**Knee confidence in youth and young adults at risk of post-traumatic osteoarthritis
3-10 years following intra-articular knee injury**

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1 **Abstract**

2 Objective: To examine differences in knee confidence between individuals with a history
3 of youth sport-related knee injury and uninjured controls.

4 Design: Historical cohort study.

5 Methods: Participants include 100 individuals who sustained a youth sport-related intra-
6 articular knee injury 3-10 years previously and 100 age-, sex- and sport-matched
7 uninjured controls. Outcomes included: Knee confidence (Knee Osteoarthritis and
8 Outcome Score); fat mass index (FMI; dual-energy X-ray absorptiometry); and weekly
9 physical activity (modified Godin-Shepard Leisure Time Questionnaire). Mean within-pair
10 differences (95%CI) were calculated for all outcomes. Unadjusted and adjusted (FMI
11 and physical activity) conditional (matched-design) logistic regression (OR 95%CI)
12 examined the association between injury history and knee confidence.

13 Results: Median age of participants was 22 years (range 15-26) and median age at
14 injury was 16 years (range 9-18). Forty-nine percent (95%CI; 39.0,59.0) of previously
15 injured participants were bothered by knee confidence, compared to 12% (5.5,18.5) of
16 uninjured participants. Although there was no between group difference in physical
17 activity, injured participants had higher FMI compared to controls (within-pair difference;
18 (95% CI)):1.05 kg/m²; (0.53,1.57)). Logistic regression revealed that injured participants
19 had 5.0 (unadjusted OR; 95%CI; 2.4,10.2) and 7.5 times (adjusted OR; 95%CI: 2.7,21.1)
20 greater odds of being bothered by knee confidence than controls.

21 Conclusion: Knee confidence differs between individuals with a previous youth sport-
22 related knee injury and healthy controls. Knee confidence may be an important
23 consideration for evaluating osteoarthritis risk after knee injury and developing
24 secondary prevention strategies.

25 **Keywords:** adolescent, knee confidence, osteoarthritis, psychological factors, sport
26 injury

Introduction

While physical activity (PA) participation and sport are considered essential for healthy adolescent development,¹ injuries sustained during these activities can have serious long-term consequences, including the development of post-traumatic osteoarthritis (PTOA).^{2,3} PTOA is a sub-type of osteoarthritis (OA). It is a chronic disabling disease characterized by pain, joint stiffness, and mobility limitations. Meta-analyses indicate that the relative risk of developing PTOA within 10 years of a significant knee injury is 3.9 (95% CI; 2.7, 5.6).⁴ Unlike idiopathic OA, which is associated with older age, PTOA onset occurs in middle-aged adults when the impact of the disease on quality-of-life and work productivity can be devastating and costly at both individual and societal levels. Representing 12% of the overall OA incidence, the aggregate annual financial affliction of PTOA in the United States is estimated at \$3.06 billion.⁵ Given this enormous burden associated with PTOA, it is imperative to investigate and understand potentially modifiable risk or protective factors that could influence the long-term consequences of knee injury in high-risk PTOA populations in order to develop strategies aimed at delaying or preventing progression to PTOA.

Knee confidence is one such modifiable factor that has been previously examined in individuals with OA and those at increased risk of OA. These studies have reported that up to 99% of individuals with knee OA are bothered by knee confidence.⁶⁻⁸ Further, low knee confidence in individuals with knee OA is associated with poorer self-reported outcomes (i.e., increased fear of movement, greater pain on walking, and poorer general health),⁹ and reduced physical function (i.e., lower quadriceps strength and increased dynamic valgus-varus joint motion).⁸ Accordingly, it has been postulated that a lack of knee confidence may reduce self-efficacy and decrease engagement in various PA behaviours in persons with OA.⁶ Therefore, it is possible that lowered knee

confidence may have a role in the development, trajectory, and symptomatic severity of PTOA via its influence on PA participation.

In adults (34-56 years) with a history of anterior cruciate ligament (ACL) tear, knee confidence was poorer ($p=0.01$) in those with symptomatic radiographic OA compared to those without any OA symptoms or radiographic changes.⁹ Further in a recent study, 70% of adults 3-years after ACL reconstruction reported being bothered by knee confidence, with lower confidence being related to reduced muscle power and hop performance.¹⁰ We hypothesize that the traumatic injury, which underlies PTOA development that is not necessarily a precursor to other sub-types of OA, may have a unique influence on knee confidence in this sub-group. Additionally, it is possible that knee confidence may act as a psychological barrier in return to sport decisions and impact lifestyle choices that could have long-term implications for PTOA development and symptom management.

To the best of our knowledge the construct of knee confidence has yet to be examined in a prospective fashion in youth and young adults with a history of knee injury in relation to an uninjured comparison group. Knee confidence warrants special examination in this age group for multiple reasons. It is unknown if knee confidence concerns may be a much greater or lesser problem in youth and young adults compared to middle and older aged individuals. Further, if knee confidence is a problem in youth and young adults it may have more significant influences on their choices for sport and PA participation in the longer term, given the importance of adolescence time period in shaping life long health behaviours. If knee confidence is indeed a modifiable treatment target for PTOA it should be addressed at the earliest possible stage before the development of severe joint disease. As well, the influence of PA participation and body composition (factors directly linked with the development of OA) on the relationship between injury history and knee confidence have yet to be examined. Therefore, the

purpose of the current study is to examine knee confidence in youth and young adults, aged 15 to 26 years old, with a history of youth sport-related intra-articular knee injury in comparison to age, sex and sport matched uninjured controls, controlling for the potential confounders of PA and body composition.

Methods

This analysis involves the first year data (June 2013-April 2015) from the Alberta Youth Prevention of Early OA (PrE-OA) longitudinal historical cohort study. In this study, 100 youth and young adults who sustained a youth (≤ 18 years) sport-related intra-articular knee injury in the past 3-10 years and 100 age-, sex- and sport-matched (at the time of injury) uninjured controls are being followed annually on a diverse range of outcomes. Recruitment and injury definition have been described in detail previously.¹¹ Briefly, participants were recruited from three sources: previous studies examining injury risk factors and prevention strategies in youth sport conducted at the XX; the XX database; or through personal distribution of study material by study investigators or participants. Injured participants had a previous history of intra-articular knee injury, defined as a clinical diagnosis of knee ligament, meniscal, or other intra-articular tibio-femoral or patella-femoral injury that required a medical consultation and resulted in missed sport participation. Injury diagnoses were obtained from injury report forms (completed by physiotherapists) or medical records (from physician clinical examination), and confirmed by the participant. At study entry, injured participants were considered 'at high risk of OA' compared to uninjured participants, but were not screened for the presence of PTOA. Uninjured controls reported no previous time loss from sport due to knee injury. Exclusion criteria for all participants included pregnancy, non-steroidal anti-inflammatory use, cortisone injection or a musculoskeletal injury that resulted in time loss (work, school or sport) within the previous 3-months, diagnosis of other arthritides,

or any current medical problem that prevented participation in the functional testing aspect of the study. Ethical approval for this study was received from Conjoint Health Research Ethics Board at the University of Calgary (ID# 25075) and the Children's and Women's Health Centre of British Columbia Behavioural Research Ethics Board (H13-00720). All participants provided consent at study entry.

All data were collected in one testing session at the University of Calgary. Participants had their height (cm) and weight (kg) measured, underwent a dual-energy x-ray absorptiometry (DXA) scan, and completed a study questionnaire (demographic details, medical and knee injury history [if applicable]), the Knee Injury and Osteoarthritis Outcomes Score (KOOS)¹², a modified Godin-Shepard Leisure Time Questionnaire (GLTQ).¹³

The KOOS is a validated self-report outcome measure developed to examine knee-related symptoms and function in active individuals with a knee injury or OA.¹² It consists of 42 items in five subscales. Within each subscale, questions are scored on a 5-point Likert scale (not at all, mildly, moderately, severely, or extremely). Subscales are summed and the total transformed into a 0-100 scale, with lower scores indicating worse outcomes. Knee confidence was assessed using question 3 from the KOOS knee related quality-of-life subscale: "How much are you troubled by lack of confidence in your knee?" Responses on the 5-point Likert scale were dichotomized into 'bothered' (mildly, moderately, severely, or extremely) or 'not at all bothered.' This question has been used to quantify knee confidence in numerous previous studies.⁶⁻⁹

Self-reported total weekly minutes of PA participation (strenuous, moderate, and mild intensities) was assessed using the modified GLTQ.¹³ The GLTQ has been previously validated against accelerometers in an adolescent population.¹³ It was decided that total PA best represented the most comprehensive measure of PA, compared to a variable that included only moderate and vigorous PA, therefore

minimizing residual confounding by PA in the relationship between injury history and knee confidence.

Body mass index (BMI; kg/m²) was derived from anthropometric measurements of participants' height (to the nearest 0.1 cm; shoes removed) and body mass (to the nearest 0.1 kg), assessed using a medical scale and stadiometer (Model 402KL, Pelstar, USA). BMI is a well known measure to describe participants' body composition within a sample by giving a crude indication of adiposity. However, it fails to distinguish between fat mass and lean mass, which can be problematic in an athletic population. Given there is a specific link between obesity, defined as excessive fat mass that may impair health,¹⁴ and the development of OA,¹⁵ a more accurate measure of fat, fat mass index, was justified to include in the main analysis.

Fat mass index (FMI; kg/m²) was calculated from whole body composition scans acquired with a Hologic Discovery A (Hologic, Bedford, MA) DXA scanner with Discovery QDR software. The scanner was calibrated daily using a phantom containing composites of bone, fat and lean tissue. Participants were positioned supine on the scanner bed according to the manufacturer's recommendations and instructed to remain as still as possible for the duration of the scan. All procedures were consistent with the official positions of the International Society for Clinical Densitometry (ISCD).¹⁶

Demographic characteristics (i.e., sex, current age, and BMI) and knee injury details (i.e., age at injury, injury type) were summarized using descriptive statistics (frequency and proportions or medians and range), and mean within-pair differences [95% confidence interval (95%CI)] were used to compare outcomes between study groups. In separate models, unadjusted conditional logistic regression (odds ratios (OR); 95% CI) was used to examine the association between injury history and knee confidence, as well as between injury history and each of FMI and PA in order to understand the role of these variables as potential confounders. Note, the association

between injury history and FMI has been previously examined in this cohort,¹⁷ however FMI was felt to be conceptually important in the relationship between injury history and knee confidence, and thus the bivariable analysis was repeated for completeness in the current paper. FMI and PA were investigated for possible colinearity. Lastly, multivariable conditional logistic regression was used to assess the association between injury history and knee confidence while controlling for FMI and PA. Analyses were considered statistically significant if 95% CI did not include 1 and p-value was <0.05. Statistical analyses were performed using SAS version 9.3 (Cary, NC, USA).

Results

Baseline characteristics (n=200) are summarized in Table 1. The median (range) age of participants was 22 (range 15-26) years and 110 (55%) were female. Thirty-three percent of the injured participants sustained their injury participating in soccer and the remaining injuries came from a wide variety of sporting environments (i.e., hockey, basketball, American football, volleyball, rugby, running, baseball, downhill skiing and figure skating). Amongst those previously injured, the median age of injury was 16 (9-18) years and the median time between injury and follow-up was 6.9 years (range 3-10). Of the 100 injured participants, 17% had patello-femoral injuries (subluxations), 13% had a grade I to II Medial or Lateral Collateral Ligament sprain, or grade I or II ACL sprain, 15% had isolated meniscal injuries and 54% experienced grade III ACL sprain (67% with concomitant meniscal injuries and all were reconstructed).

Descriptive statistics and within-pair differences for KOOS subscales, weekly PA, BMI, and FMI are summarized in Table 2 and the distribution of participants' responses to the knee confidence question is shown in Figure 1 (Supplemental material). Overall, 49% (95%CI; 39.0, 59.0) of the previously injured participants, reported being bothered by knee confidence to some degree, compared to 12% (95%CI; 5.5, 18.5) in the

uninjured group. Although there was no difference in weekly minutes of PA between groups, injured participants had a higher BMI (mean within-pair difference 1.79 kg/m², 95%CI 0.94, 2.63) and FMI (1.05 kg/m², 0.53, 1.57) than the matched controls.

The bivariable odds ratio between potential confounding variables and knee confidence were not statistically different from 1; FMI (1.2 [95%CI 0.97, 1.5]) and PA (1.0 [95%CI 1.0, 1.0]) (Table 3), although they were later included in the multi-variable model due to their conceptual significance and lack of colinearity. Without adjusting for any confounders, the previously injured participants had 5.0 (95%CI 2.4,10.2) times the odds of being bothered by knee confidence than the uninjured group. When controlling for the influence of weekly PA and FMI on the relationship between injury history and knee confidence these odds increased to 7.5 (95%CI 2.7, 21.1). In this same multi-variable model, when examining the association between each confounder and knee confidence, it was found that for every one minute increase in weekly PA, there was no change in the odds (1.0 (95%CI 1.0, 1.0) of being bothered by knee confidence and for a one unit increase in FMI, there was 0.98 (95%CI 0.70, 1.4) decreased odds of being bothered by knee confidence.

Discussion

This investigation found that almost half of all youth and young adults at high risk of future PTOA due to a 3-10 year history of youth sport-related intra-articular knee injury report being bothered by a lack of knee confidence. This translates into a 7-fold increased odds of low knee confidence compared to healthy uninjured controls. While this analysis did not find PA participation to be different between groups, individuals with a history of injury did exhibit greater FMI, higher BMI, and lower KOOS scores indicative of impaired knee-related function. This study provides preliminary evidence that lowered

knee confidence and increased adiposity warrants further examination as possible precursors to future symptomatic joint disease.

A recent meta-analysis reported that 55% of individuals return to competitive sport after ACL reconstruction and that having a positive psychological response was a key factor in returning to pre-injury participation.¹⁸ In a cross-sectional study of individuals 5-12 years post ACL reconstruction, Hart et al.⁹ found that those with knee OA had worse knee confidence and greater kinesiophobia than those without OA. Further, poorer knee confidence has also been shown to be associated with worse knee symptoms and function. This suggests that knee confidence may be an important component of a positive psychological response and therefore a clinically relevant treatment target during rehabilitation to promote return to sport and PA. Low knee confidence may be an indication of poor structural integrity of the knee joint, potentially lacking in bone, cartilage, or ligamentous stability. Alternatively, it may be a sign of incomplete or unsatisfactory rehabilitation where advanced neuromuscular and proprioceptive skills have not been adequately trained. A third hypothesis is that low knee confidence may manifest after an individual's psychological concerns such as fear of re-injury have not been specifically addressed. Previous authors have suggested that individual neuromuscular exercises aimed at improving dynamic tasks may enhance knee confidence, although this has not yet been evaluated.^{7,10}

Despite knee confidence being a concern in nearly half of participants, in the current study it was not found to be associated with total PA participation. This may be due to the nature of our self-reported measure of PA, which while validated, may not be sensitive enough to pick up subtle changes in PA that result from lowered knee confidence. For example, individuals may reduce their amount of vigorous and moderate PA and replace it with mild PA. Further, lack of knee confidence may cause participants to switch sports (e.g. instead of returning to soccer after knee injury, they now cycle and

swim) and this sport-specific information was beyond the scope of the current project. Alternatively, it may require a longer time after knee injury before knee confidence truly impacts overall PA participation. The complexity of the relationship between knee confidence and PA participation should be further examined in this youth and young adult population using different methods such as accelerometers to provide an objective measure of PA.

In the current study, knee confidence was evaluated based on the response to a single question from the KOOS quality of life subscale.¹² While the consistent results of previous studies using this question have demonstrated its face and construct validity,⁷⁻⁹ it remains to be formally evaluated. The Knee Self-Efficacy Scale, is a comprehensive, validated self-report measure, that may encompass the concept of knee confidence.¹⁹ Knee self-efficacy refers to an individual's belief in the current and future capabilities of their knee. Self-efficacy of knee function measured at the time of ACL reconstruction has been found to be predictive of self-reported physical activity, knee symptoms, and muscle function 1 year later.¹⁷ While the association between knee confidence and a global assessment of self-efficacy was not found to be significant in one previous study,⁷ knee-specific self-efficacy and its relationship to knee confidence warrants further evaluation.

Strengths of this study include the novel examination of knee confidence in a cohort of youth and young adults both with and without a history of previous knee injury. Adiposity and PA outcomes, both established risk factors for PTOA, were also examined. Limitations include the aforementioned lack of validated measure of knee confidence, as well as the inability to determine temporality of the associations between knee injury and knee confidence, given these data represents first year of data collection from the historical cohort. Additionally, the small sample size (n=100 matched pairs) limited the inclusion of further potential confounders. Future studies should seek to

understand the potential underlying physical and psychological reasons why individuals have low knee confidence. Further prospective longitudinal studies are required to adequately understand the relationship between knee confidence and the development of PTOA in a younger, post knee injury population. Finally, the effectiveness of clinical interventions that target psychological outcomes, such as knee confidence, should be evaluated both for their short term benefits as well as and the impact of these interventions on long-term function and joint health.

Conclusion

Almost half of all individuals 3-10 years following a youth sport-related knee injury are bothered to some degree by a lack of knee confidence. Clinicians must appreciate of the role of psychological factors, including knee confidence, in the acute and long-term recovery after knee injury. They should discuss concerns regarding fear of re-injury and knee confidence with their patients to determine if advanced neuromuscular exercises have the potential to improve confidence or whether specific psychological assessment and treatment is warranted. In the future, targeted combined physical and psychological interventions could be developed and evaluated for their shorter-term impact on return to sport outcomes and longer-term influence on PTOA. It is recommended that further research seeking to understand modifiable PTOA risk factors continue to examine knee confidence and its associations with other clinical outcomes with the goal of improving the joint health in this population.

Practical Implications:

- Knee confidence appears to be a greater concern in individuals with a previous youth sport-related knee injury compared to their uninjured peers.

- This historical cohort analysis provides preliminary evidence on the importance of knee confidence in a young population at high risk of post-traumatic osteoarthritis.

- Given that previous studies have found reduced knee confidence in individuals with symptomatic osteoarthritis, it may be an early modifiable, treatment target to prevent or modify future joint disease in a young, high-risk population.

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TABLE 1. Participant Characteristics

Variable	Uninjured n=100 median (range)	Injured n=100 median (range)
Sex (% female)	55	55
Age (years)	22 (15-26)	22 (16-26)
Height (cm)	171.8 (152-195)	173.0 (156-199)
Body Mass (kg)	71.6 (49.5-100.7)	74.9 (50.2-105.5)
Age at injury (years)	n/a	16 (9-18)
Injury to follow-up (years)	n/a	6.9 (3-10)

Cm: centimetres; kg: kilograms

TABLE 2. Summary of Descriptive Statistics by Study Group and Pair Difference

Outcome	Uninjured [¶] n=100	Injured [¶] n=100	Matched Pair Difference [§]	P-value
KOOS Sub-scales				
Pain	100 (69,100)	89 (53,100)	-4.9 (-7.0,-2.7)*	<0.01
Symptoms	96 (64,100)	86 (32,100)	-8.1 (-11.2,-5.0)*	<0.01
ADL	100 (87,100)	99 (63,100)	-2.8 (-4.2,-1.4)*	<0.01
Sport/Rec	100 (75,100)	94 (47,100)	-5.8 (-7.8,-3.7)*	<0.01
QoL	100 (83,100)	92 (64,100)	-8.3 (-10.2,-6.3)*	<0.01
Physical Activity (minutes/week)	135 (22.5-420)	120 (0-510)	-6.4 (-28.9, 16.2)	0.58
BMI (kg/m ²)	23.5 (18.1, 31.3)	25.0 (18.9, 38.9)	1.8 (0.9,2.6)*	<0.01
FMI (kg/m ²)	4.6 (2.1, 9.3)	5.6 (1.7,16.4)	1.1 (0.5,1.6)*	<0.01

[¶]values represent median (range)[§]value represents mean within pair difference: injured – uninjured (95% CI)

KOOS: Knee Osteoarthritis Outcome Score; ADL: activities of daily living; QoL: quality of life; BMI: body mass index; FMI: fat mass index; *statistically significant

TABLE 3. Bivariable and Multivariable Logistic Regression Examining the Odds of Low Knee Confidence in Youth and Young Adults with a Previous Knee Injury Compared to Their Counterparts Without a History of Knee Injury

Variable	Unadjusted OR (95% CI)*	Adjusted OR (95% CI) ^λ
Group		
Uninjured	1.0	1.0
Injured	5.0 (2.4, 10.2)*	7.5 (2.7, 21.1)*
Physical activity (minutes/week)	1.0 (1.0, 1.0)	1.0 (1.0, 1.0)
Fat mass index (kg/m ²)	1.2 (0.97, 1.5)	0.98 (0.70, 1.4)

[§]Crude relationship between each variable and knee confidence

^λAdjusted for physical activity and fat mass index; *statistically significant

How much are you troubled with lack of confidence
in your knee?

425
426