2021 CASEM Poster Presentations

(*Clin J Sport Med* 2021;31:e111–e130)

The Concussion and Injury Burden in Sledge Hockey: Considering Grassroots to Elite Participation

Alexandra J. Sobry,* Ash T. Kolstad, BSc,* Leticia Janzen, MSc,* Amanda M. Black, CAT(C), PhD,*,†,‡,§ and Carolyn A. Emery, PT, PhD*,†,‡,§,¶,||

*Affiliations: *Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada; †Alberta Children's Hospital Research Institute, University of Calgary, Calgary, AB, Canada; ‡O'Brien Institute for Public Health, University of Calgary, Calgary, AB, Canada; §Hotchkiss Brain Institute, University of Calgary, Calgary, AB, Canada; ¶McCaig Institute for Bone and Joint Health, University of Calgary, Calgary, AB, Canada; ||Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada; and **Department of Pediatrics, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada.*

Objective: Injuries in parasport are not well explored and may lead to detrimental effects in players with pre-existing disabilities. Previous parasport injury studies have focused on elite sledge hockey players across multiple winter Paralympics. Reported injury rates in sledge hockey are higher than other winter parasports. The objective of this study was to examine concussion and injury rates, location, type, mechanisms, and risk factors in sledge hockey.

Study Design: Cross-sectional survey.

Subjects: Sledge hockey players (ages ≥14 years) who played in the 2019 to 2020 season were recruited worldwide through email, social media and word of mouth communication.

Observation Technique: Sledge hockey players completed an online anonymous survey asking about concussion and injury history in the past year.

Outcome Measures: One-year injury rates (IR) and incidence rate ratios (IRR) with 95% Confidence Intervals (CI) were reported based on univariate Poisson regression analyses. Proportions of injury by type, location, and mechanism were described. Participants demographics (eg, age, sex, disability, level of play) were examined as risk factors for injury.

Results: Ninety-two players, across all levels of play (Junior/youth community level to National team players), initiated the survey from 3 countries (Canada 59, United States 31, South Korea 2) and 77 (84%) answered questions related to sledge hockey injuries. Forty-seven injuries including 16 concussions in 9/77 (12%) players and 31 non-concussion injuries in 20/77 (26%) players were reported. The overall IR was 13.2 injuries/1000 athlete-exposures (95% CI; 9.6-17.6). The game IR (28.4 injuries/1000 game-exposures, 95% CI; 18.6-41.7) was much higher than practice IR (4.4 injuries/1000 practice-exposures, 95% CI; 2.2-7.9) (IRR = 6.5, 95% CI; 3.1-14.5). The most common injury locations were the head (41%), wrist/hand (18%) and shoulder (13%). The most common injury types were concussion (44%) and bruising (10%). Body checking was the primary mechanism for concussion (56%) and non-concussion injury (27%). Age, sex, disability and level of play were not found to be injury risk factors.

Conclusions: Concussions and upper extremity injuries were the most common sledge hockey injuries reported, with body checking being the most common mechanism. This research will inform the development of prevention strategies in sledge hockey targeting concussions and upper extremity injuries.

Acknowledgments: The Sport Injury Prevention Research Centre is one of the International Research Centres for Prevention of Injury and Protection of Athlete Health supported by the International Olympic Committee. Carolyn Emery holds a Canada Research Chair in Concussion. Alexandra Sobry was funded through an Integrated Concussion Research Program, University of Calgary, summer undergraduate studentship.

Effectiveness of a Relative Energy Deficiency in Sport and Female Athlete Triad Education Module

Braeden Charlton, BSc,* Sara Forsyth, MD,†,‡ and David C. Clarke, PhD*

*Affiliations: *Department of Biomedical Physiology and Kinesiology, Simon Fraser University, Burnaby, BC, Canada; †Fraser Orthopaedic Institute, New Westminster, BC, Canada; and ‡Footbridge Centre for Integrated Orthopaedic Care, Vancouver, BC, Canada.*

Objective: To determine the baseline knowledge of Canadian coaches in a BC-Athletics-affiliated sample, and to determine the effectiveness of an online education module regarding the female athlete triad (Triad) and relative energy deficiency in sport (REDS).

Study Design: One-group pre-post test.

Subjects: Ethical approval for the study was obtained from the SFU Office of Research Ethics. We recruited participants from BC-Athletics-affiliated coaches aged 19-years-old and above and who coached athletes aged 13-years-old and above. Twenty-three participants (5 male, 18 female) completed the pre-intervention survey. Of those, seventeen participants (4 male, 13 female) also completed the education module and post-intervention survey.

Intervention: Participants completed an online pre-intervention survey, which included demographic questions, general knowledge questions regarding Triad and REDS, and Likert-scale questions pertaining to specific Triad or REDS risk factors. Subsequently, the participants completed an online education module designed to enhance knowledge of

http://dx.doi.org/10.1097/JSM.0000000000000932

Triad and REDS and to foster training environments that minimize the risks of both conditions. Participants then completed a post-intervention survey that was the same as the pre-intervention survey except that it was supplemented with 4 subjective questions regarding the effectiveness of the education module. Pre- and Post-intervention survey scores were compared using the Wilcoxon Signed Rank Test.

Results: In the pre-intervention survey, the participants listed a mode of zero components of the Triad and zero signs or symptoms of REDS. Following the education intervention, participants were able to list a mode of 3 components of Triad and 4 signs of REDS. Statistically significant differences were observed for 11 of 59 Likert-type questions between the pre- and post-intervention scores, representing improved scores for 19% of the questions. Participant feedback indicated that the education module was useful.

Conclusions: The participants demonstrated relatively high pre-intervention scores, yet post-intervention scores were still increased. We conclude that the online education module was effective.

Quadriceps Tendon Autograft for Primary PCL Reconstruction Results in Clinically Important Improvements and Low Revision Rates: A Systematic Review

Lauren A. Gyemi, BKin,* E. Dimitra Bednar, MSc,* Andrew J Sheean, MD,† Ryosuke Kuroda, MD, PhD,‡ and Darren de SA, MBA(c), MD§

*Affiliations: *Michael G. DeGroote School of Medicine, McMaster University, Hamilton, ON, Canada; † Department of Orthopaedic Surgery, San Antonio Military Medical Center, San Antonio, Texas; ‡ Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan; and §Division of Orthopaedic Surgery, McMaster University, Hamilton, ON, Canada.*

Objective: To summarize and assess the literature on use of the quadriceps tendon autograft in primary PCL reconstruction, with a focus on indications, functional outcomes, and complication profiles.

Data Sources: MEDLINE, Embase, Web of Science, and Cochrane Central Register of Controlled Trials were searched and screened in duplicate. Inclusion criteria were English language and human studies assessing the quadriceps tendon autograft in skeletally mature participants undergoing primary PCL reconstruction. Exclusion criteria were multiligamentous repairs, revisions, failure to stratify results by grafts, allografts, and absent primary data.

Main Results: Six articles met inclusion with 119 patients (21% female) and a total follow-up range of 12 to 84 months. Included studies demonstrated an increase in International Knee Documentation Committee (IKDC) scores from a preoperative range of 37.7 ± 21.4 to 39.5 ± 21 to a postoperative range of 74.5 ± 17.7 to 84.7 (± standard deviation not reported). Lysholm scores, Tegner activity scores, posterior drawer test, and activity levels also demonstrated an improvement postoperatively. No significant differences ($P < 0.05$) were found in the study that compared the quadriceps tendon autograft to the hamstrings tendon autograft. Included studies' revision rates ranged from 0% to 15% and included hardware removal (n = 4), manipulation under anesthesia (n = 2), arthroscopic arthrolysis (n = 2), and arthroscopic refixation (n = 2). Complication rates ranged from 13% to 65% and included moderate (n = 4) and mild (n = 4) knee pain, reflex sympathetic dystrophy (n = 3), joint space narrowing (n = 3), superficial wound infections (n = 2), complex regional pain syndrome (n = 2), and flexion deficiency (n = 2).

Conclusions: The use of the quadriceps tendon graft can be a safe and viable alternative in primary PCL reconstruction as it produced acceptable functional outcomes.

An Examination of the Barriers & Enablers in Implementation of a School-Based Concussion Policy in Ontario Elementary & Secondary Schools

Swapna Mylabathula,*,†,‡ and Charles Tator, MD, PhD*,†,‡

*Affiliations: *Faculty of Medicine, University of Toronto; †Canadian Concussion Centre, Toronto Western Hospital; and ‡Krembil Brain Institute, Toronto.*

Objective: Concussion is a major public health concern, and policies have been developed to address this. Concussions are frequent among school age children and adolescents and many occur in sports. The aim of the present study was to explore the methods, content, barriers, and facilitators to implementation of Canada's first provincial/territorial public policy on concussion, *Policy/Program Memorandum (PPM) 158: School Board Policies on Concussion* in Ontario. PPM158 was designed to prevent concussions and to improve the recognition and management of those that occur in elementary and secondary school students.

Study Design, Subjects, Observation Technique, and Outcome Measures: To evaluate the methods, content and implementation barriers and enablers of PPM158 in Ontario elementary and secondary schools, we developed an online questionnaire entitled the "Concussion Policy in Schools Questionnaire (CPSQ)" and sent it to 500 principals across Ontario. The final version of the CPSQ contains both multiple choice and open-ended questions, and thus analysis of the data required both quantitative and qualitative analysis. The Ontario Ministry of Education participated in this study.

Results: One hundred thirty-five principals responded to the CPSQ on behalf of their schools. In general, respondents cited many positive features about the implementation of regular concussion education including education of teachers, students, and coaches. However, there were some challenges identified such as difficulty providing education for parents and referees about concussion, obtaining notes from physicians, and the volume of paperwork associated with documentation of concussions required to comply with the policy. Recommendations were made for improvement such as consistency in the frequency and content of concussion education for stakeholders such as referees who currently do not receive such resources. Additionally, in response to the issue of the burden of paperwork and difficulties in communication between stakeholders, a centralized online documentation system was recommended to improve tracking of concussions in elementary and secondary school students.

Conclusions: Principals of elementary and secondary schools in Ontario reported that the implementation of concussion policies developed by school boards in compliance with PPM158 was generally successful. However, some difficulties in implementation were identified and suggestions were made to rectify current challenges. This information will

be useful for enhancing future concussion policy in Ontario and other jurisdictions.

Diagnosis and Management of Midfoot Arthritis in Adult Recreational Walkers

Gwyneth de Vries, MD

Affiliation: New Brunswick Medical Society, Fredericton, NB, Canada.

Objective: Symptomatic midfoot arthritis is present in 12% of adults. The aim of this study is to characterize midfoot arthritis presentations in the adult population of recreational walkers and to estimate the success rate of conservative management.

Study Design: Retrospective chart review.

Subjects: Adult recreational walkers with midfoot arthritis were studied in a Canadian community orthopaedic setting from 1 January 2018 to 30 November 2020.

Observation: Subjects were assessed by midfoot arthritis location, type of care (nonoperative or operative), and response to discussion of their diagnosis.

Outcome Measures: Return to recreational walking and satisfaction with precision of diagnosis.

Results: A total of 209 patients with midfoot arthritis were included (279 feet). Average age at diagnosis was 59 years (range 32-83); the majority were female (75%). Advanced imaging was performed (in addition to x-ray) in 87% of patients (85% Spect CT, 9% Nuclear medicine scan, 4% CT scan, and 2% MRI). Tarsal-metatarsal joint arthritis was the most common diagnosis (72%) with talonavicular, navicular-cuneiform and calcaneal-cuboid joint arthritis at 16%, 7% and 5% respectively. The average duration of symptoms prior to diagnosis was 8 months. In 12 patients (6%), symptoms and advanced degenerative change required surgical intervention with a relatively higher proportion of talonavicular and calcaneal cuboid joint involvement (3 feet each) represented. Eighty percent of patients with nonoperative management were confident to restart a recreational walking program following diagnosis and management. The remainder selected other activities. Specialist treatment duration averaged 5 months and 2.8 visits. Discussion of the precise diagnosis was helpful or reassuring to 91% of patients.

Conclusions: Patients with midfoot arthritis may experience significant time loss from recreational walking. An accurate clinical/radiographic diagnosis facilitates further symptomatic management (eg, orthoses, medication, surgery) and informs discussion of a return to walking for recreation or health promotion. Only a small proportion of patients required surgery (eg, fusion or debridement of the midfoot joints).

Acknowledgments: Victoria A. Smith.

Training Load, Non-training Stress and Odds of Injury and Pain in Collegiate Ice Hockey Athletes

Christian K. W. Mustapich, BKIN,* and Michael S. Koehle, MD, PhD*,†

*Affiliations: *School of Kinesiology, University of British Columbia, Vancouver, BC, Canada; and †Division of Sport and Exercise Medicine, Department of Family Practice, University of British Columbia, Vancouver, BC, Canada.*

Objective: To investigate training load (TL) and non-training stress (NTS) as contributors for injury and pain in university-level male ice hockey athletes.

Study Design: Prospective cohort study.

Subjects: Twenty-six male ice hockey athletes, aged 20 to 26.

Observation Technique: During one competitive season, subjects responded to a daily online survey which recorded scores for "Non-Training Stress," "Low Back Pain," and "Hip/Groin Pain." Following on-ice training and competition sessions, a "Rating of Perceived Exertion" score was manually collected from each athlete, which was multiplied by the duration of the session in minutes to determine a TL value. Additionally, team training staff recorded all athletic injuries which were diagnosed by a team physician or therapist and which caused the athlete to miss or modify at least one on-ice session.

Outcome Measures: The outcome measurements were: Incidence of injury, severity of low back pain and severity of hip/groin pain. Daily sums of TL and NTS scores were calculated for the 2-day and 2-week periods preceding each on-ice session. Odds ratio analyses were then used to determine the relative odds of the occurrence of injuries given levels of TL and NTS experienced over the aforementioned time periods. The same method was used to determine the relative odds of experiencing significant hip/groin or low back pain given exposure to TL and NTS.

Results: Athletes who experienced moderate and large 2-day TL were at significantly ($P < 0.05$) greater odds of injury compared to lower quartile TL groups. Moderate 2-week TL was significantly related to increased odds of significant hip/groin pain, while larger 2-week TL was significantly related to decreased odds of significant low back pain. Moderate 2-day and 2-week NTS scores were significantly related to decreased odds of significant hip/groin pain. However, larger 2-week NTS scores were significantly related to increased odds of both significant hip/groin pain and significant low back pain.

Conclusion: These findings indicate that monitoring individual TL and NTS scores are helpful to guide training programs for elite male ice hockey players in order to reduce the odds of injury and significant hip, groin and low back pain.

Saskatchewan Dance Teacher Demographics and Practice

Madison Rajchyba, BFA, ARAD, Amanda Kleisinger, MD, FRCPC, and Muhammad Siddiqui, PhD

Affiliation: University of Saskatchewan College of Medicine, Saskatchewan Health Authority (SHA).

Objective: To explore the profile of dance teachers such as age, sex, location, dance and teacher training and experience, teaching volume, work or education outside of dance, style of dance, number of studios, and recommendations to their students for accessing the health care system.

Study Design: This is a cross-sectional exploratory survey. Data was gathered using electronic questionnaires distributed via email and social media available from January 1 to February 24, 2020.

Subjects: Eighty-seven teachers from any genre completed the questionnaire with a mean age of 33.11 ± 10.8 (range 18-73) years.

Results: 82.8% respondents have obtained a qualification or certificate to teach, therefore, 17.2% teach dance without certification. ($P < 0.001$) Royal Academy of Dance (RAD) was the most common technique taught without obtaining qualification at 13.8%, and Canadian Dance Teachers Association (CDTA) 10.3% was second. 43.7% do not teach without first obtaining a formal certification, which means 56.6% teach dance technique without certification. (*P*-0.51). Of all respondents, only 36.4% have more than 1 year of professional dance experience, therefore, 63.6% have less than or equal to 1-year experience as a professional dancer. ($P < 0.001$) 68.9% of dance students are less than 18 years old. ($P < 0.001$) 50% of teachers do not have a process for reporting injuries, 46.7% do not have a protocol for injury recovery, and 20% do not modify classes for that injured dancer.

Conclusions: There is a variety of dance genres being taught. A significant number of teachers do not obtain certifications and a large majority do not have professional dance experience. Most dancers are under the age of 18 years. Half of the respondents do not have a reporting process or protocol for injured dancers. Further research with a larger sample size and a multicentre setting is warranted to explore dance teaching practices and injury prevention protocols to learn how to keep dancers safe.

Acknowledgments: We recognize the Saskatchewan Academy of Sport Medicine for their grant, Dance Saskatchewan for their help with distribution, and the SHA Regina Ethics Board for ethics approval.

The Role of Body Checking in Youth Hockey as a Cause of Concussion and Persisting Concussion Symptoms

Charles H. Tator, MD, PhD, and Victoria H. Blanchet, BSc (Hons)

Affiliation: Canadian Concussion Centre, Krembil Brain Institute, Toronto Western Hospital, University of Toronto.

Objective: To investigate the prevalence of concussion and persisting concussion symptoms (PCS) from body checking in comparison to other mechanisms (including falling, fighting, or being struck by an object such as a puck or stick) among Canadian youth ice hockey players.

Data Sources: A retrospective chart review of 87 youth ice hockey players age 10-18 years who sustained a concussion while playing hockey and were referred to the Canadian Concussion Centre, Toronto Western Hospital, Canada.

Main Results: Of the 87 players, 34 (39.1%) were concussed by a body check after which 24 (70.6%) also developed PCS. The prevalence of PCS was greater among other mechanism of concussion (86.8%) than for body checking. Those who were concussed by a body check had known duration of symptoms with a median and IQR of 4.00 [2.75, 14.50] months, with one case lasting at least 14 years. Those who were concussed by other mechanisms had known duration of symptoms with median and IQR 5.25 [3.00, 12.00] months. The incidence of PCS after body checking occurred in all age groups: 83% of players in the 13-14-year-old category, and 69.2% in the 17-18-year-old category suffered from PCS.

Conclusions: Body checking in youth ice hockey is a major risk factor for concussion and PCS, and concussed players who develop PCS from a body check can have symptoms lasting years. Despite being a single mechanism of injury, body checking results in a substantial proportion of concussions among youth ice hockey players. If the age of permitted body checking had been raised in this cohort of 34 players, the number of concussions and subsequent PCS due to body checking could have been reduced dramatically. The current policy of Hockey Canada and USA Hockey to introduce body checking at age 13-14 should be revised upwards in accordance with known risk data.

Acknowledgments: Thank you to Jin Ma, Mozhgan Khodadadi, and Connor Moore for their expertise and contribution to this research.

Development of Virtual Musculoskeletal Physical Examination Guides for Healthcare Providers and Patients

Alessandro Francella MD, Sari Kraft MD, Fahim Merali MD, and Neil M Dilworth, MB, BAO BCh

Affiliation: University of Toronto, DFCM.

Objective: To develop guides for the virtual physical examination of the musculoskeletal (MSK) system for physicians, physiotherapists and patients to improve virtual care during the COVID-19 pandemic.

Study Design: Expert consensus and surface anatomy design were used for initial draft of guides. Drafts were then distributed to a larger group of experts for feedback. Once finalized, webpages were created for the guides and contained both an HTML version as well as the pdf version of the guide. AWstats were used to determine number of guide downloads.

Subjects: Patients, physicians, and physiotherapists using virtual video consultation software for assessing MSK complaints

Intervention: Patient and provider virtual MSK examination guides

Outcome Measures: Completion of a provider virtual MSK examination guide, and a finalized patient virtual MSK examination guides, and uptake of these guides by measuring number of downloads.

Results: Both provider and patient guides were completed and finalized on May 10, 2020 and April 30, 2020 respectively. The patient guide was divided into upper and lower extremity MSK examination guides. Each guide is organized based on a regional joint examination. As of December 31, 2020, the provider guide to virtual MSK examination, a 26-page document with labelled surface anatomy figures, had been downloaded 203 times. The patient guide to the virtual MSK examination consists of an upper extremity guide and a lower extremity guide. Both are 4-page documents containing 11 to 12 surface anatomy images numbered and marked to identify examination points. The patient guides were downloaded 156 and 102 times for the upper and lower extremity versions respectively.

Conclusions: The provider and patient MSK examination guides are now available free online: http://sportmedschool.com/virtual-care-sports-medicine-physical-examination-physician-guide/ and http://sportmedschool.com/virtual-care-sports-medicine-examination-patient-guide/. They provide a comprehensive guide for both the provider and the patient to follow a MSK examination virtually, which is more frequently the situation during this COVID-19 pandemic. The guides are currently being used by the Sunnybrook Health Sciences

Centre emergency department team for their virtual emergency room project: https://sunnybrook.ca/media/item.asp?i=2228&f=virtual-emergency-department-ed, and for teaching Physical Medicine and Rehabilitation residents at the University of Toronto. Future steps include developing video demonstrations of each examination and surveying provider and patient users for constructive feedback.

Effects of a 12-Week Resistance Training Program on Anthropometry, Strength and Muscle Quality in Younger and Older Untrained Males

Dean M. Cordingley, MSc,*,† C. Nolan Turnbull, BSc,‡ Connor J. Duncan, BSc,‡ Zachariah J. Henderson, MSc,* Judy E. Anderson, PhD,§ and Stephen M. Cornish, PhD*,‡,¶

*Affiliations: *Applied Health Sciences, University of Manitoba, Winnipeg, MB R3T 2N2, Canada; †Pan Am Clinic Foundation, 75 Poseidon Bay, Winnipeg, MB R3M 3E4, Canada; ‡Faculty of Kinesiology and Recreation Management, University of Manitoba, Winnipeg, MB, R3T 2N2, Canada; §Faculty of Science, University of Manitoba, Winnipeg, MB, Canada; and ¶Centre for Aging, University of Manitoba, Winnipeg, MB, R3T 2N2.*

Objective: To investigate differences in anthropometry, strength and skeletal muscle quality before and after a twelve-week resistance training program in younger and older adults.

Study Design: A parallel group cohort design.

Subjects: Eight younger (24.7 ± 3.9 yrs) and seven older (68.3 ± 4.6 yrs) untrained males participated in the study. Untrained was defined as participating in ≤ 1 structured resistance exercise session per week.

Intervention: One repetition maximum (1RM) strength testing was performed before and after a 12-week training intervention. Participants completed a supervised 12-week, progressive, whole body resistance training program 3 days per week.

Outcome Measures: Participant body mass (kg), body mass index (BMI; kg/m^2), percent body fat (%BF; %), fat mass (FM; kg), and fat free mass (FFM; kg) were assessed. Maximal strength for chest press (kg), leg press (kg), seated row (kg), leg extension (kg) and shoulder press (kg) were determined and average strength and muscle quality [average strength(kg)/FFM(kg)] were calculated.

Results: Main effects of training status were identified for FFM (*mean difference* = 1.1 kg, $P = 0.03$), %BF (*mean difference* = 1.0%, $P = 0.03$), 1RM strength for all muscle groups (all $P < 0.001$), average strength (*mean difference* = 28.7 kg, $P < 0.001$) and muscle quality (*mean difference* = 0.39 kg/kg FFM, $P < 0.001$) with variables improving with training. Main effects of age group were identified for chest press (*mean difference* = 35.5 kg, $P = 0.002$), seated row (*mean difference* = 19.6 kg, $P = 0.04$), shoulder press (*mean difference* = 26.7 kg, $P = 0.003$), average strength (*mean difference* = 26.4 kg, $P = 0.04$), and muscle quality (*mean difference* = 0.33 kg/kg FFM, $P = 0.04$) with the younger participants having greater strength and better muscle quality. Interaction effects (training status × age group) were found for BMI ($P = 0.04$), body mass ($P = 0.03$), and fat mass ($P = 0.04$).

Conclusions: The 12-week resistance training program was sufficient to improve %BF and FFM, and induce gains in maximal strength and skeletal muscle quality for both the younger and older participants. It is interesting to note that the older adults had less strength compared to the younger participants in the upper body strength tests, but there were no differences observed in the lower body tests. These age differences should be considered when resistance training programs are created for clients of various ages.

Acute Concussion Versus Post-concussion Syndrome (PCS): Comparing Presentation and Recovery Timelines Under Sports Medicine Care

Sheharzad Mahmood, BHSc,*,† Ann-Marie Przyslupski, MSc,*,† Teresa DeFreitas, MD,*,† Martin Mrazik, PhD, R.Psych,*,‡ and Constance Lebrun, MD*,†

*Affiliations: *Glen Sather Sports Medicine Clinic, Edmonton, AB, Canada; †Department of Family Medicine, University of Alberta, Edmonton, AB, Canada; and ‡Department of Educational Psychology, University of Alberta, Edmonton, AB, Canada.*

Objective: To compare and contrast presentation and subsequent recovery of acute concussion (<90 days to resolution) versus chronic post-concussion syndrome (PCS; ≥ 90 days to resolution), and to identify potential factors for PCS prevention.

Study Design: Retrospective chart review.

Subjects: Patients with concussion treated by sport and exercise medicine physicians at the Glen Sather Sports Medicine Clinic (January 2015–December 2019).

Intervention/Observation Technique: Electronic patient chart reviews (HealthQuest). Concussion injuries were identified by diagnostic code and subdivided into acute and PCS by time from injury to first appointment.

Outcome Measures: Age, sex, referral provider, diagnostic imaging, wait-times, Standardized Concussion Assessment Tool (SCAT) scores, prescribed therapies, recovery timelines (work/school/sport).

Results: In total, 496 patients (male: n = 289, female: n = 207; age: 19.7 ± 9.4 years) presented with 561 concussions over 1471 visits. Acute concussions comprised 86.9% (n = 491) of injuries; 12.5% (n = 67) were identified as PCS; 3 (0.5%) were N/A. Patients with PCS diagnoses were more likely to be female (RR = 1.4), ≥25 years-of-age (RR = 2.8), and had undergone prior diagnostic imaging ($X^2 = 24.2$, $P < 0.00001$). Family physicians were the most frequent referral provider for both concussion types (acute: 58.1%, PCS: 76.1%). Median injury-to-appointment time was 11.0 days for acute concussion compared to 182.0 days for PCS. Initial total SCAT symptom scores were significantly greater in PCS patients (56.0 ± 33.0) compared to acute concussion patients (39.8 ± 31.9; $P < 0.00001$); symptoms most commonly reported included headache, difficulty concentrating, and fatigue or low energy. Therapies (eg, medication, intervention, referral) were prescribed in 73.1% of PCS visits compared to 44.2% of acute injury visits ($X^2 = 88.6$, $P < 0.00001$). Mean recovery timelines for return to work (148.2 days), school (68.0 days), and sport (211.0 days) were significantly longer for PCS patients than for those with acute concussion, who averaged 32.3 days, 11.3 days, and 27.7 days respectively for return-to-work, school, and sport ($P < 0.00001$).

Conclusions: Our findings of the incidence and presentation of PCS agree with current literature and further demonstrate significant delays in this population regarding return-to-work/school/sport. Continued concussion injury prevention efforts are warranted for all, especially female and adult athletes. Supplementary concussion education for family physicians may help optimize initial management and shorten delays in seeking specialist consultations.

Acknowledgments: We would like to thank the Glen Sather Sports Medicine Clinic, Alberta Innovates, and the Northern Alberta Academic Family Medicine Fund for supporting this study.

Timelines of Concussion Injury Treatment and Return to Participation of Patients Presenting to a Community Physiotherapy Clinic

Codi Isaac, PT,*,† Megan Ogle, MSc, Mec, Eng,*,‡ Calla Isaac, BSc,*,§ Ann-Marie Przyslupski, MSc,†,‡ and Constance Lebrun, MD†,‡

*Affiliations: *Isaac Physiotherapy, Edmonton, AB, Canada; †Glen Sather Sports Medicine Clinic, University of Alberta, Edmonton, AB, Canada; ‡Department of Family Medicine, Faculty of Medicine & Dentistry, University of Alberta, Edmonton, AB, Canada; and §Brown University, Providence, Rhode Island.*

Objective: To compare patient demographics, mechanism of injury (MOI), injury phase, changes in total symptom severity (TSS) scores, and return to participation survival rates to recovery timeframes.

Study Design: Retrospective chart review.

Subjects: Two hundred thirty-four patients with concussion injury (male: n = 84; female: n = 149) with various MOIs attended this community physiotherapy clinic (01/09/2016-31/08/2018). Age groups (in years): children 8-12, youth 13-17, young adult 18-29, adult 30-64, senior 65+.

Intervention/Observation Technique: Multimodal physiotherapy (cervico-vestibular, exertion, education), referral to specialist physician, psychology and/or neuropsychology.

Outcome Measures: Treatment number, treatment timeframe (weeks), weeks to recovery from injury, return to participation rates.

Results: Treatment timelines were shortest for children (6.95 weeks; 95% CI [2.25-11.65]) and longest for seniors (23.48 weeks; 95% CI [9.38-37.00]). Our average times-to-recovery for young adults (28.03 weeks; 95% CI [18.51-37.55]) and adults (36.97 weeks (95% CI [29.60-44.35]) challenge literature reports of a 10-14 day recovery timeframe for adults. No statistical difference was observed between males and females regarding time to recovery from injury, however females attended more treatments over more weeks (males: 6.54 ± 5.70 treatments over 8.68 treatment weeks (95% CI [6.45-10.91]); females: 8.62 ± 6.61 treatments over 13.73 weeks (95% CI [11.40-16.07])). Those in both the child/youth and adult groups with chronic concussion symptoms required the longest treatment timeframe (16.17 weeks (95% CI [11.60-20.74]) and 19.02 weeks (95% CI [13.58-24.46), respectively). Motor vehicle collision MOI required the greatest time-to-recovery (12.29 ± 8.29 treatments over 20.95 treatment weeks (95% CI [17.03-24.88])). Sport MOI had the shortest time-to-recovery (5.51 ± 3.64 treatments over 7.02 treatment weeks (95% CI [5.47-8.58])). Overall, TSS scores of 80% of patients decreased between intake and discharge; 20% were the same or higher. Approximately 75% of patients had a full return to work/learn and 68% had a full return to the same level of activity within the study period.

Conclusions: Concussion patients seeking community physiotherapy treatment experienced symptom, function, and participation recovery. Treatment and recovery timeframes were considerably longer than reported in the literature. Our results will aid in expanding generalizability, appropriateness, and implementation of pragmatic physiotherapy interventions for acute and chronic concussion care management pathways.

Using a Sport and Exercise Medicine Instant Messaging Group to Improve Sport Injury Treatment and Rehabilitation Access

Neil M Dilworth, MB, BAO BCh, Alessandro Francella, MD, Sari Kraft, MD, and Mark Leung, MD

Affiliation: University of Toronto, DFCM.

Objective: To determine the effectiveness of an instant messaging chat group for networking amongst sport and exercise medicine physicians in the Greater Toronto Area

Study Design: Retrospective Software Review

Subjects: Twenty-six sports and exercise medicine physicians (17 males and 9 females) with a range of <1 year to >30 years in independent practice.

Intervention: The use of WhatsApp (an instant messaging group chat software) for querying sports and exercise medicine related topics: cases, referrals, resources, news, sports news, billing and journal articles.

Outcome Measures: Rate of response, variety of queries, number of cases, number of clinical questions, number of respondents/queries, number of responses per query.

Results: The data was collected from the exported messages archive from January 13, 2020 to December 31, 2020. The size of the group increased from 7 members in January to 26 members by December. A total of 191 queries from 8 categories were contributed by all 26 members of the group. The majority of queries (41.4%) were referral information for accessing specialists, investigations and rehabilitation for patients, followed by clinical questions (22.5%) and cases (12.5%). The mean response time per query was less than an hour (52.7 minutes) with a mean of 6.9 responses and 3.0 respondents per query. Only 3.3% of Cases, clinical questions, and request for referral information went unresponded. The most common topic for queries was COVID (8.4% of all queries), followed by Spine (7.9%), physiotherapy referral information (6.8%), knee (6.3%), and then education (5.7%).

Conclusions: The crowdsourcing application of an instant messaging group software allowed for rapid exchange of regional-specific referral information, as well as timely responses to point-of-care clinical questions and case discussions. The future applications of this kind of project include using data to compile a referral database, as well as using this for other geographical regions, including the potential for a national sports medicine instant messaging group.

A Combined Surgical Approach of Concomitant Femoroacetabular Impingement (FAI) and Core Muscle Injury (CMI) Is Safe and Offers a Speedy Return to Play

Alexander E. Poor, MD,*,†,‡ James P. Villamere, MD,* Struan H. Coleman, MD,*,§ John P. Salvo, MD,¶ Eric J.

Kropf, MD,‖ Johannes B. Roedl, MD,*,** Adam C. Zoga, MD,** and William C. Meyers, MD*,†,‡,††

*Affiliations: *Vincera Institute, Philadelphia, PA; †Department of Surgery, Thomas Jefferson University, Philadelphia, PA; ‡Department of Surgery, Drexel University College of Medicine, Philadelphia, PA; §Hospital for Special Surgery, New York, NY; ¶Rothman Orthopaedic Institute, Philadelphia, PA; ‖Department of Orthopaedic Surgery, Temple University; **Department of Radiology, Divisions of Musculoskeletal Imaging and Interventions, Thomas Jefferson University Hospital, Philadelphia, PA; and ††Department of Surgery, Duke University School of Medicine, Durham, NC.*

Objective: To establish the incidence of combined hip and core muscle injuries and determine the safety and effectiveness of concomitant surgery for femoroacetabular impingement and core muscle injuries at a specialized sports medicine institution, where the primary focus is an integrative approach to these injuries.

Study Design: Retrospective, descriptive cohort study.

Subjects: One thousand six hundred sixteen consecutive patients who were evaluated for suspected core muscle injuries were included in analysis. All of them were evaluated by x-rays of the hip and pelvis, MRI a *core* protocol, and a detailed history and physical examination. Differential musculoskeletal injections were commonly used to further characterize the contribution of multiple core structures. Two hundred eighty-five patients (18%) had combined hip and core muscle injuries. Of these 245 had combined hip and core muscle surgery.

Intervention: Combined surgery for femoroacetabular impingement and core muscle injuries.

Outcome Measures: Hip Outcomes Scores, Modified Harris Hip Scores, Core Performance Score with 6-month return to play, and surgical complications.

Results: All patients who underwent combined hip and core muscle surgery had improvements in Hip Outcomes Scores and Harris Hip Scores. Of the 226 athletes (19 were treated for work-related injuries) who had combined hip and core muscle surgery, 206 (88%) returned to play within 6 months of surgery. There were complications in 6/245 (2.4%) combined cases: 1 pulmonary embolism, 2 hematomas, 2 patients observed overnight for postoperative nausea, and 1 case of joint capsule heterotopic ossification.

Conclusion: Femoroacetabular impingement and core muscle injuries often occur concomitantly, especially in athletes. Combined surgery is a safe way to treat these injuries with prompt return to play. Correcting both problems in the same operative setting offers advantages such as less anesthesia, consolidated rehabilitation "down" time, and no unaddressed injuries.

Fitness Adaptations Do Not Occur Equally During the "In-season" and "Off-season" Phases for Adolescent Ice-Hockey Players

Dean M. Cordingley, MSc,*,† and S. McRae, PhD*,‡

*Affiliations: *Pan Am Clinic Foundation, 75 Poseidon Bay, Winnipeg, MB R3M 3E4, Canada; †Applied Health Sciences, University of Manitoba, Winnipeg, MB R3T 2N2, Canada, and ‡Department of Surgery, University of Manitoba, Winnipeg, MB R3T 2N2, Canada.*

Objective: A traditional year for a hockey player consists of both an "in-season" and "off-season" phase. The aim of this study was to identify the fitness changes which occur in adolescent male ice-hockey athletes over the course of a year, and compare percent change which occur during the in-season (September-March) and the off-season (April-September).

Study Design: Longitudinal cohort design.

Subjects: Seventy male ice-hockey players (age, 12-17 years) from a local top-level league who participated in all required fitness testing sessions were included in the analyses.

Intervention: Fitness testing was conducted in a combine format in September 2018, March 2019, and September 2019. The period between the September 2018 and March 2019 was considered the "in-season," and between March 2019 to September 2019 was considered the "off-season."

Outcome Measures: Height, body mass, and body fat measurement were assessed. Wingate anaerobic tests were performed to determine peak and average power output (PO), and maximal push-ups, broad jump, sit and reach flexibility, and grip strength were performed.

Results: Over the course of a year the following variables changed to a greater extent during the off season: height (In-season = 22.1% vs. Off-season = 77.9%, $P < 0.001$), absolute peak PO (In-season = –8.6% vs. Off-season = 108.6%, $P < 0.001$), relative peak PO (In-season = 10.4% vs. Off-season = 89.6%, $P < 0.001$), absolute average PO (In-season = -37.8% vs. Off-season = 137.8%, $P = 0.001$), relative average PO (In-season = -115.5% vs. Off-season = 215.5%, $P = 0.002$) and flexibility (In-season = -0.6% vs. Off-season = 100.6%, $P = 0.04$). However, push-ups (In-season = 62.0% vs. Off-season = 38.0%, $P = 0.001$) changed more during the in-season. There was no difference in change between season for body mass, body fat, broad jump and grip strength. Over one full year (September 2018-September 2019) changes were observed in height ($P < 0.001$), body mass ($P < 0.001$), absolute peak PO ($P < 0.001$), relative peak power ($P = 0.036$), absolute average PO ($P < 0.001$), broad jump ($P < 0.001$), flexibility ($P < 0.001$) and grip strength ($P < 0.001$). There was no change in body fat, relative average PO and push-ups.

Conclusion: The magnitude and direction of change in each variable differed between seasons. These results should be considered when creating training programs for adolescent hockey players to ensure optimal fitness is obtained during both phases of the year.

The SETPACE Trial: Stroke Survivors Impressions of the Education and Teaching Provided Regarding Physical Activity, and Patient Confidence Regarding Exercise

Christopher Wavell, BSc(Kin),*,† Stephanie Marrocco, MSc,§ Rozhan Momen, BSc (cand),* and Steven Macaluso, MD‡,§

*Affiliations: *The University of Western Ontario, London, ON, Canada; †Schulich School of Medicine and Dentistry, Western University, London, ON, Canada; ‡Department of Physical Medicine and Rehabilitation, Western University, London, ON, Canada; and §Lawson Health, Parkwood Institute, Main Building, London, ON, Canada.*

Objective: The purpose is to assess patient exercise participation, self-efficacy, and impression of the exercise education provided post-stroke.

Study Design: Cross-sectional survey of stroke outpatients. Patients completed questionnaires at a stroke rehabilitation follow-up appointment or via telephone. The questionnaires used included an Exercise Impression Questionnaire (EIQ), The Physical Activity Scale for Individuals with Physical Disabilities (PASIPD), and Self-Efficacy for Exercise (SEE).

Subjects: Eighteen years of age and/or older diagnosed with stroke and receiving care at Parkwood Institute. All patients identified based on their diagnosis of stroke were eligible pending they did not meet any of the following exclusion criteria: Individuals who have significant cognitive impairment inhibiting their ability to complete the questionnaires, and/or are unable to speak or read in English. Patients were eligible to participate regardless of how long it had been since their stroke.

Intervention: Not applicable.

Outcome Measures: Self-reported knowledge of exercise (EIQ), self-efficacy in overcoming potential barriers to exercise (SEE), and overall activity levels (PASIPD).

Results: Fifty-three participants (27 male), mean age 64 (STD 13.9). The EIQ revealed the majority of stroke survivors had high self-reported confidence in "Knowing different ways to exercise with their currently level of function," "Feeling exercise is an important part of rehabilitation," "Understanding potential risks of not exercising," "They received enough education regarding exercise," and "Their questions were answered regarding exercise." Lower rates of confidence were reported in patients' knowledge of "Canadian stroke exercise guidelines," and familiarity of "Community resources for exercise." Participants recorded a mean of 17.5 MET hr/day of activity (STD 16.8) on the PASIPD. The most impactful barriers to exercise reported by participants on the SEE included if "They felt depressed," "Did not enjoy the activity," "Felt tired," or "Experience pain with the activity."

Conclusion: Stroke survivors self-report confidence in most areas of their knowledge of physical activity and exercise. Participants' levels of activity are comparable to populations with disabilities reported in the literature. Improving patient knowledge of exercise guidelines, community resources, and recognizing barriers to exercise including depression, fatigue, and pain are potential areas for improvement.

Acknowledgments: Funding provided by the Department of Physical Medicine and Rehabilitation, Schulich School of Medicine & Dentistry, Western University.

Peep the Process—A Sport and Exercise Medicine Podcast for Canadian Student Athletes

James D. Carson, MD,* Emma C. Jacobs,† Enrica M. Ammaturo, BA BEd, and Carolyn V. Smith BA

*Affiliations: *University of Toronto, Toronto, ON, Canada; and †Trent University, Peterborough, ON Canada.*

Objective: To develop a sport and exercise medicine (SEM) educational resource for high school, college and university student athletes. The focus was upon the process of injury prevention and management plus mental health during the COVID-19 pandemic.

Study design: public and medical education innovation.

Subjects: Target audience—Canadian student athletes; as a secondary target: family medicine residents and senior medical students.

Intervention: From June through September 2020, a SEM physician and 2 producers published a weekly podcast Peep the Process. Twelve episodes included understandable, pertinent and relatable conversation and featured a guest, either an athlete affected by the pandemic or a SEM support team member. Expertise was shared on a wide range of topics from sports injury management to mental health, and to the experience of 3 Paralympic athletes whose participation in the 2020 Tokyo Paralympics was interrupted by the pandemic. The podcast was published to stream on different platforms and was marketed to listeners via social media and the CASEM Newsletter. We studied the podcast development focusing upon the process, content, listener feedback, and applicability for medical learners. Target audience questions were incorporated allowing for audience engagement. Ten typical stakeholders on an advisory committee were asked to complete a feedback survey after each episode.

Results: There were 444 downloads by December 2020 from the Buzzsprout website. Seneca College reported 910 views from its Varsity Instagram account. Typical listener comments included: "The interview was easy to follow, the guest speaker was interesting and down to earth for a student audience. Good recommendations and content that student athletes can apply to their lives." Another stated: "Was very happy to hear mention that there's not one specific treatment or one specific thing that goes into resolving an injury—this is so important for the student athletes to hear."

Conclusions: This podcast acted as an educational resource for anyone involved in a student athlete's life especially during the pandemic. This podcast helped inform medical learners about managing student athletes' biopsychosocial concerns.

Acknowledgments: A grant was received from the Scarborough Health Network. In kind support was provided by Seneca College and CASEM.

Value, Limitations and Recommendations for Use of Metal-Reduction Knee MRI Sequences Following Anterior Cruciate Ligament Reconstruction

Brandon Y. H. Zhao, BScH,* Nabil A. Khan, MBChB, MMED, FCS Orth,‡ Mark F. Sommerfeldt, MD, FRCSC, MPH, Dip. Sport Med,‡,§ Anukul Panu, MD, FRCPC,† Jacob L. Jaremko, MD, PhD, FRCPC,† and Catherine Hui, MD, FRCSC‡

*Affiliations: *Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada; †Department of Radiology and Diagnostic Imaging, University of Alberta, Edmonton, AB, Canada; ‡Division of Orthopedic Surgery, University of Alberta, Edmonton, AB, Canada; and §Glen Sather Sports Medicine Clinic, University of Alberta, Edmonton, AB, Canada.*

Objective: No study to date has evaluated the utility of MRI with metal artifact reduction sequencing (MARS) In the assessment of ACL grafts. MRI assessment of ACL graft integrity following ACL reconstruction is challenging due to magnetic susceptibility artifacts distorting or obscuring the graft and tunnels. The purpose of this study is to determine whether MRI with MARS is superior to conventional knee MRI in visualization and diagnostic accuracy for ACL graft rupture.

Study Design: Retrospective case series.

Subjects: Eighteen patients, 19 knees (male, 6; female, 12; age, 33 ± 11.9 years).

Intervention: Patients underwent conventional MRI sequence (PD) and 2 types of MARS MRI (WARP, SEMAC, Siemens) following secondary injury to their ACL reconstructed knee.

Outcome Measures: Six readers with knee MRI experience reviewed sagittal PD, WARP and SEMAC sequences, providing semi-quantitative grades for visualization and diagnostic confidence regarding ACL, PCL, menisci, tibial and femoral tunnel margins, and articular cartilage.

Results: Compared to PD, WARP improved visualization of ACL (mean semi-quantitative score 3.79 vs 3.96, $P = 0.009$), femoral tunnel (3.70 vs 4.01, $P = 0.001$), and tibial tunnels (3.56 vs 3.92, $P < 0.0001$), although at the cost of poorer visualization of femoral articular cartilage (4.70 vs 4.59, $P = 0.033$), tibial articular cartilage (4.70 vs 4.58, $P = 0.022$), medial meniscus (4.75 vs 4.53, $P = 0.001$), and lateral meniscus (4.72 vs 4.56, $P = 0.026$). SEMAC performed similarly to WARP, except that WARP provided significantly better visualization of cartilage and menisci than SEMAC ($P < 0.00001$ each). Diagnostic confidence of ACL integrity was significantly improved over PD for both WARP (1.70 vs 2.17, $P = 0.034$), and SEMAC (1.70 vs 2.61, $P = 0.032$). There was no significant difference in diagnostic confidence between WARP and SEMAC ($P = 0.071$). There was no significant difference in the interobserver reliability between each sequence. The WARP sequence added 2.84 ± 0.69 minutes while SEMAC added 2.95 ± 0.40 minutes to the standard knee MRI scan time.

Conclusion: Use of metal artifact reduction sequences (WARP and SEMAC) significantly improved diagnostic accuracy and confidence in detection of ACL graft tears. When the key clinical question is ACL graft integrity, our study supports adding a WARP sequence to the routine knee MRI scan protocol.

MSK Matters—A Sport and Exercise Medicine Podcast for Canadian Medical Learners

James D. Carson, MD,* Emma C. Jacobs,† Enrica M. Ammaturo, BA, BEd, Julianne K. Falconi, MD,* and Alexandra S. Rendely, MD*

*Affiliations: *University of Toronto, Toronto, ON, Canada; and †Trent University, Peterborough, ON Canada.*

Objective: To develop a knowledge translation tool and educational resource to teach Canadian medical learners sport and exercise medicine (SEM) topics, to fill the gap of missed electives due to clinic closures during COVID-19.

Study Design: medical education innovation.

Subjects: Target audience—family medicine residents, physiatry residents and senior medical students.

Intervention: We studied podcast development, focusing upon the process, content, listener feedback, outside support and feasibility. From June through September 2020, a SEM physician along with his family medicine resident and production team produced a podcast called MSK Matters. Season one consisted of 12 episodes featuring a variety of guests spanning the entire SEM support team. The podcast was published across multiple streaming platforms and was marketed to listeners via social media and the Canadian Academy of Sport and Exercise Medicine (CASEM) newsletter. A 5 person advisory committee provided anonymous feedback via surveys after the release of each episode for continued podcast improvement. We received excellent in kind support from the Scarborough Health Network and CASEM.

Results: The content strived to mimic the discussion between resident and preceptor at a SEM teaching clinic. Each episode centered around a high yield SEM topic commonly seen in practice. The resident interviewed a standardized patient, and was blind to the case presented. The discussion led to host and guest experts offering teaching pearls. There were 1849 downloads from all platforms by December 2020. Typical listener feedback included "great podcast overall for a medical student. I really enjoyed the conciseness of the talk and the emphasis on history, physical, differential diagnosis, investigations, management. It was very helpful to hear how the resident would present the case and to hear the main pertinent positives and negatives."

Conclusions: SEM physicians can use this podcast as a model demonstrating that such medical education innovations can be quite feasible on a small budget. Our process was hugely enhanced by adding a broadcast journalism graduate to our production team. We urge SEM colleagues to create content and use podcasting as a teaching tool as knowledge translation efforts must adapt to changing clinical environments and new education technologies.

A Rapid Review in Search of Best Practice for the Management of Patients Presenting With Shoulder Pain

Breda H.F. Eubank, PhD, CAT(C),* and David M. Sheps, MSc, MBA, MD†

*Affiliations: *Mount Royal University, Calgary, AB, Canada; and †University of Alberta, Edmonton, AB, Canada.*

Objective: A rapid review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-P) 2015 guidelines. The objective was to examine the body of evidence around the management and treatment of shoulder pathology focusing on the retrieval of algorithms, clinical practice guidelines, and consensus guidelines.

Data Sources: Three electronic databases were searched from inception to June 2019: Medline, EMBASE, and CINAHL.

Main Results: The initial search yielded 8339 articles. A total of 6451 potentially relevant citations were included for review after removing 126 internal and 1762 external duplicates. After applying inclusion and exclusion criteria to the title and corresponding abstracts, 671 articles were selected for full-text review. Sixteen additional articles were retrieved after searching the bibliographies of selected studies. After a review of full-text articles, 88 articles were included in the final narrative synthesis. Algorithms, clinical practice guidelines, and/or consensus guidelines were identified for the following: acromioclavicular joint injuries, adhesive capsulitis, arthritis, brachial plexus injuries, injuries to the axillary nerve, fractures of the humerus and clavicle, glenohumeral joint injuries, rotator cuff pathology, long head of biceps tendinopathy, subacromial pain, and undifferentiated shoulder pain.

Conclusions: The rapid review process is often preferred in policy and decision-making healthcare research in which large projects require a quick turnaround time.

Acknowledgments: The search strategy was developed and carried out with the help of knowledge resource service librarian Rachel Zhao.

Treating Low Back Pain in Athletes: A Systematic Review With Meta-analysis

Jane S. Thornton, MD, PhD,*,† J. P. Caneiro, PT, PhD,‡ Jan Hartvigsen, PhD,§,¶ Clare L. Ardern, PT, PhD,‖,** Anders Vinther, PT, PhD,†† Kellie Wilkie, PT,‡‡ Larissa Trease, MD,§§,¶¶ Kathryn E. Ackerman, MD,‖‖,*** Kathryn Dane,††† Sarah-Jane McDonnell,‡‡‡ David Mockler,††† Conor Gissane, PhD,††† and Fiona Wilson, PT, PhD†††

*Affiliations: *Department of Family Medicine, Schulich School of Medicine & Dentistry, Western University, London, ON, Canada; †Department of Epidemiology & Biostatistics, Schulich School of Medicine and Dentistry, Western University, London, ON, Canada; ‡Physiotherapy, Curtin University, Perth, Western Australia, Australia; §Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark; ¶Nordic Institute of Chiropractic and Clinical Biomechanics, Odense, Denmark; ‖Division of Physiotherapy, Karolinska Institute, Huddinge, Sweden; **Sport and Exercise Medicine Research Centre, La Trobe University, Melbourne, Victoria, Australia; ††Physiotherapy and Occupational Therapy and QD research-unit, Copenhagen University Hospital, Herlev and Gentofte, Copenhagen, Denmark; ‡‡Tasmania Institute of Sport, Hobart, Tasmania, Australia; §§Heathcare in remote and extreme environments, School of Medicine, University of Tasmania, Hobart, Tasmania, Australia; ¶¶Orthopedics ACT, Canberra, New South Wales, Australia; ‖‖Sports Medicine Division, Boston Children's Hospital, Boston, Massachusetts; ***Neuroendocrine Unit, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts; †††School of Medicine, Trinity College Dublin, Dublin, Ireland; and ‡‡‡Sport Ireland Institute, Dublin, Ireland, Dublin, Ireland.*

Objective: To summarize the evidence for non-pharmacological management of low back pain (LBP) in athletes, a common problem in sport that can negatively impact performance and contribute to early retirement.

Data Sources: Five databases (EMBASE, Medline, CINAHL, Web of Science, Scopus) were searched from inception to September 2020. The main outcomes of interest were pain, disability and return to sport (RTS).

Main Results: Among 1629 references, 14 randomized controlled trials (RCTs) involving 541 athletes were included. The trials had biases across multiple domains including performance, attrition and reporting. Treatments included exercise, biomechanical modifications and manual therapy. There were no trials evaluating the efficacy of surgery or injections. Exercise was the most frequently investigated treatment; no RTS data were reported for any exercise intervention. There was a reduction in pain and disability reported after all treatments.

Conclusions: While several treatments for LBP in athletes improved pain and function, it was unclear what the most effective treatments were, and for whom. Exercise approaches generally reduced pain and improved function in athletes with LBP, but the effect on RTS is unknown. No conclusions regarding the value of manual therapy (massage, spinal manipulation) or biomechanical modifications alone could be drawn because of insufficient evidence. High-quality RCTs are urgently needed to determine the effect of commonly used interventions in treating LBP in athletes.

Acknowledgments: The authors would like to thank Dr Parham Rasoulinejad for his thorough review of this manuscript prior to submission.

Prevalence and Risk Factors for Back Pain in Sports: A Systematic Review With Meta-analysis

Fiona Wilson, PT, PhD,* Clare L. Ardern, PT, PhD,†,‡, Jan Hartvigsen, PhD,§,¶ Kathryn Dane,* Katharina Trompeter, PhD,‖ Larissa Trease, MD,†† Anders Vinther, PT, PhD,‡‡ Conor Gissane, PhD,* Sarah-Jane McDonnell, PT,§§, J. P. Caneiro, PT, PhD,¶¶, Craig Newlands,‖‖, Kellie Wilkie,*** David Mockler,††† and Jane S. Thornton, MD, PhD‡‡‡,§§§

*Affiliations: *Discipline of Physiotherapy, School of Medicine, Trinity College, Dublin, Ireland; †Division of Physiotherapy, Karolinska Institute, Stockholm, Sweden; ‡Sport & Exercise Medicine Research Centre, La Trobe University, Melbourne, Victoria, Australia; §Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark; ¶Nordic Institute of Chiropractic and Clinical Biomechanics, Odense, Denmark; ‖Department of Sports Medicine and Sports Nutrition, Ruhr University Bochum, Bochum, Germany; **Department of Applied Health Sciences, Division of Physiotherapy, Hochschule für Gesundheit (University of Applied Sciences), Bochum, Germany; ††Healthcare in Remote and Extreme Environments program, School of Medicine, University of Tasmania, Hobart, Tasmania, Australia; ‡‡Department of Physiotherapy and Occupational Therapy and QD-Research Unit, Copenhagen University Hospital, Herlev and Gentofte, Copenhagen, Denmark; §§Sport Ireland Institute, Dublin, Ireland; ¶¶School of Physiotherapy and Exercise Science, Faculty of Health Science, Curtin University, Perth, Western Australia, Australia; ‖‖Body Performance, Cambridge, New Zealand; ***Bodysystem Physiotherapy, Hobart, Tasmania, Australia; †††John Stearne Library, Trinity College Dublin, Dublin, Ireland; ‡‡‡Fowler Kennedy Sports Medicine Clinic, Western University, London, ON, Canada; and §§§Western Centre for Public Health and Family Medicine, Schulich School of Medicine and Dentistry, Western University, London, ON, Canada.*

Objective: We aimed to determine the prevalence of low back pain (LBP) in sport, and what risk factors were associated with LBP in athletes. Design Systematic review with meta-analysis.

Data Sources: Literature searches from database inception to June 2019 in Medline, Embase, Cumulated Index to Nursing and Allied Health Literature (CINAHL), Web of Science and Scopus, supplemented by grey literature searching. Studies evaluating prevalence of LBP in adult athletes across all sports were eligible.

Main Results: Eighty-six studies were included (30-732, range 20-5958, participants), of which 45 were of "high" quality. Definitions of LBP varied widely, and in 17 studies, no

definition was provided. High-quality studies were pooled and the mean point prevalence across 6 studies was 42%; range 18% to 80% (95% CI 27%-58%, I2 = 97%). Lifetime prevalence across 13 studies was 63%; range 36% to 88% (95% CI 51%-74%, I2 = 99%). Twelve-month LBP prevalence from 22 studies was 51%; range 12% to 94% (95% CI 41%-61%, I2 = 98%). Comparison across sports was limited by participant numbers, study quality and methodologies, and varying LBP definitions. Risk factors for LBP included history of a previous episode with a pooled OR of 3.5; range 1.6–4.0 (95% CI 1.9-6.4). Statistically significant associations were reported for high training volume, periods of load increase and years of exposure to the sport.

Conclusions: LBP in sport is common but estimates vary. Current evidence is insufficient to identify which sports are at highest risk. A previous episode of LBP, high training volume, periods of load increase and years of exposure are common risk factors.

Head Injuries in Rock Climbing: A Scoping Review

Joo Hyung Yoon, MD,* Wes Armstrong, MD,† Eleni Philippopolous, MISt,‡ Neil Dilworth, MD,*,§,¶ and Ivy Cheng MD, MSc, PhD,†,§,‖

*Affiliations: *Department of Family & Community Medicine, University of Toronto, Toronto, ON, Canada; †Division of Emergency Medicine, University of Toronto, Toronto, ON, Canada; ‡Sidney Liswood Health Sciences Library, Mount Sinai Hospital, Toronto, ON, Canada; §Cleveland Clinic Midtown, Toronto, ON, Canada; ¶Halton Healthcare, Georgetown, ON; and ‖Sunnybrook Health Sciences Centre, Toronto, ON, Canada.*

Objective: To synthesize what is known about head injuries (HI) within rock-climbers in all disciplines involving both indoor and outdoor settings, to inform future efforts toward concussion guidelines and mitigation strategies in climbing.

Data Sources: Six databases (MEDLINE, EMBASE, Sports Medicine & Education Index, SPORT Discus, CINHAL, COCHRANE) and grey literature sources were searched for primary rock-climbing studies, and related guidelines. Two reviewers screened citations to apply predetermined inclusion and exclusion criteria. Data abstraction was independently completed by 2 reviewers. Qualitative methods of synthesis was performed. The study followed the PRISMA-ScR guidelines for reporting. The NHLBI tool was used for critical appraisal of included studies.

Results: Three hundred forty-five papers and 20 grey literature resources were screened and 34 studies were selected. Two and thirty-two studies examined HI and overall injury patterns including HI, respectively. Most common study designs were cross-sectional (n = 17) and case series (n = 9). Individual study grades were fair but the evidence was low quality overall. HI proportions varied from 0% to 48%. Reasons for the range of HI were inconsistency in anatomical groupings of HI, injury types classified as HI, and injury evaluation settings. Outdoor climbing was associated with HI more than indoor climbing. The most common cause of HI were falls and falling objects. Safety practices, such as helmet use, were poorly documented. Climbers delaying medical care served as a source of bias.

Conclusions: A lack of high quality and quantity of evidence examining HI in rock climbing is seen with variable methodological approaches, not allowing for conclusions to be drawn. We recommend that consensus guidelines for defining and reporting HI be established and suggest a need for HI surveillance registry in collaboration with local climbing organizations. As the sport gains recognition, a significant gap to examine HI in climbing exists.

Designing an e-Module to Educate Family Medicine Residents About Physical Activity During Pregnancy

Lisa Kachaniwsky, BSc,*,‡ Sarah Whyte, PhD,* Aakriti Pyakurel, MPA,* Rachel McDonald, MD,† and Karen Fleming, MD*,†

*Affiliations: *Department of Family and Community Medicine, Sunnybrook Health Sciences Centre, Toronto, Canada; †Faculty of Medicine, University of Toronto, Toronto, Canada; and ‡Canadian College of Naturopathic Medicine, Toronto, Canada.*

Objective: To develop and pilot an effective online module (e-module) to increase family medicine residents' knowledge of physical activity in pregnancy and their confidence in providing exercise counselling to patients.

Study design: A qualitative, design-based pilot study using focus groups, observations, and interviews.

Subjects: A total of 27 Family medicine residents and 4 experts in the field of exercise in pregnancy.

Intervention: An online learning module on physical activity in pregnancy with didactic and interactive case-based elements on: (1) Health benefits and potential risks of physical activity in pregnancy to both mother and baby; (2) New guidelines and available tools for counselling pregnant women about physical activity and pregnancy; and (3) Strategies to implement physical activity prescription using updated guidelines across different patient populations.

Outcome Measures: Qualitative feedback from learners and experts on the content, usability, and perceived value of the e-module. Observed interactions between learners and the e-module at multiple stages of development.

Results: Residents valued content relevant to practice; forms of interaction that supported learning; learner-centred design; and practical resources for use outside the module. To increase their confidence in counselling patients, learners requested detailed explanations designed to help them address common questions related to the safety of physical activity during pregnancy, contraindications, and specific activities to recommend and avoid. They disliked gratuitous clicking, long videos, and repetition of basic information learned in other contexts. To incorporate this feedback, we used example cases to structure the modules, integrated explanations within the cases, drew upon both clinical and social scientific evidence, added elements that learners valued (eg, demonstration videos, take-away summaries), removed superfluous interactions, and addressed barriers to smooth navigation.

Conclusion: A design-based approach can be used to develop resources that enable learners to bring theoretical knowledge into their practice. Participants reported that e-module was valuable, "very helpful and enjoyable," "short and sweet," and "super useful". This resource has the potential to empower medical residents and other care providers to promote physical activity among their pregnant patients.

Developing a Tailored Online Concussion Education Program for Canadian University Athletes: From Needs Assessment to Design Including Behaviour Change Strategies

Amanda M. Black, CAT (C), PhD,*,†,‡,§ Kate Turcotte, MSc,¶ Taryn Taylor, MD,‖ Samantha Bruin, BA,¶ Karen Sadler, MCP,¶ Shazya Karmali, PhD,¶ Drew Halliday, PhD,** and Shelina Babul, PhD¶,††

*Affiliations: *Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Canada; †Alberta Children's Hospital Research Institute, University of Calgary, Canada; ‡Hotchkiss Brain Institute, University of Calgary, Canada; §O'Brien Institute for Public Health, University of Calgary, Canada; ¶BC Injury Prevention Research and Prevention Unit, BC Children's Hospital, Canada; ‖Carleton Sport Medicine Clinic, Carleton University, Canada; ** Queen Alexandra Centre for Children's Health, Victoria, Canada; and ††Department of Pediatrics, University of British Columbia, Canada.*

Objective: To develop an online concussion education tool for Canadian varsity athletes.

Study Design: An integrated knowledge translation multiphased approach.

Subjects: Sixty-four university representatives (46 athletic therapists/physiotherapists, 9 program administrators, 7 physicians; 31 males, 31 females) and 27 varsity athletes (14 males, 13 females) completed the needs assessment survey. Five athletes participated in engagement interviews and interaction type selection.

Observation Technique: Phases included needs assessment surveys with university representatives and athletes, content selection, mapping core behavioural goals to evidenced-based behaviour change techniques, script/storyboard development, engagement interviews with athletes, and final tool development.

Outcome Measures: University representative needs assessment survey collected information on demographics, concussion education practices, importance of topics (1- not important to 5- very important), and interest in mandating or using the tool. The athlete survey assessed important topics and education preferences.

Results: Institutions used a median (Mdn) 2 (range 1-5) approaches when educating athletes about concussion. Common approaches were classroom-style education (50%), online training (41%), and informational handouts (39%). Seventeen (27%) respondents reported plans to make the tool optional, 42 (66%) mandatory, and 5 (8%) were unsure. University representatives rated: (1) what is a concussion, (2) how to recognize a concussion and, (3) how to report concussion, as the most important topics (Mdn_{all} = 4.8/5). Athletes felt symptom recognition (96%) and effects on the brain (85%) were most important. Athletes preferred learning via computer (81%) and more preferred to learn alone (48%) versus group learning (7%). The final resource included: concussion recognition, reporting concussion importance and recovery, how to cope, and how to support teammates. It was designed to influence 4 behaviours: (1) report symptoms, (2) seek care (3) encourage teammates to report symptoms and (4) support teammates with concussion. Examples of behaviour change techniques included: Information to address knowledge/skills, problem-solving scenarios, verbal persuasion, and social comparison. Athletes are guided through different interaction types (eg, videos, flipcards, scenarios, testimonials) to maximize engagement (material review takes ~30 minutes).

Conclusions: The Concussion Awareness Training Tool (CATT) for athletes is the first Canadian education tool designed to address the needs of Canadian varsity athletes. Evaluation of reach, effectiveness and implementation challenges is underway.

Acknowledgments: This project was funded by U SPORTS, the Canadian Academy of Sport and Exercise Medicine, the Canadian Athletic Therapy Association, Ontario Athletic Therapy Association, Atlantic Provinces Athletic Therapists' Association, and Brock University Faculty of Applied Health Sciences. We would like to thank all of the athletic therapists, physiotherapists, athletic directors, administrators, physicians and athletes who assisted with the development of the tool. We would also like to thank John Jacob and his development team at the Digital Lab at the British Columbia Children Hospital for building the web-based platform.

Occurrence, Etiology and Prevention of Sport-Related Shoulder Injuries Among Youth: A Systematic Review

Eric SD Gibson, BSc,* Alexis Cairo,* Anu M Räisänen, PT, PhD,* Colleen M. Kuntze, PT, MScPT,* Carolyn Emery, PT, PhD,*,†,‡,§,¶,‖, and Kati Pasanen PT PhD*,†,**,††

*Affiliations: *Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Canada; †Alberta Children's Hospital Research Institute, University of Calgary, Canada; ‡O'Brien Institute for Public Health, University of Calgary, Canada; §Hotchkiss Brain Institute, University of Calgary, Canada; ¶Community Health Sciences, Cumming School of Medicine, University of Calgary, Canada; ‖Department of Pediatrics, Cumming School of Medicine, University of Calgary, Canada; **McCaig Institute for Bone and Joint Health, University of Calgary, Canada; and ††Tampere Research Center of Sports Medicine, UKK Institute, Tampere, Finland.*

Objective: To explore the burden of acute and overuse sport-related shoulder injuries in youth by identifying injury occurrences, risk factors, injury mechanisms, and injury prevention modalities that have undergone scientific investigation.

Data Sources: All relevant full-text articles identified from searching MEDLINE, EMBASE, CINAHL, Sport Discus, and the Cochrane Controlled Trials Registry. No date restrictions were used. All full-text studies reporting original research describing the burden of sport-related shoulder injury among female and/or male youth from 5 to 18 years old. Studies were excluded if they were synthesis/review papers; were small case series (less than 10 participants); if the participants included more than 10% adult participants; or if the full-text was not available.

Main Results: Of the 3792 studies screened, 92 described the burden of shoulder injury in youth sport. Shoulder injuries were identified in 23 unique sports. Mean seasonal prevalence of shoulder injury was 11.45% (n = 50; range 0.8-31.1%) across all reporting sports. Shoulder injuries occurred with an incidence rate of 0.448 injuries/1000 athlete-exposures (n = 27; range 0.02-2.0). The most common injury mechanisms

identified were contact with another player, and contact with the playing environment. Risk factors for acute and overuse shoulder injuries identified were side-to-side strength deficits, weak external rotator muscles, scapular dyskinesis, and male sex. The median quality score on the Downs and Black checklist was 10 (range 6-19), out of a maximum possible score of 33. One study evaluated a successful injury prevention modality in baseball. This study was a randomized controlled trial on the utility of a training program focusing on upper and lower extremity range of motion and scapular stability/control in 9 to 11 year old baseball players. Following participation, the intervention group reported a lower rate of shoulder injuries (1.7 injuries/1000 athlete-exposures) than the control group (3.1 injuries/1000 athlete-exposures).

Conclusions: Sport-related shoulder injury is affects 11.45% of youth athletes and risk factors are modifiable. The most common mechanism of shoulder injuries was direct contact with either another person or an object. Innovative, specific, and targeted primary prevention strategies are needed to reduce the burden of shoulder injuries in youth population.

Injury Reduction Programmes Which Contain Neck Exercises Can Reduce the Incidence of Sport-Related Head and Neck Injuries Including Concussion: A Systematic Review

Kerry Peek,* Theo Versteegh,† Ian Gilchrist,‡ Jonathan Elliott,§ Neil Heron,¶ Michael Webb,‖ Pooler Archbold,** and Professor Nigel D. Hart††

*Affiliations: *Discipline of Physiotherapy, Faculty of Medicine and Health, University of Sydney, NSW, Australia; †School of Physical Therapy, Western University, London, ON, Canada; ‡ School of Kinesiology and Health Studies, Queen's University, Kingston, ON, Canada; §Ulster Hospital, Upper Newtownards Road, Dundonald, Belfast, BT16 1RH ORCID; ¶Team Ineos, World Tour Professional Cycling Team; ‖Ulster Rugby; ** Belfast Royal Victoria Hospital, Belfast, United Kingdom; and ††School of Medicine, Dentistry and Biomedical Sciences, Queen's University Belfast, Belfast, United Kingdom.*

Objectives: To systematically review the literature to investigate: (1) the relationship between neck strength and sport-related head and neck injuries [including sport-related concussion (SRC)]; and (2) whether neck exercise programmes can reduce the incidence of (a) sport-related head and neck injuries; and (b) SRC.

Data Sources: Five databases (Ovid MEDLINE, CINAHL, EMBASE, SPORTDiscus, and Web of Science) and research lists of included studies were searched using a combination of medical subject headings and keywords to locate original studies which reported the association between incidence of head and/or neck injury and neck strength data, or included a neck exercise intervention either in isolation or as part of a more comprehensive exercise programme. Following review of titles and abstracts, 2 authors independently assessed full texts for inclusion. Eligible studies then underwent methodological quality assessment by 2 independent authors using the Downs and Black checklist. Data were extracted and analysed using a narrative synthesis due to the heterogeneity of included studies.

Results: From an initial search of 593 studies, 6 were included in this review. Two observational studies (total n = 6792 male and female high school and university athletes) reported that higher neck strength, but not deep neck flexor endurance, is associated with a lower risk of sustaining a SRC ($P = 0.004$). Four intervention studies (total n = 3953 predominantly male adolescent and adult rugby union players) demonstrated that injury reduction exercise programmes that included neck exercises can reduce the incidence of sport-related head and neck injuries including SRC (risk ratio <0.82).

Conclusion: This review provides evidence that greater neck strength and participation in injury reduction exercise programmes, which include neck exercises, can reduce the incidence of sport-related head and neck injuries, in particular SRC. The inclusion as well as types of neck exercises incorporated into training programmes for contact sports should be further explored particularly in adolescent and female athletes who appear most likely to benefit.

Kinetic Measurement Systems Use in Individuals Following Anterior Cruciate Ligaments Reconstruction: A Scoping Review of Methodological Approaches

Wasim Labban, PhD (student),*,† Meredith Stadnyk, MSc, MD (student),‡ Mark Sommerfeldt, MD, MSc,§,¶ Stephanie Nathanail, MA,‖ Liz Dennett,** Lindsey Westover, PhD,†† and Lauren Beaupre, PhD*,‡

*Affiliations: *Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, Canada; †Mirdif Center for Physiotherapy & Rehabilitation, Dubai, United Arab Emirates; ‡Faculty of Medicine & Dentistry, University of Alberta, Edmonton, Canada; §Division of Orthopedic Surgery, Department of Surgery, Faculty of Medicine & Dentistry, University of Alberta, Edmonton, Canada; ¶Glen Sather Sports Medicine Clinic, University of Alberta, Edmonton, Canada; ‖Orthopaedic Surgery, Alberta Health Services, Edmonton, Canada; **John W. Scott Health Sciences Library, University of Alberta, Edmonton, Canada; and ††Faculty of Engineering, University of Alberta, Edmonton, Canada.*

Objectives: Our primary objectives were to (1) describe the current approaches for kinetic measurements in individuals following ACLR and (2) propose methodological reporting considerations. The secondary objective was to examine how commonly kinetic measurement system findings were related to patient-reported outcome measures (PROMs).

Data Sources: We followed the PRISMA extension for scoping reviews and Arksey and O'Malley's 5-stage framework. Seven electronic databases (MEDLINE, EMBASE, CINAHL, SPORTDiscus, Scopus, Web of Science, and ProQuest) were systematically searched from inception to June 5, 2020, using search strategies designed in consultation with a librarian scientist. Peer-reviewed papers with original data reported on parameters measured by kinetic measurement systems in individuals 6-months post primary ACLR were included. Two authors independently screened titles and abstracts and performed full-text review.

Main Results: Of 5787 records, 2027 titles and abstracts were screened, 705 full-text were reviewed and 158 studies representing 7909 participants {35.2% females, mean age range [15.6 (SD 1.7)-48.2 (SD 5.5)] years} met the inclusion criteria. Studies were published between 1990 and 2020 with 99 (62.66%) of them published since 2015. Seven kinetic measurement systems (force plates, balance

platforms, pressure mats, force measuring treadmills, Wii balance boards, contact mats connected to jump systems, and single-sensor insoles) were identified for the assessment of 4 main movement task categories (landing/jumping, standing balance, gait, and other functional tasks). Further to the substantial heterogeneity seen in methods used and outcomes assessed, this review highlighted methodological gaps in reporting essential items related to movement tasks, kinetic system features, justification and operationalization of selected outcome parameters, participant preparation, and testing protocol details. Based on our findings, we developed methodological reporting considerations for future research. Of the 6 studies that included PROMs, 5 were published since 2018, and the studies showed inconsistency in the reported parameters and/or PROMs across them.

Conclusions: Clear and accurate biomedical research reporting is vital to facilitate cross-study comparisons and improve the clinical application of kinetic measurement systems findings. Based on the current evidence, we suggest specific methodological reporting considerations to advance this burgeoning field. Future studies are needed to examine potential correlations between kinetic parameters and PROMs.

Surgical Results of Chronic Distal Biceps Ruptures: A Systematic Review of the Literature

Arpun Bajwa,*,‡ Maciej J.K. Simon,†,‡, Jordan M. Leith,§ Farhad O. Moola,†,¶ Thomas J. Goetz,† and Parth Lodhia,†,¶

*Affiliations: *Gray's Harbor Medical Group, Gray's Harbor Orthopedics, 1211 Skyview Drive, Aberdeen, WA; †University of British Columbia, Department of Orthopaedics, Faculty of Medicine, 11th Floor – 2775 Laurel Street, Vancouver BC, V5Z1M9, Canada; ‡University Medical Center Hamburg-Eppendorf, Department of Orthopaedics, Martinistrasse 52, 20246 Hamburg, Germany; § Footbridge Clinic for Integrated Orthopaedic Care Footbridge Clinic for Integrated Orthopaedic Care, 221-181 Keefer Pl, Vancouver BC, V6B 6C1, Canada; and ¶Fraser Orthopaedic Institute, 403 – 233 Nelson's Crescent, New Westminster, BC V3L 0E4, Canada.*

Apun Bajwa and Maciej Simon contributed equally to this manuscript and therefore share first authorship.

Corresponding author: Parth Lodhia, Fraser Orthopaedic Institute, 403 – 233 Nelson's Crescent, New Westminster, BC V3L 0E4 Canada, Phone: 604-553-9110, Email: parth.lodhia@ubc.ca.

Objective: Distal biceps tendon tears can cause weakness and fatigue in activities requiring elbow flexion and supination. Surgical management of chronic tears is not well described in the literature. The purpose of this review was to determine clinical outcomes of chronic distal biceps repairs and reconstructions.

Data Sources: A search of Medline (Pubmed + Ovid), EMBASE, CINAHL physical therapy, Cochrane Database of Systematic Reviews and Central Register, and PubMed Central from beginning of inception until September 29, 2020 was performed to identify all articles including chronic distal biceps ruptures.

All studies with at least one outcome measure and 10 patients with chronic distal biceps ruptures that were surgically treated were included in this systematic review. Outcomes assessing physical function and complications were reviewed.

Main Results: Fourteen studies were included after systematic database screenings. MINORS criteria scores ranged from 5 to 19. A total of 462 cases with chronic distal biceps tendon ruptures were included. Follow-up times ranged from 4 months to 11 years. Single-incision (n = 4) and 2-incision (n = 2), or both (n = 6) surgical techniques were used in these studies. Two studies did not specify the surgical approach. Repairs used transosseous button fixation and suture anchor fixation methods. Four studies describe the use of autografts and 5 articles used allografts in the chronic repair. Range of motion (ROM) outcomes were excellent when compared to the contralateral arm. Main postoperative complications were paresthesias, which were temporary in 70% of the cases.

Conclusions: Surgical management of chronic distal biceps ruptures demonstrate improvement and overall successful outcomes for pain and function. Although there may be a slightly higher immediate complication rate, specifically neuropraxia of the LABCN, the functional outcomes remain comparable to that seen in the acute distal biceps patient population.

Concussion and Head Impacts in Youth Tackle Football: A Systematic Review and Meta-analysis

M. Patrick Pankow, BKin,*,† Reid Syrydiuk, BA,*,† Ash T. Kolstad, BSc,*,† Christian A. Clermont, PhD,*,†, Christopher R. Dennison, PhD, PEng(AB),‡ Brent Hagel, PhD,*,†,‖,** Martin Mrazik, PhD, and R. Psych Carolyn A. Emery, PT, PhD*,†,§,¶,‖,**

*Affiliations: *Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada; †Alberta Children's Hospital Research Institute, University of Calgary, Calgary, AB, Canada; ‡Biomedical Instrumentation Lab, Department of Mechanical Engineering, University of Alberta, Canada; § Hotchkiss Brain Institute, University of Calgary, Calgary, AB, Canada; ¶Evidence Sport and Spinal Therapy, Calgary, AB, Canada; ‖Departments of Pediatrics and Community Health Sciences, Cumming School of Medicine, University of Calgary, Canada; **O'Brien Institute for Public Health, Cumming School of Medicine, University of Calgary, Canada; and ††Faculty of Education, University of Alberta, Edmonton, AB, Canada.*

Objective(s): To examine rates of concussion and head impact in youth football. Additionally, to identify modifiable risk factors for concussions and head impacts and to evaluate the effectiveness of prevention strategies targeted at reducing concussions and/or head impacts in tackle football played at any level.

Data Sources: Nine databases (CINAHL, Cochrane Central Register of Controlled Trials, EMBASE, ERIC, MEDLINE(R), ProQuest Dissertations & Theses Global Database, PsycINFO, Scopus and SPORTDiscus) were searched using the developed search strategy which focused on 4 main concepts: concussion/head impacts, tackle football, modifiable risk factors, and primary prevention. Two reviewers (MPP & RS) completed title, abstract and full text screening of the returned studies with a third author (AK) available to resolve any disagreements. Two authors completed risk of bias assessment using the Downs & Black tool.

Main Results: Eighty-two articles were included in the data synthesis and 23 in the meta-analyses. The combined rate of concussion from the meta-analysis for high school football (ages 14-18) was 0.74 concussions/1000 athlete exposures [(defined as participation in a single game or practice) AE; 95% CI: 0.62-0.86] and for youth community football (under age 14) was 1.08 concussions/1000 AE (95% CI: 0.81-1.35). In games, the combined rate of concussion was 6-fold greater than practices for high school leagues and 4-fold for youth community leagues. The rate of head impacts during games was upto 2.7 times greater for high school football than youth community leagues and were more similar for practices. Contact training (eg, teaching proper tackle technique) and contact restrictions (eg, limiting contact practices), have both been shown to effectively reduce the rate of head impacts and concussion in practices.

Conclusions: The results of this systematic review and meta-analysis highlight the need for the development of interventions to address the high rates of concussion and head impact in high school and youth community football. To date, contact training and contact restrictions have the strongest evidence supporting their effectiveness at reducing these rates. Future research should use consistent concussion definitions, validated injury surveillance systems, and ensure the provision of adequate details pertaining to participant characteristics and sampling.

Acknowledgments: *The Sport Injury Prevention Research Centre is one of the International Research Centres for Prevention of Injury and Protection of Athlete Health supported by the International Olympic Committee. We acknowledge funding from National Football League Scientific Advisory Board Play Smart Play Safe Program, Hotchkiss Brain Institute and Alberta Children's Hospital Foundation. We would like to acknowledge the research coordinators, research assistants, school districts and all of teachers, coaches and students involved for their time and support in completing this project.*

Heat, Cold, and Pressure Pain Thresholds Following a Sport-Related Concussion: A Pilot Study

Corson Johnstone, MSc,* Chantel T. Debert, MD, MSc,†,‡,‖ Melanie Noel, PhD, RPsych,§ Michaela Chadder Mkin,* Geoff Schneider, PT, PhD¶, and Kathryn J. Schneider, PT, PhD*,‡,‖

*Affiliations: *Sport Injury Prevention Research Centre, 2500 University Dr NW, Calgary, AB, Canada, T2N 1N4; † Department of Clinical Neurosciences, 2500 University Dr NW, Calgary, AB, Canada, T2N 1N4; ‡Hotchkiss Brain Institute; § Department of Psychology, 2500 University Dr NW, Calgary, AB, Canada, T2N 1N4; ¶Department of Radiology, Cumming School of Medicine, 2500 University Dr. NW, Calgary, AB, Canada, T2N 1N4; and ‖Alberta Children's Hospital Research institute.*

Objective: To compare heat (HPT), cold (CPT), and pressure pain thresholds (PPTs) in youth and adults with SRC, orthopaedic injury (OI), and uninjured controls (UI).

Study Design: Cross-sectional.

Subjects: Participants aged 13 to 60 years who presented to the Acute Sport Concussion Clinic (ASCC) or community sport medicine clinics and were diagnosed with a sport-related concussion (SRC). Participants with SRC were matched to orthopaedic injured (OI) and uninjured (UI) controls by age, sex, and time since injury.

Intervention/Observation Technique: Heat, cold, and pressure pain thresholds were assessed using a TSAII Neurosensory Analyzer (˚C) and an AlgoMed Pressure Algometer (kg/cm^2).

Outcome Measures: The primary outcome measures were heat (˚C), cold (˚C), and pressure pain thresholds (kg/cm^2). Pain thresholds were measured bilaterally at 4 regions including the tibialis anterior, peripheral nerve trunk of the median nerve, articular pillars of the C4-C5 zygapophyseal joint, and the anterior temporal region. For participants with SRC, the outcome measures were collected at an initial appointment (< 30 post-injury), 24-72 hours following their initial testing session, and 30 days post-injury (or time of medical clearance to return to sport). Pain thresholds were compared between groups (SRC vs. OI and SRC vs. UI) using Wilcoxon signed-rank tests.

Results: A total of 26 individuals (12 SRC, 6 OI, 8 UI) participated in this study. Quantitative sensory testing was feasible and there were no adverse events reported. There were no statistically significant differences in HPTs, CPTs, and PPTs across groups ($P > 0.0125$). Of interest, those with SRC consistently had lower median HPT and higher median CPT point estimates than OI and UI controls and higher median PPTs than OI controls.

Conclusions: No difference in HPTs, CPTs, or PPTs across groups was identified. However, the testing protocols were feasible and summary statistics suggest that further investigation to better understand the potential heat, cold and pressure pain threshold alterations following SRC is warranted.

Acknowledgments: We acknowledge funding from Alberta Children's Hospital Research Institute, the Integrated Concussion Research Program (ICRP) and the Vi Riddell Pediatric Rehabilitation Research Program. Thank you to the Acute Sport Concussion Clinic at the Sport Medicine Centre at the University of Calgary and all of the patients and their families for supporting this research project. The Sport Injury Prevention Research Centre is one of the International Research Centers for the Prevention of Injury and Protection of Athlete Health supported by the International Olympic Committee.

Stroke and Athletes: A Scoping Review

Patricia K. Doyle-Baker, DrPH/PhD, MSc, CEP,*,†,‡, Timothy Mitchell (Cand BSc honors),* and K. Alix Hayden, PhD, MLIS, MSc‡

*Affiliations: *Human Performance Lab, Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada; †School of Architecture, Planning and Landscape, University of Calgary, Calgary, AB, Canada; ‡Alberta Children's Hospital Research Institute, University of Calgary, Calgary, AB, Canada; and §Libraries and Cultural Resources, University of Calgary, Calgary, Canada.*

Objective: This study employed Arksey and O'Malley's 5-stage-process for a scoping review and aimed to summarize studies on the topic of stroke or cerebrovascular accident in sport with a strict athlete definition.

Data Sources: We mindfully excluded sports-related stroke terms since the term "stroke" is often used in sports literature. Athletes were defined as training in sports to improve performance, actively participating in sports competitions, formally registered in a local, regional or national sports

federation, and sports training and competition as a major activity. Five databases were searched from inception until May 2020: OVID databases: MEDLINE(R) Epub Ahead of Print, In-Process & Other Non- Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R), and Embase; EbscoHost databases: CINAHL Plus with Full Text, SportDiscus with Full Text; and Scopus.

Main Results: We identified 36 eligible studies involving 39 athletes (age range of 14-56 years; 95% male) with publication dates ranging from 1979 to 2020, across 9 different countries. The major inciting event(s) prior to stroke onset were headaches (38.4%), head trauma (30.7%), and neck injury and/or vertebral artery dissection (20.5%). Several sporting activities were represented with American football as the most prevalent (30.7%).

Conclusions: We found that sports with an aspect of impact, collision, or microtrauma can lead to subsequent stroke. These sport-related traumatic events were often difficult to diagnosis because of the longer interval before ischemia occurred. Headache was the most commonly reported symptom; therefore, health care providers should be particularly attuned to the possibility of stroke when evaluating young athletes presenting with this symptom, with or without neurological deficit. Future education with a focus on recognizable symptoms and a description of common inciting events prior to a stroke could play a major role in changing attitudes toward stroke prevention in sport.

High School Student-Athletes' Experiences With the COVID-19 Pandemic: The Impact on their Physical Activity Engagement And Mental Health

Heather A. Shepherd, OT, MSc,* Taffin Evans, CAT(C), BKin,* Srijal Gupta,* Meghan H. McDonough, PhD,† Patricia Doyle-Baker, Dr. PH/PhD,† Kathy L. Belton, PhD,‡ Shazya Karmali, PhD,§ Samantha Pawer, BSc,§ Gabrielle Hadly, MPH,§ Ian Pike, PhD,¶ Stephanie A. Adams, PhD,‖ Shelina Babul, PhD,¶ Carolyn A. Emery, PT, PhD,* Keith Owen Yeates, PhD,** Daniel C. Kopala Sibley, PhD,†† Kathryn J. Schneider, PT, PhD,* Stephanie Cowle, BA,‡‡ Pamela Fuselli, MSc,‡‡ and Amanda M. Black, CAT(C), PhD*

*Affiliations: *Sport Injury Research Prevention Centre, Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada; †Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada; ‡Injury Prevention Centre, School of Public Health, University of Alberta; §BC Injury Research and Prevention Unit, BC Children's Hospital, Vancouver, BC, Canada; ¶Department of Pediatrics, University of British Columbia, Vancouver, BC, Canada; ‖Institute for Sport, Physical Education and Health Sciences, Moray House School of Education and Sport, University of Edinburgh, Edinburgh, Scotland; **Department of Psychology, University of Calgary, Calgary, AB, Canada; †† Department of Psychiatry, University of Calgary, Calgary, AB, Canada; and ‡‡Parachute, Toronto, ON, Canada.*

Objective: To describe the impact of the COVID-19 pandemic on high school student-athletes' physical activity, social connections, and mental health.

Study Design: Qualitative study using a phenomenographical methodology.

Subjects: Twenty high school student-athletes (ages 14-17, 10 males/10 females) from Calgary, Alberta.

Observation Technique: Semi-structured one-on-one interviews, 45-60 minutes, conducted via phone or Zoom.

Outcome Measures: Variations in student-athlete experiences and engagement with physical activity and mental health with the intent to develop resources to guide practice.

Results: Participants reported variations in physical activity and mental health influenced by government-imposed stay-at-home restrictions and changes to available resources and opportunities to engage in sport and physical activity and socialize with teammates and friends. Colder weather further limited opportunities to engage in physical activity outside for most student-athletes. The onset of the pandemic led to alterations in their physical activity routines including physical education classes and team sport training. Participants perceived that engaging in physical activity helped manage their stress and improved their mental health and for some, team or group training and the associated social connections were integral to engaging in physical activity and improving mental health. Participants reported engagement in physical activity increased with motivation, access to resources (eg, fitness or sport equipment, personnel), and social supports (ie, in-person, via social media). Student-athletes reported that online resources such as sport applications, online training videos, or team calls could facilitate their engagement in physical activity while promoting social connections and engagement with their friends and teammates.

Conclusions: High school student-athletes were affected by the onset of the pandemic, altering their participation in school and sports. Students reported that prior to the pandemic, both school and sports facilitated their engagement in physical activity and their social connections. The pandemic resulted in changes to mental health and wellbeing. Developing or disseminating existing resources (eg, fitness applications, infographics, virtual training) to high school student-athletes and other stakeholders (eg, coaches, teachers) may help to support engagement in physical activity and improve mental health.

Acknowledgments: The Sport Injury Prevention Research Centre is one of the International Research Centres for Prevention of Injury and Protection of Athlete Health supported by the International Olympic Committee. We acknowledge the support of the high school student-athletes who participated in this study and the Surveillance in High Schools to Reduce Concussions and their Consequences study research assistants who helped identify potential participants. We acknowledge funding through the Alberta Children's Hospital Research Institute, the Integrated Concussion Research Program, and the Faculty of Kinesiology, University of Calgary. HAS was partially supported by grant funding available from the National Football League Safety Advisory Board.

High Injury Prevalence and Concussion Rates in Female Youth Team Sports: An Opportunity for Prevention

Alexis L. Cairo,*,†,‡,§,¶ Anu M. Räisänen, PT, PhD,* Isla J. Shill, MSc,*,†,‡,§,¶ Amanda M. Black, CAT(C), PhD,*,†,‡,§ and Carolyn A. Emery, PT, PhD*,†,‡,§,¶,‖

*Affiliations: *Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Canada; †Alberta Children's Hospital Research Institute, University of Calgary, Canada; ‡O'Brien Institute for Public Health, University of Calgary,*

*Canada; § Hotchkiss Brain Institute, University of Calgary, Canada; ¶McCaig Institute for Bone and Joint Health, University of Calgary, Canada; ‖Community Health Sciences, Cumming School of Medicine, University of Calgary, Canada; and **Department of Pediatrics, Cumming School of Medicine, University of Calgary, Canada.*

Objective: To investigate sport-related injury prevalence, types, locations and mechanisms in female youth team sports.

Study Design: Secondary analysis of a cross-sectional study.

Subjects: Female students who reported playing one of the top 10 team sports for participation (ie, baseball, basketball, lacrosse, soccer, volleyball, football, rugby, ringette, field hockey, ice hockey).

Observation Technique: A 45-minute online survey administered to Albertan high school students included questions regarding demographic information, sport participation, and one-year injury and concussion history.

Outcome Measures: Self-reported most-serious injuries and concussions sustained in the past year.

Results: 51.7% (1048/2029) of high school students completing the survey were female and 481/1048 (45.9%) reported playing at least one team sport. Of these, 51.4% (247/481, 95% CI: 46.8-55.9) reported at least one sport-related injury in the past year. Injury prevalence based on "most serious injury" reported and concussion rates were 23.5 injuries/100 participants/year (95% CI: 20.4-26.9) and 7.0 concussions/100 participants/year (95% CI: 5.2-9.1), respectively. Injury and concussion prevalence were highest in ringette (42.9 injuries/100 participants/year, 95% CI: 21.8-66.0; 19.0 concussions/100 participants/year, 95% CI: 5.4-41.9) and rugby (40.7 injuries/100 participants/year, 95% CI: 28.1-54.3; 16.9 concussions/100 participants/year, 95% CI: 8.4-29.0). The top 3 most serious injury locations were the knee (25.3%), ankle (22.2%) and head (16.1%). The most common injury types were ligament sprain (30.4%), fracture (13.0%) and concussion (11.8%). 69.8% of all serious injuries in female team sports occurred via contact mechanisms. Overuse (15.1%) was the next most common mechanism reported. Of participants that reported concussion as their most serious injury, 100% were attributed to contact mechanisms (38.9% contact with someone; 61.1% contact with something).

Conclusions: Injury prevalence and concussion rates are high in female high school students. Specific consideration of concussion contact mechanisms in female youth team sports will inform development and evaluation of targeted female contact and sport-specific prevention strategies.

Acknowledgments: We would like to acknowledge research coordinators, graduate students, research assistants, school administrators, teachers and high school students who made this work possible. The Sport Injury Prevention Research Centre is one of the International Olympic Committee Research Centers for the Prevention of Injury and Protection of Athlete Health. We acknowledge the financial support of the Canadian Institutes of Health Research (Foundation Grant C Emery PI) and Joan Snyder. Alexis Cairo was funded through Alberta Innovates Summer Studentship.

Incidence of Injury and Illness in Summer and Winter Canada Games

Nicole J. Chimera, PhD, CAT(C), ATC, CSCS,* Danielle Merasty, BRSS,* and Monica R. Lininger, PhD, LAT, ATC,†

*Affiliations: *Brock University, St. Catharines, ON, Canada; and †Northern Arizona University, Flagstaff, AZ.*

Objective: To determine the incidence and frequency of injuries in athletes participating in summer and winter Canada Games.

Study Design: Retrospective, descriptive, epidemiological study.

Subjects: Eight thousand seven hundred ten (n = 5457 summer; n = 3253 winter) male and 8391 females (n = 4712 summer; n = 3679 winter) competing in Canada Games between 2009 and 2019.

Intervention/Observation Technique: De-identified data were exported by Canada Games Council and stratified by Summer and Winter Games; data were also categorized by participant sport and sex.

Outcome Measures: The outcome variables were injury/illness incidence (per 1000 athletes) and frequencies of injury type, injured body area, chronic or acute injury, and affected system of illness in overall and individual sport Summer and Winter Canada Games participants.

Results: The overall injury incidence was 359.43 in Summer, compared to 398.87 Winter Canada Games; overall illness incidence was 47.30 in Summer, compared to 68.81 in Winter. Injury incidence in male Summer Games participants was 338.83 compared to 383.28 in female and 401.48 compared to 396.58 in male and female Winter participants, respectively. Illness incidence in male Summer Games participants was 39.95 compared to 55.81 in female and 60.87 compared to 75.84 in male and female Winter participants, respectively. Female freestyle skiing participants had the highest injury incidence: 1001.82; female target shooting participants had the highest illness incidence: 192.67. Strains were most common (n = 600; 32.45%—male Summer; n = 614; 34.00%—female Summer; n = 545; 41.73%—male Winter; n = 620; 42.50%—female Winter). Thigh (n = 215; 10.99%) and shoulder (n = 191; 14.19%) were the most frequently injured in male Summer and Winter participants, respectively; shoulder was most frequent in female Summer (n = 204; 10.75%) and Winter (n = 200; 13.03%) participants. Male Summer (n = 1018; 55.06%) and Winter (n = 696; 53.29%) participants reported more acute injuries; female Summer (n = 972; 53.82%) and Winter (n = 762; 52.23%) participants reported more chronic injuries. In Summer Games, participants reported highest illness in other category (urogenital, gynaecological, neurological, psychiatric) (n = 69; 31.65%—male; n = 74; 28.14%—female) and in Winter games respiratory system (n = 85; 42.93%—male; n = 131; 46.95%—female) was most often affected illness.

Conclusions: Differences exist in injuries and illnesses between Summer and Winter Canada Games.

Acknowledgments: Canada Games Council; Brock University VPR Canada Games Grant.

Keep Your Head Up: Examining Head Impacts Through Video-Analysis in Canadian High School Football

M. Patrick Pankow, BKin,*,† Sagar S. Grewal, BSc,*,† Reid Syrydiuk, BA,*,† Ash T. Kolstad, BSc,*,† Christian A. Clermont, PhD,*,† Christopher R. Dennison, PhD PEng(AB),‡ Brent Hagel, PhD,*,†,‖,** Martin Mrazik, PhD, R.Psych,†† and Carolyn A. Emery, PT, PhD*,†,§,¶,‖**

*Affiliations: *Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Calgary, AB,*

*Canada; †Alberta Children's Hospital Research Institute, University of Calgary, Calgary, AB, Canada; ‡Biomedical Instrumentation Lab, Department of Mechanical Engineering, University of Alberta, Canada; § Hotchkiss Brain Institute, University of Calgary, Calgary, AB, Canada; ¶Evidence Sport and Spinal Therapy, Calgary, AB, Canada; ||Departments of Pediatrics and Community Health Sciences, Cumming School of Medicine, University of Calgary, Canada; **O'Brien Institute for Public Health, Cumming School of Medicine, University of Calgary, Canada; and ††Faculty of Education, University of Alberta, Edmonton, AB, Canada.*

Objective(s): To compare game-related head impact rates across playing units (eg, offence, kicking-team) and game type (ie, regular season, playoff) and to descriptively characterize head impacts by player position (eg, quarterback, offensive line).

Study Design: Cross-sectional video analysis study.

Subjects: Two high school football teams (ages 15-16) in Calgary, Alberta had a combined total of 14 games video-recorded (n = 28 team-games) during the 2019 season. Ten of 11 teams in the league had at least one game recorded.

Intervention/Observation Technique: Games were video-recorded using 3 high-definition cameras and analyzed using Dartfish video software.

Outcome Measures: The outcome measure was head impacts. Investigators (MPP & RS) were trained and upon achieving gold-standard inter-rater reliability (threshold of 80% on all variables), independently analyzed each team-game. Play-related head impacts were coded using a standardized process. Univariate Poisson regression was used to examine head impact incidence rates (IR) across team unit and game type and corresponding incidence rate ratios (IRR) were calculated. Proportions were used for descriptive analyses.

Results: Preliminary analysis from 16 of 28 team-games revealed 5100 head impacts. In total, 1798 plays were analyzed most of which were offensive (39%) or defensive (37%) plays. Defensive players incurred the most head impacts per game (IR: 10.30/team-game, 95% CI: 9.8-10.8), experiencing head impacts at 1.05 (95% CI: 0.98-1.12), 2.68 (95% CI: 2.46-2.92), and 4.00 (95% CI: 3.62-4.43) times the rate of offensive, kicking-team and receiving-team players, respectively. The head impact rate was greater in playoff compared to regular season games (IRR: 1.14, 95% CI: 1.07-1.21). Positionally, offensive (30.15%) and defensive (29.12%) linemen accounted for the most head impacts. Further analysis will consider all 28 team-games and assess the effect of the down, quarter, and score differential on the rate of head impacts while adjusting for cluster by team-game.

Conclusions: The average offensive and defensive plays occurred more frequently, and these players experienced head impacts at an increased rate compared to kicking and receiving-team players. Moreover, rates of head impacts in playoff games were 1.14-fold greater than regular season games.

Acknowledgments: The Sport Injury Prevention Research Centre is one of the International Research Centres for Prevention of Injury and Protection of Athlete Health supported by the International Olympic Committee. We acknowledge funding from National Football League Scientific Advisory Board Play Smart Play Safe Program, Hotchkiss Brain Institute and Alberta Children's Hospital Foundation. We would like to acknowledge the research coordinators, research assistants, school districts and all of teachers, coaches and students involved for their time and support in completing this project.

Four-Strand or Five-Strand Hamstring Graft for Anterior Cruciate Ligament Reconstruction—Does it Make a Difference?

Parth Lodhia, MD,*,† Goris Nazari, PhD,‡ Dianne M. Bryant, PhD,§,||,¶ Alan M.J. Getgood, MD,||,¶,** and Robert G. McCormack, MD*,†

*Affiliations: *Department of Orthopedics, University of British Columbia, Vancouver, BC, Canada; †Fraser Orthopaedic Institute, New Westminster, BC, Canada; ‡Faculty of Health Sciences - Canadian Institute for Military and Veteran Health Research, Queen's University, Kinston, Canada; §Faculty of Health Sciences, School of Physical Therapy, Western University, London, ON, Canada; ||Fowler Kennedy Sport Medicine Clinic, London, ON, Canada; ¶Lawson Research, London Health Sciences Centre, London, ON, Canada; and **Department of Surgery, Schulich School of Medicine and Dentistry, Western University, London, ON, Canada.*

Objective: To investigate the differences in clinical outcomes between 4-strand (4S) and 5-strand (5S) hamstring autografts for ACLR in patients who underwent ACLR alone or concomitantly with a lateral extraarticular tenodesis (LET) procedure.

Study Design: Post hoc subgroup analysis of the data collected in the STABILITY study, Level of evidence, 2.

Subjects and Intervention/Observation Technique: The data from the STABILITY study was analyzed to compare a subgroup of patients undergoing ACLR alone or with a concomitant LET procedure (ACLR+LET) with a minimum graft diameter of 8mm, that had either a 4S or 5S hamstrings autograft configuration. Patients with graft diameters lower than 8mm and any other configurations of hamstrings autograft were excluded.

Outcome Measures: The primary outcome was clinical failure, which was a composite of rotatory laxity or graft failure. The secondary outcome measures consisted of 2 patient reported outcome scores (PROS), namely, the ACL Quality of Life Questionnaire (ACL-QoL) and the International Knee Documentation Committee (IKDC) score at 24 months postoperatively.

Results: Out of the 618 patients randomized in the STABILITY study, 399 (228 males; 57%) fit the inclusion criteria for this study. Of these, 191 and 208 patients underwent 4S and 5S configurations of hamstring ACLR, respectively with a minimum graft diameter of 8mm. Both groups had similar demographic characteristics other than expected differences in anthropometric factors, namely sex, height, and weight, and Beighton scores. The primary outcomes revealed no difference between the 2 groups when analyzed based on rotatory stability [odds ratio (OR), 1.19; 95% CI, 0.77-1.84; $P = 0.42$] or graft failure (OR, 1.13; 95% CI, 0.51-2.50; $P = 0.76$). Furthermore, there was no significant difference between the groups in the Lachman ($P = 0.46$) and pivot shift ($P = 0.53$) tests at 24 months postoperatively. The secondary outcomes revealed no differences in the ACL-QoL ($P = 0.67$) and IKDC ($P = 0.83$) between the 2 subgroups.

Conclusion: There were no significant differences in clinical failure and PROS in an analysis of patients with 4S and 5S hamstring autografts undergoing ACLR or ACLR+LET at 24 months follow-up. The 5S hamstring graft configuration is a viable option to produce higher diameter ACL grafts.

Impact-Detecting Helmets as Indicators of Concussion and Traumatic Microvascular Injury in University Football Players

Casey M.A. Jones, MSc,* Lorelei Audas, RN, BScN,† Nelofar Kureshi, MBBS, MHI,† Lyna Kamintsky, MSc,‡ Lynne Fenerty, RN,† Christina Atkinson, MD§, Alon Friedman, MD, PhD,‡ and David B. Clarke, MDCM, PhD,†,‡

*Affiliations: *Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada; †Division of Neurosurgery, Dalhousie University QEII Health Sciences Centre, Nova Scotia Health Authority, Halifax, NS, Canada; ‡Department of Medical Neuroscience, Dalhousie University, Faculty of Medicine, Halifax, NS, Canada; and §Department of Family Medicine, Faculty of Medicine, Dalhousie University, Halifax, NS, Canada.*

Objective: To examine the association between repetitive sub-concussive impacts, concussion diagnosis, and blood brain barrier integrity in university football players.

Study Design: Prospective observational pilot study.

Subjects: Fifty-seven university male football players aged 18 to 25.

Observation Technique: Head impacts were tracked during one season of university football using ferroelectric trackers. Athletes with diagnosed concussion, and those sustaining impacts that alerted a sideline impact monitor, underwent dynamic contrast-enhanced MRI (DCE-MRI) to assess blood brain barrier (BBB) integrity. Subjects had MRI scans within one week of injury/alert, and 4 weeks following initial incident.

Outcome Measures: The primary outcome measures were head impacts and their association with clinically diagnosed concussion. Secondary measures included distribution and extent of BBB pathology 1 week after injury/alert and at 4 weeks.

Results: A total of 2648 impacts were registered from 55 contributing athletes. The majority of impacts were recorded by the front sensor (50.9%) compared with the other 4. The majority of impacts (77.8%) were in the low category (15-28 g), with 20.6% in the medium (29-62 g) and 1.7% in the high (63+ g) impact ranges. The sideline impact monitor was alerted 15 times by 10 athletes, 5 of which were diagnosed with a concussion by team medical staff. There was a total of 8 concussions in the 2019 season. On average, athletes with diagnosed concussion had greater impacts to the front sensors compared to non-concussed athletes (62.6 vs 13.9, $P = 0.019$). Five athletes alerted by the impact monitor (4 of which had clinical concussion within 7 days) underwent DCE-MRI: they had an average BBB-D of 7.6% within a week of concussion and 4.1% at 4-week follow up.

Conclusions: This preliminary study highlights the potential of impact-detecting helmets to provide relevant impact characteristics and presents a solid foundation for future work on neurological outcomes of successive sub-concussive impacts. Impacts to the front of the head put athletes at greater risk for concussion; however, the sideline impact monitor was only alerted in 62.5% of clinically-diagnosed concussions. Ongoing work with this cohort will attempt to investigate impact-induced clinical concussions by using helmet alerts and examining the extent of BBB-D.

The Effect of Axillary Crutch Length on Latissimus Dorsi Activity During Swing-Through Gait

Yarmaghan Afzal,* Gregor Kuntze, PhD,†,‡ Janet L. Ronsky, PhD, PEng,*,† and Ranita H. K. Manocha, MD, MSc†,§

*Affiliations: *Schulich School of Engineering, University of Calgary, Calgary, AB, Canada; †McCaig Institute for Bone and Joint Health, University of Calgary, Calgary, AB, Canada; ‡Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada; and §Division of Physical Medicine & Rehabilitation, University of Calgary, Calgary, AB, Canada.*

Objective: In crutch-assisted gait, latissimus dorsi (LD) is thought to assist with trunk forward progression during the body swing-through phase. Altered crutch length has been shown to change upper extremity kinematics but the impact on LD activity is unknown. The purpose of this investigation was to quantify LD activity when crutches are fitted appropriately and inappropriately.

Study Design: Cross-sectional gait laboratory study.

Subjects: Fifteen able-bodied adult males (mean age: 26; range: 23-34).

Intervention/Observation Technique: Participants were fitted with 3 crutch types: crutches fitted using standard guidelines and crutches that were 5 cm longer and 5 cm shorter than the standard fit. Participants' bilateral LD were instrumented with bipolar surface electromyography (EMG) electrodes. Participants performed 15 single-limb swing-through gait (STG) trials with each crutch length, landing on the left leg. EMG data were processed using discrete wavelet analysis.

Outcome Measures: Peak EMG intensities and timing; and total EMG intensities (during 0%-25%, 25%-50%, 50%-90%, and 90%-100% of the STG cycle). Data analysis was performed using the Wilcoxon signed-rank test (alpha = 0.05).

Results: On the left side, longer crutches resulted in higher peak intensity ($P = 0.01$) and greater total intensity from crutch initial contact to mid-stance (0%-25% of STG; $P = 0.04$) compared to standard crutches. Crutch length did not affect these parameters on the right side. On both sides, shorter crutches had greater total intensities during crutch terminal swing (90%-100% of STG; left: $P = 0.04$, right: $P = 0.02$).

Conclusions: Latissimus dorsi is most active from crutch terminal swing to crutch terminal stance. It seems to be most active on the side of the landing leg, which may explain why most upper extremity injuries reported with axillary crutch use occur on the side of the weight-bearing lower extremity. The left LD was most active with longer crutches during the first half of the crutch stance phase, likely due to the longer pendulum time seen with longer crutches. As shorter crutches increase shoulder flexion at initial crutch contact, LD may need to be more eccentrically active during crutch terminal swing in this scenario to help advance the body during the upcoming crutch stance phase.

Acknowledgments: Cumming School of Medicine & Alberta Health Services Clinical Research Fund Pre-Seed Grant (#18-

1202) and Natural Science and Engineering Research Council of Canada Undergraduate Student Research Award.

Shifts in Management of Anterior Cruciate Ligament Injury in Canada From 2009 to 2020

Micah Sommer, BSc,* Sheila McRae, PhD,† Dan Ogborn, PhD,† and Peter MacDonald, MD†

*Affiliations: *University of Manitoba, Winnipeg, MB; and †Pan Am Clinic, Winnipeg, MB.*

Objective: Management of anterior cruciate ligament injury is constantly evolving with shifts in surgical and post-operative treatment. A survey of the Canadian Orthopaedic Association was conducted in 2009 and repeated in 2020 to identify shifts in practice and areas of contention regarding ACL reconstruction (ACLr).

Study Design: Survey study.

Subjects: All members of the Canadian Orthopaedic Association were invited to complete an anonymous survey. Ninety-four of 927 active COA members (10%) responded to the survey of which 77 indicated they had performed ACLr within the past 12 months.

Outcome Measures: A survey conducted via direct email from the principle investigator in 2009 was updated to include new options in ACL injury management. A link to the 50-question survey was distributed via the COA newsletter to participate through Surveymonkey.com (Palo Alto, California) in Spring 2020. Descriptive statistics were generated and compared to previous findings where applicable.

Results: Ninety-four of 927 active COA members (10%) responded to the survey of which 77 indicated they had performed ACLr within the past 12 months. Currently, 81% prefer hamstring graft (semitendinosus-gracilis or semitendinosus) compared to 73% in 2009 over bone-patellar-tendon bone. Two percent prefer quadriceps tendon which was not used in 2009. Anteromedial portal was preferred by 77% compared to 38% in 2009, with transtibial being preferred at that time. Duration of post-operative physiotherapy shifted from 38% stating 1 to 3 months and 38% stating 3 to 6 months in 2009 to 17% indicating 3 months and 51% and 20% indicating 6 and 12 months respectively. In 2009, 56% indicated expected time to return to sport was 6 to 9 months and 29% indicated 9 to 12 months. In 2020, 25% indicated 6 to 9 months and 59% indicated 9 to 12 months.

Conclusions: Hamstring is the preferred autograft in ACLr with increased clinical agreement since 2009. There has also been a substantial shift to using anteromedial portal compared to transtibial technique for femoral tunnel positioning. Expected time to return to sport is longer. These and other shifts in practice were found highlighting the value of evaluation of practice and application of new knowledge in the management of ACL injury.

Comparison of Pain Score and Analgesic Usage Between Bone Patellar Tendon-Bone, Hamstring and Quadriceps Tendon Autographs for Anterior Cruciate Ligament Reconstruction

Jasmine Levesque, MD,* Sheila McRae, PhD,† Jarret Woodmass, MD,† Greg Stranges, MD,† Devin Lemmex, MD,† Robert Longstaffe, MD,† and Peter MacDonald, MD,†

*Affiliations: *University of Manitoba; and †Pan Am Clinic.*

Objective: To characterize postoperative pain and medication use following ACL reconstruction with a bone-patellar tendon-bone (BPTB), hamstring (semitendinosus/gracilis (STG), and quadriceps tendon (QT) autograft.

Study Design: Prospective longitudinal study.

Subjects: Patients greater than 14 years of age (skeletally mature) with complete ACL rupture and no concomitant injuries requiring significant intervention were recruited following initial consultation from the clinics of 5 fellowship trained orthopaedic surgeons. Ninety-four patients (25.0 ± 7.7 years; 49 males, 45 females) participated.

Observation Technique: Graft assignment was based on surgeon preference of type with each surgeon performing only one of the 3 techniques and documenting rationale for any divergence from that option.

Outcome Measures: Patients recorded pain and medication use in a logbook for 14 days postoperative. These books were collected at their first post-operative visit by a research assistant. Pain was based on a visual analogue scale (VAS) and analgesic medication type and quantity were recorded in 4-hour increments. Analgesia medications were divided into 3 categories: oral opioids, oral nonsteroidal anti-inflammatories, and acetaminophen. One-way ANOVA was used to compare pain medication usage of each type between grafts, by day, and also total number of pills taken on average at 48-hours, and 7- and 14-days post-operative.

Results: Twenty-seven patients received a BPTB graft, 36 received STG, and 31 received QT. There were no differences in pain scores between groups at any time point. Peak pain scores (mean ± SD) were seen at Day 1 morning (5.9 ± 2.5), Day 1 evening (6.1 ± 2.5), and Day 2 evening (6.3 ± 2.2) for the BPTB, STG, and QT, respectively and pain for all groups was reduced to <1.8 at 14-days. There were no differences between grafts in the mean number of pills of each category taken per day or the total number of pills taken at 48-hours, 7- and 14-days postoperative.

Conclusion: There was no difference in pain level or in pain medication usage between graft types. Approximately 15% to 20% of patients continued using opioids at 14-days post-operative. Health care practitioners may use this information to guide patient education and expectations regarding different graft options and the trajectory of recovery and pharmaceutical use early post-surgery.