Quadriceps architecture in individuals with patellofemoral pain: a systematic review protocol

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ABSTRACT

Objective: The objective of this review is to identify differences in quadriceps architectural parameters between healthy individuals and those with patellofemoral pain (PFP).

Introduction: Patellofemoral pain is one of the most common causes of knee pain among physically active populations. Muscular imbalance may play an important role in patellar malalignment or patellar maltracking. A systematic review will clarify the possible architectural changes of quadriceps muscles in persons with PFP.

Inclusion criteria: Eligible observational studies will include individuals younger than 50 years who have been diagnosed with unilateral or bilateral PFP. The comparator will be the contralateral, asymptomatic limb of the individual with PFP or a healthy matched subject. Studies that include measurement of quadriceps muscle size as the primary outcome will be considered. Studies in which participants had coexisting pathology, a history of lower limb surgery or injury, or pain originating from other joints will be excluded.

Methods: PubMed/MEDLINE (NLM), Scopus, Embase, Physiotherapy Evidence Database, Web of Science and CINAHL databases and multiple gray literature sources will be searched. Studies published since 1 January 1990 will be considered; there will be no language restriction. Retrieval of full-text studies, assessment of methodological quality and data extraction will be performed independently by two reviewers. If possible, meta-analyses will be performed, and a Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Summary of Findings presented.

Keywords Architecture; patellofemoral pain; quadriceps femoris

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Introduction

Patellofemoral pain is defined as the existence of pain and point tenderness in or around the patellofemoral joint.[1,2] Accounting for 25% to 40% of all knee injuries presenting to sports medicine, orthopedic and physical therapy clinics, patellofemoral pain (PFP) is one of the most common causes of knee pain among physically active populations.[1,3-5] With an insidious and atraumatic onset, the pain is provoked by increasing compressive forces on the patellofemoral joint through activities such as stair negotiation, prolonged sitting, squatting and hopping.[6,7] Although the peak point of prevalence in PFP has been noted in adolescents between the ages of 12 to 17, the annual incidence and true prevalence of PFP have not been clearly reported, especially in different populations.[5,8]

Weakness of quadriceps muscles, as a common consequence of knee pathologies, occurs due to muscle atrophy and also neural inhibition which prevents full activation of the muscles.[9,10] Weakness or decreased torque or lower strength of quadriceps muscles, in turn, may result in muscular

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imbalances[11] and has been proposed as a predictor of PFP.[12,13] Despite the multifactorial nature of the PFP, it has been suggested that muscular imbalance plays an important role in patellar malalignment or patellar maltracking and therefore it can be assumed as one of the potential causes of PFP.[8,11,14]

It has been suggested that vastus medialis obliqus (VMO) insufficiency may contribute to patellar maltracking. This is because VMO is not able to counterbalance the lateral pull of the vastus lateralis (VL) and maintain the central position of the patella in the trochlear groove.[15,16] Several studies have addressed the role of VMO in PFP patients by studying the thickness, volume or cross-sectional area of VMO using imaging techniques such as MRI, computed tomography and ultrasound imaging. Previous studies have revealed that VMO volume or cross-sectional area in PFP patients is significantly smaller in comparison to healthy matched individuals.[14,16]

On the contrary, Giles *et al.* found that all portions of quadriceps muscles (i.e. vastus medialis [VM], VL, vastus intermedius [VI], rectus femoris [RF] and VMO) atrophied in the affected limb of individuals with unilateral PFP in comparison to the contralateral asymptomatic limb.[17] However, no differences were found in quadriceps muscles thickness between PFP patients and the healthy control.[17]

Contradictory findings of the previous studies may be due to the use of different measurement parameters (i.e. volume, cross-sectional area, thickness) to evaluate quadriceps muscles atrophy. Therefore, the existence of quadriceps muscles atrophy in PFP individuals remains unresolved. A systematic review and meta-analysis by Giles *et al.*, which included 10 cross-sectional, case-control and randomized controlled trials from inception to March 2012, concluded that quadriceps atrophy was present in the limb with PFP in comparison to the contralateral, asymptomatic limb and also the healthy control group.[7] In addition, the results of this review showed that quadriceps muscle atrophy presented in PFP patients when measured by imaging techniques but not by girth measures. Only English language publications were included in the study.

Skeletal muscle strength is strongly associated with muscle quality and architecture.[16] Architectural characteristics of muscle, including parameters such as thickness, cross-sectional area and pennation angle (or fiber angle), are important determinants of force production and muscle function while performing different movements.[18-20] The accumulation of connective and adipose tissues in the muscles may result in changes of muscle quality or composition and enhancement of echogenicity.[18] Consequently, these changes may cause impairments in muscle strength associated with muscle disuse.[19] Furthermore, muscles with larger angles of fibers attached to the tendon or aponeurosis or larger pennation angles have a greater capacity to pack more contractile material within a certain volume and therefore have a larger physiological cross-section for their specified volume, which results in higher amount of capacity to produce force.[18,21-23] Jan *et al.* found that VMO fiber angle was significantly smaller in PFP individuals than in the age-. gender-, body height-, and body weight-matched healthy adults.[16] However, Engelina *et al.* found that VMO fiber angle in healthy young individuals had a degree of overlap with the values from PFP individuals of other studies.[6,15,16] These authors suggested that VMO fiber angle was not always smaller in PFP individuals.[15]

Despite the existence of several studies on VMO architecture in individuals with PFP,[6,15,16] few have investigated the association between architectural parameters of other parts of the quadriceps muscle (i.e. VM, VL, VI and RF) and PFP. In other words, changes in parameters such as pennation angle, fiber length and even muscle composition of these parts of the quadriceps muscle may have occured in individuals with PFP compared to the healthy population. Therefore, a systematic review is required to fill the gap in the literature and clarify the possible architectural changes of quadriceps muscle in this regard.

To the best of our knowledge, a previous systematic review has not been conducted to evaluate the echogenicity, pennation or fiber angle and fiber length of quadriceps muscle as a whole, or any individual part, in PFP patients. Therefore, due to the paucity of the literature and inconsistency of the findings regarding quadriceps muscles architecture in individuals with PFP, a new systematic review is needed to evaluate the literature on quadriceps architectural parameters in individuals with PFP. The purpose of this systematic review is to identify differences in architectural parameters of quadriceps muscle, as a whole or any individual part, using imaging techniques for individuals with PFP and comparing this to a contralateral, asymptomatic limb or separate control group.

Review question

Are there differences in quadriceps architectural parameters between healthy individuals and those with patellofemoral pain?

Inclusion criteria

Participants

This systematic review will include studies in which the participants are individuals (i.e. males and females) under 50 years of age who have been diagnosed with unilateral or bilateral PFP, and healthy matched subjects as controls. Also, studies in which participants with unilateral PFP have been compared to the contralateral, asymptomatic limb, as control, will be included.

Exposure

Individuals with unilateral or bilateral patellofemoral pain in each article will be evaluated according to Barton *et al.*[24] and Giles *et al.*,[7] as follows:

i) Participants have complained of pain in the prepatellar region during activities such as running, squatting, kneeling, climbing stairs, etc.
ii) Participants have presented symptoms of more than six weeks in duration.
iii) Participants have experienced an insidious onset of symptoms, unrelated to trauma.

Comparator(s)

This review will consider studies that compare individuals who have been diagnosed with PFP to healthy matched subjects or to a contralateral, asymptomatic limb of individuals with PFP.

Exclusion criteria

Studies in which participants have had any coexisting pathology, history of lower limb surgery, history of meniscus, ligamentous or bony injuries, other sources of anterior knee pain (e.g. osteoarthritis, patellar tendinopathy, etc.), major knee pathologies (subluxation, ligament damage, etc.), and/or suffered from referral pain originating from lumbar spine, hip or ankle joints will be excluded. Cadaveric studies will also be excluded.

Outcomes

This review will consider studies of primary outcomes that measure quadriceps muscle size. If muscle size was measured by multiple techniques, the data from all of the measurement techniques will be extracted and will be analyzed separately. The secondary outcomes will measure echogenicity, pennation or fiber angle and fiber length of individual parts of quadriceps. If the muscle size or pennation angle was measured from multiple regions of the muscle (i.e. mid-thigh, distal thigh), measurements closest to the mid-thigh will be used for the analysis.

Studies in which quadriceps muscle size (muscle thickness, cross-sectional area, and volume) as a whole or either individual quadriceps muscles (e.g. just rectus femoris) was measured by imaging techniques including MRI, ultrasound imaging and CT scan in PFP patients will be included in this review.

In addition, studies in which echo-intensity or echogenicity, pennation angle or fiber angle and fiber length of individual quadriceps muscles (i.e. VM, VL, RF, VMO and VI) were measured using ultrasound imaging in PFP patients will be included in this study.

Types of studies

This systematic review will include observational studies, including cross-sectional, case-control and cohort, in which the size, echogenicity, fiber length and pennation angle (or fiber angle) of individual parts of quadriceps muscles or total size of the entire quadriceps are measured using imaging techniques (i.e. ultrasound imaging, MRI, CT) in patients who suffer from PFP.

Methods

Search strategy

In this review we will consider studies published from 1 January 1990 to the present time.

The search strategy syntax for PubMed is presented in Appendix I. The PubMed syntax will be modified as needed and adopted for other electronic databases. A combination of MeSH terms and relevant keywords were used for designing the syntax. Searching will be performed with no language restriction.

Information sources

A single author will perform the electronic search in these databases: PubMed/MEDLINE (NLM), Scopus, Embase, Physiotherapy Evidence Database (PEDro), Web of Science (WOS), Cumulative Index to Nursing and Allied Health Literature (CINAHL).

Gray literature will include reports, theses or dissertations, conference proceedings and unpublished data. Other databases such as ProQuest, Google Scholar and World Wide Science will be searched. Included studies will also be reviewed bibliographically to identify related studies.

Study selection

Two reviewers will independently perform article scanning of the selected studies from the primary search based on the title and abstract. Subsequently, each reviewer will independently evaluate the full text of the potentially eligible articles. Any issues that arise will be resolved through discussion between two reviewers. Possible disagreements will be resolved through discussion with a third reviewer to reach a consensus. Reviewers' agreement will be evaluated using kappa statistics. The results of the search will be presented in a PRISMA flow diagram.

Assessment of methodological quality

Assessment of the included articles will be performed using the Joanna Briggs Institute assessment tools for quality appraisal of cross-sectional, cohort and case-control studies.[25] The methodological quality of the included articles will be assessed by two reviewers. Any disagreements that arise will be resolved through discussion or with a third reviewer.

Data extraction

Data extraction will be performed independently by two reviewers. Any disagreements that arise between the reviewers will be resolved through discussion or with a third reviewer. The following data will be extracted from each of the included studies: first author's name, year of publication, study design, sample size, sample demographics (age, gender and body mass index [BMI] or body weight) of PFP and control group, measurement method (MRI, CT, USI), and outcome measures (size, pennation angle, fiber length). The data extraction tool will be piloted for five studies. Authors of papers will be contacted to request missing or additional data, where required.

Data synthesis

The analysis will be conducted using Stata V.12 (StataCorp LP, College Station, Texas, USA). We expect that there will be an adequate number of observational studies for conducting a meta-analysis for the primary and secondary outcomes. However, if the number of defined types of articles is not sufficient for conducting a meta-analysis, narrative synthesis of the accumulated data will be presented. Sample size, mean difference and standardized mean difference, with their 95% confidence intervals (CIs), as key measures will be combined with fixed or random models. The meta-analysis data with 95% CI will be presented in a forest plot.

Heterogeneity among primary studies will be assessed by the I^2 statistic and χ^2 test. The I^2 statistics will be interpreted according to the following guide:[26]

i) 0–40% = no important heterogeneity
ii) 30–60% = moderate heterogeneity
iii) 50–90% = substantial heterogeneity
iv) 75–100% = considerable heterogeneity.

To find out the potential sources of heterogeneity among the studies, the data will be assessed using metaregression or subgroup analysis.

Publication bias will be evaluated using a funnel plot and Begg's and Egger's tests.

Assessing certainty in the findings

A Summary of Findings will be created using GRADEpro software (McMaster University, ON, Canada). The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach for grading the quality of evidence will be followed. The Summary of Findings will present the following information where appropriate: quadriceps architecture indexes in persons with and without patellofemoral pain, and a ranking of the quality of the evidence based on study limitations (risk of bias), indirectness, inconsistency, imprecision and publication bias.

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Appendix I: Proposed search strategy for MEDLINE (PubMed)

Search	Query	No. of records
#1	**Search** ((PFP[Title/Abstract]) OR PFPS[Title/Abstract]) OR ((((((''Patellofemoral Pain Syndrome''[Mesh]) OR ''Chondromalacia Patellae''[Mesh]) OR ((Patellofemoral[Title/Abstract]) AND ((((''Pain''[Mesh]) OR Pain[Title/Abstract])) OR ((''Syndrome''[Mesh]) OR Syndrome[Title/Abstract]))))) OR ((''Patellofemoral Joint''[Mesh]) AND ((((''Pain''[Mesh]) OR Pain[Title/Abstract])) OR ((''Syndrome''[Mesh]) OR Syndrome[Title/Abstract])))) OR ((Patell*[Title/Abstract]) AND ((Chondromalacia*[Title/Abstract]) OR ''Cartilage disease''[Title/Abstract]))) OR ((((''Anterior knee''[Title/Abstract]) OR ''Runners knee''[Title/Abstract])) AND ((((''Pain''[Mesh]) OR Pain[Title/Abstract])) OR ((''Syndrome''[Mesh]) OR Syndrome[Title/Abstract])))) OR ((''Patell* compression''[Title/Abstract]) AND ((''Syndrome''[Mesh]) OR Syndrome[Title/Abstract]))	5544
#2	**Search** ((((''Vastus medialis''[Title/Abstract]) AND obliq*[Title/Abstract])) OR ((((Muscle*[Title/Abstract]) OR ''Muscles''[Mesh])) AND Quadriceps[Title/Abstract])) OR (((((''Thigh''[Mesh]) OR Thigh[Title/Abstract])) OR (((((((Quadricep*[Title/Abstract]) OR ''Quadriceps muscle*''[Title/Abstract]) OR "Quadriceps femoris''[Title/Abstract]) OR ''Rectus femoris''[Title/Abstract]) OR ''Vastus lateralis''[Title/Abstract]) OR ''Vastus intermedius''[Title/Abstract]) OR ''Knee extensor''[Title/Abstract])) OR (((((RF[Title/Abstract]) OR VM[Title/Abstract]) OR VL[Title/Abstract]) OR VI[Title/Abstract]) OR VMO[Title/Abstract]))	145,889
#3	**Search** (((((((((Muscle*[Title/Abstract]) OR ''Muscles''[Mesh])) AND ((volume[Title/Abstract]) OR Bulk[Title/Abstract]))) OR ((cross-section*[Title/Abstract]) AND Area[Title/Abstract])) OR (((((((Atroph*[Title/Abstract]) OR Wast*[Title/Abstract]) OR Size[Title/Abstract]) OR Measur*[Title/Abstract]) OR Morpholog*[Title/Abstract]) OR Morphomet*[Title/Abstract]) OR Diameter[Title/Abstract])) OR ((Pennation[Title/Abstract]) AND Angle[Title/Abstract])) OR ((Fiber[Title/Abstract]) AND Angle[Title/Abstract])) OR ((Fiber[Title/Abstract]) AND Length[Title/Abstract])	4,536,111
#4	**Search** #1 AND #2 AND #3	436