Are altered knee joint biomechanics associated with the onset and progression of post-traumatic osteoarthritis? A systematic review and meta-analysis of longitudinal studies

Matthew Savage[1]; Adam Culvenor[1]; Michael Hedger[1]; April-Rose Matt[1]; Michael O'Brien[1]; Rachael McMillan[2]; Alysha De Livera[1]; Benjamin Mentiplay[1]

[1]La Trobe Sport and Exercise Medicine Research Centre, La Trobe University, School of Allied Health, Melbourne, Australia

[2]Institute for Mental and Physical Health and Clinical Translation, Deakin University, Waurn Ponds, Australia

Email: matt.savage@latrobe.edu.au

Summary

This systematic review examined the association between lower-limb biomechanics and post-traumatic osteoarthritis. Eighteen studies were included. Meta-analysis demonstrated that lower patellofemoral joint contact force following anterior cruciate ligament reconstruction was associated with worse future trochlear cartilage outcomes, with no significant associations found between biomechanics and future patellar cartilage health. Underloading of the patellofemoral joint post-surgery may present as a modifiable risk factor for post-traumatic osteoarthritis.

Introduction

Post-traumatic knee osteoarthritis (OA) affects one in two athletes within a decade of traumatic knee injury, especially in those following surgery [1]. While altered biomechanics are consistently associated with the onset and progression of insidious-onset OA in older adults, the relationship between biomechanics and post-traumatic OA in younger adults is less clear. Our aim was to evaluate the association between lower-limb biomechanics and future joint structure and symptoms in individuals following surgery for traumatic knee injuries.

Methods

Our systematic review followed PRISMA guidelines and was prospectively registered (PROSPERO: CRD42024504099). Five electronic databases were searched from inception until May 2024 for peer-reviewed longitudinal studies reporting on the relationship between lower-limb biomechanics and future joint structure (imaging) or future symptoms (patient-reported outcome measures) in individuals with a history of knee surgery for traumatic injuries. Meta-analyses were completed where possible, with the remaining studies synthesised narratively due to large heterogeneity precluding meta-analysis.

Results and Discussion

We included 18 studies (structure=12, symptoms=6). Meta-analysis of three studies demonstrated that lower patellofemoral joint contact force within the first-year post-anterior cruciate ligament reconstruction (ACLR) was associated with worse future trochlear cartilage structure (r = -0.48, 95% CI -0.63 to -0.31) (Figure 1a), but the association with patellar cartilage was not significant (r = -0.09, 95% CI -0.30 o 0.12) (Figure 1b). Meta-analysis of three studies found no relationship between knee flexion moment (KFM) or knee adduction moment (KAM) and future structural outcomes in the tibiofemoral joint (Figure 2). Narrative synthesis of other studies found that lower kinetic measures (e.g., KFM, KAM) were associated with worse future trochlear cartilage, but associations with patellar cartilage and the tibiofemoral joint were inconsistent. For symptoms, lower surrogate measures of medial tibiofemoral compartment load (KAM, medial ground reaction force (GRF)) were associated with better symptoms over time. In contrast, when examining vertical GRF alone, a measure that can be easily and reliably replicated in clinical settings, we found that a lower vertical GRF at six months post-ACLR may be associated with worse future symptoms at one year.

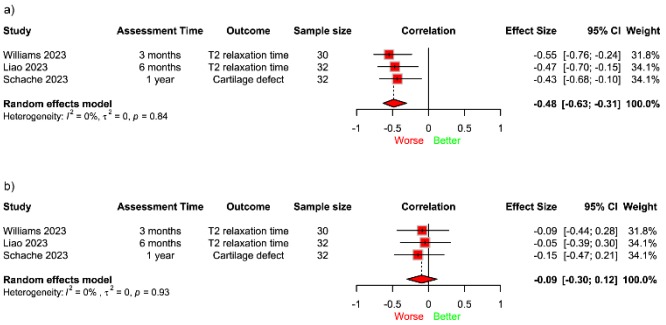

Figure 1: The association between patellofemoral contact force and future structural changes in: a) trochlear cartilage and b) patellar cartilage.

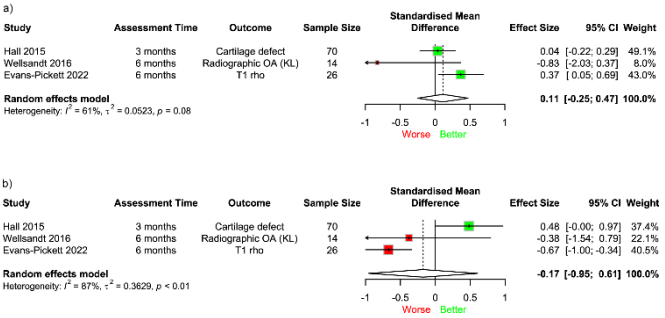

Figure 2: The association between a) knee flexion moment and b) knee adduction moment and future structural changes in the tibiofemoral joint.

Conclusions

Our systematic review highlights the complex interplay between knee joint loading and the onset and progression of post-traumatic OA. Underloading of the patellofemoral joint in the first year post-ACLR is associated with structural deterioration of patellofemoral cartilage, a pattern not observed in the tibiofemoral joint.

References

Culvenor, A. et al. (2013), *BJSM*, **47**(2): 66-7