

2021 CASEM Podium Presentations

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Rates of Injury and Concussion Associated With Body Checking Experience Among 13 to 14-Year-Old Ice Hockey Players

Paul H. Eliason, MSc,*†‡§, Luz Palacios-Derflingher, PhD,*¶, Vineetha Warriyar KV, PhD,* Stephan Bonfield, MSc, MA,* Amanda M. Black, CAT(C), PhD,*†‡§, Willem H. Meeuwisse, MD, PhD,* Brent E. Hagel, 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; ¶Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada; and ||Pediatrics, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada.

Objective: To compare rates of injury and concussion among under-15 (ages 13-14) ice hockey players in leagues allowing body checking, but who have a varying number of years of body checking experience.

Study Design: Prospective cohort.

Subjects: Under-15 ice hockey players were recruited from 2 provinces (Alberta and British Columbia) over 5 seasons of play (2013/14-2017/18).

Observation Technique: Years of body checking experience was estimated based on local and national body checking policy.

Outcome Measures: All ice hockey game-related injuries were identified using a valid injury surveillance methodology. Any player with a suspected concussion was referred to a study sport medicine physician for diagnosis and management. Multiple multilevel mixed-effects Poisson regression analysis was performed, adjusted for important covariates (year of play, level of play, previous injury/concussion, player weight, and position) and a random effect at a team level (offset by game exposure hours), to estimate all injury and concussion incidence rate ratios (IRRs).

Results: In total, 1647 players participated, contributing 1842 player-seasons, with 195 players participating in 2 seasons. There were 135 game-related injuries [injury rate (IR) = 8.31 injuries/1000 game-hours (95% CI: 6.94-9.96)] and 64 game-related concussions [concussion rate (CR) = 3.94 concussions/1000 game-hours (95% CI: 3.03-5.11)] among players with no body checking experience, 140 injuries [IR = 8.75 injuries/1000 game-hours (95% CI: 7.04-10.88)] and 61 concussions [CR = 3.81/1000 game-hours (95% CI: 2.83-5.13)] among players with 1 year of body checking experience, and 127 injuries [IR = 7.26/1000 game-hours (95% CI: 5.31-

9.93)] and 49 concussions (CR = 2.80/1000 game-hours (95% CI: 1.90-4.13)] among players with 2 + years. Relative to no body checking experience, no significant differences were found in the adjusted IRRs for game-related injury for players with 1 year (IRR = 1.06; 95% CI: 0.77-1.45) or 2 + years (IRR = 1.16; 95% CI: 0.74-1.84) body checking experience. Similarly, no differences were found in the adjusted IRR for game-related concussion for players with 1 year (IRR = 0.92; 95% CI: 0.59-1.42) or 2 + years (IRR = 0.69; 95% CI: 0.38-1.25) body checking experience.

Conclusions: Among under-15 ice hockey players participating in leagues permitting body checking, no differences were found in the rates of injury and concussion between players with and without body checking experience.

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Injury and Concussion in Canadian Female High School Rugby

Isla J. Shill, MSc,* Stephen West, PhD,*† Brent E. Hagel, PhD,*†‡§¶||, Kati Pasanen, PT, PhD,*†‡||, Carolyn A. Emery, PT, PhD,*†‡§¶||, and Amanda M. Black, (C) AT, PhD*†‡¶**

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

Objective: Describe injury and concussion rates and mechanisms of injury in Canadian female high school rugby.

Study Design: Two-year prospective cohort study.

Subjects: Participants included 214 female high school rugby players from 5 schools (Year 1) and 207 female high

school players from 7 schools (Year 2) from the Calgary Senior High School Athletics Association 2018 and 2019 rugby competition.

Observation Technique: Details of reported injuries were collected on injury report forms and subsequently validated by a certified athletic therapist on an online SHRed Injuries (Surveillance in High Schools to Reduce Injuries) injury surveillance platform. Exposure hours for players were tracked using paper or virtual weekly exposure forms by team designates.

Outcome Measures: Injury definition included injuries requiring medical attention and/or timeloss and all suspected concussions.

Results: Two hundred forty injuries were reported from 421 athlete-seasons (57 injuries/100-player-seasons). 155 injuries occurred during match play (93.7 injuries/1000-match-hours, 95% CI: 78.6-11.7) and 85 injuries occurred during training (5.3 injuries/1000-training-hours, 95% CI: 4.0-6.9). The most common injury location was head for match (69 injuries, 45%) and training (17 injuries, 21%). The most common injury type was concussion for match (62 injuries, 40%) and ligament sprain for training (24 injuries, 29%). 109 (70%) match and 37 (44%) training injuries were a result of tackling or being tackled. The most common mechanism of match and training injury was tackling (Match: 62 injuries, 37.5 injuries/1000-match-hours, 95% CI: 27.5-51.8; Training: 20 injuries, 1.2 injuries/1000-training-hours, 95% CI: 0.7-2.4). 78/240 (33%) injuries were concussions (18.5 concussions/100-player-seasons). 62 concussions occurred during match play (37.5 concussions/1000-match-hours, 95% CI: 26.8-52.3) and 16 concussions occurred during training (1.0 concussions/1000-training-hours, 95% CI: 0.7-1.4). The most common mechanism of concussion was tackling (30 concussions: 18.1 concussions/1000-match-hours, 95% CI: 11.4-28.6) during match play and being tackled (7 concussions: 0.4 concussions/1000-training-hours, 95% CI: 0.2-0.8) during training.

Conclusions: Injury and concussion rates in female youth rugby are the highest reported rates for youth rugby to date. As tackle mechanisms accounted for the highest proportion of injuries and concussions specifically, prevention strategies (eg, tackle policy change, tackle-training program, neuromuscular training) should be explored to increase sport safety.

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The Association Between the Buffalo Concussion Treadmill Test and Days to Recovery: A Retrospective Cohort Study of 855 Adolescents With Sport-Related Concussion

Rahim Lalji, MSc, DC,*,† Scott Howitt, MSc, DC,‡ Cameron Marshall, DC, Alison Macpherson, PhD,§ and Hala Tamim, PhD§

Affiliations: *Epidemiology and Biostatistics Prevention Institute, University of Zurich, Zurich, Switzerland; †Department of Chiropractic Medicine, Faculty of Medicine, Balgrist University Hospital, Zurich, Switzerland; ‡Canadian Memorial Chiropractic College, Toronto, ON, Canada; and §Faculty of Kinesiology and Health Science, York University, Toronto, ON, Canada.

Objective: To assess the association between a first attempt Buffalo Concussion Treadmill Test (BCTT) performed between 10- and 21-days following sport related concussion (SRC) and days from injury to recovery in a sample of Canadian adolescents.

Study Design: Retrospective cohort study.

Subjects: Data from 855 (480 male, 375 female) adolescents was extracted from the practice-based research network of Complete Concussion Management Inc. Participants included received a diagnosis of SRC from a regulated healthcare professional, performed first BCTT between 10 and 21 days after injury and scored 7 or higher on concussion symptom severity. Participants excluded presented with findings inconsistent with concussion, had 3 or more past concussions and diagnosed with learning, sleep or anxiety disorder.

Intervention: The BCTT was categorized as "pass" or "fail." Hierarchical linear regression was used to assess the association between a first attempt BCTT result and days from injury to recovery adjusting for participant characteristics (age, sex, history of previous concussion), injury characteristics (loss of consciousness, presence of amnesia, sport, symptom severity score) and assessment characteristics (days from injury to intake, days from injury to first attempt BCTT).

Outcome Measures: The outcome of days from injury to recovery was assessed as a continuous variable. Recovery was defined by a passed BCTT, completion of stepwise return-to-play process and assessment by regulated healthcare professional.

Results: After adjusting for participant, injury and assessment characteristics, failing a first attempt BCTT was significantly associated with 13 increased days to recovery ($\beta = 13.173$, 95% CI = 8.977, 17.369) when compared to a passed result. The BCTT, injury specific, and assessment specific characteristics together explained 11.8% variation in days to recovery ($R^2 = 0.118$). However, the BCTT alone explained only 4% of the variation in recovery time ($R^2 = 0.04$).

Conclusions: Participants who failed a first attempt BCTT were significantly associated with prolonged recovery when compared to participants with a passed first attempt.

Dynamic Neck Strength as a Potential Screening Tool for Future Concussion risk: A Pilot Study

Theodore Versteegh, PT, PhD

Affiliation: School of Physiotherapy, Western University, London, ON, Canada.

Objective: Women's soccer is one of the highest risk sports for concussion. The strongest predictor for future concussion risk is a prior history of concussion. There is also evidence to suggest increased neck strength may be protective against concussion. To determine if female varsity soccer players with a prior history of concussion, and hence known to be at higher concussion risk, also demonstrate decreased neck strength.

Study Design: Observational cohort study.

Subjects: Twenty-eight university level female soccer players.

Observation Technique: Single session assessment in January one month after the end of the competitive season.

Outcome Measures: static multi-planar composite neck strength using a handheld dynamometer was measured in pounds force (lbf) and dynamic neck strength measured as peak Rate of Force Development (RFD) in pounds force per second ($\text{lbf} \times \text{second}^{-1}$) using the TopSpin360. Self-declared concussion history was also recorded. Independent samples *t*-tests were used to compare differences between groups.

Results: 10 players declared a prior history of concussion (HxCon) at some point during their playing career, while 18 players self-declared with no history of concussion (NoHxCon). There was no significant difference in static neck strength between the groups (NoHxCon = 30.4 lbs, 95% CI 27.6-33.2, HxCon = 29.8 lbs, 95% CI 24.8-34.8, $P > .05$). There was a significant difference in dynamic neck strength between the groups (NoHxCon = $7.1 \text{ lbf} \times \text{second}^{-1}$, 95% CI 5.2-9.1, HxCon = $3.8 \text{ lbf} \times \text{second}^{-1}$, 95% CI 2.5-5.2, $P < .05$). In this cohort, using area under the curve graph demonstrated a sensitivity of 72% and specificity of 80% at an RFD of $4.5 \text{ lbf} \times \text{second}^{-1}$ to distinguish players with a history of concussion from those without.

Conclusions: In this small study, dynamic neck strength was able to differentiate players with a history of concussion, and hence at a known higher risk of future concussion, from those with no history of concussion and relatively lower risk. Future studies should explore using dynamic neck strength as a potential screening tool to assess athletes' risk of concussion.

The Presence of Additional Pathology in Grade I and II Acromioclavicular Joint Injuries

Drew Mulhall, MD,* Sheila McRae, PhD,† James Koenig, MD,† Graeme Mattewson, MD,† Peter Nemeth, MD,† and Peter MacDonald, MD†

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

Objective: Acromioclavicular (AC) joint injuries comprise 12% of shoulder girdle injuries. Studies show that many patients with grade I and II injuries remain symptomatic and have radiographic evidence of AC joint degeneration several years after initial injury. A study by Nemeč et al used magnetic resonance imaging (MRI) and found AC joint injuries had effusions and bone marrow edema. However, these findings were not correlated with injury grade. Given the poor clinical outcome of grade I and II injuries and additional MRI findings in AC joint injuries, we aim to validate our hypothesis that additional pathology exists in grade I and II AC joint injuries.

Study Design: Prospective cohort study.

Subjects: Patients categorized as having a grade I or II AC injury by a primary care physician were consented at the time of initial consult between 2018 and 2020. Thirteen patients (12 male/one female) were consented with a mean age of 28.6 ± 10.8 .

Outcome Measure: Patients underwent an MRI within 21 days of injury and additional pathologies were reported in a standardized fashion by fellowship-trained musculoskeletal radiologists.

Results: Mean time from injury to MRI was 7.9 ± 6.4 days. Nine injuries were sport-related and 4 were accidental traumas. The injury grade of 10/13 patients was upgraded

following MRI. Specifically, 5 patients increased from grade I to II and 5 patients increased from grade II to III. Three patients remained unchanged and none were downgraded. Additional pathologies identified were: muscle injury (7), rotator cuff tears (2), labral tears with paralabral cysts (2), AC joint effusions (2), and a nondisplaced fracture (one). No glenohumeral joint effusions or long biceps tendon injuries noted. One patient did not have additional findings.

Conclusions: Radiologic evidence suggests that most AC joint injuries are more severe than clinically diagnosed. Identifying additional pathology may alter diagnostic and treatment guidelines for grade I and II AC joint injuries. Acknowledging that additional pathology exists in most AC joint injuries may increase the utilization of MRI to further define injury severity in certain patient populations. This further understanding of AC joint injuries may also delay return-to-sport and guide treatment protocols.

Neuromuscular Training Warm-up Has No Effect on the Prevalence of Overuse Lower Extremity Injuries in Children's Soccer. A Cluster Randomized Controlled Trial

Hilka Matias, BM,* Leppänen Mari, PhD,* Vasankari Tommi, PhD,† Clarsen Benjamin, PhD,‡ Aaltonen Sari, PhD,§ Bahr Roald, PhD,‡ Haapasalo Heidi, PhD,¶ Parkkari Jari, PhD,* Kannus Pekka, PhD,* and Pasanen Kati, PhD*,||, **,††

Affiliations: *Tampere Research Center of Sports Medicine, UKK Institute for Health Promotion Research, Tampere, Finland; †UKK Institute for Health Promotion Research, Tampere, Finland; ‡Oslo Sports Trauma Research Center, Norwegian School of Sport Sciences, Oslo, Norway; §Institute for Molecular Medicine (FIMM), University of Helsinki, Helsinki, Finland; ¶Department of Orthopaedics and Traumatology, Tampere University Hospital, Tampere, Finland; ||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; and ††McCaig Institute for Bone and Joint Health, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada.

Objective: To examine the effects of a neuromuscular training (NMT) warm-up on the prevalence of overuse lower extremity (LE) injuries in children's soccer.

Study Design: Randomized clinical trial to evaluate the replacement of standard warm-up routines with NMT warm-up.

Subjects: Twenty Finnish youth soccer clubs ($n = 1409$ players, of which females 280, males 1129, age range 9-14) were randomized into intervention and control groups containing 10 clubs each (intervention: 44 teams, $n = 676$ players; control: 48 teams, $n = 733$ players).

Intervention: The intervention group performed a structured NMT warm-up program operated by team coaches for a 20-week follow-up period.

Outcome Measures: The main outcome measures were soccer-related overuse LE injuries. Injuries were recorded with the Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-O) on a weekly basis.

Results: The average weekly prevalence of overuse LE injuries was 11.6% (95% CI 11.0%-12.2%) in the

intervention group and 11.3% (10.7%-11.9%) in the control group. The most common anatomical locations of overuse injury were the knee (weekly prevalence 6.0% in the intervention group and 5.7% in the control group) and heel (2.4% and 2.6%). No difference in the risk for overuse LE injuries was seen between the groups: odds ratio (OR) 1.01 (95% CI 0.98-1.04). In males, the risk for substantial heel injuries was 8% higher in the intervention group compared to the controls (OR 1.08, 95% CI 1.01-1.15).

Conclusions: There is a high prevalence of overuse LE injuries in children's soccer and NMT warm-up seemed to neither reduce nor increase these overuse injuries. Small adverse effect against the use of NMT warm-up was seen as an increase in the risk for heel overuse injuries. The established benefits of NMT to overall LE injury prevention overcome this minor adverse effect.

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The Case for Early, Conservative Management for Patients Presenting With Chronic Rotator Cuff Tears

Breda H.F. Eubank, PhD, CAT(C),* Nicholas G. Mohtadi, MSc, MD,† Mark R. Lafave, PhD, CAT(C),* David M. Sheps, MSc, MBA, MD,‡ and J. Preston Wiley, MPE, MD†

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

Objective: To explore the impact of adopting an early, conservative management (CM) plan as the first stage of care for all patients presenting with chronic rotator cuff tears (RCT) in Alberta. This proposed care pathway would promote the use of ultrasound investigation for diagnosing RCT and refer patients for surgery only when CM have been exhausted.

Study Design: Descriptive survey research design/literature review.

Subjects: One hundred seventy-one patients presenting to 2 sport medicine centres in Calgary and Edmonton, Alberta.

Intervention: Patients were asked to complete the Healthcare Access and Patient Satisfaction Questionnaire. The literature was searched to estimate the probability of patients prescribed early, CM; and to identify studies that evaluated the effectiveness of early, CM in patients with chronic RCT.

Outcome Measures: Cost estimates were calculated by multiplication of patient-reported utilization volume and unit costs. Unit costs were estimated using standardized costing methods provided in the Guidance Document for the Costing of Healthcare Resources in the Canadian Setting. Average probabilities were estimated using values obtained in the literature.

Results: Estimating treatment costs in the current state, the total PPAC for a patient receiving arthroscopic surgery is approximately \$4167; while the total PPAC for a patient receiving CM is approximately \$950. The probability that patients were prescribed and exhausted CM in the current state was estimated to be 0.61. It was estimated that CM, if prescribed early, would result in successful outcomes in 77 of 100 cases. Using these values, the cost of 100 patients receiving care in the current state was estimated at \$278,801. In the proposed care pathway (ie, ideal state), 100% of patients would receive and exhaust CM. The cost of 100 patients receiving care in the ideal state was estimated at \$190,840.

Conclusions: The proposed care pathway has the potential to avoid nearly \$87,000 in public healthcare costs from surgeries avoided in the current state for every 100 patients treated successfully with CM. This has the potential to save between \$22.1 and \$51.6 million.

Bone Grafting the Patellar Defect Following BPTB ACL Reconstruction Decreases Anterior Knee Morbidity: A Systematic Review

Darius L. Lameire, BSc,* Hassaan Abdel Khalik, BSc, MMI,* Alexander Zakharia,† Jeffrey Kay, MD,‡ Mahmoud Almasri, MD, FRCSC,‡,§ and Darren de SA, MD, MBA (cand), FRCSC‡

Affiliations: *Michael G. DeGroot School of Medicine, McMaster University, Hamilton, ON, Canada; †MacSports Research Program, McMaster University, Hamilton, ON, Canada; and ‡Division of Orthopaedic Surgery, McMaster University, Hamilton, ON, Canada; ‡Mercy Health—Cincinnati Sports Medicine and Orthopaedic Center, Cincinnati, OH.

Objective: The aim of this systematic review is to evaluate the impact of bone grafting of the patellar defect on reported anterior knee morbidity and subjective outcomes following bone-patellar tendon-bone autograft reconstruction of the anterior cruciate ligament.

Data Sources: A systematic electronic search of MEDLINE, EMBASE, Web of Science, and the Cochrane Library was carried out. All English-language prospective randomized clinical trials published from January 1, 2000 to July 24, 2020 were eligible for inclusion. All papers addressing patella defect grafting were eligible for inclusion regardless of the timing of surgery, graft type, surgical technique, or rehabilitation.

Main Results: A total of 39 studies with 1955 patients were included for analysis. There were 796 patients in the no patella grafting (NPG) group with a mean age range of 22.7 to 33.0 years, and 1159 patients in the patella grafting (PG) group with a mean age range of 17.8 to 34.7 years. The VAS pain score ranged from 1.2 to 5.1 in the NPG group compared to 0.3 to 3.7 in the PG group. The proportion of anterior knee pain in the NPG group ranged from 19% to 81%, and from 15% to 32% in the PG group. Moderate to severe kneeling pain was reported in 22% to 57% of patients within the NPG group, and in 10% of patients in the PG group. The percentage of patients with ≥ 3 degrees of extension loss ranged from 4% to 43% in the NPG group, and ranged from 2% to 11% in the PG group.

Conclusions: The main findings of this review are that patellar grafting favors decreased anterior knee pain, kneeling

pain, and extension loss compared to non-grafted defects, however there are comparable functional outcomes. Due to the heterogeneity in reporting, statistical conclusions could not be drawn.

The Acute Effects of Short-Term Air Pollution Exposure During Moderate-to-Vigorous Physical Activity: A Systematic Review and Assessment of the Quality of Evidence

Andy Hung, BKin,* Hannah Nelson,* and Michael S. Koehle, MD, PhD*,†

Affiliations: *School of Kinesiology, Faculty of Education, The University of British Columbia, Vancouver, BC, Canada; and †Division of Sport & Exercise Medicine, Faculty of Medicine, The University of British Columbia, Vancouver, BC, Canada.

Objective: Despite the incontrovertible health benefits of moderate-to-vigorous physical activity (MVPA), engaging in MVPA increases the inhaled dose of air pollution (AP), potentially negating the benefits of MVPA. While modelling and epidemiological studies generally suggest the long-term benefits of MVPA outweigh the risks with the increased exposure to AP, the effects of short-term AP exposures on the benefits of MVPA remain unclear. We conducted a systematic review, in accordance with PRISMA and SWiM guidelines, to summarize the evidence on the acute health- and exercise-related effects of short-term AP exposure during MVPA in healthy populations.

Data Sources: MEDLINE, Embase, CENTRAL, SPORT-Discus, and AESD databases were searched from inception until July 2020 for randomized controlled trials in which healthy participants engaged in a bout of MVPA while exposed to ≥ 1 of the following pollutants/pollutant mixtures: ozone (O_3), particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO_2), diesel exhaust (DE), traffic-related air pollution (TRAP). Given the poor reporting quality and clinical heterogeneity of studies, the data were synthesized by vote counting based on direction of effect and conducting sign tests. The quality of evidence was subsequently assessed using the GRADE approach.

Main Results: Fifty-nine studies comprising of 1036 participants (mean age 24.3 years; 28% female) met the eligibility criteria. Evidence suggested that O_3 exposure during MVPA induced a decline in pulmonary function ($P < 0.001$; high quality evidence) and an increase in reported symptoms (predominantly respiratory-related; $P < 0.001$; low quality evidence from a high risk of bias) compared to less polluted environments, resulting in potentially impaired exercise performance ($P = 0.092$; low certainty evidence). However, the magnitude of effects could not be determined from the synthesis method. No clear adverse effects from other pollutants on health and exercise outcomes were found; the quality of evidence on these outcomes was ranked as “low” to “very low” for inconsistency and imprecision.

Conclusions: Impaired pulmonary function and increased symptoms associated with O_3 exposure during MVPA may compromise exercise performance. There was no conclusive evidence for health and exercise effects of other pollutants. Before definitive conclusions can be drawn, more adequately powered studies with a high quality of reporting are required.

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Low and High Knee Flexion Angles During Tibial Graft Fixation Yield Comparable Outcomes Following ACL Reconstruction With Quadriceps Tendon Autograft: A Systematic Review

Hassan Abdel Khalik, BSc, MMI,* Darius L. Lameire, BSc,* Jeffrey Kay, MD,† Sachin R. Tapasvi, MD,‡ Kristian Samuelsson, MD, PhD,§ and Darren de SA, MD†

Affiliations: *Michael G. DeGroot School of Medicine, McMaster University, Hamilton, ON, Canada; †Division of Orthopaedic Surgery, McMaster University, Hamilton, ON, Canada; ‡Department of Arthroplasty and Arthroscopy, The Orthopaedic Specialty Clinic, Pune, Maharashtra, India; and §Department of Orthopaedics, Institute of Clinical Sciences, The Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden.

Objective: To determine the effect of knee flexion angle during tibial graft fixation on functional and clinical outcomes following anterior cruciate ligament (ACL) reconstruction using single-bundle quadriceps tendon (QT) autograft.

Data Sources: An electronic search of MEDLINE, EMBASE, Web of Science and the Cochrane Library was carried out from 2000 to June 2020. Two reviewers independently screened studies at the title, abstract and full text stages of the review. Studies of all levels of evidence assessing functional and clinical outcomes following primary ACL reconstruction with a single-bundle quadriceps tendon in skeletally mature patients that reported knee flexion angle during tibial graft fixation were eligible for inclusion. Patient demographics, fixation technique as well as both functional and clinical outcomes were abstracted.

Main Results: Twenty studies (1594 patients) were included for analysis. There were 1100 patients in the L-KFA group (mean age range, 18.7-34.5 years), and 494 patients in the H-KFA group (mean age range, 23.2-32.1 years). Both L-KFA and H-KFA groups yielded statistically significant improvements from preoperative to postoperative scores across several functional and clinical outcomes. Extension deficit rates ranged from 1.4% to 9.5% in L-KFA studies and was 6.7% in one H-KFA study. Flexion deficit rates ranged from 3% to 4.8% in L-KFA studies and was 3.3% in one H-KFA study. Return to pre-injury activity levels ranged from 63% to 81% in L-KFA studies, and from 73.3% to 86.7% in H-KFA studies. Graft failure rates ranged from 1.4% to 8.7% in L-KFA studies, and 0% to 10.7% in H-KFA studies.

Conclusions: Both low- and high-knee flexion angles during tibial graft fixation produce very good clinical and functional outcomes with comparable outcomes between groups. There is inconclusive evidence to recommend the ideal knee flexion angle for graft fixation in primary ACLR.

The Association Between Sedentary Time and Metabolic Risk in Highly Active Older Adults

Kenneth M. Madden, MD,* † Boris M. Feldman, MD,* and Jocelyn M. Chase, MD*

Affiliations: *Gerontology and Diabetes Research Laboratory, Division of Geriatric Medicine, University of British Columbia, Vancouver, BC, Canada; and †Centre for Hip Health and Mobility, University of British Columbia, Vancouver, BC, Canada.

Objective: In older adults, time spent in sedentary behaviours (ST) has been associated with an increase in

cardiometabolic risk that is independent of time spent in higher levels of activity. Using accelerometer measures of activity levels and the continuous Metabolic Syndrome Risk Score (cMSy), our objective was to determine if this association persists in highly active older adults.

Study Design: Cross-sectional observational study.

Subjects: Fifty-four subjects (age = 71.4 ± 0.6 years, 30 women and 24 men) were recruited from a Master's Ski Team, a group of active older adults that has organized group training.

Observation Technique: All activity levels were recorded with accelerometers (SenseWear).

Outcome Measures: cMSy was calculated using principal component analysis of the criteria for Metabolic Syndrome (sum of eigenvalues > 1.0 of fasting glucose, high-density lipoprotein, triglycerides, systolic blood pressure and waist circumference). Daily activity levels (sedentary, ST; light, LT; moderate/vigorous activity, MT) were recorded with accelerometers worn for 7 days.

Results: High levels of physical activity (LT = 2.6 ± 0.2 and MT = 3.9 ± 0.2 hours per day) were demonstrated in our subjects, vastly exceeding current guidelines. ST showed a significant positive association with cMSy (Standardized $\beta = 0.312 \pm 0.115$, $R^2 = 0.36$, $P < 0.001$), independent of age, biological sex, LT and MT.

Conclusions: Despite the high activity levels in our subject pool, ST still demonstrated a strong association with cMSy. This suggests that even in subjects with high levels of physical activity, time spent sedentary is associated with increasing cardiometabolic risk.

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Incidence of Head Contacts, Penalties, and Player Contact Behaviours in Youth Ice Hockey Players: Evaluating the “Zero Tolerance for Head Contact” Policy Change

Rylen Williamson,* Ash T. Kolstad, BSc,* Maciej Krolkowski, MSc,* Luc Nadeau, PhD,|| Claude Goulet, PhD,|| Brent Hagel, PhD,* ,†,‡,§,¶ and Carolyn A. Emery, PT, PhD*,†,‡,§,¶

Affiliations: *Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, AB, Canada; †Alberta Children's Hospital Research Institute, Calgary, AB, Canada; ‡Department of Paediatrics, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada; §Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada; ¶O'Brien Institute for Public Health, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada; and ||Department of Physical Education, Faculty of Education, Université Laval, Québec City, QC, Canada.

Objective: Concussion risk in ice hockey is amongst the highest across youth sports. To reduce this burden, Hockey

Canada implemented a national “zero-tolerance for head contact (HC)” policy in 2011 for referees to penalize all player HCs. A previous cohort study revealed higher concussion rates following this HC-policy implementation in players ages 11 to 14. However, it is unknown whether the elevated risk was due to increased HC rates or other factors including concussion awareness and reporting. Therefore, the objective of this video-analysis study was to compare the rates of direct and indirect HCs and HC policy enforcement in elite U15 (ages 13-14, previously Bantam) ice hockey leagues before (2008-09) and after (2013-14) the HC-policy change.

Study Design: Cohort study.

Subjects: Thirty-two elite (upper 30% by division, body checking allowed) U15 games pre ($n_{2008-09} = 16$) and post ($n_{2013-14} = 16$) HC-policy implementation were video-recorded in Calgary, Alberta.

Observation Technique: The video-camera was positioned at the highest location near centre ice to optimize video quality, maintaining the video frame surrounding the puck.

Outcome Measures: Videos were analyzed using Dartfish video-analysis software with validated criteria for identifying HC types [direct (HC1), indirect (eg, boards, ice) (HC2)] and player-to-player contact behaviours. Referee-assessed penalties were cross-referenced with the official Hockey Canada casebook and displayed using proportions. Univariate Poisson regressions [adjusted for cluster by team-game, offset by game-length] were used to estimate HC incidence rates (IR: #HCs/100 team-minutes) and incidence rate ratios (IRR) between cohorts.

Results: A total of 506 HCs were analyzed, 261 pre- (IR = 16.6/100 team-minutes) and 245 post-policy change (IR = 15.5/100 team-minutes). The rate of HC1 (IRR = 1.05, 95% CI: 0.86-1.28) and HC2 (IRR = 0.74, 95% CI: 0.50-1.11) did not differ pre- and post-HC-policy change. Only 12.0% and 13.6% of HC1s were penalized pre- and post-policy respectively. HC1s were commonly penalized as roughing/elbowing pre-policy change (59%), while post-policy change the HC penalty emerged (76%) and roughing/elbowing penalties diminished (8%).

Conclusions: Despite policy implementation for mandatory enforcement of direct HCs, there were no differences in the rates of HC1s and HC2s or the proportion of HC1s penalized pre to post-policy change. This research will inform Hockey Canada's future referee training and rule enforcement modifications.

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