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Sodium bicarbonate improves 4 km time trial cycling performance when individualised to time to peak bicarbonate (HCO$_3^-$) in trained male cyclists

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This study investigated the effects of sodium bicarbonate (NaHCO$_3$) ingestion, individualised to time to peak blood bicarbonate (HCO$_3^-$), on 4 km cycling time trial (TT) performance. Eleven male trained cyclists volunteered for this study (height 1.82 ± 0.80 m, body mass (BM) 86.4 ± 12.9 kg, age 32 ± 9 years, peak power output (PPO) 382 ± 22 W). Two trials were initially conducted to identify time to peak HCO$_3^-$ following both 0.2 g kg$^{-1}$ BM (SBC2) and 0.3 g kg$^{-1}$ BM (SBC3) NaHCO$_3$. Following, on three separate occasions, using a randomized, double-blind, crossover design, participants completed a 4 km TT following ingestion of either SBC2, SBC3, or a taste-matched placebo (PLA) containing 0.07 g kg$^{-1}$ BM sodium chloride (NaCl) at the pre-determined individual time to peak HCO$_3^-$. Both the SBC2 (-8.3 ± 3.5 s; p < 0.001, d = 0.64) and SBC3 (-8.6 ± 5.4 s; p = 0.003, d = 0.66) reduced the time to complete the 4 km TT, with no difference between SBC conditions (mean difference = 0.2 ± 0.2 s; p = 0.873, d = 0.02). Individualising NaHCO$_3$ ingestion to time to peak HCO$_3^-$ significantly improves 4 km TT cycling performance.

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Athletes’ Junior-to-Senior Transition in Sport: A Systematic Review

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Purpose: The purpose of this study was to systematically review the literature associated with the junior-to-senior transition in sport and identify common factors associated with this process.

Background: The last decade has seen a substantial increase in empirical research associated with the junior-to-senior transition in sport. Despite this growth, previous research has been idiosyncratic in its nature. Therefore, the purpose of the current study was to systematically review the junior-to-senior transition literature, and highlight and summarise key factors that have an effect on the success of the athletes going through this process.

Methods: A systematic review procedure, informed by the PRISMA guidelines, was used in the current study. Inclusion criteria stated articles must be (a) published in the English language, (b) full-text article available and (c) contain data pertaining to factors associated with the junior-to-senior transition in sport. Papers that were not peer-reviewed were appraised using the Mixed Methods Appraisal Tool (MMAT).

Conclusions: 30 studies met the inclusion criteria and investigated a cumulative 1,668 participants experiences of the junior-to-senior transition. A review of the literature found 72 variables that are related to the quality of the transition, which were categorised into 13 factors. Factors covered numerous domains, for example: psychological (determination to succeed, adaptability, athletic identity), support (coach, teammates, family), financial, physical (greater physical/training demands), performance (substantial increase in standard) and psychosocial (social competence). In addition, the review identified limitations in the current knowledge, leading to future research directions (e.g., utilising longitudinal designs, examining female athletes).
Strength and functional symmetry is associated with post-operative rehabilitation in patients following anterior cruciate ligament reconstruction

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Introduction & Aims: More than 10,000 Australians undergo anterior cruciate ligament reconstruction (ACLR) every year, though 20-30% of patients will re-tear upon return to sport (RTS). Insufficient rehabilitation, along with inadequate lower limb strength, may contribute to re-injury. This study investigated strength and functional symmetry in ACLR patients, and its association with rehabilitation.

Methods: This study included 111 ACLR patients, assessed at a mean 12.5 months post-surgery (range 10-14). A rehabilitation grading tool evaluated the duration and supervision of rehabilitation, as well as whether structured jumping and agility exercises were included. Patients completed a 4-hop test battery and peak isokinetic knee extensor and flexor strength assessment. Limb Symmetry Indices (LSIs) were calculated to report the strength/function of the operated limb, as a percentage of the non-operated side. ANOVA evaluated differences between limbs, while correlations were undertaken to assess the relationship between rehabilitation and test LSIs.

Results: The unaffected limb was significantly better (p<0.0001) than the operated limb for all tests. Only 52-61 patients (47-55%) demonstrated LSIs ≥90% for each of the hop tests. Only 34 (30.6%) and 61 (55.0%) patients were ≥90% LSI for peak quadriceps and hamstring strength, respectively. Specifically in patients actively participating in jumping, pivoting, cutting, twisting and/or turning sports, 21 patients (36.8%) still demonstrated an LSI <90% for the single hop for distance, with 37 patients (65.0%) at <90% for peak knee extension strength. Rehabilitation was significantly associated with the LSIs for all tests.

Conclusion: Rehabilitation was correlated with limb symmetry, while symmetry was below recommended criterion for many ACLR patients. Many patients are not undertaking the rehabilitation required to address strength deficits, and are being cleared to RTS without appropriate evaluation and further guidance.

The prevalence of obstructive sleep apnea within a professional rugby league team: An exploratory study

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Introduction & Aims: Obstructive sleep apnea (OSA) is a disorder characterized by recurrent episodes of partial or complete obstruction of the upper airway. This results in non-restorative sleep leading to daytime sleepiness and decreased quality of life. It is estimated that 1-5% of the worldwide population suffer from OSA, however the prevalence within athletes is largely unknown. Therefore, the purpose of this investigation was to characterise the prevalence of OSA within a team of professional rugby league athletes.

Methods: 22 professional rugby league athletes underwent one night of home-based polysomnography, with apnea-hypopnea index (AHI) used to indicate the presence and severity of OSA. Linear models were used to determine if playing position (back, forward), ethnicity (European-Australian, Polynesian) or body composition influenced the prevalence or severity of OSA.

Results: 10 cases of OSA were found. When considering ethnicity, a moderate difference was observed between Polynesians and European-Australians for AHI during rapid eye movement sleep (ES = 0.94; ±0.77, p<0.05). Differences between forwards and backs were unclear (ES = 0.44; ±0.77, p>0.05). Increased BMI (ES = 0.83; ±0.77, p<0.05) and skinfold thickness (ES = 0.87; ±0.49, p<0.05) were associated with increased AHI. Conclusion: Within professional rugby league athletes, Polynesians may be more susceptible to OSA than European-Australians. Furthermore, our data suggests that athletes with greater BMI and skinfold thickness may be predisposed to the existence of OSA.
A comparison between arbitrary and individualised approaches to quantify external load (PlayerLoad) intensity in basketball

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Introduction and aims: Accelerometers are increasingly used to quantify external load in basketball. To maximise the utility of these data, identification of time spent working at different intensities is critical. At present, proprietary software arbitrarily differentiates external load (PlayerLoad™) into six pre-defined intensity zones. However, the utility of this approach compared to an individualised method to identify intensity zones is unknown. Therefore, the aim of this study was to compare time spent in arbitrary PlayerLoad™ intensity zones with time spent in individualised PlayerLoad™ intensity zones.

Methods: Semi-professional male basketball players (N=13; 20.4(4.6) yr) were monitored across 10-23 sessions over 8 weeks of pre-season training resulting in 242 unique data sets. External load was quantified as PlayerLoad™, using predefined proprietary cutpoints of 1, 2, 3, 4, 6, and 10 arbitrary units, then compared to time (min) spent in six separate intensity zones based on 10, 20, 30, 40, 60, and 100% of peak individualised PlayerLoad™. Independent t-tests and Cohen’s d were used to compare time in each zone between arbitrary and individualised approaches. Significance was accepted where p<0.05.

Results: The arbitrary approach yielded significantly higher durations in zone 2 (11.90(1.15) vs 9.33(2.37) min; P=0.003, d=1.38, large) and zone 3 (1.66(0.77) vs 0.80(0.86) min; P=0.013, d=1.38, large) than the individualised approach. Arbitrary and individualised approaches both reported limited time spent in zone 4 (0.10(0.11) vs 0.04(0.05) min), zone 5 (0.02(0.03) vs 0.00 min), and zone 6 (0.00 min).

Conclusion: An individualised approach to quantify PlayerLoad™ intensity produces different outcomes than a generic arbitrary approach. The lack of high-intensity activity reported using both approaches suggests the need for an adapted method, which is more sensitive in discriminating between a range of external load intensities in basketball.
Can triathletes use additional clothing to heat acclimate during training in a temperate environment?

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Introduction & Aims: To assess the acute and chronic physiological and perceptual responses to wearing additional clothing (AC; full length pants, jacket, gloves) during outdoor endurance training in temperate environments; to determine if this strategy could increase the heat load and induce heat acclimation.

Methods: Trained male triathletes completed (a) randomised cross-over cycling sessions (n=7) wearing shorts and a short sleeve top (NORM) and AC, separately; then (b) a randomised control trial (n=15) where two performance-matched groups completed a 2-week endurance cycling/running program wearing NORM or AC, in 18±4 degrees C and 67±12% RH. In (b), participants completed three separate 60 min pre-loaded cycling time-trials (familiarisation, pre- and post-program) in 33 degrees C and 55% RH. Core and skin temperatures, heart rate, sweat rate, perceived exertion, thermal sensation and thermal comfort were measured.

Results: In (a), moderate increases were observed in AC vs. NORM for the change in mean core temperature (0.4±0.3 degrees C, effect size±90% CI; 1.16±0.55), change in maximum core temperature (0.5±0.3 degrees C, 1.07±0.48) and sweat rate (0.24±0.16 L.h⁻¹, 1.04±0.59). A small increase in mean heart rate (3±3 bpm, 0.32±0.28) was observed as well as a ‘very likely’ (% difference=22.4±7.1) and ‘most likely’ (% difference=42.9±11.9) increase in thermal sensation and thermal comfort, in AC vs. NORM. In (b), all training was completed in the required attire, however, there were no signs of heat acclimation, and changes in mean power output were unclear (NORM=180±15 W and AC=186±26 W, 0.31±0.87).

Conclusion: Endurance training in AC while outdoors in a temperate environment increased physiological strain and sensations of warmth and discomfort, suggesting that this strategy can increase the heat load of a session. However, implementing AC across a two-week training program in a temperate environment was not a performance enhancing strategy for triathletes.
Influence of self-paced exercise in the heat on brain activity

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Introduction & Aims: Exposure to hot environmental conditions impairs endurance performance. This impairment is attributable to adjustments in cardiovascular function and may relate to alterations in brain activity. The aim of this study was to evaluate the relationship between self-paced exercise performance and brain activity in HOT and COOL conditions.

Methods: Eleven well-trained males completed a 750-kJ cycling time trial in HOT (35°C) and COOL (18°C) conditions in a counterbalanced. Electroencephalography activity was recorded with α- and β-activity evaluated in the frontal (F3 and F4) and central (C3 and C4) areas. Standardized low-resolution brain electromagnetic tomography (sLORETA) was utilized to localize changes in brain activity.

Results: Time trial completion was faster in COOL (48.1 min) than HOT (55.0 min; P<0.001). Power output was higher in COOL than HOT (P<0.001), with pacing patterns differing considerably. Core temperature was higher during HOT than COOL reaching 39.0 ± 0.6 and 39.8 ± 0.5°C respectively (P<0.05). Heart rate was 3 bpm higher throughout HOT than COOL (P<0.05). Perceived exertion and thermal comfort ratings were higher in HOT than COOL (P<0.05). α- and β-activity in the frontal and central areas was lower in HOT than COOL (P<0.05). sLORETA revealed that α-activity was lower in the posterior cingulated gyrus and somatosensory association cortex in HOT compared to CON at 10% (t critical: 3.796) and 100% (t critical: 3.889) of the time trial. α-activity was also lower in the supramarginal gyrus at 50% (t critical: 4.168) and in the somatosensory cortex on completion (t critical: 3.494) in HOT.

Discussion: Prolonged self-paced exercise in the heat is associated with changes in brain activity that are linked to a decreased ability to remain focused and filter out distracting stimuli (α-activity), as well as the capacity to sustain mental readiness and arousal (β-activity).

Effect of mixed-methods resistance and sprint training on eccentric utilization ratio in endurance trained veteran cyclists

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Introduction and Aim: The Eccentric Utilization Ratio (EUR) is the ratio of countermovement jump (CMJ) to squat jump (SJ) peak power performance. EUR is widely used to determine the effectiveness of resistance training interventions on lower-body strength and power. Among younger athletes, EUR has been associated with better sports performance. However the effect of resistance training on EUR in veteran endurance cyclists has not yet been in reported. The purpose of this investigation was to examine the effects of a 12-week mixed methods resistance training program on the EUR in endurance trained, masters cyclists.

Methods: Seventeen male veteran cyclists (51.8 ± 7.5 years) were divided into two age-matched groups: a sprint group (ST n=7) who replaced two of their usual weekly endurance cycling training sessions with two group track-cycling session per week and a mixed methods resistance and sprint training group (MMRST n=10) who reduced their endurance training but added MMRST consisting of twice weekly track sprint training plus twice weekly mixed-methods resistance training. A pre and post-intervention CMJ and SJ were completed on a force plate (BP400800-200, Watertown, USA). Peak power was determined during the propulsion phase of the SJ and CMJ. The EUR was measured as the ratio of the peak power measured during both the CMJ to SJ. The average of 3 trials was recorded for subsequent analysis. An independent t-test was conducted to identify any significant difference in EUR between training groups.

Results: Independent t-tests revealed the MMRST group significantly (p=.042) increased EUR following 12-weeks of mixed-methods resistance and sprint training. No change in EUR was observed in the ST group.

Discussion: The findings demonstrate 12-weeks of MMRST has a positive effect on the EUR in veteran endurance cyclists. These results suggest mixed-methods resistance training may attenuate age-related losses in strength and power that affect cycling performance in veteran endurance cyclists.
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An assessment of the role of media in the development of sports at the University of Venda

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Technological developments and advancements in recent years in electronic and print media have seen media becoming a powerful instrument in spearheading the development of sport. The advent of the electronic age particularly the computer and internet has created a global platform for the development of sport through marketing, advertising, informing and socializing users of this form of electronic media. Building a mutual and interdependent relationship between sports and media is therefore important in the development of sport. This study investigated the role that media is playing in the development of sport at the University of Venda and establish the relationship between media and sport at the University of Venda. Content analysis was used as an instrument for the research. The content of articles published on sport issues in the Nendila, Newsletter of the University of Venda were analysed. The analysis was specifically done using five variables of the roles that media can play in the development of sport which are the informative role, the educative role, the marketing role, the socializing role and the advertising role. The analysis was done using the newsletters published from 2007 to 2009. The results of the study revealed that media mainly plays an informative role through providing team performances of the various sporting codes at the University of Venda. The author recommends that the University of Venda should structure a policy which pinpoints the role of media in the development of sport.

There is a need to package and brand the sports through electronic media sources like the information technology centre through building a University sport website which can be a powerful tool to advertise and market its sports to prospective sponsors at the same time socialising and educating students in sport.

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A constraints based approach to talent identification of future elite athletes

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Introduction & Aims: Experiential coach knowledge provides a potential source of information which may contribute to the existing empirical understanding of talent identification (TID) in sport. Recent research has demonstrated that experiential knowledge can complement empirical investigations, particularly in relation to understanding complex tasks within dynamic sporting environments. This research aimed to gain an understanding of the ways that coaches identify future talent in combat sport athletes.

Methods: 20 elite international combat sport coaches (>10 years coaching experience, current national coach) from boxing (n=7), judo (n=6) and taekwondo (n=7) from 12 countries were interviewed. A three-section, semi-structured interview guide was developed to explore coach knowledge of the TID process, specifically related to their understanding of TID; current TID processes within their sport/country; and the athlete attributes necessary for long term success. Interviews were recorded and transcribed verbatim. Transcripts were analysed thematically following the guidelines from Braun and Clarke (2006).

Results & Conclusions: Coaches identified three types of constraints (individual, environment and task) as important, however, rather than any isolated constraint, it was the interactions between constraints which they believed predicted an athlete’s future success. For example, coaches emphasised the ‘building blocks’ (physical, psychological, lifestyle and technical/tactical indicators) and the relationships between these factors as predictors of future performance. These observations align with the dynamical systems framework, and may help to understand some of the current gaps in TID research. By applying a constraints model to future TID research we may be able to improve our ability to identify future sporting talent.

"Testing and training in Chinese Super League - Example LNTS": A Long-Term Concept
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Introduction & Aims: Football in China is experiencing extraordinary developments supported by a broad nationwide strategy, i.e. the "Overall Development Plan of Chinese Soccer". Major short-term (2016-2020) and long-term (2020 – 2025) targets cover all areas from schools to professional clubs with strict regulations of the Chinese Football Association. Up till now many foreign players and coaches are employed to reach international levels of performance soon. Since 3 years the Shandong Luneng Taishan Football Club (LNTS) has started a major project "The LNTS High Performance Football Lab". It includes state-of-the-art strategic fundamentals of research, technology, knowledge and application. A high-end Big Data-System is available.

Methods: The following methods are in use:
- Endurance: Treadmills, spirometry, blood gas, lactate
- Strength: Isokinetics, forceplates, isometrics for all muscle groups
- Flexibility: Machine based stretching devices
- Anthropometry: 3D-body scan
- Balance: Stability platforms
- Biomarker: Point-of-care testing for capillary blood
- Agility: Speedcourt
- Match: Amisco
- Training: GPSports
- Recovery: Cry-Chambers (minus 110 degrees Fahrenheit)
- Altitude training: Hypoxic chamber up to 5000 m altitude
- Training: multiple high-end devices for conditioning

Results: In the past 3 years 10 tests with 86 professional and young players took place. Reference-values from international top football clubs were available. The results can show the entrance levels and significant effects of training. Direct consequences could be drawn for team- and individual improvements. In addition to "big tests" with a major part of the above listed battery, a smaller monitoring- battery with more measurement points in time could be established.

Conclusion: All experiences show that also in China these approaches that are known from international top football, are imperative for accomplishing the national goals and the individual competitiveness of the single clubs.
Professional Football in China - Testing, Training, Matches, Management and Big Data: Concept and Experiences of the Shandong Luneng Taishan Football Club

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Introduction & Aims: Currently football and Big Data in China are experiencing extraordinary developments. The Shandong Luneng Taishan Football Club (LNTS) as one of the best Chinese clubs promotes “development of football with science and education” and offers new innovative IT system assistance for players, coaches, medical doctors, physios and management. The system should also serve communication and education purposes.

Methods: The technical architecture for the LNTS Big Data System needs to be flexible and secure. Data source, acquisition, storage, calculation and application are in a layered design with reduced coupling between layers. This approach also enables service- and aspect-oriented programming. The system is set up for data from functional tests, medical events, physio treatments, scouting, training and matches (videos & parameters). To design interfaces for each group of end users the method of Design Thinking has been used. A multi-disciplinary team of experts, i.e. from sport science, practical training and IT work together to define and aggregate parameters to provide actionable insights and interpretation, i.e., for the next training sessions.

Results: After a phase of 3 years a large amount of data are available, i.e.
- testing: endurance, strength, agility, biomarkers, flexibility, balance, altitude, cryo-methods, 3D-bodyscan
- training: GPSports
- match: Amisco
- injuries: number, kind, treatment
All data have been imported into the Big Data System for statistical analyses, interpretation and application. New technologies, e.g. data and artificial intelligence, are under development.

Conclusion: Past experiences with separate data-processing have shown that systems can overwhelm end users with uninterpretable floods of data. The central goal for the new LNTS Big Data System is to lead to management innovation and optimization of decision-making at all levels of club work. Current experiences show the advantages of such an innovative, incremental concept.
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The impact of exercise selection and training intensity on biceps femoris long head architectural adaptations

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Purpose: To investigate knee flexor strength and biceps femoris long head (BFlh) architectural adaptations after Nordic hamstring exercise (NHE) (with and without additional weight) and razor hamstring curl (RHC) training.

Methods: Twenty-seven recreationally-active males performed six weeks of Nordic hamstring exercise (NHE) training with (n=9) or without additional weight (n=9), or an RHC intervention (n=9). Following the intervention, participants underwent a four week detraining period. Strength results during the NHE and RHC were recorded pre and post intervention, as well as following detraining. Architectural characteristics of the BFlh were assessed weekly throughout the intervention and detraining.

Results: Six weeks of NHE training with weight significantly lengthened BFlh fascicles (+16%, \( p<0.001, d=1.40 \)). After one week of detraining, BFlh fascicles shortened significantly in the NHE weighted group (-9%, \( p<0.001, d=-0.91 \)). No significant alterations in fascicle length were seen throughout the NHE body weight and RHC interventions at any time point (\( p>0.05 \)). Peak NHE strength was significantly increased following the intervention in those who undertook NHE training with additional weight (+17%, \( p<0.05, d=0.88 \)). Whereas, the RHC group significantly increased in peak RHC strength following the intervention (+17%, \( p<0.05, d=1.08 \)). All other strength comparisons were non-significant (\( p>0.05 \)).

Conclusions: The addition of weight to low volume NHE interventions induces BFlh fascicle lengthening and these adaptations begin to decay following just one week of detraining. Body weight NHE, as well as RHC training, resulted in no significant BFfh architectural adaptations. Additionally, weight is required during NHE training to promote increases in NHE strength. Whereas, RHC interventions cause strength increases when performing the RHC, not the NHE. These findings may have implications for hamstring injury prevention and rehabilitation practices.

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The Science of Mixed Martial Arts

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Introduction and Aims: The massive increase in professionalism and global popularity of mixed martial arts (MMA) has resulted in these athletes seeking professional guidance on their physical preparation for competition. Consequently, sports scientists and other performance staff are faced with the challenge of deciphering this highly complex sport where a wide range strength and endurance qualities could potentially drive performance.

Methods: This presentation analyses the latest published findings on MMA to provide sports scientists with the tools needed to manage the physical development of these athletes, while considering the common constraints of the sport. Because of the breadth of techniques utilised in MMA, the primary technical factors are first identified. Informed by this, and recent data acquired directly from large cohorts of MMA athletes, their distinguishing physiological and biomechanical characteristics are also explored.

Results: The findings reveal that accuracy and grappling based techniques, alongside maximal lower body velocity (and related neuromuscular functions) are the primary determinants of MMA performance. Despite the dominance of these factors, practitioners should not neglect the development of anaerobic and endurance qualities also.

Conclusion: These findings will form the basis for specific recommendations to the practitioner covering tasks such as: technical coaching, strength and conditioning, periodisation strategies, performance testing and fatigue monitoring.
Sprint and endurance cycling performance, cognition and mood during consecutive days of exercise: the effects of partial sleep deprivation

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Introduction and Aims: It is not uncommon for cyclists to compete or train on consecutive days, however, less if know about how impaired sleep during these exercise efforts affects performance, both on the track and road. Therefore, the aim of this study was to determine the effect sleep quantity (8h vs 3h) between consecutive days of exercise on self-paced cycling performance, wellness, and mood states.

Methods: Ten moderate-to-well trained males performed two consecutive-day experimental trials separated either by a normal night’s sleep (CONT; 7h ± 1.0h) or sleep deprivation (SDEP; 2.0 ± 0.2h) condition. Each experimental trial included a 90min fixed-paced cycling bout on Day 1 followed by the sleep conditions. Day 2 included a 30min fixed intensity cycling ergometer session followed by a 30min recovery and two 6s Peak Power (PP) trials, a 4min time trial (TT) and a 20min TT. A modified profile of mood states (POMS), wellness questionnaires and a Stroop cognition task were recorded on Day 1 and 2 of the experimental trial. Capillary blood lactate (La⁺) and glucose (Glu) were recorded pre and post exercise while heart rate (HR) and rating of perceived exertion (RPE) were recorded throughout the cycling tests.

Results: Mean power output (PO) was significantly reduced in the 6s PP trial and 20min TT in SDEP compared to CONT, with no difference for the 4min TT. Despite changes in PO, there were no differences HR, blood La⁺ or Glu. POMS and Stroop cognition task performance were not different between CONT and SDEP conditions. However, the wellness questionnaire showed an increase in negative mood states pre exercise following SDEP compared to CONT.

Conclusion: Sleep deprivation and the associated reductions in wellness states, increased cardiovascular load reduces cycling performance and alters pacing strategies during consecutive days of exercise in a range of cycling tests that are relevant to both track and road cyclists.

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Monitoring Training Load in Classical Ballet Using Inertial Measurement Units

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Purpose: The purpose of this study was to identify whether a single 9-degree of freedom (9DOF) inertial measurement unit (IMU) can be used as an external load monitoring device in classical ballet dancers. This is performed by analysing consistent features in signals supplied by the IMU for the identification of pelvic displacement in ballet dancers for the estimation of jumps, rotations, and left—right leg dominance.

Methods: Four (n=4) dancers of both genders, two pre-professional and two professional had an IMU attached at the lumbosacral junction and then performed six separate jumps on a contact mat, movement testing consisting of eighteen (18) different ballet movements, and one classical ballet class. Each standard movement test was videoed during IMU recording for reference and a Swift contact mat was used to verify time of flight. Consistent signals in IMU recordings were analysed in Microsoft Excel and Matlab to calculate contraction time of jumps, total jumps, time of flight, total rotations at different speeds, and standing / landing leg during movement. Time of flight was used to predict magnitude of jumps. Contraction time divided by flight time is used to predict risk of injury Suitability of the IMU device for day to day utility in rehearsal was also evaluated.

Results: The IMU device is reliable relative to the contact mat (ICC: 0.975, P<0.001). Consistent signal features were found between dancers performing the 18 reference movements in all jump patterns, and speed of rotation about the Z-axis. Dancer’s found the device did not inhibit movement or their performance.

Conclusion: The results demonstrated that a single IMU fixed to the pelvis is suitable to estimate contraction time, total jumps, magnitude of jumps, total rotations, speed of rotations, and standing leg/landing leg, providing the opportunity to collect training load information in dance rehearsals, without restricting activity of the dancer or rehearsal director.
Fast visuomotor responses reflect the expected value of potential targets

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A key feature of highly skilled motor behaviour is the ability to make rapid and appropriate feedback corrections when movements are unexpectedly perturbed. Recent work shows that a lateral shift in visual feedback of limb position during movement leads to an involuntary corrective response with a latency of approximately 150 ms. The size of this fast and automatic corrective response is nonetheless tuned to the nature of the task being performed; such as its accuracy and timing requirements. In open sporting situations, however, movements may be initiated with a number of potential goals in mind, so it might be advantageous to tune feedback responses according to the expected values of POTENTIAL goals. Here we examined this issue in a virtual reality reaching task. Because value is the product of the reward associated with an outcome and the frequency with which that outcome occurs, we varied both the reward and frequency distributions of targets in a series of experiments. A statistical model of relative value that includes a term for risk aversion provided a good explanation for the modulation of feedback responses. Thus feedback control policies can be tuned according to the relative values of multiple potential goals, suggesting that even the lowest levels of the visuomotor control hierarchy contribute to value-based decision making.

Wearable inertial measurement devices are valid and reliable for assessing jump height with jump-and-reach tests

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Introduction: A wide range of sports implement vertical jump testing to assess measures such as power and neuromuscular fatigue in athletes. Many team sports use jump-and-reach apparatus to measure vertical jump height, particularly in sports with substantial jumping components. Validity of jump testing equipment is usually performed with a traditional countermovement jump, which omits the skill-based reach component. This study aims to assess the validity and reliability of a novel jump measurement device against those used in current practice.

Methods: Twenty-six participants completed the jump testing protocols on two occasions. An inertial measurement unit (VERT Classic, Mayfonk Athletic, FL, USA) was worn by participants during three countermovement jumps with arm-swing and reach. Construct and concurrent validity were assessed using jump-and-reach apparatus and a force platform respectively. Pearson’s correlation, standardised mean bias and typical error assessed the relationship between devices. Standardised typical error and intra-class correlations assessed reliability of the VERT device.

Results: Very strong correlations were found between the VERT, and both the jump-and-reach apparatus (r=0.93 [90%CI:0.90-0.95]), and force platform (r=0.95 [90%CI:0.93-0.97]). Standardised mean bias for the VERT compared to the jump-and-reach apparatus and force platform were 0.23 (90%CI:0.15-0.31; small) and 0.96 (90%CI:0.90-1.03; moderate). Standardised typical error of the estimate for the VERT compared to the jump-and-reach apparatus and force platform were 0.49 (90%CI:0.38-0.60; moderate) and 0.32 (90%CI:0.27-0.40; moderate). Inter-jump standardised typical error between the first and second jump session using the VERT were 0.31 (90%CI:0.28-0.36; moderate), ICC=0.91(90%CI:0.87-0.94).

Conclusion: The VERT device appears to show acceptable validity and reliability for practical measurement of jump height, and may be a cost-effective tool for testing in applied settings.
Development of a field-based simulation for fast bowlers during the fielding innings of a Twenty20 match

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Aim: This study aimed to assess the validity and reliability of a novel T20 cricket fast bowling match simulation (T20BS).

Methods: Six fast bowlers (age=23.6±1.4 yrs, body mass=82.3±8.8 kg, height=185.4±5.3m) completed four field testing sessions. Following a baseline testing and familiarisation session, participants completed three identical sessions consisting of the T20BS. The T20BS consisted of 4 bowling overs and 16 fielding lasting 80 minutes based on published time-motion analysis data (Petersen et al. 2009). during the bowling overs, the CA/AIS Bowling Skills Test and bowling approach speed were measured and during fielding overs a 10m sprint was monitored each over. Distance covered, heart rate and RPE was collected throughout the entire protocol. Validity was assessed via comparison to previously reported T20 fast bowling match demands (Petersen et al, 2009) and inter-session reliability was assessed (S1 vs S2; S2 vs S3).

Results: No inter-session or validity comparisons showed significant differences for any parameters (P>0.05). Distances covered showed higher reliability when comparing S2 vs S3 (ICC=0.811-0.962; CV=3.8-14.4%) to S1 vs S2 (ICC=0.488-0.871; CV=17.6-28.8%). Approach speed (S1 vs S2 ICC=0.056-0.671; CV=6.0-8.2%; S2 vs S3 ICC=-1.188-0.514; CV=10.0-13.5%), 10m sprint (S1 vs S2 ICC=-0.964-0.882; CV=1.8-8.1%; S2 vs S3 ICC=0.109-0.866; CV=1.7-5.1%) and BST (S1 vs S2 ICC=0.878; CV=26.1%; S2 vs S3 ICC=-0.467; CV=55.2%) showed higher variability. Training load measures such as heart rate (S1 vs S2 ICC=0.609-0.776; CV=3.3-9.3%; S2 vs S3 ICC=0.550-0.723; CV=4.8-6.3) and sRPE (S1 vs S2 ICC=0.888; CV=7.3%; S2 vs S3 ICC=0.677; CV=10.8%) showed acceptable levels of reliability.

Conclusions: These results show that this training protocol is a valid and reliable tool for measuring physiological responses and performance demands of fast bowlers. It is recommended that participants complete a full protocol session as familiarisation prior to testing.
Clarifying the Definition of Mental Fatigue in Elite Sport: Athlete & Staff Perceptions

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Introduction: Mental Fatigue (MF) has been shown to have a negative impact on physical performance, and thus holds potential to impact elite sporting performance. However, there are inconsistencies in the literature as to how MF should be defined, in particular, how individuals perceive and can describe the onset of MF. A better understanding of how to recognise and prevent or delay MF is dependent on establishing how those who work and compete in elite sport perceive MF. The aim of this study was to explore athlete and support staff perceptions of MF to inform a definition that will assist in managing its influence at elite levels of competition.

Methods: Focus groups were conducted with elite athletes (n=17) and support staff (n=12) to capture perceptions around the definition, manifestations, impact and causes of MF. Recordings were transcribed and content analysis used to identify common themes.

Results: Preliminary analysis revealed that MF is associated with decreased motivation and an increased emotional response. Athletes reported descriptors of tiredness, decreased concentration, lack of clarity and increased effort, whereas staff reported behaviour change as a major indicator of MF manifested through decreased enthusiasm, discipline and emotional management capacity, and increased disengagement. Prolonged and repetitive tasks, environment and professional demands were commonly perceived to induce MF. All participants perceived MF to reduce decision making ability, awareness and concentration, and increase response time to stimuli.

Conclusions: The definition and manifestations of MF are context specific. By having elite athletes describe the characteristics of MF, it will be possible to improve monitoring of the condition and examination of interventional strategies. Refining the definition will improve the ecological validity of future research in athletic populations.
Introduction and Aims: Sporting organisations commonly adopt an early identification approach to select youth athletes that display potential to excel within a sport. However, this approach assumes a direct relationship between youth and senior performance. This study aimed to examine the stability of youth soccer players’ anthropometry, motor competence, physical fitness, and decision-making skill.

Methods: Twenty-eight male soccer players from two age cohorts – early (12-13 yr, n=18) and mid-adolescence (14-15 yr, n=9) – were recruited from a high-level academy. A multifactorial assessment battery including anthropometry, motor competence, physical fitness, and decision-making was employed on two occasions 18-months apart. A multivariate analysis of variance assessed changes in players’ performance characteristic. Stability was examined using intraclass correlation coefficients.

Results: Early and mid-adolescence players presented similar changes in their performance characteristics over 18 months (F=1.66, p=0.20, η²=0.63). The early adolescence group’s stability was classified as: very low – balancing backwards and jumping sideways; low – jumping sideways, 5 m sprint, Yo-Yo, decision-making accuracy, and decision-making response time; moderate – vertical jump and T-Test; high – 30 m sprint; and very high – stature and body mass. The mid adolescence group stability’s was classified as low – balancing backwards; moderate – vertical jump, 5 m sprint, T-Test, Yo-Yo, and decision-making accuracy; high – moving sideways, jumping sideways, and 30 m sprint; and very high – stature, body mass, decision-making response time.

Conclusion: This study demonstrates the instability of players’ performance characteristics during development. Although mid-adolescence players show greater stability when compared with their younger counterparts, it is imperative that talent identification programs collect longitudinal data when determining a players’ potential for future success.
The effect of age on post-exercise recovery following high-intensity interval training: A comprehensive analysis of recovery following high intensity interval cycling

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Introduction Data about age-related differences in recovery following high intensity interval training (HIIT) in trained masters and young subjects is lacking. Therefore, this study examined the effect of age on acute (0-1 h) and chronic (1-48 h) recovery following HIIT.

Methods Masters (n=9, age=55.6±5.0 yr) and young (n=8, age=25.9±3.0 yr) cyclists underwent a 6x30 sec HIIT cycle protocol at 175% of peak power output with 4.5 min rest between efforts. During acute recovery, 40 min of supine rest occurred where heart rate (HR), oxygen consumption (\(\dot{V}O_2\)) and lactate values were collected. Chronic recovery was monitored via performance tests (10 sec cycle sprint, countermovement jump, maximal voluntary contraction of knee extensors, and 30 min time trial), perceptual recovery scales (recovery, fatigue, motivation, muscle soreness) and creatine kinase (CK) at 1, 24 and 48 h post HIIT.

Results No significant between group differences were observed for HR recovery, relative or absolute \(\dot{V}O_2\), or blood lactate values (P>0.05). Analysis of effect size (ES) showed moderate differences for HR recovery (d±90%CI=0.81±0.80) and final recovery lactate (d=0.70±0.81) taken at 20 min suggesting delayed acute recovery in masters cyclists. No significant group-time interactions were observed for performance recovery and CK (P>0.05). A significant interaction effect was found for perceptual fatigue (P=0.01) and ES analysis showed that perceptual recovery was delayed with masters cyclists reporting lower motivation (d=0.69±0.77, moderate), greater fatigue (d=0.75±0.93, moderate) and muscle soreness (d=0.61±0.70, moderate) after 48 hours of recovery.

Conclusion Despite differences in acute recovery, there were no age-related differences in performance recovery following HIIT. Masters cyclists showed a perceived delay in recovery and fatigue over the 48 hrs post-exercise which could lead negatively influence training adherence.
Motorsport Athletes Attitudes and Behaviours Towards Hydration and Thermoregulation

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Purpose: The aim of this study was to describe motorsport drivers’ attitudes and behaviours towards hydration and thermoregulation.

Methods: The survey was completed via both paper and online modalities and was divided into three components: 1) attitudes and perceptions, 2) behaviours, and 3) demographics. The survey included a total of 79 questions on a Likert-type scale rating importance, agreement, or acknowledgement of select behaviours. Chi-Square tests were used to determine differences in demographic data.

Results: One hundred drivers (56.5% of respondents) completed the survey in full. The majority of participants were closed-cabin (57.0%), amateur (72.0%) drivers who raced in Australia (75.0%). The majority of drivers (95.0%) ingested plain water across a race weekend, yet 49.0% suggested they didn’t have sufficient access to fluids during a race. Drivers (80.0%) identified the importance of monitoring their hydration status, but only 50.0% thought it important to seek professional advice. Measuring hydration status via body mass was more common in drivers with >8 years racing experience compared to those with <4 years’ experience (66.7 versus 24.9%; p<0.001). A significantly (p<0.01) higher percentage of professional drivers follow an individualised hydration plan (57.1%) and use cool suit technology (46.4%) in comparison to amateur drivers (29.2% and 4.2%, respectively).

Conclusion: Drivers identified the importance of minimising heat stress and dehydration, however often failed to measure factors that lead to heat stress. Drivers and supporting staff should implement practical tools and resources that lead to positive behaviour change in young and inexperienced motorsport athletes. The implemented behaviours should be in alignment with the level of competition, financial cost and competition demands. Further investigation into whether these behaviours affect cognitive and psychomotor performance is warranted.

Physical Fitness Characteristics of Australian Supercar Drivers: A Case Study

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Purpose: Using a case study approach this study aimed to describe the cardiorespiratory fitness, neuromuscular strength and flexibility of Australian Supercar drivers.

Methods: Three elite and one sub-elite Australian Supercar drivers participated in the study. Each driver completed a test of peak aerobic capacity, body composition to assess lean and fat mass, a series of strength measurements to assess grip strength, forearm rotation, upper body and lower body strength, and measures of flexibility of the lower limbs and torso.

Results: High inter-individual variation in cardiorespiratory fitness, body composition, upper body strength, cervical strength, wrist pronation and leg extension strength was observed amongst drivers. Participants’ peak aerobic capacity [median (IQR)] \( \dot{V}O_{2\text{peak}} \) = 45.0 (9.5) mL/kg/min were similar to those previously reported from the Australian adult population (49.1 mL/kg/min). In comparison to recreationally-active Australian males, the participants produced 240 N and 393 N higher in plantar flexion (1450 N) and leg extension (1804 N), respectively. Compared to other motor racing categories participants produced 102 N and 86 N lower than that observed in neck lateral flexion (260 N) and extension strength (314 N), respectively. Lower back flexibility [sit and reach = 44.5 (9.4) cm] was higher than the 70th percentile for males (43.2 cm).

Conclusion: The high inter-individual variability in physical fitness characteristics of motorsport athletes indicates a multidimensional approach (physical, cognitive and behavioural) may be required to determine the key attributes of elite motorsport athletes. Force development in plantar flexion and knee extension are physical attributes that may have developed as an adaptation to the demands of racing and should be considered important for strength and conditioning programs.
Does more sleep enhance recovery? Influence of post-exercise sleep extension on physiological, neuromuscular, and perceptual recovery

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Introduction: Reduced sleep quantity and quality is common following team-sport competition, which can impair athletic performance and recovery. Sleep extension can improve athletic performance, however its effect on post-exercise recovery are unknown. We aimed to investigate the effects of sleep extension on post-exercise recovery.

Methods: Ten healthy males had 17cm recovery marks (43.5±6.10cm over 10m, 47.13±6.66cm; CMJ), peak isometric knee extensor torque (PT), autonomic function (heart rate variability; HRV), perceived effort (RPE), and subjective wellbeing assessed at baseline (Pre) and 0 h, 1 h, and 2 h post a high-intensity interval exercise (HIIE) session. Participants then underwent 8 h (CON) and 10 h (EXT) time in bed (TIB) in a random order following HIIE, before recovery was reassessed 16 h post HIIE. Wrist-watch actigraphy measured total sleep time (TST), sleep onset latency (SOL), sleep efficiency (SEF), and wake after sleep onset (WASO). Multiple multi-level linear mixed models assessed the effects of EXT on recovery (standardised effect; ± 90% confidence interval). Results are shown as standardised effect sizes (<0.20 trivial, 0.21–0.60 small, 0.61–1.20 moderate, 1.21–2.0 large and >2.1 very large) ± 90% confidence intervals.

Results: The EXT increased TST (3.88 ±0.22) and SOL (1.01; ±0.86), and decreased SEF (0.67; ±0.66), without influencing subjective wellbeing (0.05; ±0.34) compared to CON. The EXT did not have a substantial influence on CMJ (0.08; ±0.50), PT (0.04; ±0.41), HRV (0.06; ±0.73), RPE (0.06; ±0.98) or total wellbeing (0.19; ±0.51) compared to CON.

Conclusion: A single night of 10 h in bed has unclear effects on markers of post-exercise recovery compared to 8 h in bed, potentially due to inflated confidence intervals for effects. These findings suggest that the effects of sleep extension are subject to large individual variation and support the need for an individualised approach to the use of sleep interventions to enhance recovery.

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Physical Profile of Elite, Sub-Elite, Regional and Junior Netball Players

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Introduction & Aims: Physical characteristics, such as physical fitness and body composition, influence selection in some elite sports. There is a lack of evidence that identifies the physical characteristics that may be associated with selection in elite netball. Therefore, the aim of this study was to examine the differences in physical profiles of netballers of various playing level.

Methods: Physical profile data of 283 athletes from a state netball association was collected from 2012-2017. This included age, height, body mass, vertical jump height (VJ), 5m, 10m, 20m speed and endurance running performance (Yo-Yo intermittent recovery test level 1 [Yo-YoIRT1]). Athletes were sorted into the following playing levels: elite, sub-elite, regional, under 21 (U21), under 19 (U19) and under 17 (U17). Kruskal-Wallis test was used to determine if there were differences between playing levels.

Results: Elite netballers demonstrated a higher performance (p<0.001) in VJ compared to all other playing levels (elite: 52.17±6.02cm; sub-elite: 48.03±7.17cm, regional: 48.35±6.10cm, U21: 47.12±6.52cm, U19: 46.45±6.24cm, U17: 47.58±6.66cm). Over 5m, U17s netballers were faster (1.12±0.07s, p<0.05) than elite (1.16±0.05s), sub-elite (1.16±0.09s) and U19s (1.15±0.07s). Elite netballers were faster over 20m (3.32±0.11s, p<0.010) compared to all other playing levels (sub-elite: 3.40±0.17s, regional: 3.42±0.16s, U21: 3.41±0.17s, U19: 3.42±0.14s and U17: 3.38±0.16s). Elite netballers achieved a greater distance (1350.8±417.3m, p<0.05) in the Yo-Yo IRT1 than sub-elite (1165.6±311.9m), regional (1048.4±397.6m), U19 (1109.7±378.4) and U17 (1219.2±397.1m).

Conclusion: These findings highlight that physical characteristics associated with age, height, body mass, speed over 20m, Yo-Yo IRT1 distance and VJ are associated with elite netball playing level. The findings provide normative data for multiple playing levels which could be used practically for talent identification and development.
The physiological and performance effects of active and passive recoveries applied between repeated-change-of-direction sprints in semi-professional basketball players

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Introduction and Aims: A novel approach has been developed to better isolate change-of-direction speed, termed the Change-of-Direction Deficit (CODD). Therefore, the aims are to investigate the physiological and performance effects of active and passive recovery modes between repeated-change-of-direction (RCOD) sprints and whether CODD is impacted by recovery modes.

Methods: 12 semi-professional basketball players (n = 8, female = 2; age: 19.9 ± 1.5 yr; stature: 183.0 ± 9.6 cm; body mass: 77.7 ± 16.9 kg; body fat: 11.8 ± 6.3%; VO2peak: 46.1 ± 7.6 mL·kg⁻¹·min⁻¹) completed 12 x 20-m RCOD sprints (Agility 505 Tests) interspersed with 20 s of active (50% maximal aerobic speed) or passive recovery in a randomized cross-over design. Physiological and perceptual measures included (heart rate (HR), oxygen consumption (VO2), blood lactate concentration ([BLa]), and rating of perceived exertion (RPE)). Change-of-direction speed was measured during each sprint using the CODD, with summed CODD time and CODD decrement calculated as performance measures.

Results: Average HR (effect size (ES) = 1.09) and VO2 (ES = 0.77) were moderately greater during active recovery (173 ± 5 beats·min⁻¹; 37.7 ± 7.1 mL·kg⁻¹·min⁻¹) compared to passive recovery (166 ± 8 beats·min⁻¹ and 33.3 ± 4.0 mL·kg⁻¹·min⁻¹) across sprints. Trivial-small differences between recovery modes were evident for [BLa] and RPE. Summed CODD time (ES = 0.76) was moderately higher during active (16.1 ± 1.3 s) than passive recovery (15.2 ± 1.0 s) and CODD decrement was significantly larger (ES = 1.94, p ≤ 0.01) during active (14.1 ± 5.6%) compared to passive recovery (6.0 ± 1.9%).

Conclusion: Passive recovery is recommended to reduce physiological stress and enhance RCOD speed compared to active recovery. Therefore, basketball players are encouraged to undertake passive recovery between repeated-sprints to improve performance while reducing fatigue and CODD.

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Practice activities explain individual performance in a major esports tournament

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Introduction & Aims: Electronic sports (esports) involve players competing in video game competitions. Competition, peer pressure and skill building influence the time a player engages in practice. However, the contribution of practice activities for successful performance remains relatively unknown. Therefore, the aim of this study was to investigate if practice activities explain individual performance in a major esports tournament.

Method: 44 professional Counter-strike: Global Offensive players (23.52 ± 2.50 y) data were collected weekly, eight weeks prior to a major esports tournament (Professional Gamers League, Major Krakow, 2017). Multiple linear regressions and stepwise linear regressions explored the relationship between independent (previous practice history and weekly practice activities) and dependent (players tournament score) variables. Previous practice history and weekly practice activities data included: total hours, accuracy (%), headshot (%), win (%), kill/death ratio, matches played, matches won, rounds played, rounds won and total score.

Results: Multiple linear regression (independent variables: cumulative win percentage, cumulative time played, average rounds played/week, average kill/death ratio and average score/week) identified practice activities were a significant predictor of score (F=4.24, p<0.01, R²=0.27). Stepwise linear regression (independent variables: average kill/death ratio and average score/week) identified practice activities were a significant predictor of score (F=7.95, p<0.01, R²=0.24).

Conclusion: Although interest in esports performance continues to gain attention, the factors that underlie successful performance remains to be answered. This study demonstrates that the quality of practice activities outweighs the quantity of practice activities. Therefore, future research should aim to further understand the dynamics of individual players and teams to develop purposeful training programs.
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**Muscle function over the oral contraceptive cycle**

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**Introduction:** Oral contraceptives (OC) are a common form of birth control both in the general community and amongst female athletes. With the use of OC, the production of endogenous female sex hormones is suppressed through a combination of synthetic estrogen and progesterone. Estrogen has a positive effect on muscle strength and repair, but it is unclear if the synthetic form of estrogen in OC affects muscle performance. Therefore, this study aimed to assess aspects of muscle function at three different hormonal environments of the OC cycle.

**Methods:** Thirteen moderately active females aged 18-29, all taking a combined monophasic OC, were tested during the non-active pill phase, the first week of the active OC and the last week of the active OC. Counter movement jumps, bilateral hopping, handgrip strength and isokinetic and isometric strength of the leg were assessed. Participants were also asked to report period pain, fatigue and muscle soreness.

**Results:** Repeated measures ANOVA showed no significant change over the cycle for most measured variables. However, isokinetic knee flexion torque at 240 degrees/sec was found to be lowest in the non-active pill phase, increased in the first week of OC and increased further in the last week of the OC. Bilateral hopping flight time was significantly higher in the first week of the OC compared to the last week of the OC. Muscle soreness was found to be significantly higher in the last week of OC compared with the non-active pill phase.

**Conclusion:** Our findings suggest that the faster and more explosive aspects of muscle function may be affected by the synthetic hormones administered in the OC. Only general muscle soreness was reported, so it could not be distinguished which muscles the soreness was related to. As bilateral hopping is a full body movement, the increased soreness in the last week of OC could potentially explain why flight time was decreased at that time point.

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**Physiological response at critical speed in Brazilian Paratriathletes**

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The sport of Paratriathlon is growing and since its inception in the Paralympic Games in Rio 2016 and at the Commonwealth Games on the Gold Coast in 2018 it is an exciting sport for the athlete, coach, spectator and scientist. Critical speed (CS) has been used as a good marker of endurance performance in swimming, cycling and running. Therefore the aim of the study was to determine the physiological responses at CS in Paratriathletes. We examined a case study approach in two Brazilian Paratriathletes both partial C5 spinal cord injured athletes who were new to the sport of Paratriathlon. One female (age 32yr, mass 58kg) and one male (age 39yr, mass 72kg) volunteered for the study. Methods; All tests were carried out on a Cosmed treadmill using the athletes own handcycle. An incremental test to exhaustion was carried out followed by three trials at 90, 95 and 100% of speed at peak oxygen uptake on separate days. Following the three trials, critical speed was derived using a linear model. Subjects then exercised to exhaustion at CS (m=29.4km.h⁻¹, f=19.4km.h⁻¹). Results; When exercising at CS oxygen uptake was 85-88% VO₂ peak and 80% HR max, despite other research suggesting that VO₂ peak is reached when exercising at CS, with Bla steady state at 3mM in the female athlete and 6mM in the male athlete. Conclusions; Critical speed testing in Paratriathletes may provide a useful racing and training intensity, that approximates to 85-88% VO₂ peak close to maximal lactate steady state.
Evaluating the influence of methodological variables on the determination of VO2max and the lactate threshold

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Introduction: Graded exercise tests (GXTs), which are used to determine peak oxygen uptake (VO2peak) and the lactate threshold (LT), are commonly employed by sport scientists and coaches to evaluate and prescribe exercise training. Two methodological choices that influence these indices are GXT stage length and the method used to calculate the LT. However, there has been little investigation of the effects of these choices on the determination of the VO2peak and the LT.

Aim: To determine the influence of stage length and method of calculation on the estimation of LT and VO2peak.

Methods: Trained male cyclists (n=17) completed five GXTs of varying stage length (1, 3, 4, 7 and 10 min), each followed by a verification exhaustive bout (VEB) to confirm VO2peak, and a series of 30-min constant power bouts to establish the maximal lactate steady state (MLSS). VO2 was assessed during each GXT and VEB, and 15 LTs were calculated from four of the GXTs (3, 4, 7 and 10 min) yielding a total 60 LTs. Agreement was assessed between the highest VO2 measured during each GXT (VO2peak), and between each GXT and VEB. Validity of the LTs was assessed using the MLSS as the criterion measure. Data were analysed using mean difference (MD), effect size (ES), intraclass correlation (ICC), and percent coefficient of variation (%CV).

Results: The VO2peak from GXT1 was 61.0 ± 5.3 mL/kg/min and the peak power 420 ± 55 W (mean ± SD). The MLSS power was 264 ± 39 W. VO2peak from GXT3, 4, 7, 10 underestimated VO2peak from GXT1 (MD = -1.2, -2.1, -3.7 and -4.8 mL/kg/min; ES = 0.23, 0.36, 0.69 and 0.88, respectively). The Modified Dmax method (MDmax) derived from GXT4 provided the most valid estimate of the MLSS (MD = 1.1 W; ES = 0.03; ICC = 0.96).

Conclusion: Methodological choices can affect determination of VO2peak and the LT – in well-trained cyclists the modified Dmax method using 4 min stages provides the best estimate of MLSS.
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Does concurrent high intensity interval training and resistance training impede resistance training induced hypertrophy and strength?

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Introduction: Coaches often prescribe high-intensity interval training (HIIT) and resistance training (RT) in programs to improve athletic performance. Previous reviews have indicated that when combined with RT, aerobic exercise can impede muscular strength and/or hypertrophy. Whether these findings are replicated when HIIT is combined with RT remains unknown.

Aim: The purpose of this systematic review and meta-analysis is to compare HIIT+RT to RT alone on measures of strength and hypertrophy.

Methods: Five electronic databases were searched using terms related to HIIT, RT, and concurrent training. Inclusion criteria were: randomised comparative studies; healthy adults; compared HIIT+RT group to a RT alone group; duration ≥ 4 weeks; measured dynamic muscular strength and/or muscle hypertrophy changes. Effect size (ES) was used to examine the effect of HIIT+RT compared to RT alone on muscle strength and/or muscle hypertrophy.

Results: 13 studies were included involving 246 participants. Compared to RT alone, HIIT+RT led to similar changes in muscle hypertrophy and upper body strength. However, greater lower body strength was found for RT alone when compared to HIIT+RT (ES = -0.29, p = 0.03). Sub analyses showed greater lower body strength gains in RT alone vs cycling-based HIIT+RT (ES = -0.53, p = 0.02) but not compared to running-based HIIT+RT (ES = -0.16, p = 0.33). No difference was observed between HIIT+RT with >24h intermodal rest and RT alone on lower body strength (ES = -0.06, p = 0.82).

Conclusion: The data suggests that HIIT+RT does not negatively impact hypertrophy or upper body strength, and that the small negative effect on lower body strength observed may be ameliorated by the incorporation of running based HIIT and longer inter-modal rest periods.

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Passing in football: Does it make a difference to score line?

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Common wisdom in football (soccer) is that the team which dominates play through possessing and successful passing the ball is the team most likely to win the game. In this study, we explored the relationship between passing and match results for a single team (Team A) in the National Premier League (NPL) division. Eight full matches from the 2015 season were viewed on QLDNPL YouTube channel, and every pass was coded as successful or unsuccessful. A pass was deemed successful if the ball was passed from one Team A player to another. Passes were deemed unsuccessful if the ball was not received by a Team A player, or was intercepted by an opposition player. We then conducted a series of correlational analyses between passing and score line.

We explored this relationship considering passing as the percentage of successful passes and the total of number of passes in a game, and game score as the margin 10 minutes into each half and at full time. Notably, Team A’s successful pass rate remained fairly consistent (range 71.13% to 80.52%, mean 75.05%, median 74.51%, standard deviation 3.2) across the eight games analysed, even during a 12 point loss in which two players from Team A were sent off. In contrast, winning games were typified by large numbers of passes (range 481 to 503 total passes in each winning game), whereas draws and losses were characterised by fewer total passes (range 287 to 362 total passes per non-winning game). We identified a small, positive correlation (r=0.19, r²=0.036) between the percentage of successful passes and full time margin, and a more substantive, positive correlation (r=0.54, r²=0.296) between total number of passes and full time margin. Variance in percentage of successful passes accounts little (3%) for variation in game score, whereas total number of passes made by a team contributes much more substantially (almost 30%) to variance in game score.
The effect of dietary nitrate supplementation on endurance exercise performance in healthy adults: a systematic review and meta-analysis update

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Background/Aims: The use of dietary nitrates has become more popular amongst athletes attempting to enhance performance. The objective of this systematic review and meta-analysis was to evaluate the effect of dietary nitrate (NO₃⁻) supplementation on endurance exercise performance.

Methods: Relevant databases, Cochrane Library, Embase, PubMed, Ovid, Scopus and Web of Science were searched from inception to September 2017. Studies were included if a placebo versus dietary nitrate-only supplementation protocol was able to be compared, and if quantifiable measures of exercise performance was ≥ 30 seconds (for a single bout of exercise or the combined total for multiple bouts).

Results: Data from the 109 trials was extracted for inclusion in the meta-analysis. A random-effects meta-analysis was conducted for time trial (TT) (n = 48), and time to exhaustion (TTE) (n = 23). Pooled analysis identified a trivial, but NS effect in favour of dietary NO₃⁻ supplementation for TT (effect size (ES) = -0.11, 95% CI = -0.23-0.02, p > 0.05). TTE trials had a small to moderate statistically significant effect in favour of dietary NO₃⁻ supplementation (ES = 0.32, 95% CI = 0.15-0.49, p < 0.01). No significant heterogeneity was detected in the meta-analysis. No statistically significant effects were observed from the univariate meta-regression.

Conclusions: Dietary NO₃⁻ supplementation is likely to elicit a positive outcome when testing endurance exercise capacity, but likely to be less effective for time-trial performance. Research focusing only on simple performance outcomes has been exhausted, but more experimental trials need to be conducted with a research focus on potential moderator variables to provide definitive conclusions and recommendations for dietary NO₃⁻ supplementation and its effect on endurance exercise performance.

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An observational examination of the prevalence, attitudes, beliefs, and knowledge of dietary nitrate supplement usage among active adults

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Background/Aims: Consumption of dietary nitrate supplements has gained popularity amongst athletes attempting to enhance performance. However, it is still unclear if the use of dietary nitrate (DN) as a form of supplementation is widespread and how the knowledge from research studies is being translated. The objective of this study was to assess the prevalence, prevalence, attitudes, beliefs, and knowledge of DN supplements among active adults.

Methods: Individuals (≥16y) completed a 42-item online questionnaire. Descriptive data analysis (median, SD, frequencies (%), and ranges) were performed. Associations between each variable were coded and assessed by chi-square (χ²) analysis.

Results: 1404 active adults (66% female) participated in the survey. 11.9% of survey respondents reported to have consumed DN (‘users’) in the past, most commonly in the form of beetroot juice (31.3%). More than two-thirds (69.4%) of users could not correctly identify the correct timing of intake relative to performance time to best improve exercise performance, and the majority of users (82.9%) were unsure of the contraindications to oral consumption of DN supplements. Only 3.9% of users experienced adverse effects after ingesting dietary nitrate supplements.

Conclusions: The results outlines the gap in knowledge that exists between current consensus recommendations and its translation to practice. Since DN are well-documented to improve sports performance, they are severely under-utilised. Educational messages that target DN consumption should be targeted towards nutritionists, coaches, and exercise physiologists to bridge the gap between knowledge-to-practice.
Introduction & Aims: Customised wellness questionnaires are common in training load monitoring systems, yet the sensitivity to variations in acute training intensity is unclear. This study examined the dosage effects of differing exercise intensities on wellness variables and subsequent associations with neuromuscular performance.

Methods: Participants (n=6) completed a 90min simulated football match shuttle running protocol on an outdoor tartan running track. The protocol was scaled relative to beep test scores (low, medium and high intensity) and completed in a randomised and counterbalanced fashion that was matched for time of day. Wellness measures (sleep quality, readiness to train, soreness, fatigue, stress level, mood, motivation) and neuromuscular performance (maximal voluntary contraction, countermovement jump, 6s Wattbike power test) were assessed pre-, post- and 24h post-exercise. Heart rate (HR) and rating of perceived exertion (RPE) were recorded during, and session RPE (sRPE) after exercise. Data were analysed using linear mixed model methods with Spearman's correlations between variables.

Results: Main effects were seen between trials for HR, RPE and sRPE (P<0.03). Fatigue and soreness increased (P<0.003), while motivation and readiness to train decreased over time (P<0.04). Wellness showed no significant effects between exercise intensities at any time-point (P>0.05). Fatigue, stress and mood were correlated with changes in MVC torque (P<0.05; r=0.28). Changes in Wattbike peak power were correlated with total wellness and soreness (P<0.05; r=0.28).

Conclusion: Wellness scores may not effectively distinguish between differing training intensities, though may be useful in determining the time-course expression of perceived capacity to perform following training. Consideration of the changes in neuromuscular performance and associated wellness should be applied when modifying training load.

Intermittent Hypoxic Training Enhances Total Work Capacity During Sustained High-Intensity Exercise

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Introduction & Aims: Reduced oxygen availability during high-intensity exercise increases the contribution from anaerobic energy. Supplemenating training with additional sessions undertaken in hypoxia (~14% O₂) has been shown to delay fatigue during intermittent high-intensity exercise (1). Our aim was to determine if hypoxic training could enhance sustained high-intensity exercise time to fatigue.

Methods: Sixteen cyclists (VO₂peak: 56±5 ml·kg⁻¹·min⁻¹) undertook a VO₂peak test, and time to fatigue test at 120% of VO₂peak to determine anaerobic capacity (1) and total work capacity before and after a 4-wk intervention. Participants were pair-matched and allocated to hypoxic (HYP 14.4% O₂, n=8) or normoxic (NORM 20.9% O₂, n=8) groups that completed two weekly sprint interval training (SIT) sessions: 8 x 1 min at 120% VO₂peak with 5 min recovery (50% VO₂peak). Participants maintained their habitual training during the 4-wk intervention and testing was conducted at sea-level using Lode cycle ergometers.

Results: There was no difference between groups prior to SIT intervention for total work capacity (HYP: 55±20; NORM: 55±12 kJ), anaerobic capacity (56±17 and 56±6 ml·kg⁻¹), or VO₂peak (55±7 and 57±4 ml·kg⁻¹·min⁻¹). SIT enhanced total work capacity in HYP (18±13%; p < 0.01) but not NORM (9±26%). Anaerobic capacity (HYP: 7±23%; NORM: -1±15%) and VO₂peak (1±6% and 1±7%) were not different following SIT.

Conclusion: This study showed that the addition of repeated SIT in hypoxia enhances total work capacity but not anaerobic capacity during supramaximal constant load cycling to fatigue. Intermittent hypoxic training may have enhanced exercise efficiency and generated a greater metabolic demand for the mechanical work performed. Our results support the addition of SIT undertaken in hypoxia for athletes seeking to increase total work capacity at supramaximal exercise intensities.

1. Faiss 2013, PloS One
2. Medbo 1988, JAP
Maximal strength training for athletes with cerebral palsy: Preliminary effects on peak force and rate of force development

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Introduction & Aims: The effects of strength training on athletes with cerebral palsy (CP) are currently unknown. Prior research examining sedentary individuals with CP has shown mixed results; to date no studies have investigated athletes with CP. The potential of these athletes to improve sports performance through strength training is also unknown. The aim of this project was to examine the effects of maximal strength training on the upper and lower body strength and rate of force development (RFD) of athletes with CP, important aspects underlying performance in many sports.

Methods: Six elite athletes with CP (state to international level; 5 male, 1 female; 4 hemiplegic, 2 ataxic CP) participated in this pilot study. Following a 12 week control period of current sport training only, subjects participated in a 12 week intervention consisting of twice weekly periodised supervised maximal strength training in addition to current training. Lower body strength and RFD were measured via isometric mid-thigh pull (IMTP), and upper body strength via 1RM chest press at baseline, end of control period, weeks 6 and 12 of training intervention, and 6 weeks post training completion.

Results: Absolute and allometrically scaled peak force (p < 0.01) and RFD (p < 0.05) in IMTP increased significantly following the training intervention with greatest changes occurring between weeks 1 and 6. Results differed between male and female subjects; CP subtype had no significant effect. No significant changes were seen in 1RM chest press.

Conclusions: Athletes with CP showed significant improvements in lower body strength and RFD following 12 weeks of maximal strength training, but no change in upper body strength. Lower body strength and RFD improved most in the initial 6 weeks of the intervention, and were influenced by gender but not CP subtype. Maximal strength training improved lower body strength and RFD in athletes with CP, key aspects underlying performance in many sports.

The reproducibility of 10 and 20 km time trial cycling performance in recreational cyclists, runners and team sport athletes

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Introduction & Aims: The logistical efficiencies of a cycling time trial (TT) mean it is often reported in non-cycling groups (e.g. runners, team sport athletes). This study examined the reliability of 10 and 20km cycling TT performance in recreational cyclists, runners and team sport athletes, with and without a familiarisation.

Methods: Thirty-one males (cyclists: 57.3±6.3 ml/kg/min, runners: 49.3±6.0 ml/kg/min, team sports: 46.8±2.6 ml/kg/min) completed 10 or 20 km cycling TTs on four separate occasions. All TTs were completed on a Velotron Pro cycle ergometer, with visual feedback provided via linked avatar software. Power output, speed and cadence were recorded continuously, and heart rate and rating of perceived exertion (RPE) were recorded each km. Intraclass correlations (ICC), standard error of the measurement (SEM), coefficient of variation (CV), and minimum difference required for a worthwhile change (WC) were determined for completion time and mean trial variables (power output, speed, cadence, heart rate, RPE, session RPE).

Results: Cyclists competed the 10km and 20km TTs in 51:43±:52 (ICC:0.88; SEM:0.18; CV:1.1%) and 31:03±:13 (ICC:0.92; SEM:0.23; CV:1.1%), respectively. The reliability of the cyclist’s performance was higher than runners (ICC:0.74±0.88; SEM:0.10-0.22; CV:1.8-2.2%) and team sport athletes (ICC:0.69-0.83; SEM:0.31-0.37; CV:1.7-2.9%) over these distances. A WC in performance for cyclists, runners, team sport is represented by 7.5, 3.6 and 12.9% improvement for 10km and a 4.9, 4.0 and 5.6% for 20km completion time. After a familiarisation, a 4.0, 3.7 and 6.4% improvement for 10km and a 4.1, 3.0 and 4.4% would be required.

Conclusion: The current data show recreational runners and team sport athletes to produce moderate to substantially reliable cycling time trial performances. Nevertheless, completing a familiarisation trial considerably reduces the minimum difference required for a change in completion time to be considered worthwhile.