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**ORAL PRESENTATIONS**

**O1**

Training load and health problems in freshman rowers  
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**Background:** Rowing is a popular sport for students in the Netherlands. First-year students have to deal with a substantial increase of training exposure during their rowing season. The aim of this study was to investigate the training characteristics and the occurrence of injuries and illnesses in the freshman rowers.

**Methods:** Novice rowers of 5 Dutch student rowing clubs were prospectively followed during the season 2013-2014. Prior to the start of the season, all participants filled in a baseline questionnaire about anthropometric characteristics, injury history and rowing experience. During the 7 months follow up, an online questionnaire was filled in on a weekly basis to monitor exposure (duration and intensity of training sessions and races) and health (injuries and illnesses). To collect this information the OSTRC Overuse Injury Questionnaire was used (Clarsen et al., 2013).

**Results:** In total, 137 freshman rowers took part in this study (63% man, 37% women; mean age 20.4± 1.5 years). Preliminary results show that 3122 questionnaires were filled in during the season (mean = 23, median = 26, range 1-34 per rower). On average, the rowers spent more than 7 hours (430 minutes) of training per week and they performed on average 2.9 race kilometers per week. The mean intensity of rowing was assessed as “somewhat hard – hard”, 14 on a scale of 6 – 20 (= Rate of Perceived Exertion).

In almost 4 out of 10 questionnaires (37%) problems during rowing in the past week were registered. In 28% of all questionnaires symptoms of health complaints during the past week were mentioned. Injuries and illnesses were the most prevalent types of these health problems (56% and 31% respectively). Eighty percent of the rowers (n=109) sustained 1 (or more) injuries during the season. The most common injury locations were knee (30%) and lower back (17%).

**Conclusions:** The injury/illness incidence is high for freshman rowers. Nevertheless, the current knowledge on the epidemiology of rowing injuries and illnesses in novice rowers is scarce. Our results can form the starting point for further research on risk factors and injury mechanisms. Finally, effective injury and illness prevention programs for rowers are needed.

**Reference**

**O2**

Protecting the clean athlete, protecting health  
Richard Budgett Dr
International Olympic Committee Medical and Scientific Director

The vision of the IOC is to change the world for the better through sport and to promote social change. Protecting the health of the athlete is an important part of this vision, in order to protect the integrity of sport, protect elite athletes, protect the health of all those exercising and to promote physical activity. The protection of clean athletes through doping control is also important for the protection of the integrity of sport and of athlete health. The focus of the IOC Medical Commission is the prevention of injury and illness; this is done through world conferences, injury and illness surveillance, International Federations (IF) and National Olympic Committees. Rowing is an excellent example of a non-contact sport, where overuse injuries are the main problem. Illness and overtraining are also important. Individual physiology and training are crucial to develop the combination of power and endurance needed to compete. Rowing is a perfect sport for the multidisciplinary team of sport and exercise medicine, physiotherapy, physiology, psychology, nutrition and biomechanics specialists. Priority for the IOC is surveillance and audit, so that changes to rules, to equipment, to training and to technique can be evidence based and the effect on prevention measured. It is important for different sport federations to take every opportunity to work with each other for cross fertilization of best practice and new ideas, including at the IOC IF meetings. The IOC and world rowing share the priority of protecting health and protecting clean athletes.

**References**
**O3 Development of a new guideline to facilitate diagnosis and management of rib stress injuries in rowers**

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**Background:** Rib stress injury is the development of pain due to bone oedema caused by overload along the rib shaft and is commonly seen in rowers (1,2). At the elite level the injury is often managed by clinicians experienced with the condition. However it has been noted by the authors that there is a lack of awareness and confidence in diagnosing and managing this condition by clinicians who are not regularly exposed to this mainly rowing specific injury. As a result, a guideline has been developed by the authors to aid diagnosis and management of rib stress injury for use by clinicians.

**Materials and methods:** A detailed literature search was conducted reviewing the diagnosis and management of rib stress injury. Detailed discussions between the authors and the rest of the Great Britain rowing medical team took place to highlight the key issues in treating rib stress injury. An up-to-date and evidence based approach to managing rib stress injury was created using both expert knowledge and the current literature.

**Results:** The outcome from the expert meetings and literature review was the creation of a new guideline for management of rib stress injuries. The guideline was created to be user friendly, informative and logical and to direct the reader through diagnosis, investigations and management of rib stress injury. A separate section is included in the guidance which helps identify both intrinsic and extrinsic factors that may predispose to injury. The guideline has deliberately been kept to two pages long so as not to overwhelm the reader or complicate the guidance.

**Conclusions:** A new clinical guideline for management of rib stress injuries has been developed to facilitate clinicians and in identifying rib stress injury and aid accurate diagnosis and management. This guideline is to be disseminated to clinicians, rowing coaches and clubs throughout the UK.

**References**


**O4 Monitoring training status using novel submaximal test**

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BMC Sports Science, Medicine and Rehabilitation 2015, 7(Suppl 1):O4

**Introduction:** Rowers in their first year of competition have a high risk of overtraining, caused by a disbalance in training load and recovery. A typical week in the rowing season consists of 5-8 training sessions, and many first year (“freshmen”) rowers have little previous experience in competitive sports. The risk is further increased by the fact that personalization of training load is difficult and that coaches are often inexperienced. In this study we investigated whether a standardized submaximal exercise rowing test (SERT) can be used as a tool to monitor training status and as such can help to prevent overtraining.

**Methods:** For a period of four weeks, the weekly training load of members of one lightweight men’s freshman crew (eight rowers) was quantified by summing heart rate scores (Edwards, 1993). Rowers undertook the SERT on a rowing ergometer (Concept 2, USA) on a weekly basis. The SERT adapted from the LSCT (Lamberts, 2011) and yields values for power output at 70, 80 and 90% of maximum heart rate, heart rate recovery (HRR, defined as the drop in heart rate in one minute after cessation of exercise) and rate of perceived exertion (RPE) on a 0-10 point scale (Foster 2001).

**Results:** One participant dropped out because he showed signs of overtraining already at the start of the experiment. For the remaining seven rowers, training load was significantly higher in weeks 2 and 3 compared to weeks 1 and 4 (P<0.01). Consequently, these weeks were categorized as ‘heavy weeks’ (H) whereas weeks 1 and 4 were categorized as ‘light to moderate’ weeks (L). HRR was shown to be significantly lower during the heavy weeks (L: 53.8±8.48, H: 50.6±6.50, P<0.05), suggesting fatigue or inaccurate recovery. No differences were found in power values or RPE scores.

**Discussion:** Obtaining relevant information on training status of individual team members can prove to be difficult in crew rowing. This study indicates that a standardized training such as the SERT helps to monitor individual rowers, especially when HRR is obtained. A sudden drop in HRR is as an early warning sign and may lead a coach to adapt the training schedule. Furthermore, the participants rated the SERT with 3.8 on the 0-10 RPE scale, indicating that the SERT is suitable to be performed on a frequent basis without risking interference with the daily training. Future research should point out whether occurrence of overtraining would indeed be lower with frequent monitoring of training status.

**References**


**O5 The effect of real-time feedback on velocity fluctuations in steady state rowing**

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**Introduction:** Rowing performance depends on maximization of mechanical power delivered by the rower(s) and minimization of power losses [1]. Though reductions of power losses may increase the average velocity of a boat, traditional feedback methods lack the accuracy to differentiate between small variations in this power losses. Therefore, we developed a feedback tool to provide real-time feedback about power parameters related to rowing. The current study evaluated the efficacy— with respect to velocity fluctuation power losses—of the real-time feedback on the power loss due to velocity fluctuations compared to the efficacy of traditional feedback.

**Methods:** A cross-over design was conducted in which 9 Dutch rowers participated. An algorithm was developed to estimate boat velocity in real-time from combined accelerometer data (sampled at 100Hz) and GPS data (sampled at 10Hz). Power loss due to fluctuations in boat velocity, averaged over each full rowing cycle, was transformed into a single numeric parameter indicating the actual average power loss to boat drag, relative to power loss to average drag. This parameter (one value per full rowing cycle) was fed back visually in real time to single scull rowers, using an android smartphone both for data processing and feedback. In addition, auditory feedback was generated using pitch mapping of the instantaneous power loss due to velocity fluctuations around the mean velocity.

**Results:** Multilevel analyses revealed that neither traditional coach feedback nor real-time feedback from the application resulted in a significant decrease of velocity fluctuations due to power loss. No
significant differences were found between both conditions. Participants rated the feedback presented by the application positive and would like to row more often with real-time feedback.

Discussion: Real-time feedback from the application was as effective as coach feedback with respect to reduction of power losses due to velocity fluctuations. No changes of power loss were found in both conditions. Firstly, this may be due to noise with respect to weather conditions which makes it difficult to measure small variations in velocity fluctuation power losses due to feedback. Secondly, rowers may need more time to adjust to the feedback parameter since they are used to train with feedback about velocity. In a next series of studies we will evaluate other relevant power parameters in terms of the power equation for steady state rowing and improve the visibility of the feedback by using Google glasses, ultimately supporting elite rowers to converge to the optimal trade-off between all relevant power terms.

Reference

O6 Bone mineral density in elite rowers
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Background: Bone mineral density (BMD) is known to be dependent on the loading pattern associated with a particular sport. High impact sports increases BMD at loaded sites with low impact sports having largely neutral findings [1]. The influence of high level rowing training has not been well explored with relatively small samples within a single category or discipline [2-5].

Methods: Subjects (n=125) were internationally competitive. Between 2011-2014 BMD was taken at the lumbar spine (L1-L4) and left femur, by Dual-energy X-ray absorptiometry (DXA, Lunar Prodigy, GE Healthcare), using the same scanner, and a qualified technician. Ethics was approved by the Australian Institute of Sport Human Ethics committee. Subjects gave prior written informed consent. Descriptive statistics are reported as mean ± standard deviation (range). Z-score and T-score. Statistical analysis was performed using independent samples t-test, significance set at p<0.05.

Results: A summary of findings is shown in Table 1. Overall, 5.6 % of rowers had Z ≤-1 at the spine and 1.6% at the femur with none Z < -2. Both spine and femur BMD, T and Z scores were lower for female lightweight than heavyweights. Male spine BMD and T score and femur T score was lower for lightweights relative to heavyweights.

Conclusion: BMD of elite rowers appears to fall largely within the optimal range for the general population however lightweight rowers, tended to have lower BMD than their heavyweight counterparts at all measured sites at the spine and for females also at the femur.

References

Table 1 (abstract O6) BMD in males and female rowers by weight category. Data are expressed mean ± standard deviation (range)

<table>
<thead>
<tr>
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<th>Males Overall</th>
<th>Lightweight</th>
<th>Heavyweight</th>
<th>Females Overall</th>
<th>Lightweight</th>
<th>Heavyweight</th>
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<td>g/cm²</td>
<td>1.33 ± 0.13</td>
<td>1.27 ± 0.10*</td>
<td>1.38 ± 0.12</td>
<td>1.29 ± 0.14</td>
<td>1.19 ± 0.09*</td>
<td>1.35 ± 0.14</td>
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<td>T score</td>
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<td>0.2 ± 0.9 *</td>
<td>1.3 ± 1.0</td>
<td>0.6 ± 1.1</td>
<td>-0.3 ± 0.7 *</td>
<td>1.0 ± 1.1</td>
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<td>(-1.1 - 3.5)</td>
<td>(-1.2-3.5)</td>
<td>(-1.2 - 0.9)</td>
<td>(-1.0 - 3.5)</td>
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<tr>
<td>Z score</td>
<td>0.7 ± 1.0</td>
<td>0.5 ± 1.9</td>
<td>0.8 ± 1.0</td>
<td>0.4 ± 1.0</td>
<td>0.1 ± 0.7 *</td>
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<td>(-1.5-3.2)</td>
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<td>(-1.5 - 3.2)</td>
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<td>Femur</td>
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<td>g/cm²</td>
<td>1.19 ± 0.13</td>
<td>1.16 ± 0.13</td>
<td>1.21 ± 0.12</td>
<td>1.12 ± 0.13</td>
<td>1.05 ± 0.09*</td>
<td>1.17 ± 0.13</td>
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<td>T score</td>
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<td>1.0 ± 0.9</td>
<td>0.5 ± 0.9</td>
<td>0.0 ± 0.7 *</td>
<td>0.8 ± 0.8</td>
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<td>(-1 - 3.8)</td>
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<td>(-0.6 - 3.8)</td>
<td>(-1.4-3.2)</td>
<td>(-1.4 - 1.3)</td>
<td>(-0.7 - 3.2)</td>
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<tr>
<td>Z score</td>
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<td>0.5 ± 1.0</td>
<td>0.3 ± 0.78</td>
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<td>(-1.1 - 1.6)</td>
<td>(-0.8 - 3.0)</td>
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* significantly lower than for heavyweights within the same gender (p<0.05)
although this is clearly linked to performance. The major injury that drove this initial work was low back pain (LBP) and current research papers still noting that LBP accounts for 32% of reported injuries in elite rowers (Wilson et al 2010). Injuries, particularly to the spine, have both immediate and longer term implications; the injury can not only prevent an athlete from competing, it can impair preparation and training and in some cases led to retirement from the sport. Furthermore, since rowing is predominately a team or crew based sport the impact of an injury goes beyond the individual athlete and can alter the subsequent success of the crew. It is not surprising therefore, that efforts to prevent injuries are important, however for athlete themselves injury prevention is perceived as less important since their focus is firmly on performance.

Rowing has been described as a motor skill that requires high levels of consistency, coherence, accuracy, and continuity. It is a highly repetitive action and thus the concept that lower back injuries are mechanical in origin and related to technique holds credence. By understanding how and why injuries occur we could impact on performance by preventing them as well as the long term well-being of the athlete. We have developed a system to measure the mechanics of the spine during rowing and have used this system to explore a situation that may precipitate injury including fatigue, training rate, experience etc. From this work we have been able to identify predictors of performance but experience derived from longitudinal measures suggest that some of these may also be important with respect to early identification of injury. However, as well as identifying injury it is important how to understand how to manage and change injury which in some instance may be related to technique and motor control. To this effect we will also explore the impact of biofeedback on performance and its use as a common language to facilitate change in rowing technique.

Reference

O8 Analytics... what’s it all about?
Laurie Miles PhD
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This presentation aims to go over a number of things. Firstly it will welcome the attendees to SAS UK HQ at Wittington House and give the audience a brief introduction into SAS as an organisation. This will include a short history of the company and an overview of what SAS does. This focuses on predictive analytics; the use of historical data to look for patterns and trend to essentially ‘predict the future’. This is the SAS differentiator – the use of data to not only report the past but gives insight to why things are happening, what will happen in the future and enable organisations to make fact based decisions to ensure the best outcomes. In order to illustrate this, and demonstrate the varied uses of advanced analytics for decision making, the presentation runs through a number of stories from both business and sport. These stories include the use of analytics to help banks reduce fraudulent transactions and make better lending decisions and well as enabling retailers to more accurately forecast sales so they can optimise their supply chains and stock levels. From the sporting world, the use of analytics to optimise performance and reduce injuries will be discussed in sports as varied as motor racing, rugby, ice hockey and rowing. Finally, the session will give some insight and opinion as to the future of data analytics. This includes discussion around the increasing volumes of data, the increasing variety of data that needs to be analysed and the speed with which analysis needs to be made to enable real-time decision making. This section will touch upon both ‘Big Data’ and ‘The Internet of Things’.

O9 Increasing lean muscle mass: nutritional and periodization strategies
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Increases in skeletal muscle mass arises as a result of positive net protein balance, such that muscle protein synthesis (MPS) exceeds muscle protein breakdown (MPB). Increased mechanical loading and provision of high quality amino acids are potent and independent stimulators of MPS through activation of key cell signaling pathways involving the mTOR-p70S6K signaling axis. Importantly, the combination of resistance exercise and dietary protein intake elevate MPS over and above their independent effects, thus highlighting that a well formulated resistance training programme (incorporating multiple sets to failure) and increased dietary protein intake (spread evenly throughout the day) should form the basis of training and nutritional strategies. However, given that many elite athletes (such as rowers) may simultaneously be training to develop endurance as well as strength, it is also important to consider the periodization of endurance type training sessions alongside high volume resistance sessions. In this regard the signaling pathway known to regulate the endurance phenotype (i.e. the AMPK-FGC-1 axis) may potentially attenuate the activation of growth related pathways thereby mediating a training interference effect by which lean mass growth is negated. As such, careful consideration should also be given to the training structure and nutrient availability both within and between days as to maximize training adaptation and recovery. In this presentation, the author presents data from both his own laboratory and others that briefly outlines the molecular regulation of muscle mass growth and endurance adaptations before providing nutritional and training periodization strategies such that both aspects of training adaptation may be developed simultaneously.

O10 Rowing: extreme physiology and possibility for injury
Henning Bay Nielsen
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BMC Sports Science, Medicine and Rehabilitation 2015, 7(Suppl 1):O10

Rowing produces marked changes in oxygen uptake, pulmonary ventilation, cardiac output and lactate with extreme levels for blood acid-base status and pronounced concentration of catecholamines in blood that could affect coagulation. With development of potassium related arrhythmia may even be developed that most often may be of supraventricular origin but sudden cardiac death is reported in rowers. Structural myocardial adaptations to intense rowing training that demands the heart to work against high pressure during the stroke need to be considered. Rare cardiac diseases such as the Brugada syndrome and arrhythmogenic right ventricular cardiomyopathy may also provoke cardiac arrest during exercise. The latter is related to genetic disorders but myocarditis could be involved and following rowing the immune system is suppressed. In the subject with vulnerable myocardium abnormal tachycardia may arise during rowing but also bradycardia in the resting period. Furthermore, it is speculated whether silent arrhythmia in combination with dehydration and coagulation disorder could provoke blood clots and even stroke that recently occurred in two Danish athletes. These cases are presented along with parameters indicative of extreme physiology during rowing.

O11 Sweat rate of highly trained junior rowers during a session of low intensity endurance training
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Background: Hyohydration is associated with impaired endurance performance and increased heat stress. Therefore, rehydration after exercise needs to be sufficient. However, several athletes tend to hypohydrate especially during training camps. To allow exact quantification of necessary rehydration volume in order to prevent hypohydration, this study aimed to determine the sweat rate of highly trained junior rowers during a session of low intensity rowing training.

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http://www.biomedcentral.com/bmcsportsscimedrehabil/supplements/7/S1
Methods: Eight highly trained junior rowers (M8+) participated in the study (age: 17.5 ± 0.5 yrs; body mass (BM): 89.5 ± 4.5 kg; height: 193.1 ± 2.9 cm; body surface area (BSA): 2.2 ± 0.1 m²; VO_{max} 64.2 ± 5.5 ml/kg/min). Haematocrit in capillary blood as well as the urine specific gravity (USG) were measured in the morning at fasting state as a measure of hydration status. BM was measured before (PRE) and directly after (POST) a session of low intensity rowing (20 km; 1.5 hours). Athletes dried themselves with a towel before weighing and wore dry underpants only. Water consumption during training was recorded. Sweat rate was calculated as follows:

\[ \text{Sweat rate (l/h)} = \frac{\text{BM}_{\text{PRE}} - \text{BM}_{\text{POST}} - \text{consumed water}}{90 \text{ min}} \times 60 \text{ min} \]

The environmental conditions were 16.5 °C and cloudy.

Results: Haematocrit values before training were 50 ± 2.6 % and USG was 1.022 ± 0.005. BM loss during the complete training session was 0.7 ± 0.5 kg. Athletes consumed 0.8 ± 0.3 l of water. The sweat rate amounted to 0.96 ± 0.26 l/h equal to 0.44 ± 0.12 l/h/m². Highest sweat rate amounted to 1.30 l/h.

Discussion: Pretest data indicated euhydration in 6 athletes, however in 2 athletes signs of mild hypohydration were detected, which possibly influenced the results.

The results demonstrate a relevant loss of body water through sweat and respiration during a single session of low intensity exercise even at moderate temperatures. In hot environment, higher sweat loss has to be expected. As data do not reflect urine and fecal body water loss, total body water loss exceeds sweat rate. This has to be taken into account when calculating sufficient rehydration volume.

Conclusion: Sweat rate of highly trained junior rowers ranges from 0.55 to 1.30 l/h in a moderate environment. Athletes and coaches should be aware of water loss to ensure sufficient rehydration during and after exercise. Furthermore, monitoring of hydration status is recommended in high performance sports.

O13 Endurance sport and cardiovascular health
Sanjay Sharma
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The cardiovascular benefits of exercise are established and individuals exercising regularly reduce their risk of adverse events from coronary artery disease by 50% and gain at least 3 additional years of life. When one considers the burgeoning epidemic of childhood obesity and its complications, exercise may be regarded as the most clinically and cost-effective prescription dispensed by healthcare professionals. The intensity of exercise required to achieve these benefits is 6-8 METS which equates to walking briskly or jogging for 30 minutes daily. Competitive athlete, particularly those engaging in endurance events such as long distance running, cycling, rowing, canoeing, triathlon, marathon and iron man events partake in physical activity of a much higher intensity for as many as 20 hours per week.

The requirement of a 5-6 fold increase in cardiac output is met by physiological structural and functional adaptations within the heart. Sinus bradycardia, large QRS complexes and a 15-20% increase in ventricular cavity size are the hallmark of the ‘athlete’s heart’ and are most pronounced in large male endurance athletes. Up to 50% of male endurance athletes show ventricular dimensions exceeding predicted upper limits for the general population. Such alterations are considered benign and reverse after a period of detraining.

The potential hazards of intensive exercise are occasionally highlighted by the sudden cardiac death of an individual during or immediately after exercise, however, such catastrophes are extremely rare, largely striking young athletes harboring inherited or congenital arrhythmogenic substrates. Despite the emotive visibility afforded by these deaths in the media, the positive reputation of exercise remains unscathed by the fact that exercise is regarded as a mere trigger for arrhythmia in a small proportion of predisposed individuals but never directly incriminated in the pathogenesis of the fatal substrate.

The past 2 decades has witnessed an extraordinarily engaging athletic milieu where humanly possible achievements seem infinite. In parallel there have been multiple reports of increased serum concentrations of biomarkers of cardiac damage and transient cardiac dysfunction after intensive endurance exercise. The mechanisms for these observations is uncertain but raise the possibility that repeated bouts of intensive endurance exercise may culminate in adverse cardiac remodeling and arrhythmogenic substrates in a small minority of endurance athletes. Perhaps the most persuasive evidence for this concern is the 5-fold increase in the prevalence of atrial fibrillation in middle aged endurance athletes compared with the relatively sedentary population of the same age.

O12 150 years of rowing faster: what are the sources of more and more speed?
Stephen Seiler
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Rowing has a 150 yr+ competitive history. Examining results from historic races like Oxford-Cambridge (established 1829) and the world championships (established 1893) reveals a linear increase in boat speed by 2-3% per decade. Boat velocity increases if propulsive power is increased and/or power losses are reduced. Over time, the propulsive power capacity of elite rowers has increased. Part of this increase is a result of recruiting athletes from a population that has become taller (1.3 cm per decade) and heavier. Modern world class rowers are typically 190-200 cm tall and weigh 90-100 kg. However, physical capacity does not scale directly with body dimensions but conforms instead to biological scaling laws. Increased rower mass also increases boat drag. Consequently, increased rower size only accounts for about 10% of the increase in boat speed. The tenfold increase in training load performed accounts for about 1/3 of the overall increase in physical capacity, and performance.

Power loss sources can be organized in terms of 1) boat drag, 2) oar blade inefficiency and 3) rowing technique. Racing rowing shells took on their modern form early, as boat design was revolutionized during the period 1830-1856. Boat weight reduction has been the only really significant source of power loss due to boat drag and indirect effects on power production. However, the best rowers are able to row with very minor imbalance in the boat. Force curve optimization is heavily discussed today. Real time measurement of boat kinematics and rower force application patterns open for new approaches to training and rower selection for team boats. It seems unlikely that one optimal force curve can be identified for all rowers in a team boat because the interaction among anatomical, muscular, and biomechanical factors probably constrains the optimal force curve for each rower.
Background: There was no comprehensive analysis of injuries among international elite-level rowers of different age categories. Objective of this study was to define the most frequent acute (traumatic) and chronic (overuse) musculoskeletal injuries in international elite-level junior, senior and master rowers.

Materials and methods: 1775 elite level rowers from 70 different countries participating at the 2007 Junior, Senior and Master World Rowing Championships were included in a survey on rowing-specific 4-page questionnaire related to potential injuries and data were compared to data obtained from previous seasons. The questionnaire was based on general data, rowing discipline, training program data and potential injuries according to an anatomical localization.

Results: Among the 1775 rowers, 812 reported a total of 1343 injuries with 935 injuries related to a chronic or overuse effect on the musculoskeletal system. Low back pain was the most frequent complaint and a high incidence of chronic injuries was associated with increased average number of rowing sessions in both junior and senior rowers. Acute injuries (n=398) were less frequent compared to chronic injuries and the majority were acquired during on-water rowing specific training while non-rowing specific injuries were provoked by football, basketball and volleyball activities. Indoor rowing training such as gym and weightlifting in addition to rowing ergometer training were associated to less frequent injuries. The risk of injury was calculated to 1.75 and 2.25 injuries/1000 training sessions/rower and injured junior rowers had rowed for a shorter time compared to the rowers who did not report injuries. Senior open-weight rowers who have sustained chronic injuries have achieved significantly better final ranking at 2007 Senior World Rowing Championships, compared to the same group of rowers who did not sustain any injury.

Conclusions: The level of reported injuries reported in elite rowers is relatively high but considering the amount of training hours rowing is a low risk sport. Among all injuries in elite-level rowers, the predominant complain is low back pain.

O15 Monitoring rowers to determine under-performance
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Introduction: Over the past few years, training load and performance in competition has continuously increased and is fraught with risk to result in the accumulation of fatigueing conditions. The coach determines training success by controlling boat speed, performance, power and soft parameters like stability of rowing technique, capacity to teamwork, and mood state. However, in team sports like rowing, monitoring of individual rowers fatigue to optimize regeneration is difficult. While training should voluntarily cause acute fatigue, the accumulation of training leads to more severe fatigue, which is called “overreaching”. When fatigue is more prolonged and recovery is impaired, the condition is defined as “non-functional overreaching” ending in a primarily unexplained, long-term, and unplanned decreasing performance, a condition defined as “Unexplained Underperformance Syndrome” (UUPS) or “overtraining syndrome” (OTS). Good standards and appropriate markers for diagnosis and treatment are currently lacking.

Clinical signs of UUPS / OTS: Athletes present with the key symptoms of prolonged underperformance and/or reduced trainability or disturbed regeneration following a period of heavy training load. Mood disturbances like fatigue, lethargy, exhaustion, sleep disturbances, and increased susceptibility to infections are present; athletes experience increased levels of perceived stress, decreased levels of regeneration and burnout. Often, athletes report about previous upper-respiratory-tract infections. Physical signs include muscle pain, non-specific irritation of the mucous membranes, increased heart rate at rest and during a given workload, performance, and maximum oxygen uptake and maximum lactate levels are decreased.

Pathogenesis: The syndrome has been linked to carbohydrate metabolism, decreased levels of peripheral hormones like catecholamines, and immune malfunction; however, until now, the diagnostic approaches are very limited. Virus reactivation and signs of inflammation are also common in severely overtrained athletes. Carbohydrate metabolism is involved with insulin resistance and increased catabolic hormones like cortisol. Signs of disturbed carbohydrate metabolism are low leptin levels, insulin resistance and reduced maximum lactate. The stress hormones like cortisol or catecholamines are increased in acute situations, however, when fatiguing, the peripheral tissues decrease hormonal receptors which is counter-regulated by increased levels of hypothalamic release hormones, in severe cases the hypothalamic-peripheral axes are disturbed. Metabolic stress will reduce early sex hormone levels like estrogens and testosterone and the release hormones FSH and LH, peripheral thyroid hormones are down regulated as well as TSH.

There are parallels between the molecular mechanisms of ‘overtraining syndrome’ and systemic inflammatory reactions in trauma or sepsis. In healthy athletes, training induces a state of acute inflammation, which is rapidly counter-regulated by anti-inflammatory mechanisms. In the fatigued athlete, these mechanisms are disturbed and this leads to chronic inflammation and reduced immune function. Training induces so-called “damage-associated molecular patterns” (damps). These include molecules like free DNA, heat-shock-proteins or uric acid, which are released from the damaged muscle, oxidative stress and immunological signaling of so-called “pattern recognition receptors” (PRRs). These processes can be analyzed in blood samples by measuring inflammatory cytokines IL-1β, IL-8 and TNF-α, whereas a typical anti-inflammatory cytokine is represented by IL-10.

Practical approaches: We now understand much more of the training processes. In general, this knowledge should lead to an improved performance/recovery balance in athletes and therefore less underperformance and injury, which is the primary goal of any diagnosis. The immunological hypothesis has gained more importance; however, practical measurements in the training process are very limited due to laboratory needs and costs.

Therefore, key symptoms of UUPS or OTS are underperformance and/or reduced trainability and disturbed regeneration following a period of heavy training load. Mood and sleep disturbances can be evaluated with questionnaires. Physiological signs are increased heart rate at rest and during a given workload.

Rest and recovery measures are the most important treatment in early cases of UUPS/OTS. When the problems are prolonged, a clinical workup including selected blood parameters should be performed.

References

O16 Training in extreme hot and cold
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BMC Sports Science, Medicine and Rehabilitation 2015, 7(Suppl 1):O16

Introduction: Over the past few years, training load and performance in competition has continuously increased and is fraught with risk to result in the accumulation of fatigueing conditions. The coach determines training success by controlling boat speed, performance, power and soft parameters like stability of rowing technique, capacity to teamwork, and mood state. However, in team sports like rowing, monitoring of individual rowers fatigue to optimize regeneration is difficult. While training should voluntarily cause acute fatigue, the accumulation of training leads to more severe fatigue, which is called “overreaching”. When fatigue is more prolonged and recovery is impaired, the condition is defined as “non-functional overreaching” ending in a primarily unexplained, long-term, and unplanned decreasing performance, a condition defined as “Unexplained Underperformance Syndrome” (UUPS) or “overtraining syndrome” (OTS). Good standards and appropriate markers for diagnosis and treatment are currently lacking.

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Practical approaches: We now understand much more of the training processes. In general, this knowledge should lead to an improved performance/recovery balance in athletes and therefore less underperformance and injury, which is the primary goal of any diagnosis. The immunological hypothesis has gained more importance; however, practical measurements in the training process are very limited due to laboratory needs and costs.

Therefore, key symptoms of UUPS or OTS are underperformance and/or reduced trainability and disturbed regeneration following a period of heavy training load. Mood and sleep disturbances can be evaluated with questionnaires. Physiological signs are increased heart rate at rest and during a given workload.

Rest and recovery measures are the most important treatment in early cases of UUPS/OTS. When the problems are prolonged, a clinical workup including selected blood parameters should be performed.

References
Since the 5th century BC consideration has been given to diet and training for improved physical performance. In contrast the impact of environmental temperature and humidity on performance has largely been ignored until recent times, despite the fact that the environmental threat can result in severe impairment of performance and even death.

As physical performance is impaired in both hot and cold environments, the challenge in these environments is to try, through various interventions, to maintain as closely as possible, elite performance. The thermal threats include: thermal discomfort detrimentally influencing concentration, dehydration, heat syncope, heat exhaustion, heat stroke, cold-induced neuromuscular dysfunction, cold injury, drowning and hypothermia.

Strategies and interventions to reduce the impact of environmental extremes on performance include: selection strategies, clothing design, acclimation and acclimatization protocols, fluid replacement strategies, artificial sweating, active cooling and chemical or psychological perceptual adjustment.

Which if these interventions are appropriate depends on the mode of exercise to be undertaken, the specific nature of the thermal threat and the characteristics of the athlete in question. It follows that for optimal performance maintenance at the elite level, these considerations should be conducted on an individual basis, and include a detailed analysis of the athlete’s conditions to be faced and thermoregulatory characteristics of the athlete in question.

References

O17
High incidence of hyponatremia in trained rowers during a four-week training camp
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Purpose: The aim of this study was to investigate the incidence of hyponatremia during 28 days of high volume rowing training.

Methods: 30 members of the German junior rowing team (21 males, 9 females) were studied during a training camp of four weeks duration. Serum sodium ([Na]+) and osmolality were assessed at baseline before entering the training camp, and at day 7, day 13, day 18, day 24, and day 28. Additionally, daily fluid intake, body mass, urine parameters and training volume were determined.

Results: Hyponatremia ([Na+] < 135 mmol/L) was observed in 70 % of the rowers. The highest incidence amounted to 43% at day 18, when training volume was highest. [Na+] decreased from 143 ± 8.7 mmol/L (baseline) to 134.5 ± 5.4 mmol/L (day 18, p < 0.01). Hyponatremia was associated with body mass gain in the preceding 24 hours (p<0.01). [Na+] returned to normal values at day 28 (139.8 ± 3.9 mmol/L). Relative fluid intake (L/m² body surface area) increased from day 7 (males: 2.79 ± 0.78 L/m²; females: 2.20 ± 0.70 L/m²) to day 28 (3.88 ± 0.69 L/m² and 2.65 ± 0.93 L/m²; p<0.05). No athlete developed symptomatic hyponatremia.

Discussion: Prolonged high volume rowing training can lead to a high incidence of hyponatremia. The observed hyponatremia is associated with increases in body mass, which is a main characteristic of ‘exercise induced hyponatremia’. However, other mechanisms are probably also involved in the development of the observed hyponatremia, like e.g. inadequate suppression of antidiuretic hormone secretion. We conclude that overdrinking should be avoided during high volume training camps and adequate Na+-availability for athletes should be ensured. If central symptoms occur during training camps, team doctors should take hyponatremia into account.

O18
Rib stress fractures in rowers
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Rib stress fracture (RSF) is a relatively frequent, severe and well documented overuse injury in elite rowers. The incidence of RSF has been estimated to be approximately 9 %, but prospective studies with rigorous injury surveillance of larger groups of rowers are needed to confirm this. The burden of RSFs lies primarily in the severity as most reported cases needed 6-8 weeks of rest, rehabilitation and gradual return to rowing before a full return was possible. Anecdotal reports of non-union of RSF emphasize the necessity of ‘playing it safe’ regarding a timely, symptom dependent return to training and competition.

Since no evidence based therapy is available that can decrease healing times of stress fractures, a RSF can be a season ending injury for an elite rower. Consequently, prevention of RSF is of paramount importance. Effective prevention of sports injuries requires thorough knowledge of incidence and/or prevalence, severity, risk factors and injury mechanisms. Several potential mechanisms of injury have been suggested. The relatively limited data provided in the literature (biomechanics of ergometer rowing) may at best give hints with regards to which of the suggested and rather different mechanisms of injury that are most likely to actually induce detrimental bending forces to the ribs during rowing. The aetiology of RSF has thus been described as multifactorial also referring to the plethora of potential risk factors for stress fractures.

The lack of longitudinal investigations of potential risk factors for RSF in rowing necessitates looking at evidence regarding risk factors for stress fractures in general. In particular, the recent research indicating that low energy availability is of great importance to bone health of endurance athletes seems highly relevant for elite rowers – especially lightweight rowers.

Future prospective studies with continuous surveillance (i.e. internet based questionnaires) of the prevalence of RSF symptoms could elucidate the true burden of RSF. If such an investigation is combined with base-line and intermittent assessment of potential risk factors for RSF stronger evidence for cause and effect relationships could be generated. This type of information could inform effective prevention strategies in the future.

Based on the currently available knowledge from biomechanical studies of ergometer rowing the implementation of dynamic ergometers could be hypothesized to reduce the risk of RSF. Moreover, some of the known risk factors for stress fractures in general might be hypothesized to also contribute to increased bone health and decreased RSF risk in elite rowers.

O19
ECG findings in competitive rowers: normative data and the prevalence of abnormalities using contemporary screening recommendations
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Background/aim: The international governing body for competitive rowing recently mandated the inclusion of 12-lead ECG during preparticipation screening. We therefore sought to describe normative ECG characteristics
and to examine the prevalence of abnormal ECG findings as defined by contemporary athlete ECG interpretation criteria among competitive rowers.

Methods: Competitive rowers (n=330, 56% male) underwent standard 12-lead ECG at the time of collegiate preparticipation screening. ECGs were analyzed quantitively to develop a sport-specific normative database and then for the prevalence of abnormalities in accordance with the 2010 European Society of Cardiology (ESC) recommendations and 2013 ‘Seattle Criteria’.

Results: 94% of rowers had one or more training-related ECG patterns including sinus bradycardia (51%), sinus arrhythmia (55%), and incomplete right bundle branch block (42%). Males were more likely than females to have isolated voltage criteria for left ventricular hypertrophy (LVH) (51% vs 8%, p<0.001) and early repolarisation pattern (76% vs 23%, p<0.001). Application of the 2010 ESC criteria, as refined to the Seattle criteria, resulted in the classification of a significantly greater number of abnormal ECGs (47% vs 4%, p<0.001). The detection of true pathology, accomplished by both interpretation criteria, was confined to a single case of ventricular pre-excitation.

Conclusions: Training-related ECG patterns with several gender-based differences are common among competitive rowers. The diagnostic accuracy and down-stream clinical implications of ECG-inclusive preparticipation screening among rowers will be dictated by the choice and future refinement of ECG interpretation criteria.

O20 Prevalence of low back pain among elite Australian senior rowers
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Background: Research shows that the prevalence of lower back (LBP) pain is high among rowers [1,2]. Previous methods of data collection on LBP in the Australia Rowing Team (ART) do not allow for comparison against other rowing populations. The purpose of this study was to collect the current prevalence of LBP across senior elite Australian rowers at one point in time, using methods comparable to those presently reported in the literature both in the general and sporting populations. A secondary aim of the study was to determine whether gender, type of rowing or weight category made a rower more susceptible to low back pain at a specific point in time.

Methods: This was a cohort study, based on a cross-sectional survey of the 77 rowers selected as part of the 2014 Australian Senior Rowing Team. Participants were asked specific questions relating to their experience of LBP, particularly current, recent and lifetime LBP. 18% had experienced LBP within the past month of being surveyed and 8% had experienced LBP within the 24 hour period before participating in the survey. A significant difference between sweep and sculling showed that sweep rowers were more likely to have experienced LBP than scullers in the 24 hours prior to the study. This was not evident when analysing for previous month, rowing lifetime or lifetime LBP prevalence. Gender and weight category did not make a rower more susceptible to LBP. These results are comparable to the experience of both other high-level rowing programs and the general population [1-3].

Conclusion: The prevalence of LBP among senior elite Australian rowers is comparable or lower than that described previously among other rowing populations [1,2,4]. Elite Australian rowers have a lower rate of point and period LBP prevalence than the general population, but a higher rate of LBP over their lifetime [3]. Gender or weight category did not make a rower more susceptible to low back pain at a specific point in time. Sweep rowing made a rower more susceptible to LBP than sculling over a 24 hour period but this was not the case over a one month prevalence period, suggesting other factors may be responsible.

References

POSTER PRESENTATIONS
P1 Contribution of aerobic and anaerobic capacity to 2000 m rowing performance
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Background: Previous studies strongly have supported importance of aerobic capacity for 2000m rowing performance [1-3] and there are few studies that demonstrated anaerobic capacity had critical role in rowing performance [4-6]. The purpose of the present study is to investigate the relationship between 2000m rowing performance and anaerobic capacity, which were estimated by critical power (CP) model [7,8] and by all-out tests of short duration as well. We also examined aerobic capacity.

Subjects and methods: Nine male collegiate rowers (age 20.0 ± 1.0 yrs, height:174.5 ± 4.5 cm , weight:70.1 ± 7.5 kg) performed 1) incremental
exercise tests to determine VO$_{2\text{max}}$. 2) CP test (400m, 600m, 800m and 1000m), and 3) 2000m test. For each subjects, the amount of work (power×time) was plotted against exercise time. The CP was determined as the slope of the linear regression between the work and time. The anaerobic work capacity (AWC) was determined as the y-intercept of the linear regression. AWC was evaluated with standard error of estimation (SEE) [8] for the sake of accurate observation. If SEE of regression line was greater than 10 % of AWC, it was recalculated except one trial that had largest error.

Results: CP (302.7 ± 35.2 watt) was correlated with VO$_{2\text{max}}$ (4.1±0.4 L · min$^{-1}$, $r = 0.70$, $p<0.05$, Figure 1) and power output during 2000 m test (P2000, 326.9 ± 29.3 watt, $r = 0.86$, $p<0.01$, Figure 2). AWC (11.4 ± 3.8 kJ) was not correlated with P2000 ($r = 0.33$). Our data demonstrated that there was significant correlation between AWC and residual error between CP and P2000 ($r = 0.79$, $p < 0.05$, Figure 3).

Discussion: These results are in accordance with the established interpretation by which contribution of aerobic capacity to rowing performance are well recognized [1-6]. However, our data suggest that anaerobic capacity estimated by AWC also have a pivotal role for rowing performance. Since CP and AWC are affected by familiarity of subject to intensive exercise [8] and physiological condition such as fatigue caused by consecutive training sessions, examination of anaerobic capacity might predict rowing performance more precisely in practical competitive situation.

References