

NO. 3

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Intersection Syndrome; an Acute Surgical Disease in Elite Rowers

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- **Intersection syndrome** is a common pathology in the forearm of rowers which can limit their participation in training and racing. Intersection Syndrome was described as peritendinitis crepitans by Nelson Howard in 1937. Theories of pathogenesis include traumatic or stenosing tenosynovitis, tenovaginitis and compartment syndrome. In this report, we demonstrate the pathology of the condition to be a fascial response to first compartment hypertrophy producing an attrition synovial disruption of the sheaths over extensor carpi radialis longus (ECRL) and/or extensor carpi radialis brevis (ECRB), resulting in the classical "audible crepitus" that defines this condition
- **Typical management** includes a protracted period of conservative treatment with rest, activity modification, splinting, and the use of corticosteroids either topically or via injection. Classically the decision to perform a surgical release is based on failure of conservative treatment, typically at the expense of significant lost training time.
- **We present a case series** of six elite Australian rowers, four male, two female, aged between 20 and 29 years of age with intersection syndrome who underwent operative intervention to reduce interruption to training schedules prior to career goal events. Prior to the decision to operate, each athlete underwent a standard team protocol of corticosteroid injection and splinting. Physiotherapy techniques included soft tissue massage through the muscle bellies, radial nerve glides, regular icing, and compression. Oral non-steroidal anti-inflammatories were used in each case. The athletes lost between 20.8% and 41.1% of available training time for their crew for that international rowing season.
- **The presentation** will include intra-operative photos, specifically drawn diagrams and histology results explaining the pathogenic mechanism of this rowing injury. The operative and post-operative procedures are discussed in detail. The number of days to commence on-water training varied between five and eight and all cases had a successful return to rowing competition. One athlete had a recurrence of symptoms due to an unrelated trauma which resulted in their retirement. Three athletes won medals at their season pinnacle event between four and eight weeks post operatively.
- **We recommend** consideration of surgical intervention for intersection syndrome in the elite rower with impending time critical competition goals to minimize lost training time and continue with high-level sporting function.

NO. 5

Kleshnev V¹

Criteria of Rowing Technique Effectiveness

1. BIOROW LTD

- **Rowing style** can be defined in respect to a rower's ability to coordinate their use of legs and trunk. This study describes rowing style across all boat types using numeric criteria in a large sample of rowers.
- **Oar angles, seat and trunk positions** were measured on-water using BioRowTel system (www.biorow.com). 1473 crews of various rowing abilities were measured. Sample size was 4030 rowers (2837 males) and 27194 data samples. All crews performed a step-test with stroke rates from 20 to 44-min-1. Data samples were time-normalized, averaged and used for calculation of discrete indicators. 1) Catch Factor (CF) was defined as the time difference between moments when the seat (Tsc) and the handle (Thc) change direction at the catch: $CF (ms) = Tsc - Thc$; 2) Rowing Style Factor (RSF) is the ratio of displacements of the seat (Ls) to handle (Lh) during the first 20% of the drive (from catch to "transition point"): $RSF (\%) = Ls / Lh$; 3) Finish Factor (FF) is the time difference between moments when the trunk (Ttf) and the handle (Thf) change direction at finish: $FF (ms) = Ttf - Thf$.
- **CF was more negative** in sweep categories than in sculling (-23.9 vs. -6.7 ms; $p < 0.01$). RSF was lower in sweep than in sculling (74.6% vs. 78.5%, $p < 0.01$). FF was similar between rowing categories (-38 ms). There was a tendency for larger boats to be associated with more negative CF and lower RSF. CF increased with stroke rate, while RSF approximated 76% from 20 to 36-min-1, then decreased to 72% at 44-min-1. There was an inverse relationship between FF and stroke rate.
- **There was a weak relationship** between CF and RSF ($r = -.34$, $p < 0.01$), which suggests they are slightly correlated, but not functionally related. When the above data set was compared against a sub-sample of Olympic standard rowers, they had more negative CF (-32.7 ms in sweep, -12.9 ms in sculling, both $p < 0.01$) and higher RSF (82.9%, 83.4%, both $p < 0.01$), which suggests: 1) Negative CF provides earlier acceleration of a rower's center of mass; more dynamic drive "using rower's weight"; and a deeper negative peak of the boat acceleration, improving blade-to-water "connection". 2) Higher RSF using faster knees extension also provides faster acceleration of a rower's center of mass and improves coordination of the antagonist muscles around knee and hip.
- **These results** provide support for the use of quantitative criteria to help define and develop effective rowing style.

NO. 4

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A Case Series of all Rib Stress Injuries in Elite Australian Rowers in the 4-Year Rio Olympic Cycle

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- **Rib stress injuries (RSI)** comprise approximately ten percent of all rowing related injuries, with a large training time loss. Current literature is largely anecdotal or limited by small athlete numbers and management is based on clinical acumen and experience rather than published data. There are no studies on RSI in a population of international level rowers over an Olympiad.
- **This case series** represents all RSI in the Australian Rowing Team during the 4-year Rio Olympiad (October 2012 to September 2016). Rowing injury and illness data were prospectively collected via an electronic health record (Athlete Medical System, AMS) and were recorded by team doctors and physiotherapists. Athletes have provided consent to storage and use of their medical record, and for participation in this research. Ethics approval was granted by the Australian Institute of Sport.
- **During the Rio Olympiad**, 15 athletes sustained 19 RSI (4 with 2 separate injuries.) More females sustained RSI (n=12) and there were similar numbers of open weight and light weight athletes. Sweepers (n=12) had more frequent injury than scullers, and stroke athletes more commonly injured their left side (n=4 vs 2). Greatest annual injuries occurred in 2015 (n=8) and reaction was more common than fracture (n=12). Most common locations were rib 6 (n=9) and posterior, axillary and antero-lateral (n=5 for each). MRI, CT, ultrasound and scintigraphy were variously used to identify and confirm RSI as reaction or fracture. On water training time loss for fracture ranged from 56 to 167 days, compared with reaction which accounted for between 24 and 97 days, with one injury contributing to early retirement.
- **Clinical signs** at presentation and day 5 differed significantly between reaction and fracture, with hallmark signs of fracture being cough, deep breath and push-up present in all RSI cases. This may assist clinicians discriminate between a stress reaction and a fracture using clinical examination and reduce reliance upon imaging for diagnosis, reducing the athletes' exposure to radiation and financial cost.
- **This case series** is the first publication of an elite cohort for an Olympiad, which provides descriptive data and clinical assessment findings of RSI to inform practice and guide future research.

NO. 6

Adams M¹

The Double Burden of Education and Being an International Top Rower Aged (U19) and (U23) Simultaneously

1. UNIVERSITÄT DUISBURG-ESSEN

- **Young rowers in Germany** have to manage a dual career (educational degree and being a top athlete) thereby limiting opportunities for social contacts and life outside of high performance sports.
- **The aims of this study** were to examine: 1) academic level of German National Team rowers aged 17-22 years; 2) time demands of training including travel time and physiotherapy; 3) time required for education; 4) reasons for drop-out of rowing; and 5) various forms of social, emotional and organizational support.
- **All rowers of the German U19/U23 National Teams** who prepared for their respective world championships in July 2017 were asked to fill out a standardized and open ended questionnaire.
- **With a response rate** of 87%, 105 questionnaires were returned (50 female rowers), 54.3% of the rowers were school pupils and 42.9% students. 84.9% of the pupils attended grammar school, 13.9% comprehensive school, 62.2% of the students did not complete their degree in regular time, although 73.3% were at universities offering partnership programs for top athletes.
- **Juniors** spent 974 min/week solely for training, while seniors spent 1114 min/week, adding up to 1353 and 1579 min/week, respectively, when travel time and physiotherapy were included. Pupils spent 1421 min/week in school and students 869 min/week at the university, adding up to a total of 1917 min/week or 1682 min/week, respectively, when travel, private tuition, preparation and follow-up were included. In total, young rowers invested approx. 55 h/week in education and training.
- **The main reason** for rowers to consider a drop-out of high-performance rowing was the lack of time for friends, followed by the lack of time for education. Athletes felt to be supported most by their parents and least by school or university. Athletes also criticized to be excluded from social activities outside rowing due to fixed training times.
- **Based on these results**, targeted communication between athletes and coach to facilitate more social life beside rowing and better support by university or school might decrease likelihood of drop out from high performance rowing.

NO. 14

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Is the Stomach's Ability to Empty Glucose Drinks Compromised during One Hour of Moderate Intensity Ergometer Rowing?

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- **Much of the physiological benefit** gained from drinking carbohydrate solutions during exercise is related to the ability of the stomach to deliver fluid and energy to the small intestine for absorption. While intense exercise ($\geq 75\% \dot{V}O_{2\max}$) can delay gastric emptying compared to resting conditions, there is no difference in emptying rates between cycling and running. However, the effect of rowing on gastric emptying rate is unclear. Therefore, we compared the gastric emptying rates of rowers at rest and during both moderate intensity rowing and cycling.
- **With local ethics committee approval** and after statistical power tests, seven male rowers (age: 25 ± 4 yrs; height: 184 ± 11 cm; mass: 81 ± 11 kg; $\dot{V}O_{2\text{peak}}$ 4.7 ± 0.5 L/min) who succeeded in passing an orogastric tube to a suitable stomach depth (assessed using a water recovery test) completed all parts of the study. Next, subjects completed separate cycling and rowing ergometer step tests to fatigue (7 x 4 min stages) to determine mode specific $\dot{V}O_{2\text{peak}}$ and the work rates associated with $70\% \dot{V}O_{2\text{peak}}$. All subjects completed 1 hour at $70\% \dot{V}O_{2\text{peak}}$ on a rowing and cycling ergometer (randomized order) and on a final occasion while subjects remained seated at rest for 1 hour. Each subject was tested at the same time of day and the interval between successive trials ranged from 3 to 7 days. After intubation, all three trials started at 0 mins with a rapid 600 mL infusion of an 8% glucose solution delivered to the stomach through the sample tube. The volume of drink remaining in the stomach was assessed every 10 min using the doubling sampling aspiration technique with dye dilution. Data was assessed using repeated measures ANOVA.
- **There were no differences** for drink volume at any time point between trials and ~95% of the initial drink volume had emptied from the stomach by 60 mins (rest: 22 ml; rowing: 34 ml; cycling: 41 ml; $P > .05$). There were also no differences in half-emptying times between trials (rest: 18 mins; rowing: 19 mins; cycling: 21 mins; $P > .05$).
- **We conclude** that the ability of a rower's stomach to deliver a glucose drink for intestinal absorption is unaffected during moderate intensity rowing in comparison to either cycling at the same relative intensity or resting conditions.

NO. 18

Boin M¹, Goebel G¹, Hofmann H¹, Hummel S¹

Optimization of the Geometry of a Rowing Seat Using FE Simulation and 3D Print

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- **Intense rowing trainings** or long rowing tours often are accompanied by discomfort and sometimes even health issues. These can be induced by standard rowing seats causing circulation-restricting pressure on the buttocks of the rower. Is there a possibility to reduce these issues by optimization of the geometry of the rowing seat?
- **This paper** introduces a method usually used in car or office seat design – optimization based on pressure distributions – applied to rowing seats. The Finite Element human body model THUMS 5.0 and the simulation tool LS-Dyna were used to simulate the distribution of the contact pressure at the interface of the body and different seat geometries. An optimization of the surface geometry of the seat was performed. The final simulation using the optimized seat surface showed a significant reduction of the maximum interface pressure. Design directions for the improvement of the seat geometry were defined based on this optimization. These directions include a smooth seat surface without holes. The seat surface should be adopted to the deformed buttock surface of the rower.
- **These guidelines** were used to define the geometry of rowing seats for two rowers. 3D printing was used to produce prototypes with the improved geometry for these rowers.

NO. 15

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Measurement of Maximal Accumulated Oxygen Deficit in Rowing

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 3. FACULTY OF HEALTH AND SPORT SCIENCES, University of Tsukuba, Japan

- **The purpose of this study** was to investigate whether accumulated oxygen deficit (AOD) would reach its maximal level (Maximal Accumulated Oxygen Deficit: MAOD) during a short exercise bout in rowing.
- **Sample size** of 15 was recommended to detect a difference corresponding to small effect size (probabilities of type I and II error were set as 0.05 and 0.2, respectively), however, 14 male university rowers (height: 173 ± 5 cm, body mass: 69.3 ± 7.4 kg, age: 20.1 ± 1.2 yrs) participated in the study. The subjects performed incremental tests on a rowing ergometer to obtain equations to predict oxygen uptake from power output and physical activity level evaluated by tri-accelerometer on rower's back as explanation variables, which enable to estimate oxygen demand according to power output and rower's body movement. Thereafter, the participants performed 2-min, 1-km, 1.5-km, and 2-km trials with at least 48 hours rest between each exercise, and AODs in each trial were calculated by subtracting measured oxygen uptake from oxygen demand estimated by extrapolating power output and physical activity level measured during each trial on the equation obtained from the incremental tests. ANOVA with Bonferroni correction was used to compare AODs among the trials.
- **Significant difference** of AOD was detected between 2-min trial (5.2 ± 1.1 L of oxygen equivalent: 1.02 eq) and 1-km trial (5.8 ± 1.6 L.02 eq), but not among 1.5-km trial (5.8 ± 1.8 L.02 eq) and 2-km trial (5.9 ± 2.4 L.02 eq). MAOD, which was defined as the highest value of AOD within each subject, was 6.4 ± 2.1 L.02 eq, and AOD in 2-min trial was corresponding to $83.7 \pm 8.7\%$ of MAOD. This attainment of AOD in 2-min test was negatively correlated with MAOD ($r = -0.87$, $p < 0.01$), suggesting that 2-min test might be too short to exhaust anaerobic capacity for rowers who had higher MAOD. We conclude that university level rowers might not be able to engage their anaerobic capacity in 2-min maximal effort.

NO. 20

Altman K¹

Development of Stroke Rate in Rowing from 2013 to 2018

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- **The purpose of this study** was to check whether the stroke rate (SR) in rowing has increased within world-class athletes over the past six years. The boat speed in rowing is the product of the SR and distance per stroke. The higher the SR at the same stroke length, power and conditions, the higher the boat speed.
- **However**, the relation between boat speed and SR is not proportional. Hence, a higher boat speed can only be achieved to a certain level by increasing the SR (Kleshnev, 2016). Nevertheless, the stroke frequency is essential for the rowing performance as it is less influenced by external conditions than the boat speed or the propulsion per stroke. Therefore, this longitudinal study shall observe the SR over different venues.
- **SR and boat speeds** are automatically recorded by Swiss Timing (Corgémont, Switzerland) at least every 50 meters. Thus, it is possible to calculate the average values of the SR for the entire 2,000-metre race track and for selected sections. Global Positioning System (GPS) data were evaluated at almost all World Rowing World Cups and World Rowing Championships from 2013 to 2018 for the A-finalists of all Olympic boat classes. The data were analysed using a variance analysis and an independent samples t-test.
- **Initial results** show that the SR has increased significantly between 2013 and 2018. Considering only the data of the medal winners of all boat classes, the average stroke frequency over the entire 2,000 meters has increased significantly from 36.7 (average of all data from 2013 to 2015; $N=396$) to 37.7 (2016 to 2018; $N=357$; $p < 0.001$; $d_{\text{Cohen's}} = 0.435$). In the second part of the race, there is a slightly higher frequency increase. Some differences in the development of the SR can be observed in between the boat classes.
- **Further results** on individual boat classes, gender differences and race sections will be presented at the conference and consequences for training will be discussed.

NO. 21

Hoffmann A¹, Altmann K¹

Way to the Top - Relationship between Junior and Elite Success in Rowing

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- › **Often talent promotion systems** are based on the assumption of a progressive trend in performance development with a normative ascent from junior to senior competition levels (Vaeyens, Güllich, Warr & Philippaerts, 2009). Previous studies show that the correlation between junior and elite success varies strongly between sports (Hoffmann & Wulff, 2013). The aim of this study is to analyse this relationship in rowing pro- and retrospectively.
- › **The study is threefold** – First, to identify national promotion strategies for long-term athlete development correlations of medal rankings (mean 2014-2018) at Junior World Championship (JWC), Under 23 World Championships (U23 WC) and World Championships/Olympic Games (WC/OG) were calculated. Second, participation and success in U23 WC and WC/OG of medalists in 2008 JWC (N=138) were analysed on descriptive level. Third, JWC- and U23 WC- results of medalists in 2016 OG (N=180) were analysed ret-respectively.
- › **Medal rankings** of JWC, U23 WC and WC/OG correlate moderately ($0.55 < r_s < 0.58$). 42% of JWC medalists make the leap to WC/OG, almost all of them via intermediate stage U23 WC. The probability of participation in WC/OG is greater for small boat JWC-medallists than for big boat medallists ($\chi^2 [1, N=138] = 4.85, p < .05, \phi = 0.19$). From junior to senior level, the change between small boat and big boat is more likely than the change between sweep and scull. 57% of the OG-medallists rowed in JWC, 80% in U23 WC. Participants in JWC reach elite level about two years earlier than non-participants ($t [136] = 7.938, p < 0.001, d = 1.37$).
- › **The generalized assumption** of participation in international junior competitions as a prerequisite for elite success was not confirmed. U23 WC seem to be an important milestone in rowers' career development. The results are discussed in detail for women/men, scull/sweep and small boats/big boats. Finalists' data are analysed regarding the correlation between junior and elite results.

NO. 23

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Extended Standard Echocardiography in Pre-Participation Screening of Athletes

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- › **Echocardiography** is an important part of the investigation of competitive athletes. Since electrocardiography cannot sufficiently detect cardiac risk factors, an echocardiographic examination during the first investigation of squad athletes is required by some of the sports federations. Therefore, an extensive standardized protocol for consistent exclusion and monitoring of cardiac abnormalities is necessary right at the beginning of the athlete's career.
- › **As competitive athletes** should have a normal cardiac morphology and function, the following issues were evaluated. Firstly, we introduce an extended standardized transthoracic investigation. Secondly, we describe unusual findings inside our cohort and discuss the potential pathological value for the athlete's career and physical health.
- › **Extended standardized echocardiographic examination** in our hospital has been performed since 2017. It contains the proposed transthoracic investigation in adults according to European recommendations, as well as additional documentations comprising views of coronary arteries, three dimensional and triplane acquisition and tissue Doppler images of the right ventricle. Successful image acquisition and parameters which are crucial for the diagnosis of relevant diseases, were analyzed retrospectively.
- › **In the present study**, 55 male athletes have been analyzed by comprehensive transthoracic echocardiography as described above. In three (5%) patients suspect results with referring to potential sudden cardiac death causes were found. A bicuspid aortic valve was found in two athletes, one of them with additional indicators for hypertrophic cardiomyopathy. One athlete presented regional deformation abnormalities due to myocarditis. Besides, one patient showed slight aortic regurgitation without aortic root abnormalities and another patient presented left ventricular hypertrophy due to arterial hypertension. Moreover, four patients showed indications of an athlete's heart.
- › **Nine (16%) patients** showed explicit cardiac abnormalities. Out of them, five findings had pathological value and implicated medical therapy and frequent control investigations respectively. Echocardiographic investigation requires a high level of accuracy, especially in sports-medicine. Therefore, the standardized examination should be extended with respect to image acquisition as well as additional analyses by post processing as shown to ensure comparable quality of data inside various sports-medical facilities.

NO. 22

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Sonographische Verlaufskontrollen bei Muskelverletzungen im Profi-Sport – Bedeutung und Limitationen

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- › **The racing shell** is propelled forwards by the oar acting as a one-arm lever with the fulcrum on the blade and force application at the handle. The handle, arms and shoulders rotate around the swivel, which results in a movement asymmetry in sweep-rowing. Because of the different hand positions at the handle, a distinction is made between oarside-arm (OA) and non-oarside-arm (nOA) and the respective side (shoulder and leg). The nOA pulls further outboard and with a longer lever compared to the OA. Hypothetically, during the dominant nOA pull, a higher torque on the handle and greater asymmetry of the stretcher forces is expected.
- › **The study** investigated male elite athletes of the German Rowing Federation (light- and open-weight, body height 190±10 cm, body mass 83.9±9 kg, N=32 in a coxless four. The forces at the handle, nOA and stretcher of the oarside- and non-oarside-leg (OL and nOL) were measured using the german mobile measuring system. The effects of dominant OA pull in comparison to baseline (usual rowing) were variance-analytical examined.
- › **The results** confirm the hypothesis, because in comparison to baseline (normal rowing, 20 str./min), the dominant nOA pull produced an increased nOA force (203±39 N vs. 246±39 N; $p < 0.001$), higher stretcher forces of the nOL (294±51 N vs. 314±53 N; $p < 0.011$) as well as lower stretcher force of the OL (231±49 N vs. 212±46 N; $p = 0.003$). Dominant nOA pull tends to increase the handle power (682±139 W vs. 705±131 W; $p = 0.06$), but also asymmetries of stretcher force (24±22% vs. 39±24%; $p < 0.001$).
- › **Dominant nOA pull** increased propulsion of the handle force. Here it should be noted that the increased asymmetry of stretcher force leads to an asymmetric load on the lumbar-pelvic region and thus, increases the risk for back pain. Consequently, dominant nOA pull must be muscular prepared with strength training and its amount in on-water training should be controlled to avoid pain in the lumbar-pelvic region.

NO. 24

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Exploratory Study on Bone Mineral Density in Women Rowers before and after Water Season

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- › **Sweep rowing** is a team sport where athletes on alternating sides of a boat use a single oar to propel a racing shell through the water. Athletes likely experience unequal forces on each side of their body due to the one-sided nature of sweeping. This discrepancy in physical stress has been observed to contribute to muscle imbalances (Janshen et al., 2009), but the potential to produce disparities in bone mineral density (BMD) has not been investigated. This study investigated if on water sweep rowing affected leg BMD in trained female rowers. The fall/winter macrocycle in Calgary, Alberta involves a six-month dry-land season with equal bilateral activities of ergometer, resistance and cross training, followed by spring/summer macrocycle of four to six-months of sweep on water training (seven water sessions/week). National and/or international competitive female (N=8) rowers (mean SD(±); age 24.7±1.8yrs; HT: 178.1±4.0cm, %BF 22.2±2.7) volunteered to have two Dual-energy X-ray absorptiometry bone scans performed within the first month of on water training (pre) and at the season end (post). Sweepers identified as either 'star'(n=4) or 'port' (n=4) side and recorded their inside (on the same side as their oar) and outside (on the opposite side as their oar) leg. Star (n=4) had higher BMD in both legs post (L (inside) 1.191-1.203 and R (outside) 1.223-1.234 g/cm²) and the difference between the inside to outside was similar pre and post (0.031 and 0.030 g/cm²). Port (n=3) (1 post had an error and another missed the scan) did not show the same trends. Port had higher pre BMD on inside (n=3), 1.199 g/cm² compared to the outside 1.186 g/cm² and higher post BMD on the outside (n=2) 1.212 cm² compared to the inside 1.160 cm². The differences inside to outside pre (n=3), 0.012 cm² was less than post (n=2), 0.035 cm². Future research with a larger sample size is needed before such imbalances can be identified as a mechanism for injury risk.

NO. 26

Turner K, McCarthy A², Rice A³

A Comparison of the Physiological Responses to Identical Power Outputs on the Concept II Bikeerg And Concept II Rowerg

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3. ROWING AUSTRALIA, Australia

- Rowers use cross-training to supplement the volume of training required to create local and central adaptations as well as injury rehabilitation. Stationary cycling is often used for rehabilitation as it reduces compressive forces on the thoracic cage and upper extremities as well as the reducing the load through the lumbar spine.
- Our group have previously shown marked differences in physiological responses for the same rower on a CI RowErg (RowErg; Concept II RowErg; Concept 2 Inc., US) and Wattbike (WB; Wattbike Pro, Wattbike, UK) at identical power outputs (Lindenthaler, et al 2018). With the introduction of CIH BikeErg (BikeErg; Concept II BikeErg; Concept 2 Inc., US) we hypothesised that the similar resistance designs of the two CIH ergometers would produce more similar physiological responses than our previous study.
- Ten well trained, local male rowers (mean \pm SD: age = 20.2 \pm 2.7yr, body mass = 79.3 \pm 9.9kg) were recruited for this study. On a single day two submaximal incremental tests consisting of 4 six-minute workloads interspersed with 2 min recovery periods were undertaken on a RowErg and BikeErg. Workloads were calculated as being 50%, 62.5%, 75% and 87.5% of their most recent 2000m RowErg score and were matched on both ergometers. Trials were separated by 45 mins and diet was controlled prior to each ergometer trial. Stroke rate/cadence and physiological variables (Volume of O₂ consumed, Volume of CO₂ exhaled, Minute Ventilation, Respiratory Exchange Ratio, Heart Rate) were measured during the final 2 min of each workload each stage while Blood lactate concentration and Rating of Perceived Exertion were measured during the recovery period.
- RowErg produced significantly higher values for VO₂, VCO₂, VE and HR than BikeErg. RPE was higher for all workloads on RowErg but was not significantly different from BikeErg. While rowing VO₂ and VCO₂ were ~0.7 L/min higher, HR was 15 b/min higher and VE was up to 30 L/min higher during heavy exercise compared to cycling. BLA was similar for workload 1 and 2 but was higher for workload 3 and 4 on the RowErg with a >3 mmol/L difference during heavy exercise.
- The data shows at identical wattages RowErg requires a considerably higher metabolic load compared to the BikeErg despite the similar ergometer design from the same manufacturer. These data are consistent with our previous work using a RowErg and Wattbike and strengthen the concept that the RowErg may not be accounting for all the work done during a full rowing stroke cycle, especially the power required during the recovery phase of the rowing stroke.

NO. 28

Planinc N¹, Štumberger N², Zupet P¹

The Occurrence of Rib Stress Fracture among Slovenian Rowers

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- Introduction:** Lack of data in clinical practice often leads to false or late diagnosis of the stress fracture of ribs, which is the main reason for the loss of training hours. It is more likely to occur in elite rowers than in nonelite rowers and in most cases, it occurs in ribs four to eight, mostly along the anterolateral/lateral rib cage. In this study, we have analyzed the occurrence of rib stress fracture among rowers in Slovenia and the potential risk factors.
- Methods:** The study involved 47 rowers, who are training at the competitive level. 15 of them were young juniors aged under 15 years (U 15), 19 were aged under 18 years (U 18) and 13 were elite rowers. We have based our questionnaire on the standardized Nordic questionnaire for the assessment of the incidence of musculoskeletal symptoms in the working population, which was customized for rib stress fracture. We collected and cleaned the data in MS Excel and performed statistical analysis in the SPSS. To determine the differences between variables, we used chi-square (χ^2) test, with a statistical significance level of $P < 0.05$.
- Results:** Among 13 elite rowers, two men suffered a stress fracture of ribs (15.38%). There were no stress fractures in other categories. We analyzed different risk factors among elite rowers (gender, weight, numbers of months of competitive rowing, average training hours per week and per day, average training hours on water and on ergometer per week, average time of stretching exercises before and after training session) but none of them was statistically relevant.
- Conclusion:** We had two rib stress fractures among elite rowers and none among younger rowers. Rowers reported the stress fracture during intensive and frequent training, so we can imply that the number of hours and the intensity of training are potential risk factors but we could not find statistically relevant correlation. Our results have limited relevance because of small sample but the literature supports our findings of higher incidence among elite rowers compared to younger categories.

NO. 27

Planinc N¹, Hauptman N², Zupet P¹

Incidence of Low Back Pain in Slovenian Rowers

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- Introduction:** Back pain is one of the major health problems among rowers. It leads to significant training and competition absences. In older rowers, it is often associated with degenerative disease of intervertebral discs, ligaments and facet joints while in younger rowers we also have to pay attention to possible infection, tumor, spondylolisthesis, segmental instability or fracture. Not only the incidence of back pain is high it also presents very soon in young rowers. Therefore, we have decided to study the occurrence of back pain in Slovenian rowers and find potential risk factors in different age groups.
- Methods:** 86 professional competitor rowers from different clubs in Slovenia participated in the retrospective study. 56 of them were men aged 11 to 28 and 30 of them were women aged 12 to 28. Each of them was asked to fill in a questionnaire based on Standardized Nordic questionnaire for assessment of skeletal muscular symptoms in working population. The questionnaire was fitted and adjusted to focus on back pain in rowing. Data was collected in 2016 and we got signed informed consent from all participants. Parents signed the informed consent for minors. Hi-square test was used to determine the differences in categorical variables and t-test was used to determine the differences in continuous variables. $P < 0.05$ was considered for statistically specific difference in variables.
- Results:** Over last 12 months 24% of young juniors aged under 15 years (U 15) suffered from back pain while the percentage increased in older juniors aged under 19 years (U 19) to 52.6% and to 52.9% in elite rowers. 68.3% of rowers have suffered from back pain at least once before the age of 15. Risk factors are different in different age groups. Male gender proved to be an important risk factor for back pain especially among junior rowers ($p = 0.008$). Hours of training per week and hours of training per day also proved to be important in the previously mentioned population ($P = 0.037$ and $P = 0.008$). Number of training hours on ergometer was confirmed to be an important factor in young juniors (U 15, $P = 0.001$) and older juniors (U 19, $P = 0.009$), change of rowing style is important among juniors ($P = 0.050$) and presence of skeletal muscle diseases was confirmed as an important factor in the population as a whole ($P = 0.003$), but especially in young juniors (U 15) ($P = 0.012$).
- Conclusion:** Our study showed that incidence of back pain increases with age until older juniors (U 19) and that approximately one out of two rowers suffers from back pain in a 12 – month period. A significant difference is shown between male and female gender among juniors. There are other risk factors in different age groups that influence the occurrence of back pain. Because of high incidence and early set on of back pain in rowers prevention is very important.

NO. 29

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Cartilage Alterations in Asymptomatic Elite Rowers are Dependent on Technique: A T2 Mapping Study

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- Introduction:** Previous studies demonstrated a high amount of cartilage degeneration in hip joints of asymptomatic elite rowers. Because the center of rotation is located unequal for sweep oars and equal for skulls, the study purpose was to assess whether the location of cartilage alteration is dependent on rowing technique.
- Methods:** We performed an observational, cross-sectional study in elite rowers with a descriptive and analytical assessment. All Athletes of the national elite team and U23 team (n=55) were asked to participate in this study. Only asymptomatic rowers were recruited. Finally, 20 athletes (9 female and 11 males) gave their written consent. In November 2017, we analyzed hip joints of these 20 symptomless elite rowers (9 males / 11 females, 8.1 \pm 2.8 years of training, mean age: 22.8 \pm 2.8 years, age range: 19-28 years) at the University Hospital. This included five sculling athletes (one oar in each hand) and 15 sweep-oar rowers (rower uses both hands to operate a single oar). The hip joint in sweep-oar rowers were further classified as inner hip (the hip on the side of which the oar is tucked into the water; n = 10) and outer hip (the hip on the opposite side of which the oar is tucked into the water; n = 5). The classification has been made in order to evaluate the differences in the course of movement. Magnetic resonance imaging was performed on a 3T scanner and included morphologic assessment and cartilage T2* calculation over a region of interest in seven radial images (peripheral and central zone) through the upper hemisphere of the joint. Measurements and the post-processing was done by an orthopedic surgeon (B.B.) with more than 11 years of experience in generating radial scans from a 3D dataset to depict the hip joint structures, such as the labrum and articular cartilage, in a perpendicular fashion with minimal distortion. Cartilage assessment was performed by one orthopedic surgeon (B.B.), who is an expert in hip MR imaging with approximately 12 years of clinical experience in musculoskeletal radiology, and one radiologist who had 15 years of clinical experience in musculoskeletal radiology. Reader 1 repeated the grading with a time interval of at least two weeks to minimize recall effects. In every case the grading was performed independently. Findings were compared between sweep-oars (inner and outer hips) and skulls.
- Results:** The outer hip of sweep-oars demonstrated lower T2* values in the anterior acetabular region when compared to skulls ($P = 0.034$). The inner hips of sweep-oar rowers revealed lower T2* values in the anterior-superior region compared to skulls ($P = 0.032$). On the femoral side, the outer hips showed lower T2* values in all central regions ($P = 0.037$) when compared to the inner hips. All hips revealed some degree of morphological apparent cartilage degeneration.
- Discussion:** Elite rowers revealed cartilage changes in hip joint cartilage. The amount and location of degradation was different for skulls and oars, which may reflect a distinctive movement pattern in both techniques, in which sweep oar rowers curve around the center of rotation of the oar.

NO. 34

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Cardiac Etiology of Exercise Induced Hypoxemia within Elite Athletes

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- **Exercise induced hypoxemia (EIH)** is a common finding within a group of elite athletes. It is generally thought, that the cause lies in the pulmonary circulation. We report on a group of 8 elite athletes with severe EIH (SpO₂ below 92%) further examined for the origin of the EIH. The task was to perform differential diagnoses between functional shunts in the pulmonary circulation and cardiac shunts.
- **Method:** Eight national level endurance athletes (cycling, running and rowing) with severe EIH (SpO₂ reproducibly below 92%) have been examined with stress transthoracic echocardiography with injection of agitated saline. The saline was administered via cubital vein during the last two steps of the stress echo protocol and in the presence of the hypoxemia. Differential diagnosis was based on previously published reports for evaluation of cardiac shunts – number of microbubbles and latency (number of cardiac cycles) between the injection and the appearance of the microbubbles in the left heart. Trans-oesophageal echo has been performed in the follow up procedure to evaluate the anatomical etiology of the shunt.
- **Results:** Four athletes presented pulmonary etiology of the hypoxemia. Four athletes presented cardiac origin with right to left shunt causing the EIH. Concurrent transesophageal echocardiography discovered one atrial septal defect and three patent foramen ovale (PFO). One athlete out of three with present PFO underwent catheterization closure of the PFO. Follow up exercise testing and stress echo confirmed no signs of shunt and no signs of EIH in that patient. Performance measures of that athlete improved significantly.
- **Conclusions:** Exercise induced hypoxemia is generally thought to be caused by anatomical or functional shunts within the pulmonary circulation. Our findings suggest possibly higher prevalence than originally thought of cardiac etiology of the exercise induced hypoxemia within a group of elite athletes. Successful treatment by catheter-based closure device improves performance and eliminate other clinical signs of the right to left cardiac shunt. Further evaluation of larger group of elite athletes with EIH is warranted for better understanding of the real prevalence and possible treatment of the cardiac origin of the EIH.

NO. 36

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Influence of Stroke Characteristics on Power Calculation in Wind Braked Rowing Ergometers ORAL

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- **In wind braked rowing ergometers** like the C2 (Concept 2, Morrisville, USA), mechanical power output (PC2) is calculated without direct measurement of force or distance. Few studies investigated the validity of PC2 by comparing it to external reference systems, reporting a systematic underestimation independent of the absolute power output. However, according to unpublished results of our group, there is a relevant variability of the difference between PC2 and reference systems between rowers. Notably, it has never been investigated if the rowing style influences this difference. To this end we aimed to evaluate the impact of the rowing stroke structure on the accuracy of PC2.
- **A measuring device for rowing ergometers** was used for this study, see Mentz et al. (2018). Two different stroke structures were programmed with peaking force relatively early (SE) or relatively late (SL) during the catch. Stroke frequency was 27/min. PC2 was logged using the float app. Mechanical power output of the measuring station (P_{REF}) was compared to PC2. Data were analyzed by a mixed model using stroke number, -structure, and -number*structure as fixed effects.
- **P_{REF}** was 440 ± 4 W with SE and 439 ± 2 W with SL, while PC2 was 420 ± 4 W and 419 ± 1 W. Percentage differences between P_{REF} and PC2 were 4.9 ± 13.4% with SE and 5.2 ± 14.5% with SL, leading to significant differences between strokes (p < .0001; η² = .986), stroke structure (p = .014; η² = .007), and the interaction of strokes*structure (p < .0001; η² = .169). In depth analysis showed that ΔSE-SL was significantly different (p < .05) exclusively for stroke 1-5.
- **SE and SL altered the difference** in the power estimation of the C2 ergometer in comparison to the reference system significantly, mainly due to huge differences from stroke 1 to 5. However, the influence of the stroke structure appears to be practically irrelevant from strokes 6 to 50. Future studies are necessary to evaluate the influence of variables like drive to power ratio, stroke rate and more extreme stroke structures on C2 power estimation.

NO. 35

Randall I¹

The Process of Innovation in Rowing. From Discovery to Validation, from Certification to Adoption. What a New Oar Design Offers Rowers, Coaches and Oar Manufacture

1. RANDALLfoil

- **The new oar design** is a hydrofoil attached to the top of a cleaver blade which acts as a depth limiting device. This study looks at an efficacy trial conducted by Dr. Valery Kleshnev in 2017 on an early prototype. This trial followed an investigation on the effect of braking splash and oar depth conducted by Kleshnev in 2015. This study showed that a 9-degree difference in oar angle can cause 48 cm extra contact with the water by the oar shaft. An extra 6 degrees of the blade depth increases drag resistance and decreases the speed by 3.5% (14s over 2km race).
- **The 2017 trial** used A BioRow telemetry system installed on two single sculls (Wintech Medallist and Wintech International): one with normal blades (Wintech RDS), another one with the new design attached to the similar type oars (Wintech RDS). Four junior scullers were tested in pairs side-by-side, then swapped the oars and repeated the test. The test was a 1000m continuous piece with target stroke rates at 20, 24, 28, 32 spm rising stroke rate every 250 m with the last 100 m max. The weather was moderate crosswind about 3-4m/s, with 5-6m/s gusts, slightly tail direction. The results showed an improved performance for the new design over the standard oar. The results highlighted three key performance areas: catch slip, blade efficiency and average speed: 1) The catch slip measured 8.7 degrees (with a minimum of 5.8) which showed an improvement over standard blades with 12.6 degrees; 2) The blade efficiency measured 84.4% showed an improvement over standard blades with 81.5%; 3) The boat speed measured 5.11 (m/s) showed an improvement over standard blades with 4.89 (m/s).
- **Due to the conditions** there were some small fluctuations in data however the overall results show that the new design has a positive effect on oar performance. The positive efficacy trial led to the decision to make an investment in the further development of new design, commercialisation and subsequent pursuit of FISA certification, which was granted in August 2018.

NO. 37

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Anthropometric Characteristics of Elite Junior Rowers Affects Long-Term Career Attainment: A Retrospective Analysis Covering Twenty-Three Years

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- **Introduction:** Standing height (SH) and body mass (BM) are well established determinants of rowing performance, which therefore typically included in most talent identification and development (TID) programs. However, the effect of these variables on long-term career attainment in junior rowers has not been examined. Therefore we aimed to (i) analyse if differences in anthropometric characteristics of elite junior rowers affect subsequent career attainment, and (ii) to define normative anthropometric data ranges.
- **Methods:** Former German Junior National Team rowers (N=910; 399 females) were grouped according to their highest career attainment, i.e. participation in U19-, U23-, Senior World Championships or Olympic Games (OG). Differences in SH, BM and body mass index (BMI) between attainment levels were analysed using unpaired t-tests and magnitude-based inferences (MBI), effects of anthropometrics on career attainment were analysed with a proportional odds model (POM). Interquartile ranges (IQR) of the OG group were used to define normative data ranges.
- **Results:** SH and BM very likely differed between career attainment in males, the same was found in females for SH and BMI. SH (odds ratio (OR)=1.072, P=.0002) and BMI (OR=1.049, P=.0004) had a significant effect on career attainment in males, as BM (OR=0.958, P=.0171) and BMI (OR=0.787, P=.0004) had in females. IQR of SH and BM were 190-196 cm and 84-93 kg in males, 178-184 cm and 68-73 kg in females.
- **Discussion:** Even within an elite sample of U19 National Team rowers, anthropometric characteristics at junior age discriminate between, and affect subsequent attainment level. Accordingly anthropometric characteristics of U19 rowers contribute to long-term career attainment. Interestingly higher BM and BMI of female rowers were associated with lower career attainment, probably do to a impaired power to body mass ratio. Further we provide evidence-based normative data that rule out an anthropometric limitation of junior rowers for career progression to Olympic level. All in all, our data underlining the relevance of anthropometric assessments and their consideration for TID programmes in rowing. As TID is multi-dimensional and partly inherently, anthropometric data should not used exclusively.