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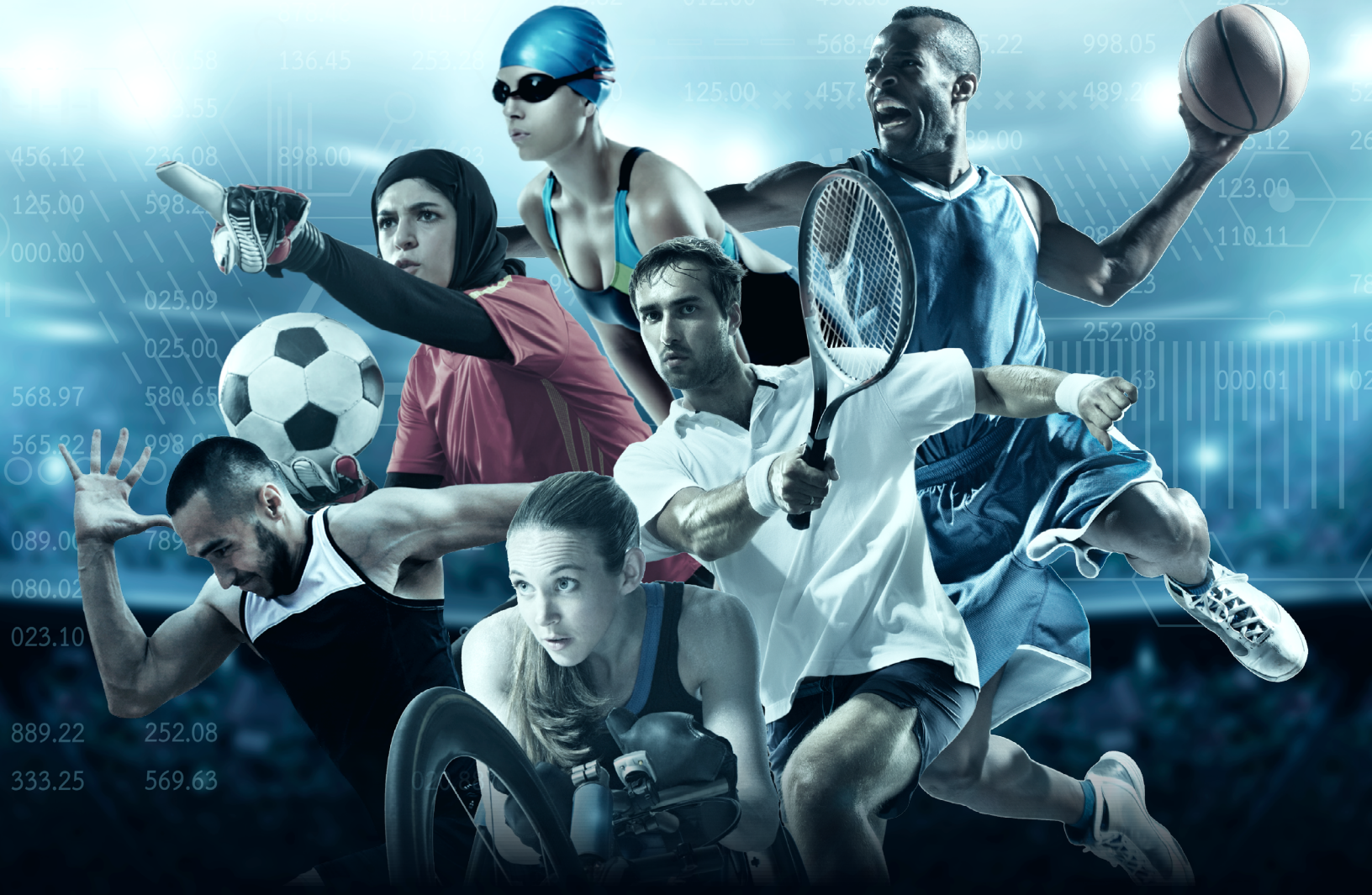
UNIVERSITY OF TORONTO

TANENBAUM INSTITUTE FOR SCIENCE IN SPORT

CONFERENCE 2024



ABSTRACT BOOK

September 14 & 15, 2024

Goldring Centre for High Performance Sport, Toronto

TABLE OF CONTENTS

WELCOME

Welcome to the 2024 inaugural Tanenbaum Institute for Science in Sport (TISS) Conference. On behalf of TISS and its conference planning committee, welcome to this landmark conference entirely devoted to presenting and mobilizing the latest research to ultimately support high-performance athletes perform better, recover faster, compete and train safer.

It is immensely gratifying to see this conference come to fruition, not only because of the excellence of the researchers and practitioners who have accepted the invitation and travelled from afar to share their expertise with us, but also because we are an institute that is only in its second year of operations established through the generous benefaction of the Larry and Judy Tanenbaum Family Foundation.

It is incredibly exciting to come together for two intense days of experts sharing their accumulated knowledge across a broad spectrum of sport science, medicine, and analytics disciplines. Speakers whose research has been instrumental in supporting the physical and mental needs of high-performance athletes competing at the 2024 Paris Olympic and Paralympic Games - from training to coaching to rehabilitating from injury – we have such a wonderfully rare opportunity to share knowledge that is both very current and very timely.

We hope that over the next two days you enjoy, learn, and network with the high-performance sports research and athlete communities. Thank you for being part of this conference and furthering the TISS mission of "*translating discoveries into innovations that positively impact athlete health and performance across all athlete populations.*"

Best wishes,

Ira Jacobs DrMedSc FCAHS FNAK FACSM
Director, Tanenbaum Institute for Science in Sport
Professor, Faculty of Kinesiology & Physical Education, University of Toronto

AGENDA

CONFERENCE DAY 1: SEPTEMBER 14, 2024

The Latest Research in Sport Science and Sport Medicine

TIME	SESSION
0900	**Registration & Breakfast**
0945	**Day 1 Welcome and Opening Remarks** *Larry Tanenbaum, Gretchen Kerr, Ira Jacobs*
1000	**Advancing Athletic Excellence: The Role of Cutting-Edge Science in Elite Sports** Session Chair: *Joseph Baker* Presenter: *Jamie Burr*
1100	**Transition Break**
1105	**The Art and Science of Small Wins: Achieving the 1% Gains in Wheelchair Curling** Moderator: *Andy Van Neutegem* Panelists: *Kyle Paquette, Mick Lizmore, Mark Ideson*
1205	**Stretch Break**
1220	**Cutting Edge TISS-Funded Research Currently Underway – Part 1 (Projects T01-T12)** Session Chair: *Ira Jacobs*
1320	**Morning Wrap-Up & Remarks** *Ira Jacobs*
1330	**Lunch & Poster Viewing**
1430	**Cutting Edge TISS-Funded Research Currently Underway – Part 2 (Projects T13-T23)** Session Chair: *Ira Jacobs*
1530	**Transition Break**
1535	**5 Big Opportunities for High Performance in the Age of AI** Session Chair: *Devin Pleuler* Presenter: *Sam Robertson*
1635	**Stretch Break**

AGENDA

TIME	SESSION
1645	**Return to Play: Advances in Orthobiologic Therapies and Regenerative Medicine** Session Chair: *Daniel Whelan* Presenter: *Jas Chahal*
1745	**Day 1 Closing Remarks** *Ira Jacobs*
1800	**Networking Reception & Poster Viewing**
1845	**Day 1 Adjourns**

CONFERENCE DAY 2: SEPTEMBER 15, 2024

Knowledge Application for the High Performance Sport and Athlete Community

TIME	SESSION
0830	**Registration & Breakfast**
0915	**Day 2 Welcome and Opening Remarks** *Larry Tanenbaum, Gretchen Kerr, Ira Jacobs*
0930	**Paris 2024 Debrief: Sex, Drugs, AI and Other Threats to Sport Integrity** Session Chair: *Anne Merklinger* Presenter: *Yannis Pitsiladis*
1030	**Stretch Break**
1045	**Addressing Inequities in Sport: Psychological Considerations for Female High Performance Athletes** Session Chair: *Gretchen Kerr* Panelists: *Tara-Leigh McHugh, Catherine Sabiston*
1145	**Stretch Break**
1200	**Protein & the High Performance Athlete: New Myths and New Knowledge** Session Chair: *Jennifer Sygo* Presenter: *Daniel Moore*
1300	**Lunch & Poster Viewing**
1400	**Concussion in Athletes** Session Chair: *Doug Richards* Presenter: *Michael Hutchison*
1500	**Stretch Break**
1515	**Early Athlete Development and Training** Session Chair: *Anthony Capotosto*, Moderator: *Joseph Baker* Panelists: *Jessica Fraser-Thomas, Johan Pion, Fieke Rongen, Alex Roberts*

AGENDA

TIME	SESSION
1615	**Stretch Break**
1630	**Application of Wearable Tech in Novel Sports** Moderator: *Alex Hutchinson* Panelists: *Sam Robertson, Devin Pleuler, Jason Vescovi*
1730	**Day 2 Closing Remarks** *Ira Jacobs*
1745	**Networking Reception & Poster Viewing**
1830	**Conference Adjourns**

PRESENTATION & POSTER INDEX

T#	PROJECT TITLE
T01	Sleep apnea in Paralympic Ontario-Resident aThletes with Spinal cord injury (SPORTS) Study *Abrity Gomes, University Health Network*
T02	Athlete Concussion Surveillance in Special Olympics Sports *Kelly Arbour-Nicitopoulos, University of Toronto*
T03	Assessing the Implementation of Mental Health Champions in Elite Youth Sport Organization *Abimbola Eke, University of Toronto*
T04	Recombinant Human Growth Hormone for Patellofemoral Pain in Active Patients: A Pilot, Randomized Placebo-Controlled Trial *Ajay Shah, Sunnybrook Research Institute*
T05	Gymnast Wrist Injury Prevention Program (G-WIPP) *Andrea Chan, University Health Network*
T06	Evaluating Neuroinflammation in Athletes With Concussion *Carmela Tartaglia, University Health Network*
T07	The Chronic ACL Deficient Knee: A Multidisciplinary Collaborative to Keep These Athletes in the Game *David Wasserstein, Sunnybrook Research Institute*
T08	The Effectiveness of an Early Muscular Strength Rehabilitation Program Prior to Anterior Cruciate Ligament Reconstruction on Subjective and Objective Measures of Knee Function: A Pilot Randomized Control Trial *Tim Burkhart, University of Toronto*
T09	Optimizing Exercise Training Intensity Using Wearable Technology – a Feasibility Study *Robert Bentley, University of Toronto*
T10	Influence of Menstrual Cycle Phase on Metabolic and Performance Adaptations to Sprint Interval Training *Jenna Gillen, University of Toronto*
T11	Establishing a Multidisciplinary Preventative Elite Athlete Wellbeing Strategy: Managing Body Image Interference and Mitigating the Effects of Performance Deficits and Injury Risk *Delaney Thibodeau, University of Toronto*

TISS-FUNDED RESEARCH

T#	PROJECT TITLE
T12	Development of Convolutional Neural Network for Motion Artifact Mitigation in Wearable PPG Devices *Daniel Franklin, University of Toronto*
T13	Exploring the Role of the dlPFC in Motor Imagery With tDCS *Molly Brillinger, University of Toronto*
T14	Athlete Negotiations of a Concussion Risk Threshold in Canadian Amateur Rugby *Michael Jorgensen, University of Toronto*
T15	A New Perspective on Concussion Assessment and Management: A Novel Multimodal Exertional Test *Kyla Pyndiura, University of Toronto*
T16	PRehab tO PreparE Living Liver Donors for Enhanced Recovery (PROPELLER): A Randomized Feasibility Study *Daniel Sibley, University of Toronto*
T17	Developing a Cell-Based Model to Investigate the Influence of Novel Nutraceuticals on Muscle Metabolism *Cassidy Tinline-Goodfellow, University of Toronto*
T18	Investigating MiRNA Expression in Athletes With Sport-Related Concussion *Genevieve Ammendolia Tome, University of Toronto*
T19	Effect of Ischemic Preconditioning on 2-km Rowing Ergometer Performance in Males and Females *Vanessa Lin, University of Toronto*
T20	The Effects of Online vs. Offline Application of Transcranial Direct Current Stimulation in an Endurance Context *Sydney Winokur, University of Toronto*
T21	Advancing Knee Osteoarthrosis (OA) Subject-Specific Modeling: AI-Enhanced Finite Element Methodology *Mahziyar Darvishi, University of Toronto*
T22	Individualizing Athlete Training Through Strategic Implementation of Wearable Technology *Adam Di Salvo, University of Toronto*
T23	Non-invasive Estimation of the Anabolic Sensitivity of Dietary Leucine After Resistance Exercise and at Rest in Oral Contraceptive Users and Males *Nicki Pourhashemi, University of Toronto*

T01

Sleep apnea in Paralympic Ontario-Resident aThletes with Spinal cord injury (SPORTS) Study

Abrity Gomes, University Health Network; Julio Furlan, University Health Network

Research Area: Rehabilitation Science, Neurorehabilitation, sleep disorders, sleep medicine, and sports medicine

Research Question: The specific objectives of this study are:

(1) To determine whether CPAP therapy in athletes living with SCI who developed moderate-to-severe SRBDs is effective in improving cognitive impairment, in reducing fatigue, depression and anxiety, and ultimately, in enhancing their work and social participation, and quality of life.

(2) To assess the effectiveness of CPAP therapy in para-athletes living with SCI who developed a moderate-to-severe SRBD in improving their performance in sports and perceived risk of injuries.

(3) To evaluate the experience and perspective of athletes undergoing CPAP therapy to better understand their challenges and the risk of sports related injuries.

Background Rationale: Restorative sleep is essential for a person's health and wellbeing; it helps restore the immune, nervous, skeletal, and muscular systems, and is a vital process to help us maintain mood, memory, and cognitive and physical performance.[1] Untreated moderate-to-severe sleep-related breathing disorders (SRBDs), which include central and obstructive sleep apnea, can lead to excessive daytime sleepiness, stroke, myocardial infarction, metabolic dysfunction, kidney dysfunction, and death.[2,3] SRBDs have been associated with fatigue, depression, anxiety, stress, chronic dysphoria, somatic complaints, reduced activity level, and emotional apathy that can negatively affect sports performance.[3,4,6] SRBDs can also cause cognitive impairment including a decline in attention, concentration, memory, and ability to learn new tasks, which can also have a negative impact on person's sports performance, work performance and productivity, occupational health and safety, and are linked with workplace stress, burnout, and job dissatisfaction.[3,5,7,8] Moreover, there is a growing body of evidence that suggests untreated moderate-to-severe SRBDs adversely affects individuals' performance in sports-related activities, especially among those high-performance athletes.[9-11]

Briefly, SRBDs after SCI seem to reflect a complex interplay among several factors including increased body mass, reduced lung volumes altering "traction forces" and airway patency, preference for sleeping in the supine position, altered balance of parasympathetic and sympathetic tone in the airways, neuroplastic changes in the medullary respiratory control circuitry, altered chemosensitivity of respiratory motor output, and medication-induced effects.[12] SRBDs are a very common problem after spinal cord injury (SCI), with instances being reported in up to 50% of those with paraplegia, and up to 91% of those with tetraplegia.13 Despite the fact that the frequency of SRBDs after SCI is considerably greater than in non-disabled persons, this condition is still largely understudied, under-recognized, and undertreated in the SCI population.[13-15]

Adaptive sports allow individuals living with SCI to participate in recreational or competitive sports, which have many positive health and psychosocial benefits.[16,17] Nevertheless, para-athletes face major challenges when playing competitive sports due to their disability and secondary medical conditions such as cardiovascular dysfunction, low energy availability, and low bone mineral density.[18-20] In addition, para-athletes perceive risk behaviour (described as related to inattention, negligence and

impatience) and excessive training as important risk factors for injuries when practicing or playing sports.[18] The results of a prospective study suggest that rugby players with cervical SCI have worse sleep than rugby players without SCI, and disruption of sleep is exacerbated during training camp with a greater impact on the para-athletes with SCI.[21]

Continuous positive airway pressure (CPAP) therapy is the current treatment of choice for moderate-to-severe SRBDs. CPAP therapy has been shown to increase the calibre and decrease the collapsibility of the upper airways in the short and long terms, respectively, after proper treatment.[22] Moreover, non-disabled individuals who are adherent with CPAP therapy often experience substantial symptomatic improvement (i.e., reduced daytime sleepiness, improved quality of life and driving safety) and potentially reduced cardiometabolic risk.[23,24] In people living with SCI, there is emerging evidence of the efficacy of CPAP therapy, but the differences between people with SCI and non-disabled individuals remain unclear. The preliminary data (n=11) from an ongoing study (ClinicalTrials.gov Identifier: NCT04007380) led by Dr. Furlan suggest that a 4-month CPAP trial significantly improves sleep quality, and reduces daytime sleepiness, fatigue, stress, anxiety and mood in individuals living with chronic SCI.

Proposed Approach: This mixed methods research project will include:

1. A single-arm clinical trial to evaluate the effectiveness of CPAP in improving fatigue, mood, anxiety, cognition, quality of life, social and work participation, and sports performance among adults with any level and severity of SCI, who are diagnosed with moderate to severe SRBDs; and

2. A qualitative study that will include semi-structured interviews to identify the perspectives of athletes with SCI who undergo CPAP therapy, and their perceptions about the risk of sports-related injuries.

Study Steps:

The population will include adults with any level or severity of chronic spinal cord injury (SCI) who play a wheelchair sport at a high performance level and are not receiving CPAP treatment at the time of recruitment. Prospective individuals who fulfill the inclusion and exclusion criteria and have provided informed consent will undergo home-based sleep apnea testing using the ResMed ApneaLink Air™ to screen for sleep apnea. All participants will complete initial assessments, including questionnaires that assess fatigue, daytime sleepiness, cognitive impairment, depression, anxiety, stress, quality of life, level of participation, and stress and recovery among athletes.

Individuals with SCI diagnosed with moderate-to-severe sleep apnea will undergo sports performance testing using physiological tests (i.e., Graded Exercise Test (GXT) with VO2 and Sprint Test (Wingate)), followed by a patient-centered 2-week auto-titrating APAP trial to determine the optimal pressure for CPAP therapy. Subsequently, individuals with SCI who achieve acceptable CPAP/APAP adherence and titration for the treatment of moderate or severe sleep-related breathing disorders (SRBD) will start a single-arm intervention period, using CPAP every night for a minimum of 4 months (n=15). All participants in the single-arm trial will complete final assessments using similar questionnaires at the end of the 4-month period of CPAP therapy. Additionally, they will be invited to a face-to-face interview to share their experiences, perceptions, and challenges related to the use of the unattended-hospital or home-based sleep apnea test and CPAP device.

Potential Impact: The proposed research will address an important knowledge gap with regards to the neurocognitive and psychosocial implications, and the negative impact on sports performance of untreated SRBDs in the para-athletes living with SCI, and how CPAP/APAP therapy can improve their participation and performance in sports with additional benefits to their mental health, well-being, and quality of life.

The experience and challenges of the para-athletes living with SCI undergoing home-based sleep study and CPAP/APAP therapy will be captured in a qualitative study. By better understanding the psychosocial limitations of SRBDs, we will be able to address an important service gap since we will gain insights from para-athletes living with post-SCI SRBDs. This approach allows us to gather insights directly from those who are living with SRBDs after SCI. The valuable information gathered from this study can then be used to enhance current methods and create strategies that contribute to more effective diagnosis and treatment of moderate-to-severe SRBDs among athletes living with SCI.

T02

Athlete Concussion Surveillance in Special Olympics Sports

Kelly Arbour-Nicitopoulos, University of Toronto; Nick Reed, University of Toronto; Emily Bremer, Acadia University; Tom Davies, Special Olympics Canada; Kirsten Bobbie, Special Olympics Canada; Victoria Formusa, Special Olympics Canada

Research Area: Disability sport and concussion

Research Question: What is the incidence rate and history of concussion among Canadian Special Olympic competitive athletes?

Background Rationale: Concussion in sport is a public health concern yet athletes with intellectual disability are underrepresented within the research, education and care on concussion. Athletes with intellectual disability may not be adequately protected when participating in sport due to their increased likelihood to sustain a concussion and higher risk of prolonged recovery following a concussion due to pre-existing conditions with balance, memory, and other cognitive deficits. There is a need for surveillance data on concussion incidence amongst athletes with intellectual disability across Canada to enhance decision-making on concussion prevention and management within this athlete population.

Proposed Approach: A cross-sectional study design that uses the administration of surveys during National and Provincial Special Olympics Games among athletes with intellectual disability and their caregivers to capture retrospective concussion history. The survey contains questions on athlete's concussion history (e.g., during sport activities or outside of sport, symptoms, number of times diagnosed in past 12-months and lifetime) and demographic information (e.g., sport participation, age, sex/gender) to examine factors that influence injury and injury reporting.

Potential Impact: Having a better understanding of concussion incidence among Special Olympics athletes in Canada will help to inform optimal concussion education and care for competitive athletes with intellectual disability and the development of more effective measures to identify the severity of sports concussion within this population. Collectively, this research aims to accelerate the rate of recovery and return-to-play for athletes with intellectual disability to improve injury recovery length and outcomes.

T03

Assessing the Implementation of Mental Health Champions in Elite Youth Sport Organization

Abimbola Eke, University of Toronto; Katherine Tamminen, University of Toronto; Jordan Sutcliffe, Royal Military College of Canada; Courtney Walton, University of Melbourne; Jo Henderson, University of Toronto; Rosemary Purcell, University of Melbourne

Research Area: Health Sciences

Research Question:

(a) How can upskilling Mental Health Champions and providing active and passive information to athletes and parents enhance awareness and promote positive mental health?

(b) How do parents and athletes perceive the implementation of a Mental Health Champion program?

Background Rationale: Mental health disorders are a significant global concern, affecting over a billion individuals worldwide (Rehm & Shield, 2019). Adolescents are particularly vulnerable to these issues, with rising rates of mental health disorders reported in recent years (Mojtabai et al., 2016). In Canada, youth represent the age group most likely to experience mental health disorders, with the onset of these conditions peaking during the mid-teen years (Pearson et al., 2013; Solmi et al., 2022). When left untreated, mental health concerns can severely impede the physical and psychological development of young people (Slominski et al., 2011). Despite the growing focus on the mental health of elite adult athletes (Poucher et al., 2021), research on elite youth athletes' mental health remains limited (Purcell et al., 2023). Elite youth athletes, typically aged 12-17, engage in sports primarily focused on performance and progression to higher competition levels. These athletes encounter unique stressors, such as intense training regimens and high expectations, which can exacerbate mental health issues (Walton et al., 2021). Unresolved mental health problems can lead to burnout, sport dropout, and hindered psychological development (Isoard-Gautheur et al., 2016; Riley et al., 2017; Weiss, 2016). Sport organizations often lack the resources necessary to provide appropriate mental health information and support for coaches, athletes, and parents (Wiersma & Sherman, 2005). Coaches, in particular, may not have adequate training or awareness to effectively address mental health topics (Duffy et al., 2021; Ferguson et al., 2019). Parents, however, are crucial in their children's sports experiences, offering emotional, financial, and logistical support (Harwood et al., 2019). They are often the first to recognize signs of mental health issues (Mendenhall & Frauenholtz, 2015) and play a vital role in seeking help for their children (Logan & King, 2001; Swann et al., 2018). Despite this, many parents feel ill-prepared

to handle these concerns. Therefore, it is essential to equip parents to better support their elite youth athletes' mental health.

The rationale for this study is based on the premise that equipping organizations with Mental Health Champions may significantly enhance awareness, intervention, and support for athletes and parents (Walton et al., 2021). The quality and thoroughness of program implementation are crucial for community engagement and the success of health promotion and prevention programs (Durlak & Dupre, 2008). Effective implementation protocols are vital for both research studies and the long-term adoption and success of such programs (Vella et al., 2019). This study will utilize a pilot/feasibility approach to evaluate the practicality and impact of implementing Mental Health Champions in elite youth sport organizations, ensuring that programs are effectively designed to meet the specific needs of this group.

Proposed Approach: The research will involve recruiting two elite youth sport clubs/organizations in Ontario to serve as case study sites for the pilot project. Purposeful sampling will be used by the PI to identify the two potential clubs in Ontario that will be recruited for the program. The inclusion criteria are: (a) being an elite youth sport club (athletes aged 12-17 years) in Ontario, (b) have an identified mental health support need (e.g., the club does not currently have paid mental health professionals/ staff members in their organization), and (c) willingness to participate in the mental health pilot program throughout a competitive season. Following recruitment, the sport clubs/organizations will identify the individuals within the organization that will be named Mental Health Champions. The MH Champions will undergo training (e.g., mental health first aid, ethics training), and they will be provided with materials and resources developed by the research team and tailored to the sport club (e.g., to provide information on specific topics that are relevant to their athletes/parents) - these materials will be sent out to parents and athletes by the MH Champions on a monthly basis over the course of the season (October 2024-April 2025). The MH Champions will also be supported throughout the season via monthly meetings with the researchers.

Potential Impact: The results of this research will have impacts in the following areas:

1) Within the research/academic discipline of sport psychology via presentations and publications to academic audiences;

2) For practitioners in sport organizations, and psychological practitioners working with elite youth athletes and their parents, via presentations to non-academic audiences and materials developed and disseminated via project website and association networks (e.g., Canadian Sport Centres; Canadian Sport Psychology Association newsletter; Canadian Counselling and Psychotherapy Association newsletter, etc.)

3) Training of research team members via ongoing mentorship and training opportunities;

4) Strengthening partnerships locally and internationally between the research team members (e.g., University of Toronto – Faculty of Kinesiology and Physical Education and the Temerty Faculty of Medicine, Department of Psychiatry; between University of Toronto and University of Melbourne; between research team and community members of elite youth athletes and their parents)

The proposed research will be the first of its kind in Canada and internationally to examine the issue of mental health among elite youth athletes and to specifically engage youth and parents to understand the issues and obstacles in help-seeking for mental health concerns among this population. The research—in its design and its deliverables—will serve as a model for other countries and jurisdictions to develop effective approaches to support elite youth athletes and their parents in seeking support for mental health concerns.

T04

Recombinant Human Growth Hormone for Patellofemoral Pain in Active Patients: A Pilot, Randomized Placebo-Controlled Trial

Ajay Shah, Sunnybrook Research Institute; David Wasserstein, Sunnybrook HSC

Research Area: Orthopaedics, Biologics, Regenerative Medicine

Research Question: The purpose of the current study is to quantify the clinical and biomechanical effect of rHGH on muscle function in an early PFOA active patient group. It is hypothesized, based on previous clinical and preclinical studies, that patients undergoing a six-week treatment program with

rHGH supplementation and a traditional physical therapy program will experience increased muscle strength and volume, and improved function compared to a placebo group receiving only the exercise regimen.

Background Rationale: From a musculoskeletal perspective, preclinical studies have shown the potential for rHGH to result in significant symptomatic improvement in patients with osteoarthritis. Animal studies have investigated the impact of intra-articular knee injections of rHGH on cartilage degeneration in white New Zealand rabbits, finding that repeated administrations resulted in statistically significant cartilage regeneration. Another example includes a recent pilot, randomized placebo-controlled trial evaluating rHGH in patients undergoing ACLR. rHGH was found to improve quadriceps strength by 29% with decreased cartilage degradation. However, little research has been done on patients with degenerative conditions such as PFOA, and it is unknown whether the same muscle strength gains can occur in patients with chronic anterior knee pain.

Proposed Approach: This study will be a single-center randomized, double-blind, placebo-controlled pilot clinical trial. Eligible participants will be 18-50 years old with isolated PFOA, with three inclusion criteria:

1. Pain around or behind the patella aggravated by at least one activity on history or one clinical examination maneuver that loads the patellofemoral joint, and

2. Radiographic evidence of PFOA

Patients will be randomized in a 1:1 fashion to either Genotropin (HGH of rDNA origin, Pfizer Canada) or a placebo containing the same preservatives but no active hormone, over a period of six weeks. The study participants and investigators will be unaware of the treatment status - in line with a double-blind trial. Using the methodology previously established by Mendias et al, Genotropin will be delivered by a

subcutaneous injection into the abdomen or gluteal region twice per day for six weeks at a dose of 0.5mg per body surface area (0.5mg/m2). All patients will undergo evidence-based physical therapy designed and tailored for PFOA for the duration of treatment and follow-up.

Potential Impact: The proposed impact of this study is that it will transform the current treatment paradigms for knee arthritis and other chronic degenerative musculoskeletal conditions in young active patients. If shown to be a safe and effective treatment, it will provide specialists with an alternative avenue for management of PFOA in young active patients where there are currently limited treatment options. This will result in improvements in individual patients' health through the development of novel guidelines. In addition, this specific population often indicates the desire to return, or continue, to participate and compete and a relatively high level of activity. This research, therefore, would offer a pathway for these individuals to return to sport in an efficient manner while reducing the risk of injury propagation. The results of this proposed research will also expand research efforts into long-term solutions for OA, which will have downstream benefits for the healthcare system, such as a renewed interest in nonoperative management options of chronic musculoskeletal disease. Finally, improving the disease state of patients with PFOA will lead to socioeconomic impact through a reduction of costs for surgical treatments, and working hours lost to disability, particularly among a group of young, otherwise healthy individuals.

T05

Gymnast Wrist Injury Prevention Program (G-WIPP)

Andrea Chan, University Health Network; Stefania DiLeo, University of Toronto; Erin Day, University of Toronto; Ryan Paul, Toronto Western Hospital; Timothy Burkhart, University of Toronto; John Theodoropoulos, Mount Sinai Hospital

Research Area: Injury risk reduction; patient education; safe sport

Research Question: Overall research question: Does a comprehensive education program combined with anti-hyperextension wrist bracing reduce the incidence of symptomatic distal radius physeal stress injury in (pre)adolescent gymnasts (level 6 and above) competing in high-risk events (floor and vault)?

This research question will be answered, in part, by addressing the following questions:

i) What is(are) the prevalence, incidence, and risk factors for wrist pain/injury among adolescent artistic gymnasts?

ii) Do anti-hyperextension wrist braces effectively reduce the biomechanical risk factors associated with Gymnast Wrist in adolescent female artistic gymnasts?

Background Rationale: Gymnasts experience repetitive compressive and torsional loads at the wrist while in extreme extension.1 In skeletally-immature gymnasts, such loads may predispose to distal radius physeal stress injury, otherwise known as Gymnast Wrist (GW).2,3 Without appropriate intervention, a series of sequelae may arise, including physeal growth arrest of the distal radius, deformity, and distal radioulnar joint dysfunction.4,5 These skeletal manifestations can lead to time off sport or even early retirement, surgical intervention, and ultimately dysfunction that can affect their adult lives. Up to 88% of

gymnasts report experiencing wrist pain, with the floor and vault events cited consistently as contributors to wrist pain in females.6-8 Nonetheless, to enhance their likelihood for success, gymnasts are often taught to conceal this pain.9,10 Such findings necessitate the need for an evidence-based program which educates participants on the risk for GW, as well as identifies and provides GW risk reduction strategies. The epidemiology of wrist pain and injuries in young athletes has previously been reviewed.11 Hand impact forces, which are biomechanical risk factors for wrist pain and injury, have also shown to be attenuated upon the application of wrist braces.12 However, despite their potential increased susceptibility, adolescent artistic gymnasts are largely underrepresented in such studies. Therefore, the purpose of the current research is to i) conduct a systematic review and meta-analysis of the prevalence, incidence, and risk factors for wrist pain and/or injury in adolescent artistic gymnasts, and ii) establish the effectiveness of anti-hyperextension wrist braces for reducing biomechanical risk factors for GW within female members of this population. Findings from this research will contribute to the effective design and successful implementation of the Gymnast Wrist Injury Prevention Program (G-WIPP) for which the ultimate goal is to provide an avenue for safe sport engagement amongst (pre)adolescent gymnasts.

Proposed Approach: i) A systematic review and meta-analysis were completed by searching five databases. 6104 articles were retrieved. Two authors independently reviewed the titles/abstracts and full texts of eligible articles, retaining 40 for analysis. The retained studies were meta-analyzed to determine the pooled prevalence and incidence rates of wrist pain/injury among adolescent artistic gymnasts, as well as systematically reviewed to determine associated risk factors. Results will be available at the time of the conference.

ii) A biomechanical analysis will be conducted to quantify upper extremity kinematics and kinetics within adolescent female gymnasts (age 10-19 years; level 6-10) with and without bilateral anti-hyperextension wrist braces (Tiger Paws, Albuquerque, NM). Hand impact forces and moments will be recorded using two floor-embedded, six degree-of-freedom force plates (AMTI, Watertown MA) and a Tekscan pressure sensor (Flexiforce 5250) during 3 floor and 3 vault exercises. Segment motions and joint angles will be quantified during all tasks using a markerless motion tracking system (Theia3D, Kingston ON). Data analysis will compare all kinetic and kinematic variables between braced and unbraced trials. Using inverse dynamics, upper extremity net joint reaction forces and moments will also be calculated. After task completion, surveys will be administered to obtain participant feedback on the use of braces, including perceptions toward their comfort, potential performance impacts, whether their continued use is likely, and the extent of their previous knowledge toward wrist brace availability.

iii) A contextual qualitative analysis of the wrist injury and prevention understanding amongst gymnasts, and attitudes towards the use of protective wrist guard use during high-risk events. This will be done via a grounded theory qualitative mixed methods study which will use a pre-interview written questionnaire and a semi-structured virtual interview for adolescent athlete and coach participants.

Potential Impact: The current systematic review and meta-analysis aims to enhance understandings toward the epidemiology and risk factors for GW among adolescent artistic gymnasts. This understanding is important as a main perceived barrier to uptake of prevention programs includes little knowledge of the injury itself or motivation of coaches to implement.13,14 Therefore, this review and the contextual qualitative analysis will support the effective implementation of the Gymnast Wrist Injury Prevention

Program (G-WIPP). The current biomechanics research aims to provide supporting evidence for wrist bracing as a strategy to reduce the risk of GW in young artistic gymnasts, thereby justifying their inclusion in the G-WIPP. Together, these studies serve as the initial G-WIPP steps to support enhancements to the health, well-being, and safety of young gymnasts and will provide valuable insight into the methods through which gymnastics organizations may promote safe sport to ensure all athletes obtain its benefits.

T06

Evaluating Neuroinflammation in Athletes With Concussion

Carmela Tartaglia, University Health Network; Michael Hutchison, University of Toronto; Charles Tator, University Health Network

Research Area: Neuroinflammation

Research Question: The primary objective is to understand the role of neuroinflammation in patients with concussion.

We hypothesize that inflammatory abnormalities can be detected in concussion and allow differentiation from musculoskeletal injury controls. Additionally, we hypothesize that baseline inflammatory markers will predict 3-month outcomes and relate to injury marker NfL. Furthermore, we also hypothesize that there will be differences between the inflammatory markers between males and females with concussions.

Background Rationale: Concussion is a common mild traumatic brain injury (mTBI) that affects millions worldwide. Acute concussions tend to resolve within a few weeks. However, 10-20% experience long-lasting symptoms such as headache, anxiety, depression, and concentration and memory problems (1, 2). Although the incidence of concussion in Canada is difficult to ascertain since most patients do not seek medical attention, one recent report revealed over 150,000 concussions/year in Ontario (3). Concussions are most prevalent in motor vehicle accidents, military, falls, intimate partner violence, injuries at work, and sports; with hockey and football having the highest incidence amongst sports (4). Multiple concussions have been linked to long-term health issues including dementia, Parkinson's disease, mood disorder, attention deficit disorder, and chronic traumatic encephalopathy (CTE) in former contact sports athletes (5-7).

There are currently no biomarkers for concussions nor are there any prognostic factors for outcome after concussion. Additionally, there is a lack of understanding in the pathophysiological mechanism of concussions. To date, the markers of injury that have been focused on in brain injuries are neurofilament light chain (NfL), tau, and S100B. However, there is growing evidence that suggest inflammatory changes occur in all traumatic brain injuries, including mTBI and concussions (8).

Evidence from experimental models have shown that repeated concussion and even a single concussion can lead to astroglial and microglial changes (9). Previous studies have identified elevated levels of inflammatory markers in plasma, such as interleukin-6 (IL-6), interleukin-1β (IL-1β), tumor necrosis factor (TNF)-β, and monocyte chemoattractant protein 1 (MCP-1) in individuals with concussions in the acute stage (10,11,12). Furthermore, research has shown that inflammatory markers like MCP-1 are associated with post-concussion syndrome (12), while eotaxin (CCL11) is linked to chronic traumatic

encephalopathy (CTE) (16). Proinflammatory cytokines like IFN-c and TNF (19) have been implicated in clinical repeated concussion, potentially influencing neutrophil recruitment and inflammation in the brain (17,18, 20). These studies have also indicated that inflammatory changes can persist long after the initial injury (21,7).

Cognitive deficits, a common symptom after concussion, have indirect associations with inflammation. Studies in rats have demonstrated that immune system stimulation can lead to cognitive impairments (25, 26), while sepsis has been linked to lasting cognitive issues (27). Post-operative cognitive dysfunction and early cognitive dysfunction in surgical patients have been associated with inflammation, particularly IL-6 and S100b (28, 29). Inflammation has also been implicated in cognitive dysfunction in healthy older adults (30-32).

Sex differences in inflammatory responses following concussion have also been observed. In males, a positive correlation between interferon (IFN)-β and symptom severity has been reported, while in females, there is a different pattern with a negative relationship between symptom severity and cytokines IFN-β, TNF-β, and myeloperoxidase (MPO), and a positive relationship with MCP-4 (13-15).

The relationship between concussion and neurodegenerative conditions, especially chronic traumatic encephalopathy (CTE), is illusive but has raised questions about how inflammation may contribute to delayed neurodegeneration (22, 23, 24). Research has shown similarities in tau pathology between CTE and subacute sclerosing panencephalitis (SSPE), a fatal disorder triggered by the infection of measles virus and manifests itself after a symptom-free period of several years (33), which bears resemblance to that of CTE. The neurofibrillary tangles of SSPE stain with antibodies specific for 3R and 4R tau, like the tau inclusions of primary age-related tauopathy (PART), Alzheimer's disease (AD) and CTE (34) but unlike PART and AD, and exactly like CTE, the neurofibrillary tangles of SSPE are present in superficial cortical layers (35, 36).

A recent study using electron cryo-microscopy of tau filaments from two cases of SSPE demonstrated that the tau folds of SSPE and CTE are identical (37). Like in CTE, the vast majority of tau filaments were Type I, with a minority of Type II filaments. They conclude that the CTE tau fold can be caused by different environmental insults, which may be linked by inflammatory changes (36). In SSPE, the tauopathy has been postulated to result from diffuse brain inflammation triggered by infection with measles virus and not from a direct effect of the virus. This does raise the possibility that the inflammatory reactions to a brain injury, even if mild, may predispose to delayed neurodegeneration.

Various inflammatory markers have been implicated in concussion but each cytokine separately may be of limited pathophysiological importance for concussion severity and outcome, and may differ substantially between individuals, but the pattern of many cytokines acting together and via different pathways might be prognosticating. The finding that even 12 months after concussion, elevated inflammatory markers were observed warrants further investigation (10). We postulate that a comprehensive approach to understanding the possible role of long-term neuroinflammation in the neurobiological changes occurring post-concussion is critical to understanding differential outcomes after concussion.

We have preliminary evidence from former professional athletes with repeated concussions and without recent head injury or evidence of AD or other neurodegenerative disease such as Parkinson's disease (PD) or frontotemporal lobal degeneration (FTLD) -spectrum that their cerebrospinal fluid (CSF) inflammatory profile differed from healthy controls using multiplex proximity extension assay (PEA) technology. There is increasing evidence that neuroinflammation may play a role in mTBI/concussion and

the long-term consequences. Variability in the results of existing studies of inflammatory mechanisms in concussion may be due to a lack of deeply characterized patients and small number of markers evaluated. Our project aims to overcome this challenge by evaluating a large number of inflammatory markers in individuals with sports-related concussion. Blood samples will be analyzed for markers of inflammation and degeneration. Discoveries of specific neuroinflammatory markers could facilitate creation of assays that may be useful for assessing readiness for return to play in athletes (or full recovery in all populations). As well, discovery of specific biomarkers could inform clinical trials so as to be able to bring targeted therapy and thus deliver personalized medicine.

Proposed Approach: The study is designed as a prospective longitudinal study. A total of 80 participants aged 18-30 diagnosed with a sports-related concussion in the acute phase or a musculoskeletal injury within the first 7 days of injury will be enrolled as outlined in the inclusion/exclusion criteria. Subjects forming the acute concussion group will be patients from the MacIntosh Sport Medicine Clinic, UHN Emergency Rooms, or Canadian Concussion Centre Clinics at Toronto Western Hospital. Musculoskeletal injury controls will also be recruited from these clinical sites. Subjects from both groups will complete 3 questionnaires (ie. Symptom questionnaire from SCAT-6, Neuro-QoI Depression, and Neuro-QoI Anxiety) and have their blood drawn. At the 3-month follow-up, participants will be contacted over the phone to complete the same 3 questionnaires.

The inflammatory profiling of plasma from all participants will be done through the PEA technology, a highly sensitive and specific immunoassay, using Olink Explore Inflammation I and II panels. An ultra-sensitive Simoa SR-X Analyzer instrument from Quanterix, USA, will be used to analyze the plasma of all subjects for NfL.

Potential Impact: Understanding the role of inflammation is crucial as it can provide diagnostic, prognostic, and possible avenues for intervention. We therefore aim to understand the role of neuroinflammation in acute and persisting phases of concussion by evaluating blood biomarkers for inflammation. The results of this study will further the knowledge of pathophysiological mechanisms underlying concussions in sports. A better understanding of the role of neuroinflammation in concussion could help prognosticate on outcome and reveal new avenues of treatment.

T07

The Chronic ACL Deficient Knee: A Multidisciplinary Collaborative to Keep These Athletes in the Game

David Wasserstein, Sunnybrook Research Institute; Sebastian Tomescu, Sunnybrook Health Sciences Centre; Jas Chahal, Womens College Hospital; Michael Catapano, Mount Sinai; Paul Marks, Sunnybrook Health Sciences Centre; Kosaran Gumarathas; Institute of Medical Sciences; David Lawrence, MacIntosh Sports Medicine Clinic

Research Area: Orthopaedics

Research Question: The primary goal of the CAD Knee Study Group is to better define, understand and treat the CAD knee athlete

Background Rationale: An athlete with a symptomatic Chronic ACL Deficient knee ("CAD Knee") can be defined as someone who failed prior ACLR or is beyond the acute/subacute phase of their primary ACL injury (the exact timeframe where structural changes occur is unknown and likely patient-specific therefore demanding further research). The CAD knee athlete population includes persons with wide ranges of age and sport-intensity, including the adolescent elite athlete to the middle-aged recreational athlete and these patients all share common structural knee changes that may include having the highest rates of concurrent cartilage and meniscal lesions, static anterior translation of the tibia, tear or loss of the medial meniscus posterior horn (secondary stabilizer of the knee. Providing a holistic approach to returning patients and athletes to play whereby both anatomical changes and patient symptoms are addressed, challenges the classical surgical paradigm of performing ACLR in isolation and suggests the need for novel approaches and thinking.

Proposed Approach:

1. Development of a CAD Knee patient registry

Using a 3-site collaboration (SHSC, WCH, Dovigi/SHS), we will create a registry of patients who present under the defined criteria of a CAD knee using a RedCap database.

2. Development and validation of a cadaveric model of the CAD Knee

This study will develop a validated model of the CAD knee by performing a transection of the ACL and then subjecting the knee to acotroled and standarized loading protocol that simulates the clinical scenario of return -to- sport

Potential Impact: The results of this proposal will be to develop the shared, multi-site clinical research arm and to develop the biomechanical in vitro modelling of the CAD knee condition. Our goal is to draw increased attention to this challenging patient population on a local and global scale. Overall, this research will lead to better ideitification of CAD patients and improvement of treatmensnt for this condition.

T08

The Effectiveness of an Early Muscular Strength Rehabilitation Program Prior to Anterior Cruciate Ligament Reconstruction on Subjective and Objective Measures of Knee Function: A Pilot Randomized Control Trial

Tim Burkhart, University of Toronto; Anita Borhani, University of Toronto; Michael Catapano, Mount Sinai Hospital; David Wasserstein, Sunnybrook Health Sciences Centre; Daniel Whelan, St. Mike's Hospital; Jas Chahal, Women's College Hospital

Research Area: Orthopaedic Biomechanics

Research Question: The overall objective of this project is to determine effectiveness of an early muscular strength rehabilitation (EMSR) program on improving subjective and objective measures of

knee function following an ACL injury and subsequent surgical reconstruction compared to standard clinical care (Standard)

Background Rationale: There are more than 250,000 Anterior Cruciate Ligament (ACL) injuries annually in North America with the majority being treated surgically. Rehabilitation programs are often delayed prior to surgery or do not begin until a significant post-surgery period. It is likely that these delays result in musculoskeletal deficits, contributing to high complication rates. Recently, the OPTIKNEE working group identified the need for improved strength and exercise modality rehabilitation for knee related injuries. While there has been increasing interest in early rehabilitation, this has primarily focused on regaining rage of motion and early weight-bearing. Early application of strength focused rehabilitation programs however, has not been thoroughly researched as a valid approach for optimizing patient outcomes following ACL injury and ACLR

Proposed Approach: Indiviuals with an acte ACL injury will be recruited and randomized to either to either an early muscular strength rehebailtion protocol or the current standar if care. patients will be invited to the Biomechanics of Orthopaedic Sport Medicine (BOSM) lab for four different data collection sessions: (1) at baseline - within one week of ACL injury as per a clinician's assessment; (2) MRI confirmation - when the ACL injury is confirmed by MRI; (3) six weeks post MRI confirmation; (4) pre-op - approximately one week before ACLR; (5) post-op - six weeks post-ACLR. At each time point atients will complete strength testing, patient reported outcomes, clinical assessments, and biomechanical testing

Potential Impact: This proposal will challenge the current paradigm of effective treatment and rehabilitation for ACL injuries. Current rehabilitation, immediately following injury, typically focuses on managing inflammation and maintaining range of motion with little concern for the uninjured limb. We contend that a lack of early (i.e., immediate) bi-lateral strength focused rehabilitation is partly responsible for the continued high complication rates following ACL treatment and rehabilitation. We hypothesize that this intervention will result in improved patient outcomes and better functional performance allowing athletes to recovery more effectively and return-to-their sport more efficiently and safely

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T09

Optimizing Exercise Training Intensity Using Wearable Technology – a Feasibility Study

Robert Bentley, University of Toronto; Adam Di Salvo, University of Toronto

Research Area: Exercise physiology

Research Question: The primary research objective is to assess the feasibility of utilizing novel wearable technology to optimize the training intensity for individualized, or personalized, cardiorespiratory, field-based, real-world training. A secondary research objective is to determine whether physiological responses to typical in-field exercise training assessed in real-time using wearable technology align with laboratory-based physiological thresholds and intensities by assessing the time spent at or above identified physiological thresholds.

Background Rationale: Exercise training regimes that are personalized, or individualized (e.g., physiological threshold-based) produce superior cardiorespiratory adaptations compared to standardized (e.g., percent heart rate) training intensities. Advancements in wearable technology provide a unique opportunity to assess central and peripheral physiological parameters while applying this information to optimize exercise training intensities for each individual based upon physiological thresholds. More advanced, commercially available, wearable devices can assess a variety of physiological parameters, including pulmonary ventilation and the rate of oxygen consumption, cardiac function including heart rate, rhythm and strain, and skeletal muscle oxygenation. These research-grade wearable devices are an accessible, technological platform that when harnessed will substantially advance efforts to guide athletes through optimized high-performance sport training.

Proposed Approach: The proposed project is a feasibility assessment of advanced wearable technology in which varsity athletes (n=18; 50% female) will be enrolled for 2 weeks. During week 1, athletes will complete 3, 1-hour laboratory testing sessions (Session 1: Peak rate of oxygen consumption, lactate threshold and ventilation thresholds; Session 2: Anaerobic capacity; Session 3: Aerobic power-duration relationship). During week 2, athletes will complete their typical, in-field aerobic exercise training sessions (2 x 1 hour) with real-time feedback from wearable technology. Following the completion of their typical aerobic exercise training during week 2, a feasibility assessment questionnaire will be administered to explore the following four aspects: 1) Acceptability, 2) Implementation, 3) Practicality, 4) Integration.

Potential Impact: Optimizing the stimulus for cardiorespiratory adaptation is a necessity when creating the foundation for successful high-performance athletes. In the short-term, the proposed project will provide critical metrics pertaining to feasibility of incorporating wearable technology to guide and optimize athlete training. This work will transform the high-performance sport training landscape by applying technology-based, training tools to augment athlete training. This training approach will create the foundational knowledge required to develop targeted, personalized or 'precision' training interventions, similar to the emerging field of personalized medicine, to optimize high-performance sport training.

T10

Influence of Menstrual Cycle Phase on Metabolic and Performance Adaptations to Sprint Interval Training

Jenna Gillen, University of Toronto; Celine Bailleul, University of Toronto; Martin MacInnis, University of Calgary; Jennifer Williams, University of Toronto

Research Area: Exercise Physiology

Research Question: Does performing sprint interval training in the follicular phase vs. luteal phase influence metabolic and performance adaptations to training?

Background Rationale: An emerging training methodology, known as 'menstrual cycle phase-based training,' has sparked interest across media, fitness circles, and academic research focusing on female athletic performance. This approach involves adjusting training intensity and volume according to the

menstrual cycle, with higher levels in the follicular phase (~2 weeks) and lower levels in the luteal phase (~2 weeks). Proponents of the approach suggest that the lower levels of estrogen and progesterone in the follicular phase might yield superior performance and metabolic responses to exercise training. Yet, the evidence supporting this concept is scant, and existing studies lack robust methods for detecting menstrual cycle phases. Given the attention this method has garnered among coaches and athletes, there's a pressing need for high-quality research to ascertain if the menstrual cycle should significantly impact female training program design.

Proposed Approach: Twenty-four recreationally active females will partake in six SIT sessions on a cycle ergometer during either the follicular or luteal phase of their menstrual cycle (n=12/group). Our primary outcome will be 250kJ time trial performance, a reliable gauge of endurance. Additionally, we will assess changes in anaerobic exercise performance using the Wingate anaerobic bike test and study metabolic adaptations in muscle samples taken pre- and post-training. We will adhere to best practices for menstrual cycle phase detection, including menstrual cycle monitoring, calendar-based counting, urinary ovulation tests, and sex hormone analysis.

Potential Impact: The results gleaned from this study will hold significance for female athletes and coaches, offering crucial insights into whether considering menstrual cycle phases should be a pivotal and widely applied consideration in program designs aimed at improving endurance exercise performance.

T11

Establishing a Multidisciplinary Preventative Elite Athlete Wellbeing Strategy: Managing Body Image Interference and Mitigating the Effects of Performance Deficits and Injury Risk

Delaney Thibodeau, University of Toronto; Sasha Gollish, University of Toronto; Danika Quesnel, University of Toronto; Ming-Chang Tsai, CSI Pacific; Amanda Uliaszek, University of Toronto

Research Area: Sport psychology; mental health

Research Question: This multidisciplinary and industry-informed study includes four phases guided by use-inspired principles to: (1) develop and test a measure for widescale use by researchers, athletes, and sport staff; (2) collect novel and insightful data (with the support from USA and Canada Olympic committees); (3) co-develop a nomological framework that will guide future research efforts and multidisciplinary clinical practice guidelines for elite athletes; and (4) inform an impactful collaborative and preventative athlete wellbeing strategy as a template for broad use in elite sport in Canada

Background Rationale: There are a multitude of reactive and treatment-focused approaches to athlete performance deficits and injury risk at the expense of prevention efforts that mitigate sport challenges before they become unmanageable. In the current proposal, the end goal is a preventative athlete wellbeing strategy that focuses on an integral factor: body image interference. An athlete's focus on their body is a highly understudied yet important factor in limiting sport performance and heightening injury risk. Athletes who put attention on their body's shape, weight, and appearance deplete cognitive resources needed to meaningfully engage and perform in their sport while also risking injury. Mary Cain, who was the fastest runner in the World before quitting, exemplifies this relationship: "I was on

the starting line and I had lost the race before the race started…because in my head all I was thinking was not the time I was trying to hit but the number on the scale I had seen earlier that day". Olympic diver Tom Daley similarly expressed, "It was just before I left for the World Cup in Shanghai, and my fat percentage was down to 3 per cent…Although it felt great to see that number, I was also really struggling with energy, concentration, and was getting injuries." This body image interference is critical to performance and injury risk but is not well-understood or highlighted in clinical practice because there is no way to measure the construct. As such, the first aim of this study is to develop and test a measure of body image interference that can be used among athletes and administered by sport leaders. Once the measure is deemed reliable and valid, a second aim is to collect "pilot" novel and insightful data to identify predictors and protective factors of body image interference in addition to performance and injury risk outcomes among elite athletes. This data collection is supported by the USA and Canadian Olympic and Paralympic committees. The data will be analyzed and interpreted collaboratively with clinicians, athletes, coaches, and sport psychologists in a series of meetings to inform guidelines for clinical practice (aim #3a) and a nomological framework for research insights (aim #3b). Taken together, the work will also identify foundations for a multidisciplinary collaborative athlete wellbeing strategy aimed at proactively supporting athletes from a strength-based athlete-centered perspective. This use-inspired work is timely to drive innovation in elite athlete wellbeing with tailored and focused prevention efforts that complement the pervasiveness of reactive treatment strategies in sport.

Proposed Approach: This phased and iterative study involves many methodologies leading to use-inspired outcomes for elite athletes. For aim #1 (measure of body image interference), we will follow highly respectful measurement development principles. First, we will generate items drawing on theory, existing body surveillance, monitoring, checking measures we have used in previous work, and utilizing screening tools including SEES-A and REDS. Next the items will be tested for face validity. A purposefully sampled group of 16-20 experts (identified as leaders in sport and para-sport, body image, performance, injury risk) will be invited to review the items, the stem, and the response anchors, to classify items, and to respond to questions for validity evidence. The items that are reviewed favourably will be maintained, and other items may be refined based on feedback and research team discussion or removed. The goal is to have a short self-report survey that can be used for research and practice intentions. The measure will be developed with a proactive approach to managing athlete wellbeing. The survey will also be created with accessibility features such as telephone-based survey and text-to-speech completion options to be available for visual and sensory impairments recognized in Para sport.

Once the measure is developed, it will be tested for factor structure, invariance across identity factors (race & ethnicity, gender, and ability), construct validity, and internal consistency. Furthermore, addressing aim #2, a collection of self-report surveys will be collated to explore validity and reliability evidence while also exploring "predictors" and "outcomes" of body image interference (quotes used because the cross-sectional design precludes causality). Elite athletes [N=300, sample size based on a=.05, 1-b=.80, d = .30, < 12 independent variables (protective and risk factors) and 2 dependent variables (performance and injury risk) and body image interference (mediator variable)] will be recruited with support from competitive sport organizations (e.g., Olympic committees and varsity athletics) and asked to complete a one-time survey. Data will be analyzed using descriptive statistics, bivariate correlations, exploratory and confirmatory factor analysis, multi-group invariance, and structural equation modelling. This data collection will address aim #2 and will serve to inform aim #3 (i.e., co-

develop a nomological framework that will guide future research efforts and clinical practice guidelines for elite athlete wellbeing). Specifically, we will follow the AGREE-II and NICE standards for guideline development. Following a review of literature and rapid review, an end-user group of sport psychologists, certified mental performance coaches, sports medicine clinicians, clinical psychologists, athletes, coaches, and researchers will be presented with the findings from data collection and engaged to develop assessment criteria to integrate body image interference into athlete wellbeing. Independent AGREE methodologists will appraise the development process. Researchers will also engage with the data to present a nomological framework that will be used for theoretical and conceptual studies. Aim #4 is addressed as part of this guideline development process whereby University of Toronto leaders (Sports Medicine, GP-CPS, KPE) will take part in a follow-up meeting to discuss the foundations of an impactful collaborative supportive athlete wellbeing strategy.

Potential Impact: This work will enhance knowledge and inform prevention efforts aimed at athlete wellbeing. The work is timely given the pervasive focus on athlete welfare in Canada. The focus on body image interference is a novel concept that warrants research and practice efforts to improve sport contexts – from environments, uniforms, and policies to equipping elite athletes with preventative efforts to secure and manage their own mental and physical health.

T12

Development of Convolutional Neural Network for Motion Artifact Mitigation in Wearable PPG Devices

Daniel Franklin, University of Toronto

Research Area: Wearables, Motion Artifacts, Vital Signs Monitoring, Machine Learning, Artificial Intelligence

Research Question: Can the combination of multi-modal wearable sensors and machine learning lead to 'active noise cancellation' for wearable vital signs monitors?

Background Rationale: Photoplethysmography (PPG) utilizes light to non-invasively quantify blood dynamics within the body. It is widely used for vital signs monitoring (including heart rate and blood oxygenation) within clinical, sport, and consumer health environments. However, PPG is highly susceptible to inaccuracies caused by movement, referred to as motion artifacts (MAs). The use of deep neural networks to mitigate MAs is an expanding research area with promising results shown by convolutional and recurrent neural networks. However, many published architectures train models to one output metric, such as heart rate, from a noisy PPG signal, rather than reconstructing a denoised PPG. This approach neglects other important information that can be extracted from the PPG signal and limits the model's scope to be only applicable in specific contexts. For instance, previous models could not also predict blood oxygen saturation, heart rate variability, and breathing rate—all of which could be derived from a PPG. The primary reason for proxy measure predictions is that most data collection methods for these models lack paired motion artifact and motion-free PPG data. This means that supervised models cannot create motion-free PPG signals, as there is no way to assess the errors of model outputs during training. To further establish the need for PPG reconstruction, clinical analysis of PPG waveforms is currently in the standard-of-care for cardiovascular and interventional radiologists in the care of patients with low perfusion. Lastly, active research on advanced hemodynamic parameters, such as PPG-derived

blood pressure estimation, vascular dynamics, and pulse wave timings all require high quality PPG signals in the presence of motion – further highlighting the necessity of reconstructive algorithms and sensors.

Proposed Approach: The main objective of this work is to collect a novel multi-modal motion artifact dataset with time-synchronized noise-free data using actuators and real motion across populations with varying age, sex, and ethnicity. A multi-stage approach will entail 1) Controlled Bench Tests with Fundamental Motion Perturbations, 2) Controlled Bench Tests with Real-World Motion Playback, and 3) Deployment and Validation in Wearable Devices under Real-World Ambulation. Each stage/aim will generate data for a publicly available benchmark dataset and enable the development of deep neural networks for the reconstruction of multi-wavelength PPG signals

Potential Impact: Wearable technologies offer a unique glimpse into patient function and biology outside of episodes of care. The novel datasets obtained over timescales and locations previously unattainable will revolutionize our understanding of disease and improve the quality of care for remote patients. Currently, the market for wearable technology is estimated at 140 billion USD in 2022 and is expected to quadruple within 10 years. In addition to remote health management, a large segment of this market is consumer health/wellness, sports, and athletics. Optical PPG sensors are the most widely implemented biosensor technology within this sector, however, the practical limitations of current devices to correct for motion drastically reduces the usability and interpretability of large-scale datasets for all these wide ranging and impactful applications. Uniquely, this project aims to reconstruct real-time physiological waveforms to realize a generalized 'active noise cancellation' for optical wearables. Previous examples of PPG motion artifact reduction datasets lack time-synchronized motion artifacts and reference data or use synthetically generated motion artifacts rather than real ones. The successful implementation of this project will result in more accurate acquisition and application of wearable device datasets in the presence of motion for remote healthcare and sport applications.

This project proposal is also aligned with the DSI-TISS Catalyst Grant for Data Science in Sport Analytics. Motion artifact mitigation strategies will be pivotal for the successful widespread implementation of wearables throughout Athletics and Sport Medicine. Currently, there are no alternative technologies to PPG which can non-invasively estimate arterial and tissue oxygenation, en mass. The combination of novel sensors and machine learning algorithms for signal reconstruction will enhance all areas wearables are utilized – including fundamental research to enhance training methodology, providing personalized training regimes and feedback, and protecting the health of athletes.

T13

Exploring the Role of the dlPFC in Motor Imagery With tDCS

Molly Brillinger, University of Toronto; Timothy Welsh, University of Toronto

Research Area: Motor Behaviour

Research Question: Does modulating dlPFC functioning using tDCS have a greater effect on motor imagery performance compared to the physical execution of actions?

Background Rationale: Motor imagery is widely used in sports as a form of mental practice to enhance

motor performance and learning. Several theories of motor imagery are based on the premise that imagined movements are functionally equivalent to physical movements. A newer account, the Motor-Cognitive model, holds that imagined movements depend more on higher-order executive resources than physical movements do. According to this model, executive functions enable individuals to monitor and elaborate on the developing motor image while inhibiting the motor command from being physically executed. The dorsolateral prefrontal cortex (dlPFC) is considered a hub for various executive functions, such as inhibitory control and working memory. Thus, dlPFC is potentially an important region for motor imagery. The current study was designed to examine the functional role of dlPFC in motor imagery.

Proposed Approach: Participants (n=24) physically performed and imagined performing a serial disc transfer task and tasks that assess executive functions (Go/No-Go, which measures response inhibition, and N-back, which measures working memory). All tasks were performed before and after undergoing 20 minutes of anodal, cathodal, or sham transcranial direct current stimulation (tDCS) applied over the right dlPFC. Results from the disc transfer task showed that anodal tDCS significantly modulated imagined movement time (MT) more than physical MT, whereas cathodal and sham tdcs did not impact imagined MT compared to physical MT. None of the stimulation types affected performance on the Go/No-Go or the N-back tasks. Altogether, these findings suggest that the dlPFC may play a distinct role in motor imagery, but more research is required to clarify the reliance of motor imagery on executive functions such as response inhibition and working memory.

Potential Impact: This research has important implications for sports and athletics, particularly in using motor imagery to enhance motor performance and skill acquisition. Motor imagery offers athletes a valuable method for refining their skills, enhancing focus, and mentally preparing for various scenarios without the physical demands of traditional training. But to fully harness its potential, it is essential to develop a a comprehensive understanding of the neural mechanisms underlying motor imagery. More specifically, understanding the cognitive components of motor imagery and how they differ from physical execution is key to designing training protocols that effectively integrate motor imagery with physical practice. The results from this work, as well as previous research, suggest that motor imagery may rely more heavily on executive functions such as inhibitory control and working memory compared to physical execution. Consequently, training protocols may be designed not only to simulate physical actions but also to enhance these cognitive processes, leading to more effective skill development. The results from this work also support individualized approaches, providing insight as to why some athletes benefit more from motor imagery training than others. Athletes with stronger executive functions may experience greater improvements, while those with weaker cognitive abilities may not gain the same advantages. This highlights the importance of developing cognitive-based training protocols tailored to each athlete's motor and cognitive profile, enabling more targeted interventions that optimize performance. Although this work offers valuable insights, further theoretical exploration is needed to fully capture the complexities of motor imagery and its relation to physical execution. Continued development in this area will be crucial for enhancing application of motor imagery in sports and maximizing its effectiveness as a training tool.

T14

Athlete Negotiations of a Concussion Risk Threshold in Canadian Amateur Rugby

Michael Jorgensen, University of Toronto; Lynda Mainwaring, University of Toronto

Research Area: Behavioural Psychology

Research Question: How do athletes negotiate thresholds of concussion-related risks?

Background Rationale: Rugby union (rugby) is one of the most popular team contact and collision sports worldwide. Normalization of pain and playing injured are taught to rugby players at a young age. This entrenched culture of risk and the high physical demands of the sport create a substantial risk for injury, especially sport-related concussion (SRC), at all levels of competition. Rugby governing bodies have implemented policies and laws to manage the risk associated with SRC. In response to risk management, rugby athletes engage in risk-taking behaviours (e.g., hiding symptoms) so that they can continue to compete; they also engage in risk-taking behaviours that contradict the safety directives imposed by their sport governing bodies. Atkinson contends that the negative connotations associated with risk are contrasted by the belief that risk-taking can be both calculated and rewarding for individuals. This duality of risk tolerance and risk aversion highlights a tension within rugby and sport more broadly when attempts are made to negotiate personal thresholds of risk. Despite the tensions, challenges, and differing perspectives on risk management in sports, theories on risk and safety in sports remain largely underdeveloped. Therefore, developing a substantive theory describing the process by which a threshold of risk is specifically negotiated within a sport culture is warranted.

Proposed Approach: The present study employs a qualitative research design informed by Straussian grounded theory. Two methods of data collection occur concomitantly. Method one. Data collection consists of online semi-structured interviews (informed by method two) and demographic questionnaires. Method two. Field observations are conducted and documented through written notes to inform the development of questions for the semi-structured interviews (method one) and to provide rich data (e.g., exemplars) for theory generation. Observations occur at the practices and games of amateur rugby clubs within the Greater Toronto Area (GTA). Written notes from these observations outline how athletes act and interact with others (e.g., verbal and non-verbal communication) as they navigate personal risk events during competition and practice. For example, ongoing field observations have identified instances of athletes admitting they lied to trainers about their injury. Data collection has been completed. A total of 30 participants have been interviewed (18 athletes, 3 match officials, 4 coaches, 3 administrators, and 2 medical support staff). Field observations were also conducted over the 2022 and 2023 seasons. The data analysis approach followed Straussian grounded theory which led to the development of a substantive theory and theoretical model.

Potential Impact: The theory generated by this research can be used to develop more effective concussion prevention and management strategies designed to reduce the probability of injury, accelerate the rate of recovery, improve injury outcomes (e.g., return to play), and encourage protective behaviours (e.g., concussion symptom reporting). The identification of risk negotiation strategies employed by athletes can inform the development of new training and education programs to improve the identification of sport-related concussions by members of the rugby community (e.g., athletes, coaches, and match officials). By understanding how athletes navigate personal risk events and the role of psychosocial and behavioural factors in the risk negotiation process, sport governing bodies can

develop policies and guidelines aimed toward minimizing threats to athlete safety. Finally, developing a theory on the risk negotiation process undertaken by athletes may lead to improvements in athlete conduct and support effective injury risk management, thereby enhancing and sustaining athlete performance and well-being as well as raising awareness of the harmful effects of the culture of risk in rugby. Targeted policies, education programs, and behaviour change interventions can also be developed from this research.

T15

A New Perspective on Concussion Assessment and Management: A Novel Multimodal Exertional Test

Kyla Pyndiura, University of Toronto; Alex Di Battista, University of Toronto; Doug Richards, University of Toronto; Nick Reed, University of Toronto; David Lawrence, University of Toronto; Michael Hutchison, University of Toronto;

Research Area: Sport-Related Concussion

Research Question: Research Questions:

1) What are the physiological and subjective responses, performance differences, and failure rates between healthy athletes and athletes with concussion on the Multimodal Exertional Test (MET)?

2) Does an athlete's performance on the MET align with medical clearance to return-to-play?

Background Rationale: Multi-plane exertional tests have become an informative tool to assist with clinical concussion management and return-to-sport medical decisions. However, current tests require expensive equipment, large spaces, and clinical expertise. Thus, we developed a multimodal exertional test requiring minimal resources.

Proposed Approach: Healthy, uninjured athletes (CTL, n = 116) completed the study assessment at a baseline time point and athletes with concussion (SRC, n = 40) completed the assessment at six time points (1-, 2-, 3-, 4-, 6-, and 8-weeks post injury). During the study assessment, participants completed a Post Concussion Symptom Scale and a 4-stage, 12-task MET while wearing a heart rate chest strap monitor. Performance metrics, symptom severity scores, and average and maximum heart rate were captured throughout the MET, and pass (completed all 12 tasks) or failure (can occur in three situations: >10 symptom difference from initial score, athlete stops the MET, or examiner stops the MET due to visible signs) on the MET was noted. Multilevel Bayesian statistical modelling will be performed to estimate group differences. All models will be simulated using the Hamiltonian Monte Carlo Engine STAN.

Potential Impact: The findings from this project may underscore the potential utility of the MET in enhancing concussion management strategies by providing an understanding of recovery trajectories and readiness for safe return to play.

T16

PRehab tO PreparE Living Liver Donors for Enhanced Recovery (PROPELLER): A Randomized Feasibility Study

Daniel Sibley, University of Toronto; Chris McIntosh, University Health Network

Research Area: Clinical

Research Question: Is a phase III RCT of prehabilitation versus usual care for living liver donors feasible?

Background Rationale: Living donor liver transplantation (LDLT) is an established treatment for end-stage liver disease. Unfortunately, recent research demonstrates that living liver donors (LLDs) experience significant postoperative pain, dysfunction, and adverse psychosocial outcomes that may persist for up to several years. Preserving health and quality of life for LLDs are priorities of care as they receive no direct medical benefit from their donation. Prehabilitation has emerged as a promising strategy to improve functional capacity prior to surgery resulting in enhanced recovery and quality of life after surgery.

Proposed Approach: This is a feasibility randomized controlled trial of prehabilitation in LLDs. The objective of this study is to assess the feasibility of conducting a large-scale randomized controlled trial of prehabilitation prior to LDLT. Thirty LLDs undergoing donation surgery at the Ajmera Transplant Program at UHN were randomized 2:1 (intervention:control) by a computer-generated randomization sequence. The intervention consisted of multimodal prehabilitation comprising: (1) exercise, (2) nutrition support, (3) psychological and behavioural counselling, and (4) LLD peer mentor sessions. Feasibility outcomes included recruitment, retention, safety, and tolerability. Additional outcome measures (i.e. clinical, patient-reported, and physical outcomes) were collected at baseline, preoperatively, and at 4 and 12 weeks postoperatively.

Potential Impact: This study will provide the essential data for determining whether a phase III RCT of prehabilitation versus usual care for LLDs is feasible. Estimates of effect will support sample size calculations in this population where such data are not currently available. LLDs in the intervention arm may experience benefits related to quality of life or surgical outcomes as a result of participation in this study. This study will contribute to the TISS vision of becoming a global leader in sport science, sport medicine, and clinical care.

T17

Developing a Cell-Based Model to Investigate the Influence of Novel Nutraceuticals on Muscle Metabolism

Cassidy Tinline-Goodfellow, University of Toronto; Paul Babits, University of Toronto; Daniel Moore, University of Toronto; Nathan Hodson, Manchester Metropolitan University

Research Area: Muscle Metabolism

Research Question: The goal of the proposed TISS scholarship was to work on developing a model for screening nutraceuticals and supplements in muscle cells by using ex vivo human serum (i.e. adding human serum to cells).

Background Rationale: Previous work using ex vivo serum on muscle cells show a modest ~10-15% increase in protein synthesis over a 4h ex vivo treatment period when comparing serum collected from individuals while fasted or after ingesting protein (fed), using typical cell culture assays for protein synthesis (i.e. Puromycin labelling). Since supplements and nutraceuticals may only give a small, but meaningful, boost to performance or muscular outcomes, we had to first develop a sensitive enough assay to detect potentially small changes.

Proposed Approach: Over the past 12 months we have developed a protocol for the use of stable-isotope amino acid tracers (subsequently referred to as 'tracers') in a muscle cell model. We have demonstrated that the use of tracers to measure muscle protein synthesis in cells is sensitive to acute changes in nutrient availability compared to commonly used alternative, puromycin, is used as a proxy for protein synthesis.

Potential Impact: Using our more sensitive tracer-based assays, we can assess different nutraceuticals on muscle cells in a high throughput-style assay to determine their influence on muscle protein synthesis and to identify candidates for human testing.

T18

Investigating MiRNA Expression in Athletes With Sport-Related Concussion

Genevieve Ammendolia Tome, University of Toronto; Michael Hutchison, University of Toronto; Alex Di Battista, University of Toronto

Research Area: Concussion Biomarkers

Research Question: This study aimed to 1) estimate differences between miRNA expression in participants with SRC and healthy controls and 2) assess the implications of altered miRNA expression on biological function post-concussion.

Background Rationale: Micro-ribonucleic acid (miRNA) are small non-coding RNA transcripts that impact transcription and translation of messenger RNA (i.e. protein synthesis). After a concussion, injured neurons and surrounding cells may alter gene expression to initiate inflammatory and recovery mechanisms. Due to their small size, miRNAs can cross the blood brain barrier into peripheral circulation, allowing for detection in blood samples. Previous research has observed differences in miRNA expression between concussed participants and healthy controls, baseline and post-concussion measurements and at various time-points in recovery post-concussion. The current understanding of concussion pathophysiology is mainly derived from animal models of brain injury. Analyzing miRNA can provide insight into biological pathways altered post-concussion in humans.

Proposed Approach: To assess differences in miRNA expression post-concussion, blood samples were collected and analyzed from healthy athletes and from athletes with concussion 4 days post-injury. A differential expression analyzed was used to assess these differences. An over-representation analysis was employed to understand the biological implications of the differences in miRNA expression.

Potential Impact: This project may provide greater insight into biological pathways involved in concussion pathobiology and provide considerations for future biomarker research in concussion.

T19

Effect of Ischemic Preconditioning on 2-km Rowing Ergometer Performance in Males and Females

Vanessa Lin, University of Toronto

Research Area: Exercise Physiology

Research Question: Can Ischemic preconditioning improve 2-km time-trial performance in trained male and female rowers?

Background Rationale: The primary objective of the proposed research is to examine whether there are sex-differences in exercise performance and physiological responses after acute Ischemic preconditioning (IPC) application. To address this primary objective, we will examine the effects of IPC on 2-km rowing ergometer performance in trained male and female rowers.

IPC is a non-invasive vascular occlusion technique that involves brief repeated cycles of ischemia followed by reperfusion via a blood pressure cuff placed on the limb(s)(1-3). In a clinical setting IPC has been observed to promote protective effects that prevent against ischemia reperfusion injury in various tissues (1-3). Interest in this physiological intervention has grown due to its potential to enhance exercise performance. IPC has been proposed as a potential ergogenic aid due to enhanced ischemic tolerance as well as the ability to stimulate vasoactive responses that promote increased blood volume and deoxygenation kinetics in the active muscles during exercise (4). Several studies have reported improved maximal exercise capacity resulting in positive performance outcomes following IPC for a variety of different exercise modalities and intensities (1-5).

There is a paucity of literature published that has investigated whether there are sex differences in the ergogenic response to IPC. This is particularly noteworthy because clinical literature reports that the cardioprotective effects of IPC are sex dependent, with IPC being ineffective in females compared to males (3,6). One clinical study that investigated the preconditioning effects during percutaneous coronary intervention in 382 subjects found that there was a failure to induce the preconditioning effects in the female subjects (6). From the clinical studies and studies on animal models it has been suggested that rather than an inability of females to be preconditioned, there is a threshold that must be exceeded before preconditioning effects can be observed. This sex-dependent response has been suggested to be due to the innate cardioprotective actions of estrogens in females (3,6). Estrogen is involved in the activation of various pathways through binding to estrogen receptors that alter the expression of several cardioprotective genes including nitric oxide synthase (NOS) (10). Upregulation of NOS and increased activity of NOS has been shown to have cardioprotective effects (10). In addition to innate cardioprotective effects, estrogen also appears to contribute to sex differences in the mechanisms

related to preconditioning. Mitochondrial KATP channels and reactive oxygen species (ROS) have been shown to play a role in preconditioning and appear to be mediated by the presence of estrogen (10). KATP has been suggested to be a 'trigger' of preconditioning that is enhanced in the presence of estrogen since estrogen activates the KATP ion channels. Estrogen also mediates the presence of ROS which is released in response to ischemic injury (10). ROS contributes to increased damage to surrounding tissues and is involved in activating protection via preconditioning (10). Protection occurs through the activation of super oxide dismutase (SOD), a cellular mechanism that mediates oxidative injury through degrading ROS resulting in less damage to the cell (10). Studies have shown that the presence of estrogen contributes to the reduction in oxidative stress that is associated with ROS (10). Although there is evidence that estrogen plays a role in the regulation of protective mechanism, the full extent of the role that estrogen plays in the potential sex-dependent response to IPC has yet to be determined.

Thus, it is reasonable to speculate that the ergogenic effects of IPC may also be sex dependent. Support for this speculation is found in the limited studies that have examined IPC responses in females and reported no change or negative performance outcomes after IPC (1-5). For example, one study that investigated the effects of IPC on 10-30m sprint performance found no effects on performance in males and negative performance effects in females (7). In another study that investigated the effects of IPC on maximal during single leg knee extensions the authors found that IPC increased muscle force to a greater extent in males compared to females, a similar increase in resting blood volume between sexes, increased O2 extraction in males and decreased O2 extraction in females (3). The observed difference in hemodynamic response could be a potential mechanism contributing to the difference in the magnitude of response to IPC between sexes. Lastly, in a recent study that investigated the effects of simultaneous bilateral arm and bilateral leg IPC in trained male and female rowers, the authors observed a significant decrease in time to reach peak power output in females during the 500-m rowing ergometer test (13). There was no difference observed for total time of the 500-m test, peak power output or mean power output between the IPC and Placebo condition across the sexes (13). The observed improvement seen in the female participants could suggest that the simultaneous arm and leg IPC provides enough stimulus to exceed the threshold needed to elicit preconditioning effects in females (13). However, to our knowledge this study is the first to investigate simultaneous arm and leg IPC application, thus it is challenging to draw any conclusions from the results. Additionally, the authors only performed one 5-min cycle of IPC which differs from the 4-5 cycles of 5-minute intervals that is commonly used in most IPC studies. Due to limited studies designed for a proper sex-based comparison, the full-extent of these sex-dependent responses to IPC remain equivocal.

With burgeoning popularity of IPC amongst high performance athletes it is increasingly important for there to be evidence to support the application of IPC, especially if there are potential negative performance outcomes for female athletes. The proposed research will investigate potential sex-differences in response to acute application of IPC and help to elucidate the efficacy of IPC for both males and females. Investigation into potential sex-differences will be achieved through an intentional research design that is appropriately statistically powered for a sex-based comparison.

The proposed research will investigate the potential sex differences in performance and physiological responses during a 2-km rowing ergometer time trial after acute IPC application. The exercise modality of Rowing was chosen for this investigation due to the ability to test 2-km rowing performance on the rowing ergometer. The 2-km rowing ergometer test is the most common selection tool used throughout rowing organizations at all levels. Furthermore, the 2-km rowing ergometer test is considered one of the most reliable endurance performance tests with a typical error measurement of 0.5% (8). Additionally, rowing

is a sport where IPC could easily be implemented into pre-race regimes, allowing for in-field application opportunities of IPC.

To date, three studies have investigated the effects of IPC on rowing ergometer performance. In a study that investigated the effects of IPC on one forearm on 1-km rowing ergometer performance in elite male rowers, the authors observed a 0.6% improvement in performance following IPC12. In another study that investigated the effects of lower-limb IPC on 2-km rowing ergometer performance, there were no performance improvements observed (8). Finally, as mentioned previously, in the study that investigated the effects of simultaneous upper and lower-limb IPC application on 500-m rowing ergometer performance there was a significant decrease in time to reach peak power output in females. In terms of physiological responses to IPC for these studies, there was a significant increase in heartrate over the first 500m and a significant decrease in blood pH after exercise in the IPC study that examined the effects of IPC on 2-km rowing ergometer performance (8). In the simultaneous upper and lower limb IPC study there were no significant differences in heartrate or blood lactate concentration following IPC.

Thus, the proposed study is designed to test the following hypotheses:

1. That IPC will improve 2-km rowing ergometer performance and that performance will improve by a greater magnitude in males compared to females.

2. This proposed study has also been designed to test the hypothesis that the differing performance outcomes in males and females following IPC will also be accompanied by differences in physiological responses in males and females following IPC

Proposed Approach: Based on an initial a priori sample size calculation using G*Power 3.1.9.6 statistical software we will recruit aim to recruit 40 participants (n = 20 male, n = 20 female). The sample size calculation was determined for a repeated measures within-between interaction (2 x 3) ANOVA based off a statistical power of 0.80 and significance of $p < 0.05$ and an effect size of 0.22. A required sample size of 36 was initially calculated. To account for attrition due to participants dropping out, 40 participants in total will be recruited.

In an attempt to have approximately similar leg muscle masses to characterize both male and female participants, we will initially aim to recruit open weight female (≥59kg) and lightweight male (≤72.5kg) rowers. In the event that our initial recruitment activities do not result in a sufficient number of volunteers to participate, then we will expand the inclusion criteria to include light weight female rowers (≤59kg) and open weight male rowers (≥72.5kg).

Additionally, we will attempt to recruit trained rowers who have at least 1 year of rowing experience and a recent 2-km rowing ergometer time that is equal to or faster than the junior varsity rowing ergometer standards outlined in the U of T rowing team selection document. The U of T ergometer standards will be used as criteria in the proposed research in an attempt to ensure that participants have a minimum fitness level that is considered competitive at the collegiate level.

U of T 2-km Rowing Ergometer Standards Junior Varsity:

Open weight - Males 6:48 min, Females 7:48 min

Light weight - Males 7:00 min, Females 8:00 min

The proposed protocol involves 4 visits to the Human Physiology laboratory located in room BN60 of the University of Toronto's Clara Benson building. The first visit will serve as the familiarization trial where

the cuff pressures required for IPC application will be established and a maximal aerobic fitness will be assessed on the rowing ergometer. The experimental trials will occur during visits 2-4 where participants will complete a 2-km time trial on a commercially available rowing ergometer (Concept 2E, Morrisville, VT, USA). There will be three experimental trial conditions: control (CON), placebo (PLA) and IPC. All four trials will occur within a 3-week period with at least 72 hours in between trials to prevent any carry-over effects from the second window of protection from IPC.

Familiarization Trial (~60 min)

The familiarization trial will involve a limb occlusion pressure (LOP) test followed by an incremental ramp test to exhaustion on the rowing ergometer to assess aerobic fitness via the determination of peak oxygen consumption rates (VβO2peak). After informed consent has been obtained from participants, they will have their height, weight and blood pressure measured prior to a limb occlusion pressure test (LOP) test to identify the pressure required to occlude blood flow below the occluded limbs.

Limb Occlusion Pressure: The LOP test will be used to determine the necessary cuff pressures for the IPC experimental condition. Participants will lay supine on a massage table while pneumatic pressure cuffs (Zimmer ATS 2200 TS; Zimmer Surgical, Dover, OH) are placed proximally on both thighs. A pulse oximeter probe will be placed on the second distal phalange of the foot. The cuffs will be rapidly inflated to the individual systolic pressure for 30s followed by 30s of cuff deflation. The pressure of the cuffs will increase in increments of 20 mmHg for intervals of 30s inflation/deflation. This process will be repeated until there is a loss of a distal pulse via the pulse oximeter. Manual palpitation of the tibial artery will be used as additional confirmation for limb occlusion. To maximize reliability and validity of the LOP measurements the LOP test will be repeated twice on each leg. Since rowing involves both upper and lower body muscle engagement, IPC application could occur on the arms or legs8. For this investigation lower-limb IPC was chosen because the lower-limb musculature contributes more to rowing performance than upper body musculature14. Total rowing power can be broken up into three main motions; 40% leg drive, 50% trunk swing and 10% arm pull14. Additionally, the lower limb IPC application in this proposed study will allow for comparison to previous studies that have utilized a similar protocol.

Aerobic Fitness Assessment: To assess aerobic fitness participants will perform an incremental test on the rowing ergometer. Participants will be equipped with a chest-based heart rate (HR) monitor (Polar Electro, Kemple, FIN) and the portable oxygen uptake analyzer (METAMAX 3B, Cortex Biophysik, Liepsiz, GER) to measure pulmonary gas exchange and breath-by-breath ventilation. Participants will be given the information for the incremental exercise test. Participants will then sit on the Concept 2 rowing ergometer and adjust the foot plates as needed. At a self-selected drag factor and stroke rate participants will be given 5-10 minutes to warm-up. For the test, the display of the rowing ergometer will be set to show watts and stroke rate. The Initial power output for the test will start at 160w/120w for lightweight males/females and 200w/140w for heavyweight males/females (9). Every 2 minutes participants will increase their power output by 40w9. VβO2 and mean power output (MPO) will be measured. Peak oxygen consumption rates (VβO2max) will be determined in order to characterize the aerobic fitness levels of each participant.

Experimental Trials 2-4 (~90-120 min): The experimental trials will occur during visits 2-4 where participants will complete a 2-km rowing ergometer time-trial test under the three experimental conditions. Trial 2 will serve as the CON trial. The order of the PLA and IPC trial conditions will be counterbalanced for trials 3 and 4. We will aim to have the participants complete all 3 experimental trials within a 15-day period with at least 72-hours in between trials to prevent any potential effects from the

second window of protection for IPC.

Prior to each trial participants will be advised to avoid strenuous activity in the 12 hours leading up to the trial and will be directed to abstain from alcoholic or cannabis products in the 24-hours preceding each of the trials. Participants will arrive in the lab at the same time of day ± 1 hour for each of the trials. Details about the participants training, sleep and dietary log will all be collected.

CON trial: Participants will lay supine on the massage table for 40 minutes to mimic the conditions of the PLA and IPC trials. Resting whole blood, unlysed blood samples will be collected from the index finger after the 40 minutes of passive rest. Participants will then complete a self-directed warm-up for 5-10 minutes on the rowing ergometer. The drag factor that the participants select will be recorded and used for subsequent trials. 5-minutes of recovery will occur before the start of the 2-km time-trial. On the concept II rowing ergometer display, participants will be able to see their stroke rate, 500m split time, projected finish time, distance remaining and average 500m split time.

PLA trial: Participants will lay supine of the massage table for 5 minutes while the pneumatic pressure cuffs are placed on the proximal part of both thighs. The PLA trial will involve 4 x 5 min intervals of cuff inflation and deflation. The cuffs will be inflated for 5-min to 40 mmHg to provide the feeling of pressure without occluding blood flow followed by 5-min of cuff deflation (0 mmHg). After the PLA participants will follow the same procedure as described in the CON trial for the 2-km time trial.

IPC Trial: Participants will lay supine of the massage table for 5 minutes while the pneumatic pressure cuffs are placed on the proximal part of both thighs. The IPC trial will involve 4 x 5 min intervals of cuff inflation and deflation. The cuffs will be inflated to the LOP determined in the familiarization trial. Limb occlusion will be confirmed via a pulse oximeter and manual palpitation of the posterior tibial artery. After IPC participants will follow the same procedure as described in the CON trial for the 2-km time trial.

Physiological variables/data collection: During each of the exercise tests HR (bpm), VβO2 (L•min-1/ml kg•min-1) and near infrared spectroscopy (NIRS) will be continuously monitored on a beat-by-beat and breath-by-breath basis. Blood lactate will be collected at rest and post-exercise at minute 0, 2, 5, 8, 10. NIRS devices (PortaMon, Artinis Medical Systems, BV, NED) will be placed and secured to both legs. The devices will be placed 15 cm above the base of the patella on the vastus lateralis muscle. The NIRS device will be used to assess changes in deoxygenation kinetics and regional blood volume during the maximal exercise test.

Performance Metrics: The total time to complete the 2-km time trial, the average split for each 500m section of the 2-km time trial and the MPO will be recorded.

Potential Impact: The proposed research aims to build off previous investigations that have examined the effects of IPC on maximal aerobic exercise performance. With varying responses to IPC for maximal aerobic exercise performance, the efficacy of IPC as an ergogenic aid remains inconclusive. In order to establish evidence-based recommendations for the use of IPC to enhance sport performance additional investigations are needed. To address the methodological variance throughout the literature, the proposed research is designed to optimize the potential for an ergogenic response through implementing a protocol developed from previous reports and recommendations. The use of IOP will maximize the possibility of consistent stimulus delivered across all participants. Using IOP will account for individual differences in leg circumference, to better ensure that the optimal pressure is being utilized to occlude blood flow to the limb. The IPC protocol outlined in the proposed research also aligns with previous investigations with 4 x 5 min cycles of IPC. The use of the 4 x 5 min IPC application protocol will allow for

comparison to other maximal aerobic exercise performance IPC investigations.

Another significant aspect of the proposed research is the intentional study design to facilitate a statistically sufficient sex-based comparison. Investigation into the potential sex-differences in response to IPC is needed to determine if there is a sex-dependent response to IPC. With no effects or negative performance effects previously reported for IPC application on females, it is increasingly important to have a better understanding of the underlying physiological mechanisms. With females making up only approximately 11% of the all the participants in IPC studies, the potential for any sex-dependent responses remains unknown (11). The proposed research will address this knowledge gap by investigating the potential sex-differences that may exist in response to IPC application. Bifurcating for sex is needed to better determine the efficacy of IPC for both males and females. With more knowledge about differences between sexes in response to IPC, more appropriate recommendations can be made for IPC application. More knowledge about the potential sex-dependent responses may also provide better insight into studies that employed a mix-sexed sample. It has been speculated that the mixed-sex samples may be biased due to a lack of response in females. Thus, the proposed research will help to address the knowledge gap that currently exists in regard to the effects of IPC in females.

In addition to the inclusion of both males and females, the proposed research will examine the effects of IPC in trained rowers. Rowing is a sport where the margin to victory can come down to less than a second, meaning that the potential ergogenic effects of IPC can provide a competitive advantage to the athletes. To our knowledge rowing has only been investigated on three previous occasions with mixed reports coming from each of the studies. Due to differing study designs with different TT distances used in each of the investigations, it is challenging to compare the results. Notably, only one of the investigations examined the effects of IPC on 2-km rowing ergometer performance. The 2-km TT distance is the most relevant for rowing since the standard rowing competition distance is 2-km. Furthermore, 2-km rowing performance on the rowing ergometer is the most common selection tool utilized at all levels. Thus, examination into the effects of IPC on 2-km performance is relevant for the rowers who are interested in implementing IPC into their pre-race regime. The 2-km rowing ergometer test is also considered one of the most reliable endurance performance tests with a typical error in performance time of ~0.5% between repeated TT in well trained rowers (8). With minimal variability between repeated TT performance, the 2-km TT is a suitable performance test to assess physiological and performance outcomes. The reliability of the 2-km TT also allows for increased confidence in the observed results (8). Additionally, rowing is a unique sport for IPC literature in particular since the IPC application can be considered both local and remote due to the significant involvement of both upper and lower body musculature. Lastly, rowing is a sport where IPC can be easily implemented into pre-race regimes, allowing for potential future in-field application opportunities of IPC.

T20

The Effects of Online vs. Offline Application of Transcranial Direct Current Stimulation in an Endurance Context

Sydney Winokur, University of Toronto; Joyce Chen, University of Toronto

Research Area: Biophysical Kinesiology

Research Question: What is the tDCS application protocol that results in reliable improvements in time to fatigue?

Background Rationale: Athletes are always looking for a competitive edge to help optimize their performance. Recently, the use of non-invasive brain stimulation as an ergogenic aid has been investigated as a potential addition to training regimens to do exactly that. An example of this is transcranial direct

current stimulation (tDCS), which may modulate human cortical functions through weak direct currents that lead to (reversible) changes in cortical excitability (Nitsche et al., 2008). In addition to this ability, tDCS is a cost effective and safe tool (Antal et al., 2017).

A potential application of this new technology in an athletic context is using tDCS to combat or delay the onset of fatigue. Central fatigue, more specifically supraspinal fatigue, occurs due to a decrease in voluntary activation within the primary motor cortex (M1) resulting in suboptimal output to the motor units (Taylor et al., 2006). The ability of tDCS to enhance cortical excitability (Nitsche et al., 2008) has the potential to mitigate these effects, which may prolong one's time to fatigue. For example, when tDCS was applied to M1 prior to a time to exhaustion cycling task, exercise tolerance increased (Angius et al., 2018). However, other work has yielded inconclusive results using tDCS during similar tasks (Chinzara et al., 2022). The specific effects of tDCS depend on the parameters of its application, which may explain the variable results within the current literature (Amann et al., 2022). All the research that has examined the effects of tDCS on endurance performance has applied it prior to the exercise intervention in the form of priming (Machado et al., 2019). However, prior research that investigated the application of tDCS in a motor learning context has found opposing effects of stimulation when applied before (offline) versus during (online) a motor learning task (Hurley & Machado, 2017). When tDCS with anode on M1 was applied during a motor learning task greater reaction time change ratios were observed, indicating faster motor learning. However, when applied prior to the task, the opposite effect was seen indicating slower learning (Stagg et al., 2011). Despite the opposing responses to stimulation depending on the specific parameters, it remains to be determined if these effects persist for priming and online tDCS applied in an endurance context. Additionally, inter-individual differences in anatomy can also contribute to theses varied results (Li et al., 2015). It is possible to address these differences by using current flow modelling to then create an individualized electrode montage (Laakso et al., 2019).

The primary aim of this research is to investigate changes in endurance performance after receiving 5-minutes of online or offline or sham (control) tDCS. The secondary aim is to determine if a personalized electrode montage using current flow modelling results in enhanced effects of tDCS on time to fatigue.

Proposed Approach: A within-subject study design will be used to test the hypothesis. This will minimize the variance associated with individual differences (Li et al., 2015). Each participant will undergo 4 separate conditions in a semi-randomized order: (1) sham tDCS, (2) priming (offline) anodal tDCS, (3) online anodal tDCS, and (4) individualized online anodal tDCS. There will be a washout period of at least 48 hours between sessions as that is what is suggested for durations of tDCS that lead to longer lasting aftereffects (Nitsche et al., 2008).

At the beginning on the first session participants will receive an MRI to gather a scan of their brain to be used for current flow modelling. This will later be used to construct the individualized electrode tDCS montage. Following this, each session will begin with 3-4 baseline leg extension MVIC at the start of the session to determine peak torque (Tpeak) as measured using the biodex dynamometer. Participants will then be set up to receive tDCS with the anode over M1. They will then either receive 5-10 minutes of

anodal or sham tDCS. Immediately following this, participants will begin a time to fatigue task in which they will perform, an isometric leg extension hold at 20% of their Tpeak until failure. During this task participants will either receive online or sham tDCS to the M1. We will collect data on time to fatigue, RPE, and changes in mean power frequency during the time to fatigue leg extension task.

Potential Impact: Through this research tDCS can begin to be established as an ergogenic aid for endurance athletes. Being safe, portable, cost effective, and easy to use, this technology is an ideal additive to a coach's arsenal to improve their athletes performance. Although some evidence attributes performance gains to tDCS, results are still widely variable throughout the literature. This project aims to contribute additional evidence that can guide future studies regarding the optimal methods for applying non-invasive brain stimulation to enhance endurance performance. Specifically, this study will address time-dependent effects of tDCS and inter-individual differences in electric field generation. This is important in further understanding effect of tDCS on elite endurance performance and its potential implications for training.

T21

Advancing Knee Osteoarthrosis (OA) Subject-Specific Modeling: AI-Enhanced Finite Element Methodology

Mahziyar Darvishi, University of Toronto; Timothy Burkhart, University of Toronto

Research Area: Biomechanics, Finite Element Modelling, Artificial Intelligence

Research Question: Can an AI-based approach optimize patient-specific modeling for osteotomy tibia procedures in knee osteoarthritis, thereby improving surgical outcomes and patient satisfaction while minimizing the time and resources required for the process?

Background Rationale: Osteoarthrosis (OA), a chronic degenerative disease affecting spinal and peripheral joints, particularly the hands, hips, knees, and feet, continues to be a widespread issue. Approximately 3.9 million (13.6%) Canadians aged 20 years and older are diagnosed with osteoarthritis, constituting over half of the total hospital care expenditures for musculoskeletal diseases. Knee joint OA is notably prevalent. While invasive knee replacement surgeries are common, they pose risks such as infections and blood clots, occasionally resulting in fatal outcomes. In contrast, less invasive and joint preserving osteotomy treatment approaches provides pain relief, preserves the knee joint, and delays the need for replacement. Finite element modeling serves as a powerful tool in this context, enabling the exploration of stress patterns pre and post-surgery to determine the optimal approach for osteotomy tibia. However, challenges arise due to regional variations in geometry and material properties within and between individuals. Therefore, creating accurate patient-specific models with intricate three-dimensional geometries and feasible finite element meshes for knee joint analyses is time-intensive, taking several working days per individual.

Proposed Approach: To develop patient-specific OA knee models, the lower extremities of OA patients will be CT scanned and the the images imported into an open-source image analysis software (3D Slicer). The images will be reconstructed to extract the precise 3D geometry of each patient's knee.

The geometric models will then be exported to ABAQUS where the finite element (FE) mesh will be created. The simulated stress analysis will involve fixing the distal tibial while a force equivalent to half of the body weight is applied to the femur. The model will be validated by comparing the model outputs to experimental (cadaveric) data. Once the models are developed and validated, an extensive dataset consisting pre- and post-surgergical patient records, intrasurgical decision, and modeling outcomes, will be produced forming the foundation for AI implementation. AI algorithms, utilizing the models as input, will enable stress calculations on the knee without extensive manual modeling, drastically expediting OA knee modeling. The AI model's outcomes will be compared and validated against the results obtained through the finite element method.

Potential Impact: By overcoming challenges in patient-specific knee joint modeling, it will substantially enhance the understanding of osteomy, joint preserving, treatement of OA. The developed methodology has the potential to transform clinical approaches by enabling precise evaluation and prediction of osteotomy tibia surgery outcomes without invasive procedures. This non-invasive method could lead to earlier diagnoses, personalized treatment strategies, and preventative interventions, thereby improving the quality of life for individuals affected by OA.

T22

Individualizing Athlete Training Through Strategic Implementation of Wearable Technology

Adam Di Salvo, University of Toronto; Robert Bentley, University of Toronto

Research Area: Exercise Physiology

Research Question: How can advanced wearable technology be strategically applied to (1) optimize athlete training, (2) calibrate individual subjective assessments of perceived exertion to physiological measures.

Background Rationale: For success in high-performance sport, it is imperative that exercise training sessions deliver an optimal stimulus for cardiovascular adaptation and improvements in cardiorespiratory fitness. However, prescribing training at the optimal zone is challenging due to discrepancies in subjective ratings of exertion and limited access to laboratory-based threshold assessments. While heart monitors are readily available, evidence suggests that training programs based on an individual's physiological thresholds (i.e., ventilation and lactate thresholds) yield enhanced cardiovascular adaptation. Recent advancements in wearable technology now allow for real-time monitoring and more precise control over an individual's training stimulus. This provides an opportunity to strategically implement such technology to optimize individual training while 'calibrating' individual subjective assessments of perceived exertion to physiological training thresholds.

Proposed Approach: This is a prospective observational study in which endurance and mixed sport athletes will be equipped with three wearable devices assessing 1) pulmonary ventilation and rate of oxygen consumption; 2) cardiac function including heart rate, rhythm and strain; 3) vastus lateralis oxygenation. Each device provides live, real-time feedback of physiological parameters. Participants will first complete a progressive exercise test to exhaustion to identify peak rate of oxygen consumption, ventilation and lactate thresholds. After identification of physiological thresholds, athlete's will be

randomized and counterbalanced into one of two groups. Group 1 will complete in-field training sessions accompanied by coaching cues to adjust their training intensity to be within desired threshold-based training zone(s). Group 2 will complete their regular training without live feedback. Subjective ratings of perceived exertion (Borg 6-20) will also be collected, and all athletes will be given information regarding RPE values tied to various training intensities. Following completion of the athletes training sessions, analyses will determine whether real-time feedback leads to more efficient training sessions (i.e., improved ability to stay within optimal training zones), as well as evaluate how real-time feedback from wearables affects athletes' perception of training intensity.

Potential Impact: Findings from this work will provide the important foundational information required to strategically apply advanced wearable technology to create targeted or personalized training interventions. This can importantly enhance exertional capacity and increase competitive sport performance by tailoring training interventions to the unique abilities of an athlete and requirements of their sport. Secondly, this work has the potential to lay the foundation for incorporating advanced wearables into high-performance sport environments and optimizing training stimulus, particularly when there may be both time and economical constraints.

T23

Non-invasive Estimation of the Anabolic Sensitivity of Dietary Leucine After Resistance Exercise and at Rest in Oral Contraceptive Users and Males

Nicki Pourhashemi, University of Toronto; Jonathan Aguilera, University of Toronto; Daniya Idrissova, University of Toronto; Daniel West, University Health Network; Daniel Moore, University of Toronto

Research Area: Protein Metabolism, Sports Nutrition, Exercise, Sex Differences

Research Question: The purpose of the present study is to compare dietary leucine retention following resistance exercise as part of post-exercise recovery and lean mass 'growth' compared to rest in females on monophasic oral contraceptives and males (n=7, each), using a non-invasive 'breath-test.'

Background Rationale: Dietary amino acids (AA), such as the essential AA leucine (Leu), cannot be stored in the body and must be used for protein synthesis (PS) or as an energy source (i.e., oxidized). Traditional methodologies to study the effects of nutrition and exercise on protein turnover can be cumbersome or invasive, as muscle biopsies or blood sampling are often required. To circumvent this challenge, our laboratory has developed a non-invasive invasive [13C]Leu 'breath-test' that demonstrates increased leucine retention after resistance exercise in males. As leucine is an amino acid that must be acquired from the diet and is preferentially metabolized in skeletal muscle, this increased retention (i.e. increased anabolic sensitivity) is consistent with enhanced muscle PS with resistance exercise. However, studies investigating protein metabolism in females, let alone those on oral contraceptives, are relatively scarce compared to males.

Proposed Approach: Participants and metabolic trials: Using a counter-balanced within subjects design, healthy recreationally active males and females on monophasic oral contraceptives during the active pill dates 10-21 (18-35 years) consumed a mixed macronutrient beverage at rest (FED) or following resistance exercise (EXFED), separated by a 3-30 day washout period.

Analytical procedures: Leu oxidation (OX) was determined through CO2 production (via indirect calorimetry), and 13CO2 enrichment (via isotope ratio mass spectrometry) over the 6 h postprandial period. Leu retention, an estimate of whole-body anabolic sensitivity, was determined by the difference between total Leu intake and OX.

Potential Impact: This project will provide valuable knowledge on the impact of synthetic female sex hormones on protein metabolism during the critical post-exercise recovery phase, ultimately paving the way for future sex-specific sports nutrition strategies. Data collection is currently ongoing for eumenorrheic females (follicular and luteal phases), which will further shed light onto differences between the impact of natural and synthetic hormones on anabolism. Since this technique is non-invasive, it can also be applied to vulnerable populations including those in clinical settings, active growing children, and older adults who are more prone to muscle atrophy. With the technological developments that permit the intrinsic labeling of complete proteins (e.g., dairy, egg, beef), our technique has the potential to be leveraged to study the anabolic potential of whole foods.

POSTER INDEX

SUBMITTED ABSTRACT

P#	POSTER TITLE
P13	The Impact of Early Specialization on Ice Hockey Goaltender Hip Kinematics *Courtney Hlady*
P14	Learning the Meanings of Talent in Sports: A Computational Analysis of NHL Scouting Reports *Yifan Liu*
P15	Modelling Para-Swimmers' Performance Using Multiple Linear Regression on Inertial Measurement Variables *Julien Clément*
P16	The Association of Concussion and Vision History With Baseline Oculomotor Function for Healthy Interuniversity Athletes *Katelyn Mitchell*
P17	Biomechanical Assessment of a Two-Foot Vertical Jump in ACLR Patients *Pratham Singh*
P18	Epidemiology of Injuries to Professional Ice Hockey Goaltenders Playing in the National Hockey League *Evan Curd*
P19	44 Year Variations in NHL Draft Lag by Country, Position, Draft Rank and Handedness *Yiru Wang*
P20	Existence and Extent of Pay Discrimination Based on Players' Race and Nationality in NBA: 35 Years of Historical Data *Yiru Wang*
P21	The Relationship Between Early Success and Career Longevity in Competitive Figure Skating *Michelle Lee*
P22	Malaysia Talent Plan (MyTP) in Sports: Development and Implementation *Tengku Fadilah binti Tengku Kamalden*
P23	Psychological Considerations in Sports Talent Identification: A Review and Taxonomic Classification *Tengku Fadilah binti Tengku Kamalden*

P01

Examining Return to Play Protocols for ACL Injuries Using the International Classification of Function, Disability, and Health (ICF): A Rapid Review

Varun Jain, McMaster University; Vanessa Tomas, McMaster University; Peter Rosenbaum, McMaster University

Introduction: Anterior cruciate ligament (ACL) injuries are a common occurrence, espe-cially in sports. These injuries require a comprehensive return-to-play (RTP) protocol that is suited for the individual. This review aims to assess existing RTP protocols for ACL injuries, using the WHO's International Classification of Functioning, Disability, and Health (ICF) framework. The objective is to identify trends and gaps in the protocols based on the domains of the ICF framework.

Methods: A rapid review was conducted from the following databases: Embase, MEDLINE, and CENTRAL. Studies were screened using Covidence and reviewed using National Collaborating Centre for Methods and Tools (NCCMT) guidelines. The analysis examined the included return-to-play protocols and assessed them using the domains of the ICF framework.

Results: Fifteen studies were included in the review. Based on the protocols of the included studies, three key trends were observed: 1) Focus on functioning and disability rather than contextual factors, 2) Player's psychological needs are considered in only a few studies (n=4), and 3) Most return-to-play protocols were fairly rigid.

Discussion/Conclusion: This review highlights key trends and gaps in existing RTP protocols for ACL injuries. , The protocols can be improved by aligning themselves with the ICF, potentially paving the way for a standardized ACL RTP protocol.

P02

Map the Gaps: Where Are Your Elites Not Coming From

Gillian Ramsay, University of Toronto; Kathryn Johnston, University of Toronto; Benjamin Csiernik, Ontario Tech University; Jesse Korf, AusCycling; Donna Rae-Szalinski, AusCycling; Joseph Baker, University of Toronto

Introduction: While spatial analysis has been used in sport science to investigate outcomes such as accessibility to local facilities, evacuation plans, disaster management of large sporting events, and tracking player movements during games, its use in the context of athlete development is limited. To help address this gap, the present study used GIS technology to map the location of elite cyclists within Australian Cycling (AusCycling) to explore whether the spatial distribution of high-performance athletes provided insight into areas of over or under representation. It was hypothesized that more populated states and areas with more AusCyling memberships (i.e., more registered cyclists), would be home to more elite-level (i.e., categorized) athletes.

Methods: ESRI ArcGIS software was used to spatially analyze 132 elite para and non-para cyclists. De-identified postcodes were geocoded into an ArcGIS Online database. Geospatial analyses were performed to investigate descriptive statistics for the number of athletes by state and territory compared with regional populations and AusCycling total memberships over a six-year span.

Results: Southern Australia (SA) has the most elite cyclists (n= 36), despite being the 5th most populous state in Australia (1.7 million in population) (fig.1 and fig.2). Surprisingly, New South Wales (NSW), the biggest state with a total population of 8.1M, ranked third in elite athlete representation (n= 22). In addition, NSW had 28% of total memberships to AusCycling with SA contributing 7%, and yet SA has 27% of the elite athletes.

Discussion/Conclusion: Currently, NSW is under-represented. Despite having the greatest population and most cycling memberships, and therefore potentially a population with the greatest interest in cycling, the representation of these cyclists as elite level athletes is not seen as compared to SA. Future work is needed to explore the mechanisms of these effects to better support athletes in all states.

P03

Ice Hockey Goaltending Injuries: An Epidemic, or to Be Expected?

Ben Csiernik, Ontario Tech University; Kathryn Johnston, University of Toronto; Joseph Baker, University of Toronto; Nick Wattie, Ontario Tech University

Introduction: Recent mainstream media has brought attention to the number of professional ice hockey goaltenders experiencing hip and lower body injuries (LBI), blaming new goaltending techniques as part of the cause. The purpose of this study was to evaluate goaltending injury trends in ice hockey to determine if the evidence aligns with or contradicts the current zeitgeist.

Methods: 1197 reported goaltending injuries (798 LBIs) from the National Hockey League regular seasons were retrieved between 2000-2024. Pearson correlation coefficients were used to evaluate trends in the number of injuries, and the number of games missed due to injury. Holt's exponential smoothing was used to forecast future goaltending injury.

Results: A statistically non-significant correlation was found between season and the number of games missed due to all injuries ($R = 0.39$, $p = 0.066$), while a large statistically significant correlation ($R = 0.51$, $p = 0.013$) was found between season and the number of games missed due to LBIs. However, there was no correlation between the number of injuries and season, and number of LBIs and season. For all injuries and LBIs, forecasting estimates using Holt's exponential smoothing predict a decrease in overall injuries per game played, and LBI per game played over the next five seasons (Figures 1, 2).

Discussion/Conclusion: Data demonstrates there has been no statistically significant increase in overall injuries or LBIs among goaltenders. This may indicate changes in goaltender playing style have not led to an increase in injuries. Coaches, clinicians, and athletes should consider that while LBIs are common, their prevalence and impact may not be as severe as described. Future forecasting demonstrates that goaltending injury trends appear stable (if not improving), implying the current approach to managing goaltenders (e.g. training load monitoring) is effective.

P04

How Special Is Specializing in Taekwondo? An Investigation Into Elite Athletes' Lifelong Sport Participation Experiences

Ceili Peterson, University of Toronto; Kathryn Johnston, University of Toronto; Antonia Cattle, University of Toronto; Joe Baker, University of Toronto

Introduction: With recent attention being paid to the different participation patterns in early sport engagement in mainstream sports (e.g., early specialization versus early diversification), it is important to explore these patterns in sports receiving less attention (e.g., Taekwondo) and across different countries and cultures.

Methods: The Exposure to Sport Scale (ESS) was adapted as an online survey using REDCap. In completing this survey, adult taekwondo athletes (i.e., 18+) currently or formerly competing internationally at a senior-level reported demographic information as well as historical and current sport practices, engagement in competitions, and play experiences across sport(s). The sample (n = 45) included participants from North America (n = 15), South America (n = 16), Asia (n = 10), and Other (i.e., nations with participants under 5 athletes) (n = 4). Utilizing athletes' historical data , they were classified as high/moderate/low specializers, diversifiers, or 'other' based on the age athletes transitioned into single sport participation and the total number of sports they were involved in, with 12 years of age used to distinguish "early" from "late" sport engagement. Median ranking values were used to prevent skewing effects from outliers in the dataset, especially due to the small sample sizes when separated by continent .

Results: Findings revealed cross-cultural differences in the effect of different early engagement patterns in sport. More specifically, in North America, diversified athletes obtained the higher rankings, while in South America and the mixed nation group, highly specialized athletes were ranked higher. Finally, in Asia, moderately specialized athletes obtained the higher rankings.

Discussion/Conclusion: Findings indicate variability across nations in the relationship between different sport pathways and eventual success. These results could inform coaching and training strategies that match the specific constraints of different cultures and development systems.

P05

Keep Your Head in the Game; Cognition's Role in Predicting Success of High Performance Athletes

Hannah Rabinovitch, York University; Magdalena Wojtowicz, York University; Hannah Rabinovitch, York University; Joe Baker, University of Toronto; Thomas Romeas, Université de Montréal

Introduction: Recent studies of high-performance athletes have primarily focused on single-domain cognitive differences between athletes, though less is known about the predictive value of general cognitive abilities on athletic success. This study examined the relationship between baseline cognitive strengths and elite success (i.e., securing medals) among high-performance athletes.

Methods: 198 elite athletes (60% female; aged 13.41 - 35.50 years old) from a Canadian national sport institute completed the Vienna Test System (VTS, Schuhfried, Austria) cognitive battery between 2018-2023. Athletes were classified as either Tier 5 (n=103; won at least 1 medal at the international level of competition) or Tier 4 (n=95; competed at the international level without winning a medal; McKay et al., 2021). Performance on VTS measures of sustained attention, selective attention, inhibition, planning ability, mental flexibility, and future athlete success (i.e., Tier status) was examined using stepwise logistic regression.

Results: Tier 5 athletes (n=103) primarily came from short track speed skating (37%) and artistic swimming (29%). Our regression model revealed that higher performance on the sustained attention task significantly predicted being a Tier 5 athlete (B =.041, OR = 1.04, p<.014). In the covariate analysis which included sport and sex, being female (B =1.10, OR = 3.00, p<.001) was associated with a greater likelihood of Tier 5 status. In contrast, participating in boxing (B=-3.43, OR = .03, p<.001) and water polo (B =-1.74, OR = .17 p<.001) were significant covariates of not being a Tier 5 athlete.

Discussion/Conclusion: These results suggest a relationship between baseline sustained attention and future medal success. In our sample, female sex was associated with a greater likelihood of Tier 5 status, though our cohort includes relatively more females (60%) than males. Nevertheless, the influence of sex and sport type may be equally important and should be further explored with a larger sample.

P06

Unlocking Athletic Minds: A Multivariate Approach to Understanding Cognitive Functioning in High Performance Athletes

Carmel Camilleri, York University; Kathryn Johnston, University of Toronto; Nick Wattie, Ontario Tech University; Joseph Baker, University of Toronto; Magdalena Wojtowicz, York University

Introduction: Recent studies indicate that high-performance athletes often exhibit superior cognitive abilities. However, much of the research has solely focused on individual cognitive domains (e.g., executive functioning). This approach overlooks the interconnections between different domains, which require a comprehensive examination of athletes' cognitive profiles. Our study aims to fill this gap by adopting a multi-domain multivariate approach to understand baseline cognitive strengths in high-performance athletes.

Methods: 162 elite athletes from the Canadian Sport Institute Ontario (64% female; aged 17-25) completed a cognitive battery encompassing 12 tasks evaluating: visual attention/search, visuospatial processing, verbal/spatial working memory, verbal reasoning, inhibition, spatial planning, mental rotation, deductive reasoning, and paired associate learning. Participants' scores were sex-and age=matched to a normative sample of non-athletes (n ~ 5,000) and converted into T-scores.

Results: The proportion of high scores was examined, and multivariate base rates (MBRs) were calculated for three cutoff points: the 75th, 84th, and 91st percentiles. When interpreting MBRs, most athletes achieved one or more high score(s) at ≥75th, ≥84th, and ≥91st percentiles (i.e., 81.5%, 67.9%, and 59.3%). Multiple correspondence analysis was also conducted based on the proportion of high scores achieved at the 75th percentile, resulting in the identification of three dimensions: Dimension 1

encompassed visual attention, visuospatial working memory, and paired associate learning, Dimension 2 represented mental rotations, while Dimension 3 included visuospatial processing and verbal working memory.

Discussion/Conclusion: By taking a multivariate approach, this study examined athletes' multi-domain cognitive profiles, revealing unique relationships between their strengths and weaknesses. Further research is required to explore whether this type of profiling may be associated with sport-specific athlete performance.

P07

Analyzing Short-Track Speed Skating Performance Factors With Wearable Inertial Measurement Units

Julien Clément, ÉTS Montréal

Introduction: The study focuses on short-track speed skating performance factors and employs wearable inertial measurement units (IMUs) to analyze on-ice movements.

Methods: Twenty-nine short-track speed skaters, from two teams, participated in this study. Movella IMU Link suits were employed for data collection, and recorded speed trials for each athlete, focusing on lower body kinematics. Data processing involved multiple Python scripts in order to segment data by skating strokes.

Results: From an initial pool of 535 tested factors, multiple statistical analyses identified 7 significantly associated with lap time, with notable differences between genders and teams. These factors, such as the inter-foot spacing or the pelvic height, are actionable by athletes, and could help athletes to gain up to 0.51 seconds per lap if improved by 10 cm.

Discussion/Conclusion: They are considered viable options to enhance lap times and overall performance outcomes. This research contributes to understanding short-track speed skating performances by identifying factors that are linked to lap times, offering practical implications for coaching strategies and athlete training regimens.

P08

Measuring Where It Hurts! Quantifying Landing Impacts in Freestyle Snowboard

Mary Claire Geneau, Canadian Sport Institute – Pacific; Ming-Chang Tsia, Canadian Sport Institute - Pacific

Introduction: Understanding the physical demands of a sport is crucial for tailoring appropriate training interventions and monitor athlete fatigue (Halson, 2014). In freestyle sports such as Big Air snowboard, training and competition load is primarily experienced through landings. Big Air athletes execute aerial maneuvers in training and competition which result in large magnitudes of ground reaction force upon landing (Harding & James, 2010). As these maneuvers become more difficult, they often require greater

flight times and/or higher rates of rotation, which may lead to an increase in landing impact (Ross et al., 2020). Furthermore, if the jumps are not landed well (e.g., athlete falls or touches their hands on the ground, forces experienced by the athlete may change. It is unknown, however, if trick difficulty or landing quality directly correspond with impact, thus external load. Thus, the purpose of this study was to assess the relationship between both trick difficulty and landing quality with landing impact.

Methods: Eleven Canadian National Snowboard Team athletes participated in a 7-day big air training camp. To measure landing impact, a single inertial measurement unit (IMU) (Xsens DOT) was securely fastened to each athlete's front boot. The IMUs collected triaxial acceleration-time data at 60Hz. Jump landings were recognized as negative acceleration > 6 g. The impact of each landing was quantified as the peak negative acceleration recorded for that feature. Trick difficulty was quantified as the number of rotations about all axes performed by the athlete, and landing quality was recorded as either "complete" or "touch down" (hand touch to the snow). A multiple linear regression model was used to assess the relationship between trick difficulty, landing quality and landing impact (Table 1).

Results: There were 574 jumps measured over the 7-day camp. Landing impact ranged from 8.82 (±1.34) g to 11.40 (±0.50) g, and rotation ranged from 0 to 1620 degrees (i.e., 4.5 rotations). Landing impact was significantly influenced by both the number of rotations and the quality of landing (Table 1). The coefficient for rotation was significant at 0.0007 (or 0.126 g) ($t = 2.118$, $p = 0.035$), suggesting that for every additional half rotation (180 degrees), there was a 0.126 g increase in impact. Additionally, the landing quality coefficient demonstrated that completing a landing reduced the impact by 1.77 g ($t = 4.689$, $p < 0.001$).

Discussion/Conclusion: These results suggest that trick difficultly cannot effectively estimate jump landing impact experienced by Big Air snowboard athletes. However, the quality of the landing significantly affects the impact of the jump, where a poorly executed trick results in an impact 1.77g greater than when it is landed well. Therefore, sport scientists should consider directly measuring landing impact in these athletes using microsensor technology like IMU to better understand external load experienced by athletes in this sport.

P09

Concussion in Special Olympics Canada Athletes: What Happens After a Concussion?

Nikoleta Odorico, University of Toronto; Zachary Scanlan, University of Toronto; Christina Ippolito, University of Toronto; Emily Bremer, Acadia University; Nick Reed, University of Toronto; Kelly Arbour-Nicitopoulos, University of Toronto

Introduction: All athletes are at risk for concussion, including athletes with intellectual disability. Special Olympics Canada (SOC) provides over 45,000 Canadian children, youth, and adults with intellectual disability with training and athletic competition opportunities in 18 Olympic-type sports across 12 provincial and territorial chapters. However, little is known about concussion amongst SOC athletes. This study explores what actions are taken in response to concussion incidents.

Methods: As part of a larger concussion surveillance study, athletes and caregivers completed surveys at two Special Olympics events (National Winter Games in Calgary, AB [February 2024]; Spring Provincial Games in Waterloo, ON [May 2024]). The online survey contained questions about athlete demographics (age, gender, SOC sport involvement), athlete concussion history (in life, in past year), and response to a sustained concussion as applicable. This study focuses on respondents' response to a sustained concussion. Demographics, concussions history, and response to concussion will be described using descriptive statistics.

Results: To date, 186 surveys (171 by athletes, 15 by caregivers) have been completed; 47 respondents have reported an athlete diagnosed and/or suspected concussion in their lifetime. Of athletes with a concussion history, athletes identified as a man (n=30, 60%), woman (n=15, 32%), and non-binary (n=1, 2%) with a mean age of 32.9 years (SD=9.7 years). Seventy-two percent (n=34) of athletes played high-risk sports (e.g., alpine skiing, floor hockey, basketball) and 85% (n=40) of athletes played low-risk sports (e.g., bocce, swimming, weightlifting). In response to a concussion, athletes told a trusted adult (n=33, 70%), sought medical attention (n=35, 74%), followed a return-to-school/work protocol (n=18, 38%), followed a return-to-sport protocol (n=27,57%), and did nothing (n=8, 17%).

Discussion/Conclusion: Many SOC athletes with a history of concussion have not engaged in positive health behaviours (e.g., following return to activity protocols, etc.) following their concussions, which may lead to poor concussion outcomes. Efforts must be made to improve concussion-related decisions to ensure safe sport participation for SOC athletes.

P10

Targeting Sports Performance and Neurorehabilitation With Optimized Brain Plasticity: Preclinical Evidence

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Introduction: Our brain's ability to acquire new skills is the basis for an athlete's sports performance and capacity to recover from injury. Fundamentally, this brain plasticity involves a delicate interplay between proteins (receptors and kinases) at neuron communication sites known as synapses. We have identified an exercise paradigm (intensity and duration) in rodents that engages the receptors and specific signaling cascades that are both necessary and sufficient for forming long-term brain plasticity.

Methods: C57BL/6J mice (n=9-10/group, 50:50 male/female) exposed to treadmill exercise (20 minutes) were assigned to control or exercise groups of various speed intensities (EX## = m/min: EX15, EX20, EX25, EXHIT25+15) and tracked up to 1 h after recovery from EX20. Finally, we trained a subset of animals with EX20 5× a week for 4 weeks. We isolated brain tissue and mapped the activation and longevity of biochemical responses for plasticity-related proteins in each of our intensity, timed, and trained groups.

Results: Brain fractions revealed an inverted-U relationship with intensity of exercise, maximal after EX20 for engagement (phosphorylation) status on a series of plasticity-related proteins. Both synaptic glutamate receptor (NMDAR and AMPAR subunits) phosphorylation expression along with kinase-specific (PKA, PKB) activation status were significantly enhanced, but short-lived, returning to baseline within the hour. Additionally, 4-weeks of training at EX20 led to a sustained activation of protein activity suggesting a capacity for training within these signaling pathways.

Discussion/Conclusion: Together, these findings suggest a window of brain sensitivity or "priming" whereby the brain more readily engages mechanisms of plasticity, and by extension the capacity to acquire a new skill or recovery of skill after injury is heightened. We hypothesize that engaging this dose-specific exercise effect prior to skill learning/therapy (1) shortens the time necessary to acquire the skill and (2) reinforces the structural brain changes necessary for skill development/performance. Work is supported by CIHR and Dani Reiss Innovation Fund for Healthy Aging Research.

P12

Validation of Inertial Measurement Units and Force Plates in Measuring Jump Height and Peak Velocity During a Counter Movement Jump

Iris Willaert, École de technologie supérieure; Julien Clément, École de technologie supérieure

Introduction: Countermovement jumps (CMJs) are commonly used to assess athletes' lower limb strength and neuromuscular fatigue, particularly in explosive sports like speed skating. Key metrics for CMJs typically include jump height and peak velocity. While force plates have traditionally been used to measure these metrics, their high cost and lack of portability limit their practicality. Inertial Measurement Units (IMUs) have emerged as cost-effective and portable alternatives. This study compares the effectiveness of two IMU sensors (Enode Pro and Output Sports) and two force plates (AMTI and Pasco) in assessing CMJ performance, evaluating their accuracy against a gold standard motion capture system (NDI Polaris Spectra system).

Methods: Twenty-eight athletes(14 female, 14 male) from the elite speed skating team participated in the study. The Pasco force plate was stacked on the AMTI plate for simultaneous data collection. Each athlete performed five CMJs on these stacked plates while wearing a waistband. The Enode sensor was attached to the waistband, and the Output sensor was taped to the top of the right foot, per manufacturer instructions. Jump height results from all devices were compared against those of the Polaris. Peak velocities recorded by the IMU sensors and the Pasco were compared with those from the AMTI.

Results: Both force plates accurately measured jump height (AMTI:38.08±6.72 cm, ICC=0.99, P=1.0; Pasco:38.30±6.60 cm, ICC=0.99, P=1.00) relative to Polaris (38.22±6.80 m/s, ICC=0.99). Both IMU sensors showed significant differences in jump height compared to Polaris (Enode:44.28±7.2 cm, ICC=0.96, $p<0.001$; Output:35.22±13.27 cm, ICC=0.80, $p<0.04$), yet they accurately measured peak velocity (AMTI:2.66±0.27 m/s, ICC=0.97; Pasco:2.67±0.27 m/s, ICC=0.99, $P<0.99$; Enode:2.62±0.24 m/s, ICC=0.98, $P<0.98$; Output:2.59±0.62 m/s, $P<0.95$).

Discussion/Conclusion: These findings suggest that IMU sensors like Enode and Output are reliable for measuring peak velocity during CMJs, presenting a viable alternative to traditional force plates for this metric. However, their accuracy in jump height measurement remains less consistent.

P13

The Impact of Early Specialization on Ice Hockey Goaltender Hip Kinematics

Courtney Hlady, University of Toronto; Timothy Burkhart, University of Toronto

Introduction: Ice hockey goaltenders face a high risk of intra-articular hip injuries, such as femoroacetabular impingement syndrome (FAIS) and labral tears. The increased risk is suggested to be due to extreme hip motions. More severe FAIS bony morphologies and poorer hip function in early specialized (ES) hockey players may be attributed to negative impacts on neuromuscular control and movement patterns; however, this has not been quantified in goaltenders. Therefore, this study aimed to compare hip kinematics between ES and not early specialized (NES) goaltenders.

Methods: Twenty-six goaltenders' (13 ES) kinematics were quantified during common goaltending tasks (i.e., butterfly drops, power and butterfly slides) performed on a slide board using Theia3D markerless technology (Figure 1). Maximum and minimum hip flexion, adduction, and internal rotation (IR) angles were determined, as were the concurrent hip angles in the two other planes at these positions. The groups were compared using independent t-tests or Mann-Whitney U tests for discrete data and statistical parametric mapping for hip angles over time.

Results: ES goaltenders demonstrated increased IR and abduction at lower flexion but less IR and abduction at higher flexion (Figure 2). Neither group reached the expected extreme ranges of flexion, adduction, or IR typically associated with mechanical bony impingement of FAIS (Table 1). However, the maximum internal rotation (18.5-24.1°) and abduction angles (19.7-33.5°) in each task have been shown to significantly increase labral strains and deformations during moderate flexion.

Discussion/Conclusion: The ES goaltenders may minimize combined flexion and IR or abduction to avoid pain in hips with FAIS or labral tears or have adopted advantageous hip control strategies to avoid abnormal hip contact mechanics that contribute to developing these pathologies. This study also suggests hip loading throughout IR and abduction may influence goaltenders' increased risk of intra-articular hip injuries.

P14

Learning the Meanings of Talent in Sports: A Computational Analysis of NHL Scouting Reports

Yifan Liu, University of Toronto; Kathryn Johnston, University of Toronto; Joseph Baker, University of Toronto; Yang Xu, University of Toronto

Introduction: Definitions of talent in sports science vary among stakeholders. This diversity triggers a central question: How can talent be effectively defined and understood? In response, this paper introduces a novel computational framework that combines advanced AI tools and statistical methods, using textual data from National Hockey League (NHL) scout reports.

Methods: This paper studied 839 NHL scout reports from 2008 to 2014 from the Central Scouting Bureau. We assumed that talent is defined by multiple latent dimensions (e.g., physical, technical), each represented by a group of terms describing athletes' abilities. To derive the latent talent dimensions, we experimented with both bottom-up (unsupervised) and top-down (guided by established field standards) research frameworks.

We started by extracting terms from each scout report and expanding each into a detailed one-sentence description using Large Language Models (LLMs). Next, we grouped these expanded descriptions into clusters using their dense vector representations. For the bottom-up approach, we applied K-means clustering and experimented with various latent dimensions. For the top-down method, we predefined four dimensions: physical, technical, cognitive, and psychological. We then matched each key term to the closest predefined dimension.

Results: The clustering performance was evaluated using the Silhouette score, which assessed the balance of inter-cluster and intra-cluster similarities. For the bottom-up approach, the optimal number of dimensions was around 5 (Silhouette score = 0.96). The 5 clusters can be interpreted as: cognition and intelligence, puck possession, physicality and mobility, defensive ability, and offensive ability. The top-down method resulted in a lower silhouette score than the bottom-up approach (Silhouette score = 0.67).

Discussion/Conclusion: This research introduced a novel computational framework for understanding talent in sports science. We revealed that a bottom-up approach offers a better characterization of the latent dimensions in NHL-scouted athletes compared to a top-down approach guided by the field standard four dimensions of talent.

P15

Modelling Para-Swimmers' Performance Using Multiple Linear Regression on Inertial Measurement Variables

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Introduction: Inertial measurement units quantify swimming performance by generating many metrics. However, this large number of metrics can create confusion on which variables to focus on. The purpose of this study was to define a simple model linking a small number of variables to performance to help the coaches focus on some relevant parameters as part of their training approaches.

Methods: Six Paralympic swimmers completed 50m freestyle laps over six months. A single sacrum-worn IMU (60 Hz, Movella Dot; Netherlands) recorded tri-axial linear accelerations and angular velocities. Data was processed generating seventy-two parameters. Pearson correlation coefficients were calculated to identify independent variables most strongly correlated to performance (swim time). A multiple backward

linear regression method was run on twenty-six independent variables. The number of variables included in the final model was determined by optimizing the adjusted R-squared.

Results: Eight variables were significantly associated with swim time and included in the final model ($R^2 = 0.86$, $F = 181.4$, $p < 0.001$). The model is composed of variables reflecting efficiency, symmetry, motor variability and steadiness. The specific results are presented in Table 1.

Discussion/Conclusion: In the present study we elaborated a model to explain swimming performance based on variables related to both swimming technique and inter-cycle variability. It highlighted the crucial role of variability on performance, supporting recent findings. The current findings enable coaches to track key parameters of their athletes during training and to quantify the time gains a swimmer can achieve with minor adjustments. For example, in our model, an increase of 0.1 m2/s of the Stroke Index can improve the swim time up to nearly 1s on a 50m freestyle lap. This research contributes to understanding swimming performances, offering practical implications for coaching strategies and athlete training regimens.

P16

The Association of Concussion and Vision History With Baseline Oculomotor Function for Healthy Interuniversity Athletes

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Introduction: Eye movement (i.e., oculomotor) deficits are commonly detected following concussion, such as horizontal saccades. However, it is unclear how previous concussion and vision history affect oculomotor performance for healthy athletes. Therefore, the purpose of this study is to determine if concussion history, visual acuity, and corrected vision are associated with baseline oculomotor performance.

Methods: Interuniversity athletes (N= 102, age= 19.2 ±2.0 years; females= 45) who completed a pre-season health questionnaire and dynamic vision assessment were included in this study. Binocular visual acuity (VA) and oculomotor performance were assessed via RightEye using infrared eye tracking (90Hz), whereby athletes viewed a 15" monitor while seated at an average distance of 56.8 ±1.7cm. Outcome measures include composite vision and saccade scores (0 to 100), and horizontal saccade velocity (deg/s) and efficiency (distance from ideal trajectory, mm) for left and right eyes. Linear regression models were used to determine if previous concussion, VA, and corrected vision were associated with outcome measures.

Results: Overall, 32 (31.4%) athletes reported previously concussion with an average of 1.6 ±0.8 concussions. Average VA was approximately 20/20-1 (0.02 logMAR) and 33 (32.4%) reported having corrected vision. Corrected vision was associated with lower oculomotor performance scores (ß= -10.98, 95% CI [-16.47,-5.49], p< .001) and saccade scores (ß= -7.29, 95% CI [-13.11,-1.46], p< .05), as well as increased horizontal saccade velocity (Left: ß= 6.14, 95% CI [0.62,11.65]; Right: ß= 6.23, 95% CI [0.72,11.73];, p< .05) and worse horizontal saccade efficiency (Left: ß= 1.48, 95% CI [0.42,2.55]; Right: ß= 1.81, 95% CI [0.61,3.02]; p< .01). Previous concussion and VA were not significantly related to any outcome measures.

Discussion/Conclusion: Athletes with corrected vision may exhibit altered oculomotor performance, specifically horizontal saccades, regardless of previous concussion and VA. Therefore, vision history may be important to consider for clinical interpretations of oculomotor dysfunction following acute concussion.

P17

Biomechanical Assessment of a Two-Foot Vertical Jump in ACLR Patients

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Introduction: Approximately 3% - 30% of people experience re-injury following return-to-play (RTP) after ACL reconstruction (ACLR). Current RTP test batteries typically involve horizontal and vertical jumping testing that quantify how far or high a patient can jump and are primarily measures of the underlying strength required during the take-off phase. However, these tests do not assess the many potential underlying neuromuscular strategies that a patient may adopt when performing these tests. Therefore, the purpose of this study was to quantify knee biomechanics in ACLR patients in response to a two-foot vertical jump.

Methods: Five ACLR patients (M: 3, F: 2; Age: 22.0 [1.10]) who were cleared for RTP were recruited. Motion data, ground reaction forces and muscle activation were collected synchronously while each patient performed a two-foot vertical jump. Data were analyzed from landing to 200 ms after landing. Each patient also performed resisted knee extension and flexion on a Biodex dynamometer. The limb symmetry index (LSI = involved limb/uninvolved limb) was quantified for all variables.

Results: The LSI for knee range of motion in flexion/extension, abduction/adduction and internal/external were 0.94, 0.93, 1.46, respectively. The LSI for the peak vertical force was 0.76 and sEMG across all muscles ranged from 3.54-31.82. The LSI for peak torque during extension was 0.76 and during flexion was 0.89.

Discussion/Conclusion: Despite strength deficits in the involved limb, greater peak muscle activation was observed. This may indicate that the neuromuscular contributions are adapting to the injury where increased neural drive is required to achieve similar or less output. This may indicate that these patients are not yet ready to RTP despite passing a commonly used vertical jump test. Understanding neuromuscular contributions during dynamic movements may provide a better indication of when patients are ready to RTP following ACLR.

P18

Epidemiology of Injuries to Professional Ice Hockey Goaltenders Playing in the National Hockey League

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Introduction: Hockey goaltenders are exposed to unique in-game physical demands, different than those experienced by other positional players. While previous research has attempted to identify the injuries experienced by elite goaltenders, these have been limited by the use of secondary data or data from small samples over relatively short time interval (one to two seasons). Therefore, the purposes of this study were to: i) quantify the number and type of injuries occurring in NHL goaltenders; and ii) quantify time lost due to these injuries.

Methods: A retrospective analysis was performed on 14 consecutive years of injuries to NHL goaltenders sustained from the 2009/2010 to 2022/2023 NHL seasons. The total days missed (TDM) was used as a surrogate measure for injury severity. For each individual diagnosis, the total number of injuries were quantified in addition to the mean, median, standard deviation (SD), minimum, and maximum TDM.

Results: There were 1585 injuries recorded over 14 NHL seasons resulting in 31,406 TDM. The most injured anatomical region was the hip/groin, followed by the knee and head. Proximal adductor injuries accounted for the largest number of injuries (n=371) leading the highest total TDM (6,126). Concussions (n=110) and MCL sprains (n=95) (Table 1) were he second and third most common injuries, respectively. The majority of the injuries occurred during games (n=904) followed by practice & off-ice activities (n=618). The most common mechanism was non-contact (n=673), followed by 'unknown' (n=325), and incidental contact (n=252).

Discussion/Conclusion: Understanding injury patterns and the relative timeline of return to play for goaltender specific injuries will allow physicians and other important stakeholders to better manage team and player expectations, and could have significant impact on team decisions regarding roster management and potential acquisitions. Identifying the most common and severe injuries is also a first step in implementing effective injury risk reduction strategies.

P19

44 Year Variations in NHL Draft Lag by Country, Position, Draft Rank and Handedness

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Introduction: With professional ice hockey organizations relying on entry drafts for talent acquisition, understanding how athletes reach the National Hockey League (NHL) is crucial.

Methods: This study explored the factors influencing and predicting draft lag, the time it takes for a drafted hockey player to enter the NHL (i.e., playing at least one game), while considering the influence of within-year relative age effects on the time to entry. The dataset comprised 10,530 observations between the 1980 draft and the 2023/24 season, each representing a player's birthdate, draft date, draft overall ranking, position, height, weight, nationality, previous team, and handedness. Model performance was evaluated using the concordance index for a Cox model, and the continuous rank probability score (CRPS) were assessed using a Random Forest model.

Results: Descriptive results are shown in the Figure 1. The Cox model revealed all predictors except handedness were statistically significant. The model had a concordance index of 0.776, indicating a strong ability to distinguish between players who will enter the NHL sooners versus later based on

the predictors. Players who were drafted earlier and were shorter tended to enter the NHL sooner. Conversely, older players at the time of the draft, forwards, goalies, heavier players, and those from the USA or Russia (compared to Canada) tended to enter the NHL later (more details see in Table 1). The Random Forest model corroborated these findings, highlighting draft overall ranking and weight as the most important predictors (see Figure 2). The CRPS was 0.163, indicating the model's reasonable predictive accuracy.

Discussion/Conclusion: Overall, our study highlights the importance of considering a range of factors, including physical attributes and draft rankings, when predicting NHL entry. By recognizing these influences, hockey organizations can improve their drafting strategies and development programs, ultimately enhancing player progression to the NHL.

P20

Existence and Extent of Pay Discrimination Based on Players' Race and Nationality in NBA: 35 Years of Historical Data

Yiru Wang, University of Toronto; Daniel Sailofsky, University of Toronto

Introduction: Pay discrimination based on nationality and ethnicity has been increasing in popularity in physical culture studies and sports economics. Recent studies have yielded mixed findings on this topic.

Methods: In response, we have conducted a comprehensive study utilizing a large, unbalanced panel dataset ranging from 1990 to 2023/4 season with 13,663 observations, to investigate the presence of pay discrimination. We employed a linear mixed-effects model, accounting for players' performance and personal characteristics, and treated players as random effects. Players were categorized by their ethnicity (White, Black, and Other) and geographical region (North America, Europe, and Other), resulting in a nine-level factor variable, including Black North America, White North America, Other North America, etc. The response variable we have here is salary cap adjusted salary.

Results: Descriptive results are shown in Figure 1 and Figure 2. The empirical results from the linear mixed effect model indicate that both White and Black European players receive a statistically significant higher salary compared to Black North American players, with all performance statistics and personal characteristics controlled (more details see in Table 1). A log-likelihood ratio test confirmed the overall significance (< 0.001) of the demographic group variable, suggesting the existence of salary discrimination among demographic groups.

Discussion/Conclusion: In conclusion, this study highlights the persistent issue of pay discrimination based on race and nationality within the NBA. The significant salary differences observed underscore the need for continued vigilance and proactive measures to ensure equity in professional sports. By acknowledging and addressing these disparities, the industry can move towards a more inclusive and fair environment for all athletes.

P21

The Relationship Between Early Success and Career Longevity in Competitive Figure Skating

Michelle Lee, University of Toronto; Joseph Baker, University of Toronto

Introduction: While early athletic development and success are often promoted and rewarded, it may increase an athlete's risk for injury, burnout and/or premature dropout. Broader athletic training in childhood has been linked to more elite achievement and career longevity. For example, the early career of a high-performing senior athlete is typically characterized by lower intensity main-sport practices, diversification of sport participation, later 'milestone' achievements, and reduced risks of injury, burnout and/or dropout.

Methods: The career trajectory of 391singles figure skaters from Ontario were analyzed. The data consisted of these skaters' competition results from their start (2006-2010) to conclusion in competitive singles figure skating. For this analysis, skating level, early versus late success, and career length were recorded.

Results: The average career length of all participants (N=391) was 2.59 years (SD=1.9), while skaters who achieved some level of success (N=26) competed for an average of 6.2 years (SD=3.1). The average career length of those with early success is 6 years (SD=2.6), and later success is 9.6 (SD=2.55). More specifically, the average senior career length of a skater with early success was 3.64 years (SD=2.4), in comparison to skaters with later success at 6.50 years (SD=2.3).

An independent sample t-test revealed a significant difference between the average career lengths of skaters who achieved either early success or later success ($p<0.001$, CI -5.8, -1.5). Similar results were found when examining the average senior career length of only athletes who competed at the senior level ($p=0.007$, CI -5.1, -0.64). In both groups, athletes with early success had a shorter career, while athletes with later success had a longer career.

Discussion/Conclusion: From an applied perspective, this research may have direct, practical implications for key decision makers by challenging perceptions that early performance is associated with later success and/or career longevity. Additional support may be required to promote career longevity in an early developing sport like figure skating.

P22

Malaysia Talent Plan (MyTP) in Sports: Development and Implementation

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Introduction: Since the 1980s, Malaysia has implemented various Talent Identification and Development (TID) programs, implemented across multiple agencies to nurture talents. These initiatives are essential for nurturing future champions through innovative technologies, evolving methodologies and proven studies. Globally, different models and talent plans have been established to enhance national sporting

potential, such as the Long-Term Athlete Development (LTAD) in Canada, the American Development Model (ADM), and the Foundation, Talent, Elite, Mastery (FTEM) frameworks in Australia and Japan. In Malaysia, stakeholders play a crucial role in identifying and developing potential talents. The Malaysia Talent Plan (MyTP) is a comprehensive guiding document tailored to Malaysia's needs and empower stakeholders to support the national sporting ecosystem and promote a vibrant sporting culture.

Methods: Feedback surveys were collected from representative stakeholders' groups (n=32) during the MyTP Strategic Planning workshop. Additionally, critical inputs were obtained through a series of Focus Group Discussions (FGDs) among 8 stakeholders' groups, including parents (n=6), athletes (n=8), sports clubs/community members (n=12), teachers and coaches (n=10), national sporting associations (NSAs) (n=67), government agencies (n=102), private sector representatives (n=16), and academicians (n=30). The study also recorded qualitative data through various interviews and controlled discussion sessions to ascertain the requirements of a national talent model suitable for Malaysia. Following a thorough analysis, a talent model was developed that is uniquely tailored to the Malaysian context, emphasizing the importance of inclusivity in sports culture and the spirit of contributing to the community.

Results: The analysis of the findings are summarised by the following salient outcomes:

• 93.8% (n=30) strongly agreed that Malaysia needs a guiding policy to consolidate talent development across communities.

• The importance of empowerment, inclusivity and collaboration between public and private bodies.

• The inclusion of Recreational & Leisure domain to harness potential talents of the broader public.

• The shift from focusing on athletes' post-career to encouraging them and other stakeholders to give back and contribute to the sports ecosystem.

• The national talent model must allow flexibility while maintaining a baseline code of conduct to ensure stakeholders can effectively implement their own TID programs.

As a result, the MyTP Model was developed to reflect on the aspirations and requirements collected throughout the engagements. The MyTP Model consists of four continuous stages and one domain (Recreational and Leisure) designed to create an inclusive sporting ecosystem that fosters both sports culture and high-performance sports. The 4 stages are as follows:

1. Initiation

2. Specialisation

3. Performance

4. Giving Back

Discussion/Conclusion: The Sports and Youth Ministry of Malaysia has set an ambitious target with the Road to Gold (RTG) initiative, aiming to secure Malaysia's elusive Olympic gold medal. Through MyTP, Malaysia has a strategic pathway for future generations to unleash their potential and embrace a sporting culture for an improved quality of life. By offering a holistic approach, the MyTP empowers stakeholders to develop their Talent Identification and Development (TID) programs, strengthening high-performance pathways and promoting sports culture as a lifestyle. The MyTP model aspires to build an inclusive and democratic framework that benefits all Malaysians.

P23

Psychological Considerations in Sports Talent Identification: A Review and Taxonomic Classification

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Introduction: The learning and acquisition of sports skills, as well as the performance of competition results, are all related to the appropriate psychological quality and personality characteristics of the athletes. A potential sportsperson is not only a natural entity, but also a social entity. So, the sports activity he/she performs is both physical (physiological activity) and mental, and the physiological along with psychological activities are unified, among them, psychological activities play a regulating, controlling, and dominating role in athletes' athletic vitality.

Methods: This study summarizes and categorizes the psychological factors that affect talent identification based on sports psychology and psychological characteristics by reviewing existing literature, thus improving the understanding of the regularity of TID and providing the theoretical basis for enhancing future sports talent identification programs.

Results: Due to the unique nature of psychological factors, compared with other qualities such as physiology, morphology, and genetics, there is a greater variability, and people usually cannot accurately predict and judge all psychological activities of a person. Based on the review and content, a taxonomic classification of psychological factors in talent identification can be proposed to better understand and get a handle on the psychological factors involved. On the whole, the above psychological factors can be divided into three categories, namely, psychological traits, motivation, and psychological ability. Among them, psychological traits include personality, temperament, mental toughness, and emotional intelligence. Motivation comprises intrinsic motivation, extrinsic motivation, self-esteem, and interest. Mental ability mainly contains general mental ability and specialized knowledge.

Discussion/Conclusion:

1. The psychological characteristics of each athlete are quite dissimilar, which will have a great impact on the development of one's sports career.

2. Physical and physiological indicators are significant in talent identification, but psychological factors should also be considered.

3. The proposed taxonomic classification of psychological factors in talent identification may allow researchers to improve or further develop the scales.

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