower limb produced a little more gain in performance than that in a control group (VO2max, 6.3% vs 4.0%; time to exhaustion, 27% vs 17%, equivalent to ~0.5% difference in a time trial) in this randomized controlled but not blinded trial of 16 **recreationally trained males and females**. [Paton, C]. A placebo effect?

Reviewers' Comments
David Rowlands

This is another excellent review of most of the sport performance research presented at what is probably the world's leading conference for such. The critique of statistical presentation is appropriate and informative. The statistical significance or non-significance of a finding is obviously

inadequate. It would be helpful if ECSS had a policy about inclusion of clinical or practical inference in abstracts and presentations.

I agree the technology presentations were highlights. On the basic science side, Mark Tarnopolsky's work on exersomes (clearly presented by Anton Wagenmakers in Mark's absence) was again of most interest [Tarnopolsky, M]. In diabetes rehabilitation, Anton Wagenmakers' presentation on the role of the microvascular system suggests to me that a dysfunctional microcirculation is the primary problem, not some intra-myocellular biochemical perturbation [Wagenmakers, A]. The plenary session on healthy urban environments was excellent, especially the contribution of the speaker (Fiona Bull) from Perth [Bull, F]. Continued urban sprawl and car dependency is not good for public health. Vienna beats the likes of Auckland in this respect.

Personally, I'd love to get back to innovative sport performance work! Unfortunately the grants and institutional recognition are in health research.

Robert Lamberts

As always it was a pleasure reading your report, which provides a great overview of the conference. I love how you are not scared to make fair comments about abstracts by authors who have over-interpreted their data or have used the wrong study design to answer their question. Not everyone will agree, but it makes reading the article a lot more instructive and enjoyable!

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