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Title

Is impaired knee confidence related to worse kinesiophobia, symptoms, and physical function in people with knee osteoarthritis after anterior cruciate ligament reconstruction?

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Authors' contributions

All authors were involved in drafting the article and all authors approved the final version submitted for publication.

Abstract

Objectives: To compare knee confidence and kinesiophobia (fear of re-injury) in those with and without knee osteoarthritis (OA) following anterior cruciate ligament reconstruction (ACLR), and determine whether poorer knee confidence is associated with greater kinesiophobia, worse knee-related symptoms, and functional impairments in those with knee OA.

Design: Cross-sectional

Methods: Sixty-six individuals, 5-12 years following ACLR, with (n=30) and without (n=36) knee OA were included. Knee injury and Osteoarthritis Outcome Score (KOOS) quality-of-life question (Q3), assessed knee confidence and Tampa Scale of Kinesiophobia assessed kinesiophobia. In the OA group, knee-related symptoms (International Knee Documentation Committee (IKDC), Anterior Knee Pain Scale (AKPS)), self-reported function (KOOS activities daily living (KOOS-ADL), sport/recreation (KOOS-S/R), and performance-based function (hopping, one leg rise tasks) were assessed. Between-group differences in knee confidence and kinesiophobia were evaluated with the Chi square test and analysis of variance (ANOVA) respectively. In the OA group, between-group differences (none, mild/moderate and severe/extreme problems with knee confidence) in kinesiophobia, symptoms and function were determined with ANOVAs: $p<0.05$.

Results: Following ACLR, participants with knee OA had significantly worse knee confidence ($p=0.010$) and greater kinesiophobia ($p=0.006$) than those without OA. In those with knee OA, poorer knee confidence was significantly associated with worse symptoms (AKPS, $p=0.001$; IKDC, $p<0.001$), kinesiophobia ($p=0.030$), KOOS-ADL ($p=0.005$), KOOS-S/R ($p=0.001$), single-leg hop ($p=0.011$), side-to-side hop ($p=0.013$) and one leg rise ($p=0.001$).

Conclusions: Psychological impairments are evident in people with knee OA following ACLR, compared to those without. Future studies should further investigate the psychological impairments associated with knee OA after ACLR.

Keywords: anterior cruciate ligament reconstruction; osteoarthritis; knee; injury; function

Introduction

Anterior cruciate ligament (ACL) injury is a well-recognised risk factor for post-traumatic knee osteoarthritis (OA), with 50-70% of people developing knee OA 10-15 years following injury.[1, 2] Surgical reconstruction (ACLR) does not reduce the risk of OA.[3] Knee OA after ACLR primarily affects younger adults,[4] with potential to limit physical activity.[5] Consequently, any physical and psychological impairments may adversely impact quality of life and work participation. Recently, our research team observed that greater knee OA severity is associated with worse symptoms and poorer function at 5-10 years following ACLR.[6] While functional impairments such as muscle weakness and poorer functional performance are well-described in ACLR populations,[5, 7] the nature and impact of psychological impairments remain largely unknown, especially in those with knee OA.

Knee confidence and kinesiophobia are two psychological factors that are likely to be impaired in those with knee OA following ACLR. Kinesiophobia, defined as "an irrational and debilitating fear of physical movement and activity resulting from a feeling of vulnerability to painful injury or (re) injury",[8] predicts return to sport after ACLR.[9,10] Furthermore, people who have not returned to sport are less confident about their ACLR knee than those who have.[9,10] Worse knee confidence is also described in people with knee OA, and associated with higher pain and greater knee instability.[11] Knee OA is highly prevalent after ACLR, and factors such as knee confidence and kinesiophobia play a key role in those recovering from ACL injury[9,10] and in those at risk of [12] or with knee OA.[11] Thus, it is important to understand whether the presence of knee OA following ACLR in younger adults increases these psychological impairments, beyond those seen after ACLR alone.

Psychological and functional impairments are likely to co-exist and be inter-related.[9,11,12] Worse kinesiophobia is associated with lower physical activity levels after ACLR[9] and reduced daily

functioning[13] in those with knee OA. While no studies have investigated knee confidence in those with knee OA after ACLR, lower knee-related confidence is associated with lower physical function[12] and quadriceps strength[11] in older knee OA populations. Thus, it appears that knee confidence and kinesiophobia are psychological impairments that may contribute to, or result from, functional impairments. It is important to understand whether the relationship between psychological and functional impairments is seen in young adults with knee OA following ACLR. Knowledge of this relationship may provide a more comprehensive approach to rehabilitation.

The aims of this study were twofold. Firstly, to compare knee confidence and kinesiophobia between those with and without knee OA after ACLR; and secondly, to investigate the relationship between knee confidence and kinesiophobia, knee-related symptoms, and functional impairments in those with knee OA after ACLR. We hypothesised that those with knee OA after ACLR would have poorer knee confidence and greater kinesiophobia than those without knee OA. In addition, we hypothesised that poorer knee confidence would be associated with greater kinesiophobia, worse knee-related symptoms and worse functional impairments in those with knee OA after ACLR.

Materials and methods

Volunteers who had undergone a primary ACLR (hamstring-tendon or patellar-tendon graft) five to 12 years prior were recruited from the community via advertisements and referrals from orthopedic surgeons, allied health and medical practitioners. Exclusion criteria for all participants were: i) aged <18 years at the time of ACLR; ii) subsequent arthroplasty performed on the reconstructed knee; iii) concomitant pain from the hips, ankles, feet or lumbar spine; iv) neurological or medical conditions; v) contraindications for x-ray (pregnancy, breastfeeding); and vi) an inability to understand written and spoken English. Participants with OA were included if they were symptomatic[14] and had radiographic knee OA (Kellgren

and Lawrence (KL) grade ≥2) in at least one compartment (tibiofemoral or patellofemoral) of the reconstructed knee[15] (OA group). Participants were included in the no-OA group if they were asymptomatic[14] without radiographic knee OA (KL≤1 in all knee compartments). A trained observer (KMC) assessed all radiographs, blinded to symptoms. All participants provided written informed consent prior to undergoing radiographs and data collection. Data pertaining to age, gender, height, and weight were recorded. Ethics approval for the study was obtained from the University of Melbourne Human Research Ethics Committee (0931086).

Knee confidence was assessed in all participants. Since there is no specific patient-reported outcome measure for knee confidence, we used Item 3 of the Knee injury and Osteoarthritis Outcome Score (KOOS) quality of life (QOL) subscale,[12] "*How much are you troubled with lack of confidence in your knee?*" Participants responded on a five-point Likert scale, which consisted of: not at all (0); mildly (1); moderately (2); severely (3); and extremely (4). Kinesiophobia was assessed in all participants using the Tampa Kinesiophobia Scale.[16] The Tampa Scale quantifies fear of movement and re-injury due to movement and physical activity. It consists of statements on subjective experience of injury and physical activity on a scale from 0 to 68, where 68 indicates greater fear of re-injury due to movement.

In the OA group, knee-related symptoms were assessed using the 2000 International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form[17] and the Anterior Knee Pain Scale (AKPS).[18] The IKDC measures knee-related symptoms and function in daily living and sports activities on a scale from 0-100, with zero indicating lowest levels of knee function and maximum knee symptoms. The IKDC is widely used in assessing symptoms in individuals with knee pathology including ligament and articular cartilage injury and arthritis.[19] The AKPS measures items including limp, weight-bearing, walking, stairs,

squatting, running, pain, swelling. A score of zero on AKPS indicates maximum anterior knee pain symptoms and disability.[20]

In the OA group, patient-reported functional impairments were measured using the KOOS activities of daily living (ADL) and sport and recreation (S/R) subscales.[21] A normalised score (0-100) was calculated for each subscale, where 100 indicated no limitations with function in ADL and S/R, and zero indicated maximum limitations. Physical activity levels relating to work and sporting activities were evaluated using the Tegner Activity Scale (TAS).[22] A score of zero indicated sick leave or disability pension because of knee problems, and a score of 10 indicated participation at the level of national or international elite competitive sports.

The following physical tests were used to evaluate performance-based functional impairments in the OA group:

i) Single-leg hop for distance evaluated as the maximum horizontal distance (centimetres) hopped by the participant with the ACLR leg;[23]

ii) Side to side hop, evaluated by the maximum number of hops performed by the participant over two parallel strips (40cm apart) in a 30-second period;[24] and

iii) One leg rise test, evaluated by the number of times the participant could stand up from a sitting position using only the ACLR leg (up to a maximum of 50 repetitions).[25]

Data were analysed with the Statistical Package for the Social Sciences (PASW Statistics 18, SPSS Inc., Chicago, IL). Between-group differences in participant characteristics were assessed using independent t-tests for continuous variables, and Chi square tests for categorical variables. Between-group differences in knee confidence categories and Tampa Scores were evaluated with Chi square tests and analysis of variance (ANOVA), respectively (p=0.05). Any knee confidence category with less than three individuals

was combined with the category below. Two combined categories were formed: *"mildly or moderately troubled by lack of confidence"* and *"severely or extremely troubled by lack of knee confidence"*.[12] Thus, within each group (OA and no-OA), three categories were formed based on the knee confidence: i) no trouble; ii) mildly-moderately troubled; and iii) severely-extremely troubled. Where appropriate, ANOVAs were re-run using covariates identified as being associated (Pearson's correlation coefficients (r)) with the dependent variable (e.g. age, gender, height, pain on a visual analogue scale during testing). *Post hoc* tests of simple effects (Least Significant Difference) were used to compare the three categories of knee confidence in the OA group for the Tampa Scores, with a trend value set at 0.05 and significance set at 0.01.

Results

Thirty OA participants (mean±SD: age 45±11 years, height 1.72±0.08 m, body weight 78±14kg, BMI 26±4 $kg.m^{-2}$, time since ACLR 9±2years) and 36 no-OA participants (age 39±9 years, height 1.71±0.08 m, body weight 79±15kg, BMI 27±4 $kg.m^{-2}$ time since ACLR 8±2years) were included. There were no significant differences in height (p=0.070), body weight (p=0.598), BMI (p=0.533), and time since ACLR (p=0.167); however there was a significant difference in age (p=0.022). The participants in the OA group had mild to moderate symptomatic (KOOS: Pain, 82±19; Symptoms, 75±18; ADL, 88±17; sport/rec, 69±23; quality of life, 69±25) and radiographic OA severity.

A significantly greater proportion of participants in the OA group reported worse knee confidence in their ACLR knee than no-OA group (p=0.010) (Figure 1). In the no-OA group, 58% had no trouble with knee confidence, 33% were mildly-moderately troubled, and 8% were severely-extremely troubled. In the OA group, 27% had no trouble with knee confidence, 40% were mildly-moderately troubled, and 33% were severely-extremely troubled. Tampa Scale data were available for 47 participants (93% of OA-group and

53% of no-OA group). However, despite the smaller sample, we observed significantly worse kinesiophobia in the OA-group (mean±SD, 36±4) than those in the no-OA group (32±3; mean difference -5, 95% confidence interval [CI] -1 to -8). While older age was significantly correlated with better Tampa Score (r=-0.289; p=0.049), inclusion of age as a covariate did not change the between-group difference in Tampa scores.

There was a significant difference in Tampa Score between the categories of knee-related confidence (p=0.031) (Table 1). Compared to those not troubled by knee confidence, post-hoc tests revealed trends of worse kinesiophobia in participants who were severely-extremely (mean difference -7, 95% CI -14 to 0), and in participants who were mildly-moderately troubled (-6, -12 to 0). AKPS scores were significantly different between the three categories of knee–related confidence (p<0.001). Post-hoc tests revealed that participants who were severely-extremely troubled with a lack of knee confidence had worse AKPS scores than those not troubled (22, 10 to 34). Significantly worse AKPS scores were also observed in participants mildly-moderately troubled (12, 1 to 24) when compared to those not troubled by a lack of knee confidence. Male gender and higher Tegner activity levels were both significantly correlated with higher AKPS score (r=0.425, p=0.019; r=0.382, p=0.037, respectively), but did not alter outcomes of analyses when included as covariates.

IKDC scores were also significantly different between the three categories of knee confidence (p<0.001). Participants who were severely-extremely troubled with a lack of knee confidence had lower IKDC scores than those not troubled (mean difference 33, 95% CI 18 to 48) and those mildly-moderately troubled (15, 2 to 29). Participants who were mildly-moderately troubled by a lack of knee confidence also had lower IKDC scores than those not troubled with a lack of knee confidence (17, 3 to 32). Inclusion of gender and

Tegner Activity score as covariates in further analyses did not change outcomes, with differences between groups remaining significant.

In participants with knee OA, those with worse knee confidence had lower KOOS-ADL scores (p=0.005) and KOOS-S/R scores (p=0.001). Those severely-extremely troubled by a lack of knee confidence had significantly lower KOOS-ADL scores than those not troubled (mean difference 14, 95% CI 4 to 23). Trends for lower KOOS-ADL scores were also noted in participants who were severely-extremely troubled by a lack of knee confidence when compared to those mildly-moderately troubled (7, -1 to 16). Similarly, participants who were severely-extremely troubled had significantly lower KOOS-S/R scores than those not troubled with a lack of knee confidence (37, 16 to 59). Trends of lower KOOS-S/R were observed in those severely-extremely troubled compared to those mildly-moderately troubled with a lack of knee confidence (21, 1 to 40). Similar trends were noted when those who were mildly-moderately troubled were compared with those not troubled with lack of knee confidence (17, -4 to 37).

Worse knee confidence was significantly associated with worse performance on single-leg hop for distance (p=0.011), side to side hop (p=0.013), and one leg rise (p=0.001) tasks. Post-hoc tests revealed that those who were severely-extremely troubled with a lack of knee confidence exhibited poorer performance than those with no trouble with knee confidence in the single-leg hop for distance (mean difference 43cm, 95% CI 8 to 79), side to side hop (14 repetitions, 2 to 26) and one leg rise (24 repetitions, 9 to 39). Trends for poorer performance on the single-leg hop for distance (30cm, -2 to 62) and side to side hop (10 repetitions, -1 to 22) were noted in those who were severely-extremely troubled with a lack of knee confidence when compared with those mildly-moderately troubled. Post-hoc tests also revealed significantly poorer performance in one leg rise (17 repetitions, 4 to 30) in participants who

were severely-extremely troubled with a lack of knee confidence compared to those mildly-moderately troubled. Inclusion of gender and height as covariates did not change outcomes.

Discussion

We observed that those participants with OA following ACLR had lower knee confidence and higher kinesiophobia than those without knee OA. In the OA group, poorer knee confidence was associated with greater kinesiophobia and worse patient-reported and performance-based functional impairments.

The proportion of participants troubled with severe to extreme lack of knee confidence was similar to that observed in older individuals (62±7years) with medial compartment OA and varus knee malalignment (32%).[11] However, our cohort contained a greater proportion of participants troubled with severe to extreme lack of knee confidence (33%) than older individuals (62±9years) with or at high risk of developing knee OA (7%).[12] The lower rate of worse knee confidence reported by Colbert et al.[12] may reflect their inclusion of people at risk of knee OA as well as those with symptomatic and radiographic OA. Similarly, we observed that those with knee OA following ACLR had worse knee confidence than those without knee OA after ACLR. Combined, these findings suggest that worsening of knee confidence might be a consequence of knee OA in non-traumatic and post-ACLR populations. Impairments in muscle strength, proprioception and balance are frequently reported in knee OA populations[26, 27] and may be the features that lead to lack of knee confidence in individuals with knee OA.[11] Further studies are required to confirm this relationship.

Our study is the first to show that individuals with knee OA after ACLR have worse kinesiophobia than those without knee OA. While no previous studies have evaluated kinesiophobia in people with knee OA,

it has been evaluated in ACLR cohorts. In our post-ACLR OA group, greater kinesiophobia was observed than that previously reported in athletes 3-4years after ACLR (Tampa score mean±SD 17±6).[9] It is plausible that the persistent pain and symptoms that accompany knee OA drive increasing kinesiophobia over time. Worse kinesiophobia is associated with altered muscle activation patterns in people with chronic low back pain[28,] and similar relationships may exist in knee OA populations. Considering that neuromuscular impairments are frequently reported in both ACLR[7] and knee OA[4] populations, this relationship requires further evaluation. Our findings of an inter-relationship between poor knee confidence and high kinesiophobia also highlight the importance of psychological impairments in people with knee OA following ACLR. This relationship is strengthened by previous findings of low knee confidence and high kinesiophobia in athletes who fail to return to their pre-injury sporting activities after ACLR.[9] Further evaluation of psychological impairments following ACLR is necessary to better understand the temporal relationship between psychological, neuromuscular, and functional impairments, and the prospective effect of psychological and functional impairments on development of knee OA.

Since lower functional performance can increase the risk of knee OA development,[25] neuromuscular impairments (e.g. hamstring or quadriceps weakness)[29] or psychological impairments (e.g. poor confidence, greater kinesiophobia) associated with ACLR could contribute to incident knee OA after ACLR. This theory is consistent with that proposed by Colbert et al.,[12] who suggested that reduced physical function associated with poor knee confidence may play a critical role in initiation and progression of non-traumatic knee OA. Indeed, low knee confidence was related to poor self-reported and performance-based functional impairments in our study, and in older individuals with knee OA.[12] While it is unlikely that psychological impairments alone can precipitate the structural disease progression associated with knee OA, it is plausible that the negative spiral of knee pain leading to reduced physical function following ACLR results in neuromuscular and psychological impairments and further functional impairments, thus placing those who have undergone ACLR at a higher risk of developing knee OA.

Our study has important clinical implications. Current ACLR post-operative rehabilitation and OA management programs primarily focus on pain management and therapeutic exercises to address strength and functional impairments, with the primary aim of returning the individual to their desired level of physical activity. Findings of this study suggest that effective management of knee OA after ACLR requires a multidisciplinary approach, including education, pain management, psychological interventions, and therapeutic exercise programs. Given that poor physical function seems to initiate a vicious cycle of symptoms and psychological, neuromuscular, and functional impairments, and could lead to development or progression of knee OA, it is important to improve and maintain physical function in ACLR. Physical interventions with the potential to improve knee confidence and reduce kinesiophobia may include bracing, taping, and movement retraining. Psychological interventions such as cognitive behavioral therapy have been shown to be effective in the management of chronic low back pain,[30] and thus should be investigated as a potential intervention to improve knee confidence and reduce kinesiophobia in those with knee OA after ACLR. Future research should investigate a more comprehensive, multidisciplinary approach to post-ACLR management to ensure both psychological and functional recovery.

There are a number of limitations of this study that should be acknowledged. We assessed knee confidence using one question from the KOOS-QOL subscale. Whilst this specific approach has not been validated, this question has been shown to be a reliable method of assessing knee confidence.[12] Further studies should investigate a broader range of psychological factors in people with OA after ACLR. We had a smaller sample size with kinesiophobia data (n=47). However our sample size was sufficient to detect a significant between-group difference and we had 93% of data in the OA group. Hence, the smaller sample size didn't considerable affect our secondary aims. The cross-sectional nature of the study design precludes any conclusions regarding the temporal relationship between knee confidence and knee OA after ACLR. Longitudinal studies are required to ascertain the role of knee confidence and

progression of knee OA after ACLR. Due to insufficient sample power, factorial regression analysis could not be performed to determine factors related to knee confidence. Therefore, future studies should evaluate factors associated with knee confidence in a larger cohort. Finally, while our sample size may limit the generalisability of our results, it was sufficient to detect significant between-group differences and address the aims of our study.

Conclusion

In summary, this study identified the presence of two psychological impairments in individuals with knee OA after ACLR: reduced knee confidence and greater kinesiophobia. Further research is needed to determine whether these psychological impairments are a precursor or consequence of knee OA after ACLR. The inter-relationship between knee confidence, kinesiophobia and patient-reported and performance-based functional impairments indicates that psychological impairments associated with this patient group should not be ignored in rehabilitation programs, and warrant further investigation in future efficacy studies.

Practical implications

- People with knee OA after ACLR have greater trouble with knee confidence and fear of re-injury
- Worse knee confidence in people with knee OA after ACLR is related to greater fear of re-injury, worse knee symptoms and worse physical function
- Improvements in knee confidence may aid in improving knee symptoms and physical function

Competing interests

The authors declare that they have no competing interests.

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Table 1 Knee confidence and its relation to kinesiophobia, symptoms, self-reported and performance-based functional impairments in ACLR participants with OA

Figure caption

Figure 1. Proportion of participants in the no-OA and OA groups across the three knee confidence categories

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Table 1. Knee confidence and its relation to kinesiophobia, symptoms, self-reported and performance-based functional impairments in ACLR participants with OA

	None	Mild-moderate	Severe-extreme	ANOVA	None vs. Mild-moderate		Mild-moderate vs. Severe-extreme		None vs. Severe-extreme	
	Mean (SD) [range] n=8	Mean (SD) [range] n=12	Mean (SD) [range] n=10	p-value	MD [99%CI]	p-value	MD [99%CI]	p-value	MD [99%CI]	p-value
Tampa	33 (4) [30 to 43]	34 (6) [23 to 41]	40 (6) [34 to 45]	0.031*	-1 [-6 to 4]	0.694	-6 [-12 to 0]	0.024*	-7 [-14 to 0]	0.020*
AKPS	95 (10) [81 to 100]	83 (10) [56 to 97]	73 (10) [46 to 98]	0.000**	12 [1 to 24]	0.012*	10 [-1 to 21]	0.023*	22 [10 to 34]	0.000**
IKDC	92 (12) [86 to 99]	75 (12) [56 to 92]	60 (12) [38 to 84]	0.000**	17 [3 to 32]	0.004**	15 [2 to 29]	0.006**	33 [18 to 48]	0.000**
KOOS-ADL	98 (8) [88 to 100]	92 (8) [72 to 100]	84 (8) [13 to 96]	0.005**	6 [-3 to 16]	0.106	7 [-1 to 16]	0.041*	14 [4 to 23]	0.001**
KOOS-S/R	89 (18) [80 to 95]	72 (18) [30 to 100]	52 (18) [25 to 100]	0.001**	17 [-4 to 37]	0.049*	21[1 to 40]	0.011*	37 [16 to 59]	0.000**
HD (cm)	98 (29) [61 to 151]	85 (29) [10 to 118]	55 (29) [8 to 94]	0.011*	13 [-21 to 47]	0.327	30 [-2 to 62]	0.023*	43 [8 to 79]	0.004**
SSH (n)	22 (10) [6 to 42]	18 (10) [1 to 37]	8 (10) [1 to 17]	0.013*	4 [-8 to 16]	0.417	10 [-1 to 22]	0.023*	14 [2 to 26]	0.006**
OLR (n)	35 (12) [10 to 50]	28 (12) [16 to 50]	11 (12) [1 to 25]	0.001**	7 [-7 to 21]	0.213	17 [4 to 30]	0.003**	24 [9 to 39]	0.000**

Abbreviations as follows: ACLR, Anterior cruciate ligament reconstruction; OA, Osteoarthritis; SD, Standard deviation; MD, Mean difference; CI, Confidence Interval; Tampa, Tampa Kinesiophobia Scale; AKPS, Anterior Knee Pain Scale,; IKDC, International Knee Documentation Committee Form; KOOS, Knee Injury and Osteoarthritis Outcome Score; ADL, Function in activities of daily living; S/R, Function in sports and recreation activities; HD, single leg hop for distance; SSH, side-to-side hop; OLR, one leg rise. *Symbol indicates $p \leq 0.05$ and **indicate $p \leq 0.01$

Figure 1