Athlete Monitoring and Much More at the Virtual 26th Annual Meeting of the European College of Sport Science

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The outstanding feature of this virtual conference is the ability to view all presentations at your convenience and pace. **The Wow! Factor**: the four best presentations. **Accessing Abstracts and Videos**: links to the conference program and registration. **Acute Effects**: beat the heat; mental fatigue; ischemic preconditioning; running style; warm-up; post-activation potentiation; foam rolling and stretching; cold-water immersion, foam rolling and a supplement for recovery. **Injury Risk**: genes, training attention, and biomechanical screening for ACL; genes for Achilles tendon; EMG biofeedback and shoulder; prevalence and risk factors in ballet dancers, soccer, American football, and rugby; dementia. **Injury Recovery**: jumper's knee; Achilles tendon. **Monitoring**: an expert's commentary; heart-rate variability; blood and psychometric markers; inconsistent evidence; machine learning; GPS in soccer; subjective and blood markers in soccer; risk scores in American football; survey of coaches. **Nutrition**: strategies for endurance and sprint events; chronic effects of antihistamines, resveratrol, metformin, cannabidiol, and carbohydrate; acute effects of delayed carbohydrate, Spirulina, menthol, beetroot juice, and caffeine. **Performance Analysis**: passing in football; pacing in running, speed skating and cross-country skiing; running in soccer; biomechanics of swimming; Vaporfly shoes for running; switch transitions in canoe slalom; stroke intention in tennis; 16 movement analyses; 14 competition analyses; 11 correlates of performance. **Talent Identification and Development**: various factors and maximum mean power in elite cycling; half-game rule in youth rugby; female vs male coaches in female basketball and football. **Tests and Technology**: sampling variation at ECSS; strength-endurance profiles; wearables for running gait; shoe-cleat position for cyclists; Takei jump meter; critical speed for swimmers; seven industry-sponsored sessions; 15 miscellaneous items. **Training**: sprinting; blood-flow restriction; heat + cooling; heat + resistance; plyometric vs isometric; flywheel resistance; elastic bands; strength; squat and/or deadlift; periodized; compression stockings; hypoxia ± nitrate; skill feedback; mindfulness; decision reinvestment; feedback theory-related; Covid. KEYWORDS: competition, elite athletes, ergogenic aids, injury, monitoring, nutrition, performance, talent identification, technology, tests, training.

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I'll be sorry to see the passing of the ECSS virtual conferences, because I have been able to "attend" all the presentations on a given topic at my own pace, including replays and fast forwards. Do you realize just how much better that serves the cause of scientific communication than a traditional conference? OK, I couldn't ask questions directly, but most presenters showed an email address for follow-up (alas, the message boards were still impractical). Of course, the real reason for conferences is live networking, and even more important for ECSS conferences is a holiday in a lovely European city. So what about fusing virtual and real conferences, by showing pre-recorded talks, then having the presenters answer questions live? Think about it: no more running over time, no more presentation gaffs, no more extreme anxiety, and you can re-view or view any talks you missed back in the hotel or back at home until the end of the year. I know, it won't happen, but it's a pity.

A feature this year is an extensive pre-congress satellite "industry partner programme", representing state of the commercial technical

art in several key aspects of athlete assessment. There are no abstracts, but the GSSI satellite has links to handouts.

Misinterpretations of significance and non-significance appeared to be as prevalent as ever this year, although a few brave and enlightened souls openly referred to magnitude-based inference or decisions. See my article on last year's fiasco and my discussion paper for what we should do about it: test substantial and non-substantial hypotheses and/or use Bayesian assessments of uncertainty, both of which underlie magnitude-based inference/decisions.

The Wow! Factor

Once again I have kept the focus of this report on presentations relevant to performance and injury of competitive athletes. This year I thought only four had the Wow factor: a monitoring study of cyclists, lactate metabolism and pacing in runners, a really professional video about passing in football, and my own presentation on misinterpretation of statistical significance. The symposia relevant to monitoring weren't quite in the wow category, but the range of perceived utility of the various measures is fascinating.

Accessing Abstracts and Videos

By focusing on athlete performance and injury, I have omitted most of the conference! Once again no-one is summarizing other presentations this year, so if your interests are physical activity of non-athletes or the biology, psychology or sociology of exercise, check out the scientific program at the conference site. These links are open to anyone, as is the list of winners of the young-investigator awards.

To find and view the videos, you will need to register (available until the end of the year). You can then Join the Congress App from your ECSS account page, which will take you to the conference home page, with links to the various sessions. Unfortunately there is no session shown there for the not-debated posters (the e-posters). To find the abstract of the presentations I have reviewed, copy the presenter's name and initials shown in brackets […] into the Search Engine there. The Search Engine Results will also have a link to the PDF of e-posters (not debated), but to find the video or PDF of all the other kinds of presentation, you will have to use Find in your browser to find the session ID in the conference app, then open the session and use Find in your browser to find the presenter's name.

The book of abstracts can also be downloaded from your ECSS account page; search it in Acrobat using advanced search (Ctrl-Shift-F). The book of abstracts is the only way to identify and end up viewing the e-posters that I have not reviewed. I made repeated unsuccessful requests to the ECSS office for a listing of the e-posters to be shown in the conference app. I was also unsuccessful in repeated requests to get the search engine to return links to the videos of the Oral & Poster sessions.

The videos of plenaries, invited symposia, and young-investigator award (YIA) sessions have multiple speakers, hence it was too difficult for the ECSS tech team to provide individual video links. Find the session in the conference app via the session ID that I have provided; when you open the session, the link to the video is at the top of the page.

I spent way more than a full week on this report, but I am bound to have missed some presentations with useful information for competitive athletes. So I suggest you use the search engine, with your sport or topic of interest as the key word. Do it in a small group for more value and fun. Use this report for a conference debrief, too. If you are an author of a missing abstract that you think should be in included, or if I have got something wrong, please get back to me ASAP and I will augment or amend this report accordingly.

Acute Effects

The abstracts are unhelpful for this symposium (IS-PN03) on solutions for **elite athletes** to **beat the heat**, so you'll have to view the video for "the science behind the use of novel cooling **headband** technology, neck cooling **collars** and **ice pack headwear**" [STEVENS, C.]. You can also find out what athletes actually do to beat the heat [TAYLOR, L.], and learn about "the science and development of **menthol** products." [ROSS, M.]

In a systematic **review**, "17 of 19 studies displayed a negative effect of **mental fatigue** on a myriad of sport-specific psychomotor performance outcomes." [HABAY, J.; CP-MH05]

Ischemic preconditioning "attenuated exercise-induced muscle damage and soreness, and prevented the declines in muscular strength and explosive performance after a fatiguing resistance exercise" in a controlled trial of 12+12 **male collegiate athletes**. [CHENG, C.F.; CP-PN04]

Outcome of an acute study of changing the

running style of 12 (male?) **participants**: "verbal instruction to increase the stance time should be used to increase the duty factor [ratio of stance time to flight time], and verbal instruction to increase flight time should be used to decrease the duty factor. [NIJS, A.; OP-AP01]

Eight **male recreational runners** of modest fitness apparently had ~20% improvements in running economy in a ~2.5-min run to exhaustion following a **warm-up** with static or dynamic stretching compared with no stretching in a crossover, yet there were negligible changes in time to exhaustion. [FAELLI, E.; OP-AP01]

A low-volume squat protocol was more effective and less fatiguing than a high-volume protocol to induce **post-activation potentiation** of countermovement jump height in a crossover of 23 **male athletes**. [BAENA RAYA, A.; OP-BM06]

The **meta-analyzed** difference in the acute effects of **foam rolling** and **stretching** on various measures of strength and explosive power was pretty clearly trivial, but I don't approve of meta-analyzing standardized effects. [KONRAD, A.; CP-AP05]

Total **cold-water immersion** induced better **sleep** than partial immersion in a crossover study of 12 well-trained **male endurance runners**. [CHAUVINEAU, M.; OP-PN06]

A meta-analysis of five publications "does not support the advantage of **foam roller** or stick massage to improve **recovery** of muscle damage indirect markers". [MEDEIROS, F.V.; OP-MH04]

There were minor differences in significance (!) in the acute beneficial effects on **post-exercise recovery** (of creatine kinase, perceived fatigue and physical performance) following **cold-water immersion**, a **supplement** of protein and carbohydrates, or **active recovery** compared with a placebo drink in a crossover with 15 (male?) **elite basketball** players. [MARIN GALINDO, A.; YIA, OP-BM09]

Injury Risk

Compared with controls, frequencies of allelic variants of several **genes** were higher or lower by ~10-15% in patients with **ACL** ruptures compared with controls. [SEPTEMBER, A.V.; OP-MH01]

"**Training** of external **focus of attention** [of 31 **female recreational athletes**] during an **ACL** prevention program may improve injurious movement patterns, but the changes may not be clinically significant." [PANTANO, K.; OP-MH01]

Biomechanical screening with wearable sensors identified a high prevalence of risk pattern for **ACL** injury in one or more movement tasks of 18 **male** and 16 **female young** healthy **competitive athletes**. [DI PAOLO, S.; OP-MH01]

Proteoglycan **genotypes** were risk factors for **Achilles tendon** injuries in a case-control study of several hundred South African and UK **participants**. [LAGUETTE, M.N.; OP-PN05]

EMG biofeedback with eight **male volunteers** was effective "in reducing the overload on stabilizer muscles during resistance training exercises, with implications on the prevention of **shoulder disorders**." [VIEIRA, T.; CP-BM03]

A prospective cohort study of 123 professional **ballet dancers** provided the incidence rate of medical attention and **time-loss injuries**. [MATTIUSSI, A.; OP-MH01]

High **exercise volumes** and **acute increases in sprint distance** were related to an increase in risk of **injury** in 35 **professional male soccer** players over two seasons. [COLLINS, J.; OP-AP04]

A systematic review of 30 studies of the **genetic** predisposition to injury in **football** found that "only two polymorphisms have had their results successfully replicated in independent population samples." [MCAULEY, A.B.T.; E-Posters]

Conclusion of a two-decade longitudinal study of 110 players: "football academies should regularly assess the **maturity status** and timing of **young football** players, as the impact of **injuries** varies with maturation status and timing." [MONASTERIO, X.; YIA, OP-AP10]

There was a high prevalence (~50%) of self-reported **concussion** in the 226 British **American football** players who responded to an email survey, but compliance was not stated. [TRAVIS, E.; E-Posters]

Injury rates and some risk factors in **amateur rugby union** were investigated in this 3-y study of 126-195 **female** and 479-959 **male** players. [DOLAN, P.; CP-MH01]

"The SCORES study (Screening Cognitive Outcomes after Repetitive head impact Exposure in Sport) is an online longitudinal study monitoring signs of prodromal **dementia** at 6-month intervals for at least 10 years [in Europe]… This acceptability study explored taking part from the perspective of participants after one round of testing to maximize future engagement with the study." [BOUCHER, E.; CP-MH01]

MH05]

Injury Recovery

In a controlled trial of 18+16 sub-elite **male youth soccer** players with **jumper's knee**, a novel **alternative therapy** program consisting of isometric strengthening and stretching of the hamstrings, proprioception exercises and core stability exercises added to the conventional treatment (eccentric strengthening and stretching of the quadriceps) resulted in shorter recovery duration (47 ± 16 vs 58 ± 25 d, mean $\pm$ SD). [NIERING, M.; OP-BM03]

See the second and third presentations in this symposium (IS-MH06) for the latest in management of **Achilles tendon rupture**. [ELIASSON, P.; WEISSKIRCHNER, K.]

Monitoring

Several presentations and symposia were relevant to monitoring of athlete training, performance and recovery. There was a wide range in the apparent or perceived utility of monitoring, so I asked an experienced coach-scientist, Tiaki Brett Smith, to review this section. His commentary: "The key is to make sure you implement best-practice, accurate, and logistically practical measures, with a really simple colored output to support the notion of systematic progressive overload and effective application of the FITT principles [frequency, intensity, time and type]. I build everything for the coaches. I believe our goal as applied sport scientists is to understand the various complexities to the degree that we can provide the athletes and coaches with concise coherent understanding of our data. That way we can generate simple measures and report structures to inform best practice, which in turn leads to success (because without success it just doesn't matter how good your systems are). It doesn't work to have applied sport scientists who are divorced from day-to-day operations, generating complex reports solely for themselves, thereby impeding the understanding and buy-in from coaches and athletes."

I also discussed monitoring with Victoria University's machine-learning expert, Sam Robertson. We agreed that machine learning is limited fundamentally by not accounting for repeated measurement and by the need for big datasets. Mixed modeling is more realistic and trustworthy in many monitoring settings.

Wow, a great study of remote monitoring in time of Covid! It was only **recreational cyclists**, but there were 25 of them (23 **males**, 2 **females**). Distance covered in six 40-min time trials on their own indoor bike trainers was 3.5% less when their waking self-recorded **heart-rate variability** was "abnormal" (not defined in the abstract or e-poster). [CRAWFORD, D.; E-Posters] Another bouquet is for the use of mixed modeling, but here are some brickbats: use of statistical significance, standardization, and dichotomization of the heart-rate variability; failure to use log transformation; and failure to show percent effects.

The abstract is uninformative, so you will have to view the first speaker's video in the symposium (IS-AP01) on individualized recovery management for results from a nine-year multi-center research program (https://regman.org; use Chrome to translate from German). **Blood** and **psychometric markers** got the big thumbs-up (literally) for monitoring endurance, strength and interval training, performance markers got big thumbs-up for strength and interval but a medium thumbs up for endurance, while measures of muscle contractility, heart-rate variability and sleep got small-medium thumbs-up, depending on the training. "At the group level, popular **recovery strategies** hardly contribute to faster recovery of [most] markers but can promote recovery of psychometric measures… At the individual level, some athletes [may] benefit, while others [may be better off with] passive recovery". The speaker implicated placebo effects sometimes, and he argued for a common-sense "plausible" approach to interpreting markers, given the inconsistent evidence, especially at the individual level. [WIEWELHOVE, T.]

From the second speaker's more informative abstract: "Surprisingly, no parameters have been established with adequate sensitivity and reliability for the monitoring of fatigue and recovery during athletic training cycles… Thus, individualizing load monitoring, e.g., by using individual reference ranges, and joint consideration of selected parameters in multivariate classifiers might be a solution." In the video she emphasized the importance of **coaches' experience**, highlighting a recent study of **swimmers** showing that "no monitoring tool improved the coach's prediction" (Crowcroft et al., 2020, in IJSPP). In response to a question, she opted for **perceived exertion**, other validated **subjective scales**, and some measure of **heart rate** as the easiest and most useful measures to monitor. [SKORSKI, S.] The third speaker's topic of training in the heat is summarized under Training below. [IHSAN, M.]

In a symposium (IS-AP02) on talent development in **elite cycling**, the second speaker presented a published study showing that daily training prescription based on **heart-rate variability** (by reducing training load when variability declines) "could result in better performance enhancement than traditional periodization in well-trained cyclists." He had specific advice on how to use trends and smallest importance changes in heart-rate variability. [JAVALOYES, A.]

In this symposium (IS-AP03), **machine learning** was promoted as the way forward to balance **performance** enhancement and **injury** risk by "intense monitoring in recreational sports, **professional sports**, and **performing arts**". The first presenter, an expert on sports injuries, mentioned a recent study that was reasonably successful at identifying elite youth football players who were more likely to get injured. In response to questions, he said that he hoped to improve the effectiveness of monitoring by accounting for athletes' perceptions of the process, but he had no suggestions for improving athlete compliance other than to personalize the process and provide timely feedback [VERHAGEN, E.]. The second presenter, a scientist-practitioner with an elite football team, highlighted the importance of factors influencing decisions about athletes beyond the data provided by the "black-box" analysis. In his summary, "people are the key" and "generate big value from small data" [MCCALL, A.]. The third presenter shared her system of monitoring health of dancers via baseline testing and a monthly questionnaire with visual-analog scales addressing physical and mental health on an app. Providing appropriate feedback improved compliance; assuring trust and confidentiality was also important [STUBBE, J.].

From a symposium (IS-SP01) on effective **feedback** of information to coaches… The first speaker considered feedback of **GPS-derived data** to be effective in English **professional soccer**, but there is room to increase informal reflection, decrease information, and improve communication by making the feedback informal, daily, individualized, and integrated with all stakeholders. [ANDREW, M.]

"Training on the edge without tipping over" is how the second speaker succinctly characterized the goal of monitoring; she then described the "MORE transfer project" (part of the REGman project, above), whereby an athlete monitoring system is being implemented in various sports.

The system consists of daily subjective assessment of **stress**, **recovery** and **training load**, and ~weekly or on-demand blood tests for **creatine kinase** and **urea**. Values of each variable are fed back graphically with an individualized reference range, leaving it to the coach to integrate the data; however, this "univariate" feedback was hardly used by **soccer** coaches, in preference to a simplified "dashboard" summarizing all their athletes. Customization of the dashboard to sports and coaches is important, but even so, some unnamed sports have opted out. [HECKSTEDEN, A.] Perhaps even this well-researched and well-designed system adds nothing to the coach's expert eye.

There is no abstract for the third speaker, Patrick Ward, who is a sport-scientist practitioner in **American football** (see his blog). His topic: communicating data and engaging decision makers in the scientific process. Science and analytics have input into four groups of decision makers: management and scouting, coaching, strength and conditioning, and sports medicine (NFL athletes apparently don't make decisions). He advocates getting decision makers involved in a Socratic (questioning) manner in each step of the "PPDAC" cycle: problem, plan, data, analysis, conclusion. His specific advice when reporting data: avoid jargon, clutter, and vague statements; use probabilities, base rates, pessimistic and optimistic outcomes, and session estimated risks; convey messages interactively and with clear legends and definitions; guide the decision maker towards a decision with "bottom-line up-front"; customize the feedback to the preferences of the decision maker; highlight the key information, e.g., with colors and **risk scores**, but allowing the decision maker to dig deeper. In question time, the chair (Barry Drust) raised the issue that sport scientists often have difficulty deciding what data are important. In reply, Ward gave examples that implied he provides data he knows to be important for the coach. His self-confidence probably helps convince coaches, but how valid are the risk scores?

"There are differences in planning models, in methodological proposals, and in load management and fatigue **monitoring** methods" between **soccer**, **basketball**, **futsal** and **tennis** in this international survey of 261 coaches and physical trainers. [VARELA OLALLA, D.; E-Posters]

Nutrition

Nutrition for the **endurance athlete** was the topic of a pre-conference symposium (PAS-03)

sponsored by the Gatorade Sports Science Institute: see the program, handouts, and 2-h video. There is little useful practical information in the presentation by Yannis Pitsiladis (who talked mainly about the sub 2-h marathon). Michelle King dealt mostly with mechanisms of heat stroke and gut permeability, but has some general recommendations to prevent gastrointestinal symptoms during exercise, including "gut training". Trent Stellingwerff has some very practical advice on fuel and hydration for endurance events. Kristin Jonvik gave "an overview of potential future research topics with respect to endurance sport nutrition," to which Yannis added in discussion time that we need to do more research in actual competitions and with new monitoring technologies. The chair (Ian Rollo) asked each speaker for a concluding comment about the next big thing for endurance performance: Kristen, fuel for cognitive performance; Trent, multidisciplinary teams and field sensors; Michelle, individual tolerances via biomarkers; Yannis, innovations consistent with the spirit of sport.

From the plenary on **sprint** performance (PS-PL01): "[Nutritional] strategies include **creatine** supplements to enhance the phosphocreatine energy system, and supplement strategies to enhance the buffering capacity of extracellular (e.g. **bicarbonate** supplementation to increase blood buffering capacity) and intracellular (**β-alanine** supplementation to increase muscle carnosine stores) origin. **Caffeine** supplementation has the potential to enhance sprint performance by masking the perception of fatigue or soreness during longer/repeated sprints and/or by direct effects on muscle contractility. Newer areas of investigation include the effects of acute or chronic supplementation with various **antioxidant** nutrients/phytochemicals on the production of reactive oxygen species. There is also interest in the potential effects of bitter **tastants** (e.g. quinine) on corticomotor excitability." [BURKE, L.]

The focus of this symposium (IS-MH02) was negative effects of three drugs or supplements. Avoid **anti-histamines** when training, because "blockade of histamine H1/H2 receptors by common over-the-counter antihistamines led to marked impairments of microvascular and mitochondrial training adaptations in human muscle." [DERAVE, W.] "Evidence for a beneficial effect of **resveratrol** supplementation on the cardiovascular system in humans is weak, and studies have even shown that resveratrol can reduce exercise training-induced cardiovascular adaptations." [HELLSTEN, Y.] "In this talk we highlight recent evidence that adding **metformin** to regular exercise may not have added benefits, and at times may be detrimental." [MILLER, B.]

Although **cannabidiol** has been removed from the WADA prohibited list, the use of cannabidiol for pain management, sleep and recovery "poses a serious risk to athletes," because other banned cannabinoids can occur in cannabidiol products. [CLOSE, G.]. The other two speakers in this symposium (IS-PN01) presented preliminary evidence for its beneficial effects. [MCCARTNEY, D.; JAMES, L.]

Carbohydrate intake does not appear to modify strength training in this **meta-analysis**. [VÅRVIK, F.T.; YIA, OP-PN09]

"Seven weeks of **Spirulina** supplementation reduced markers of muscle damage following acute exercise in this placebo-controlled trial of 9+8 **male rugby-union** players. [CHAOUACHI, M.; OP-PN04] Is that a good thing, given damage is a stimulus to adaptation?

Delaying nutrient intake could in theory increase post-exercise signaling responses and thereby enhance performance. However, a 3-h **delay in post-exercise carbohydrate** intake following a bout of high-intensity interval exercise resulted in *fewer* high-intensity intervals to exhaustion 24 h later compared with no delay (13 vs 18) in this double-blind crossover with 9 **healthy males**. [DIAZ-LARA, J.; GSSI Award presentation session]

Compared with an impossible-to-blind control, time to exhaustion in a ~25-min run with ingested **menthol** and menthol mouth-rinse increased respectively by ~17% and ~10% in a crossover with 13 healthy **male runners**. [TSUTSUMI, Y.; OP-PN04] (I had to read values off the graph in the video; 15% is equivalent to ~1% in a time trial.)

Effects of supplementation with **beetroot juice** vs placebo on 5000-m swim times were reported only for three of the 500-m laps (the significant ones, of course), but it looks like it worked better in **females** than **males**. Interestingly, heart rate was spectacularly higher with beetroot juice, but the relationship between performance change and heart-rate change was not reported. [POON, C.L.S.; E-Posters]

In a crossover with 15 experienced **male** and **female** players of **floorball** (a kind of indoor

hockey), **caffeine** didn't have any substantial effect on sprint and dribbling speed, but passing scores went down and shooting scores went up. [BALASEKARAN, G.; E-Posters]

Performance Analysis

Wow! Watch the really professional video "illustrating changes in landscapes of **passing** opportunities" in five **football** matches. "This model can provide insights regarding the dynamics of passing opportunities." [GOMEZ JORDANA, L.; OP-AP07]

Wow! Cluster analysis of 200-m split times in a 5000-m time trial of 44 endurance **female** and **male runners** and **triathletes** revealed three reasonably well-defined **pacing** strategies ("negative + kick, positive + kick, positive + [a little] kick"). There were some substantial differences between clusters in the means of a measure of lactate metabolism determined in prior testing. "Measuring lactate accumulation rate seems to be a promising parameter for optimizing pacing strategies in running events." [QUITTMANN, O.J.; YIA, OP-AP11]

Four split times for 1500-m long-track **speed skating** showed different changes between 48 **females** and 41 **males** as the skaters matured between ages 13-19 y in this impressive mixed-model analysis of **pacing**. [MENTING, S.G.P.; YIA, OP-AP11]

Speeds on some sections of a **cross-country skiing** course showed higher correlations with overall speed, so these are the sections that help determine the winners and losers. "Coaches and athletes can use this information to optimize **micro-pacing** strategies and improve performance." [STAUNTON, C.A.; YIA, OP-AP11]

Total distance, sprinting distance, sprinting actions with the ball and maximal velocity were **predictors of match performance** of **professional soccer** teams during two seasons in the German Bundesliga. [CHMURA, P.; OP-AP05]

The symposium (IS-BM01) on state-of-the-art of **swimming biomechanics** has useful information on kinematics and kinetics derived from **3-D video** analysis. [GONJO, T.; OLSTAD, B.; KUDO, S.]

In a retrospective analysis of competition times of five male and six female **elite distance runners**, critical speed derived from critical-power modeling of 10-km, half-marathon and marathon times was 3.5% higher with **Vaporfly shoes**. [RODRIGO CARRANZA, V.; YIA, CP-MD01] Effects on run times were not shown, and adjustment for environmentals would have been nice.

In a sophisticated modeling study of **canoe slalom**, "the more times an athlete uses a **switch transition** [of the paddle] during a race, the more likely the extra time associated with the transition will contribute to a longer race time [up to 3 s]." [WAKELING, J.; CP-AP05]

"Two **expert tennis** players (Federer and Djokovic) showed that by **disguising initial stroke intention** they could impose tactical superiority and create advantageous point dynamics. Suitable training program of disguised shots should have competitive utility." [DIMIC, M.; E-Posters]

Miscellaneous movement analyses…

- View this plenary (PS-PL02) for the latest on mechanisms of **muscle force**. [HAHN, D.; WESSNER, B.]
- Kinematics of **baseball pitching**. [TAKUYA, A.; DAISUKE, Z.; TAKASHI, A.; CP-BM03]
- Pelvic and trunk kinematics measured with wireless sensors during **pitching** in 39 **adolescent baseball** players. [TOMOAKI, T.; E-Posters]
- 2-D motion analysis in **sabre fencing**. [KENTA, N.; E-Posters]
- **Kicking** in **women's Gaelic football**. [GILSENAN, L.; E-Posters]
- Double integration method to estimate center of mass kinematics in the **golf swing** doesn't work. [GOMEZ, M.; OP-BM07]
- Case study of a "new technique of **giant swing backward** of horizontal bar" by a **top male gymnast**. [YAMASHITA, R.; E-Posters]
- Historical development of **men's gymnastics movements**. [SANO, T.; MORII, R.; E-Posters]
- Comparison of **shot put** and **discus throws** of **elite males**. [SASAKI, D.; E-Posters]
- Kinematics of the swinging and support limbs during **soccer kicking**. [RABELLO, R.; CP-BM02]
- Frequency and rate of dynamic and stationary **kicks** in **soccer** at various levels. [TAKENO, Y.; E-Posters]
- **Kicking** kinematics in 18 experienced **male soccer** players. [BERTOZZI, F.; YIA, OP-AP10]
- Technique of four **world-class table-tennis** "**choppers**". [YUKI, N.; E-Posters]
- **Tennis**-**shot classification** using a wrist-

mounted device and neural networks. [HOLLAUS, B.; OP-AP07]

- **Volleyball spike movement** of **elite female** players. [CATALA, J.; CP-AP04]
- Biomechanical analysis of three **hamstring exercises** in 10 **male participants**. [VAN HOOREN, B.; YIA, OP-BM08]

Various competition analyses…
- Positional and temporal **running demands** of **elite camogie** (an Irish female stick and ball game). [CONNORS, P.; CP-AP04]
- Differences in **race demands** between junior, under-23 and professional **road cyclists**. [GALLO, G.; OP-BM01]
- **Small-sided games** in 19 **non-professional soccer** players [ORRÙ, S.] and 10 **elite young male soccer** players [PANASCI, M.; OP-AP04]
- Playing styles of **strikers** in 960 Chinese **football super-league** matches based on player-vector framework. [YUESEN, L.; OP-AP07]
- Differences in **referees' physical performance** between match levels in 108 matches of the Chinese **football super league**. [JIANG, J.Y.; OP-AP07]
- Various **performance indicators** in 10-12 elite **male age-group handball** players. [WAGNER, H.; OP-AP07]
- Analysis of **female handball offensive performance** during exclusions in 47 matches of the Euro 2018. [TREJO, A.; OP-AP07]
- Monitoring of **workload** during training and matches in a **handball** team. [RENOUF, F.; OP-AP09]
- **Energetic demands** in the **men's** European **handball** championship 2020. [VENZKE, J.; OP-PN03]
- Effect of playing position on **peak locomotor intensity** in **elite handball** small-sided games and matches. [FLEUREAU, A.; CP-AP03]
- **Locomotor demands** of **forwards** and **defence-men** in **ice hockey**. [BIELMANN, C.; E-Posters]
- Machine learning to determine **performance indicators** in **women's collegiate lacrosse**. [BUNN, J.A.; CP-AP04]
- **Age of bench-press peak performance** of 5,493 **male** and 3,342 **female** elite **power-lifters** is ~35 y. [YI, W.; E-Posters]
- As a **performance indicator**, the area outlined by the positions of the ball bounce in a

tennis rally is a work in progress. [KIM, H.; CP-AP04]

Various correlates of performance…
- Correlation of **kinematics** with **ball velocity** in **baseball** pitchers. [WADA, N.; OP-BM05]
- **Training characteristics** of 14 **professional female cyclists** ("successful" vs "less successful") of one team over 7 y. [VAN ERP, T.; OP-BM01]
- Effect of internal and external **training loads** on match activities and subjective markers in **professional football**. [BOVIN, M.; CP-MH01]
- Changes in **VO2peak** and **football**-specific **intermittent running** performance following pre-season training in 47 **sub-elite** players. [RØMER, T.; YIA, OP-AP10]
- Residual torque enhancement is related to **iron-cross performance** on rings in **men's gymnastics**. [BUSQUETS, A.; E-Posters]
- **Physiological determinants** of performance in trail running of different distances by 14-24 **runners** [SABATER PASTOR, F.; OP-AP01]
- Effect of **gender** on molecular and physiological determinants of **sprint** performance. [MARTIN RODRIGUEZ, S.; YIA, CP-PN02]
- **Some factors** affecting **men's 1500-m speed skating**. [FENG, J.; E-Posters] I can't understand much of this poster.
- "**Polyrhythmic production ability**" of **artistic swimmers** of two levels of experience. [VATHAGAVORAKUL, R.; OP-BM04]
- Seasonal changes in **body composition** with that in performance tests in 26 male and 3 **female experienced triathletes**. [SOEDER, J.; OP-AP08]
- Effect of **gender** on simulated **triathlon** performance. [COLOSIO, M.; YIA, OP-BM09]]

Talent Identification and Development

In a symposium (IS-AP02) on talent development in **elite cycling**, the first speaker presented evidence from a career-long study of talented cyclists "to show the importance of the combination of **physical**, **cognitive** and **psychological** factors for success, [whereas] the essential role of **tactical skills** is relatively unexplored." [ELFERINK GEMSER, M.] The third speaker showed how **maximum mean power** over different durations (10 s to 20 min) monitored in road cyclists during competitions can be used to

identify talent, enhance training, and provide insight into the best role of a cyclist within a team. [LAMBERTS, R.]

Analysis of a **male youth rugby** longitudinal database led to the suggestion that implementation of a **half-game rule for adolescents** to enhance meaningful game time might increase player retention. And there was no relative-age effect on retention. [MCEVOY, P.; OP-AP05]

In a survey of 1214 Spanish **female basketball** and **football** players, "athletes perceived that the **motivational climates** created by female coaches were more empowering and less disempowering than the ones created by the men coaches. In addition, athletes' autonomy was more satisfied when their coach was a woman." [MARTÍNEZ GONZÁLEZ, N.; CP-SH03]

Tests and Technology

Wow! "There was an unacceptably high prevalence of misleading assessments of magnitude based on statistical significance and non-significance at last year's ECSS conference. Researchers should account for **sampling variation** by replacing the nil-hypothesis test with tests of substantial and non-substantial magnitudes or preferably magnitude-based decisions." [HOPKINS, W.; OP-AP07] Great video, which you can also see here.

Strength-endurance profiles were better than load-velocity profiles to predict bench press 1-RM in 30 **resistance-trained subjects** (19 **males**, 11 **females**). [MITTER, B.; OP-AP03]

In a systematic review of 132 articles, "**wearable devices** were found to be generally valid and reliable tools for assessing **running gait**, [and] development of multi-modal wearable technology would further aid analysis outside of the laboratory." [MASON, R.; OP-AP07]

Results of a biomechanical analysis of 12 (male?) **experienced cyclists** "agree with two classical references in bike fitting, recommending using the **shoe-cleat position** under the first metatarsal head in relation to a backward position." [GARCÍA GONZÁLEZ, P.; OP-BM01]

The Takei Vertical Jump Meter had much lower same-day typical error (3.0%) than the HomeCourt (5.9%) and MyJump2 (5.5%) apps in this reliability study of **countermovement jumps** of 14 **male** and 16 **female collegiate students**. [PUN, W.Y.; CP-AP03]

The smallest important effect on speed for swimmers is ~0.3%, so a typical error of "<4%" is not "reliable" for **critical speed**, as claimed; in any case the protocol was unrealistic for many **swimmers**. [SCOTT, B.; CP-AP04]

Miscellaneous tests and technology…

- "Stadium 4.0 – a turnkey solution from Kistler" was the topic of an industry-sponsored session about a complete ready-to-use **biomechanical analysis system**. View the announcement and access the 27-min video (via the pre-congress link in the conference app, PAS-05), if you're thinking of buying.

- View an industry-sponsored session (PAS-06) overview and 45-min video on "Beauty" (the Cortex mobile metabolic system) "and the Beast" (a big treadmill), if you're thinking of buying the latest in **breath-by-breath monitoring**.

- View an industry-sponsored session overview and 45-min video (via the pre-congress link in the conference app, PAS-07), if you're thinking of buying Simi's fully automated **markerless tracking system**.

- A **deep-learning** algorithm to estimate **running** parameters from an **inertial sensor** embedded in a heart-rate chest strap. [ZIGNOLI, A.] ANTA, a Chinese sportswear firm, funded this study. The video was presented by Laurent Mourot; access it via the industry partner programme link in the conference app, session ID PAS-04.

- Kistler also had a session on use of a **force platform** for **golf** kinetics: view the announcement and access the 30-min video (via the pre-congress link in the conference app, PAS-08).

- Polar sponsored a session that included mention of their devices for **heart-rate** and motion monitoring and examples of analysis. View the overview and the video (via the pre-congress link in the conference app, PAS-01). The video includes a new statistical model to predict **endurance world records** (Thorsten Emig) and validation of a Polar sensor for **swimming** (Christoph Zinner).

- The latest **motorized tether** for assessing **running** acceleration and deceleration, including change of direction, was the topic a session sponsored by 1080Motion. View the announcement and the 59-min video (via the pre-congress link in the conference app, PAS-02).

- Optimal sensor placement in **smart clothing**. [HOAREAU, D.; OP-AP09]

- A novel lower extremity **inertial sensor** for quantifying load [BASTIAANSEN, B.J.C.;

OP-AP01]

- A novel, semi-automatic method for **muscle cross-sectional area** in **ultrasound** images. [RITSCHE, P.; OP-AP08]
- Error in **ultrasound** measures of **muscle cross-sectional area.** [HERNÁNDEZ BELMONTE, A.; OP-AP08]
- **Wearables** plus **machine learning** to detect whether a **pass** with an **American football** was caught or dropped. [EISENBRAUN, J.; CP-AP04]
- Video coding using simplified categories to assess **player loading** in **basketball**. [HUYNH, P.T.; E-Posters]
- Norms for **fitness tests** in age-group **male** and **female basketball** squad players. [SCHNEIDER, C.; CP-AP04]
- Measuring **stroke rate** and **stroke distance** in **kayak** and **canoe sprinting** with a GNSS system. [MIYAMOTO, N.; TAKEDA, M.; CP-AP05] I couldn't understand the method.
- Torque effectiveness of sport students with a **non-circular chain ring** in **cycling**. [HAAB, T.; OP-BM01]
- Various measures of body composition based on **bioelectric impedance** in **football** players of **three levels**. [CANNATARO, R.; E-Posters] Abbreviations not defined in abstract or poster.
- **Instrumentation** of an **oar** in **rowing** to provide feedback to rower and coach on the 3-D motion of the blade. [ICHIYA, F.; E-Posters]
- A novel reactive **agility test** and 20-m sprint test in **elite** and **club-level male touch rugby** players. [WONG, C.L.; OP-AP05]
- A magnet-based **timing system** for **ski gates**. [PÉREZ CHIRINOS, C.; CP-AP05]
- A waterproof **metronome** under a **swimmer's** cap allows control of stroke rate. [FASSONE, M.; YIA, OP-AP11]
- Reliability of **change of direction testing** using motorized resistance and assistance in 7 **male** and 3 **female team-sport athletes**. [WESTHEIM, F.; OP-AP07]. See also [AHLBECK, F.; OP-BM07] for validity.

Training

From the plenary (PS-PL01) on **sprint** performance: "Although the most effective strategy to improve muscle power is by loaded contractions performed at the highest speed possible (explosive-type **strength training**), reducing the level of fatigue allowed during the training session is associated with greater improvement in jumping and sprinting performance." [CALBET, J.A.L.]

Get the latest on **blood-flow restriction training** in this symposium (IS-BM04). Take-home message: "gains in skeletal muscle size and strength with [such] training have been typically demonstrated when using light exercise loads, making it an attractive application following injury." [CENTNER, C.; COOK, S.; PATTERSON, S.]

In a symposium (IS-AP01) on individualized recovery management, the third speaker focused on "**training in the heat** - will post-exercise cooling enhance recovery or interfere with adaptation?" The answer is in the video: "it will *likely* not negatively influence adaptations" but presumably not enhance adaptations. [IHSAN, M.]

"**Heat stress** applied concurrently with long term **resistance** training did not improve upon performance gains" in a controlled trial of 8+10 **recreationally active males**, but it's the usual misleading interpretations of significance and non-significance. It looks to me like the added heat stress was likely harmful for some measures. [CHANDRASIRI, S.; E-Posters]

In a controlled trial of 8+8+8 **male and female endurance runners** of modest fitness (VO2max ~50 ml/min/kg), the addition of **plyometric**, **isometric** or **circuit** training (control) twice a week for 6 wk produced improvements in a 2.4-km time trial of 3.1%, 2.4% and 0.4% respectively. There were parallel changes in economy, VO2max and jump height. [LUM, D.; OP-AP01]

Six weeks of a twice-weekly **squat exercise** based on flywheel resistance training improved strength to a greater extent than usual training in a controlled trial of 10+10 **female soccer** players. [PECCI, J.; OP-AP02]

Conclusions of a controlled trial of 16+16 **male sub-elite adolescent handball** players: "the combination of a shoulder strengthening program using **elastic bands** and regular handball training can be recommended compared to regular handball training only to increase measure of shoulder strength endurance, maximal shoulder strength, and throwing velocity." [BAUER, J.; E-Posters]

In an uncontrolled trial, 8 wk of **strength** training improved exercise economy and race performance in 12 **male** and 3 **female triathletes**. [VILLANOVA, S.; OP-BM01]

A controlled training trial of 6+6+7 (male?) **amateur soccer** players doing **squat**, **deadlift** or **combined** training was presented as differences in significance. [PARK, Y.J.; CP-AP02] In the

poster, the differences between the changes look inconclusive.

An uncontrolled 25-wk **periodized** training macrocycle improved performance in 12 highly-trained track and field (male?) **throwers**. [ZARAS, N.; OP-AP02]

"Wearing **compression stockings** while training for a few weeks did not contribute to an improvement in running and jumping performance" in a controlled trial of 24 (male?) **experienced runners**, as shown by p values only (no data), even in the video. [DAR, G.; OP-BM06]

Improvements in endurance performance in hypoxia were similar following 4 wk of training in **hypoxia** with **nitrate** supplementation, hypoxia with placebo supplementation, or normoxia in a controlled trial of 10+10+10 **endurance trained male participants**. [SOUSA, A.; OP-PN04]

Feedback on skill execution in **cricket** batting and fielding had large effects on improving accuracy of anticipation and small (not moderate, as stated) effects on performance success in a meta-analysis of five studies. [TISSERA, K.; OP-SH01]

In a single-blinded cross-over of **mindfulness** training vs control, 17 **male college athletes** experienced a substantial reduction in salivary cortisol but "no significant differences" in six dimensions of mood following a lab-based **soccer** simulation. [SUN, F.; CP-SH03]

"An individual's tendency to pay conscious attention to the decision making process (**decision reinvestment**) can influence decision making, especially under pressure." This 3-wk video-based decision-training study of 20 **female national-level water-polo** players revealed "a positive influence of decision reinvestment on decision making in the post-test and retention [a test 3 wk later]", but a "not significant" effect on "transfer" of decision making to the pool. [MALHOTRA, N.; CP-AP03]

Conclusions of a systematic review of 51 studies of **optimal feedback** control theory-related approach to learning whole-body skills: "Generally, 'self-organization' training is recommended to reap the benefits of functional, non-task-relevant variability. However, if the trainer/coach aims to specifically lower all movement variability, use of the prescriptive approach is warranted." [VAN ANDEL, S.; E-Posters]

Search for OP-MD01 or **Covid** for various effects of the pandemic on training and performance.

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