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Comparison of hip and knee strength in males with and without patellofemoral pain

Lori A. Bolgla [a,*], Jennifer Earl-Boehm [b], Carolyn Emery [c], Karrie Hamstra-Wright [d], Reed Ferber [e]

[a] EC-1334, Department of Physical Therapy, College of Allied Health Sciences, Georgia Regents University, Augusta, GA 30912, USA
[b] Department of Kinesiology, University of Wisconsin-Milwaukee, Milwaukee, WI, USA
[c] Faculties of Kinesiology and Medicine, University of Calgary, Calgary, AB, Canada
[d] Department of Kinesiology and Nutrition, University of Illinois at Chicago, Chicago, IL, USA
[e] Faculties of Kinesiology and Nursing, University of Calgary, Calgary, AB, Canada

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ABSTRACT

Objectives: The primary purpose of this study was to compare hip strength in males with and without patellofemoral pain (PFP). The secondary purpose was to compare knee strength in males with and without PFP.
Design: Secondary analysis of cross-sectional data for males with and without PFP from a larger randomized controlled trial examining hip and core versus knee-muscle strengthening for the treatment of PFP.
Setting: Laboratory setting.
Participants: Sixty-six males with PFP and 36 controls.
Main outcome measures: Peak isometric force for the hip abductors, external rotators, internal rotators, extensors, and knee extensors expressed as a percentage of body mass (%BM).
Results: No differences existed with respect to any of the hip strength measures ($P > .05$). Males with PFP demonstrated almost 17% less knee extensor strength than controls (mean difference = 7.3 %BM; 95% confidence interval, 1.3–13.4 %BM; $t = 2.41$; $P = .02$).
Conclusions: Unlike females, males with PFP did not demonstrate hip muscle weakness. However, differences did exist with knee extensor strength. These data provide preliminary evidence for the potential need for sex-specific interventions for individuals with PFP.

1. Introduction

Patellofemoral pain (PFP) is one of the most common knee pathologies experienced by active adults (Kannus, Aho, Jarvinen, & Niittymaki, 1987; Taunton, Ryan, Clement, McKenzie, Lloyd-Smith, & Zumbo, 2002). PFP is thought to result from abnormal patella tracking that can lead to excessive lateral patellofemoral joint stress (Fulkerson, 2002). Factors like quadriceps weakness (Lankhorst, Bierma-Zeinstra, & van Middelkoop, 2012; Pappas & Wong-Tom, 2012), delayed and/or reduced vastus medialis activation (Boling, Bolgla, Mattacola, Uhl, & Hosey, 2006; Van Tiggelen, Cowan, Coorevits, Duvigneaud, & Witvrouw, 2009), and reduced knee flexibility (Piva, Goodnite, & Childs, 2005; Witvrouw, Lysens, Bellemans, & Peers, 2000) have been identified in individuals with PFP. These factors have been examined based on the assumption that the patella moves laterally relative to a "fixed" femur during activities of daily living. Under this theory, clinicians typically have prescribed quadriceps strengthening exercises. Although quadriceps exercise has been considered the "gold standard" approach (Bolgla & Malone, 2005; Natri, Kannus, & Jarvinen, 1998), many individuals continue to experience residual symptoms following this treatment approach (Nimon, Murray, Sandow, & Goodfellow, 1998).

Suboptimal outcomes have led researchers to investigate factors other than the patellofemoral joint. Powers (2003) has theorized that altered hip movement can increase the quadriceps angle (*Q*-angle) and lead to abnormal lateral patella tracking. Both excessive hip adduction and hip internal rotation increase the *Q*-angle by

* Corresponding author. Tel.: +1 706 721 1517; fax: +1 706 721 3209.
E-mail address: lbolgla@gru.edu (L.A. Bolgla).

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positioning the patella more medial relative to the fixed tibial tuberosity. Results from cadaveric studies have shown that these femoral movements cause increased lateral patella stress (Lee, Morris, & Csintalan, 2003).

Powers, Ward, Fredericson, Guillet, and Shellock (2003) and Souza, Draper, Fredericson, and Powers (2010) investigated this theory using kinematic magnetic resonance imaging in subjects with patella instability and PFP, respectively. For individuals with patella instability, Powers et al. (2003) assessed patella movement during non-weight bearing and weight bearing knee extension. These individuals demonstrated greater movement of the patella on the femur during non-weight bearing knee extension. The opposite movement occurred during weight bearing knee extension. Images during this maneuver showed movement of the femur under a relatively fixed patella.

Souza et al. (2010) compared patella movement in females with and without PFP during weight bearing knee extension. Like Powers et al. (2003), those with PFP demonstrated greater femoral internal rotation under a relatively stable patella than controls. Together, these data from both investigations were clinically important as individuals with PFP typically complain of pain during weight bearing activities (e.g., stair ambulation, running and jumping). They further highlighted the need to better understand the interrelationship between hip external rotator and abductor muscle function and lower extremity kinematics (Powers, 2010).

Souza and Powers (2009b) assessed the gluteus maximus, the strongest hip external rotator, in female runners with PFP. They identified gluteus maximus weakness as the only predictor variable for increased hip internal rotation. Dierks, Manal, Hamill, and Davis (2008) also reported increased hip adduction and hip abductor weakness following prolonged running in individuals with PFP. Moreover, Ferber, Kendall, and Farr (2011) reported increased hip abductor strength and reduced pain in runners with PFP following a 3-week hip abductor strengthening program.

Based on a systematic review, results from several studies support the presence of hip abductor and external rotator muscle weakness in females with PFP (Prins & van der Wurff, 2009). There also is emerging evidence regarding the benefits of hip abductor and external rotator strengthening exercises for females with PFP (Fukuda et al., 2012; Fukuda, Rossetto, Magalhães, Bryk, Lucareli, & de Almeida Aparecida Carvalho, 2010; Khayambashi, Mohammadkhani, Ghaznavi, Lyle, & Powers, 2012; Mascal, Landel, & Powers, 2003).

Only one investigation has compared the effects of hip strengthening to knee strengthening in males and females with PFP (Khayambashi, Fallah, Movahedi, Bagwell, & Powers, 2014). Eighteen males and 18 females with PFP participated in either a strengthening program targeting the posterolateral hip or quadriceps muscles. All subjects, regardless of group assignment, demonstrated improvements in pain and function. However, subjects in the hip strengthening group exhibited superior outcomes compared to those in the quadriceps group. These findings suggested that males with PFP also may benefit from a hip strengthening program. A limitation of this study was the exclusion of controls to determine if males with PFP exhibited hip weakness.

Although females are 2.2 times more likely to develop PFP than males (Boling, Padua, Marshall, Guskiewicz, Pyne, & Beutler, 2009), PFP remains a common overuse injury in active adults (Kannus et al., 1987; Taunton et al., 2002). Despite substantial evidence of hip and knee strength deficits in females with PFP, very little is known if similar impairments exist in males. Identification of these differences will help determine the need for sex-specific interventions for PFP.

The primary purpose of this study was to compare hip strength in males with and without PFP. The secondary purpose was to determine if males with PFP exhibited knee weakness compared to controls. We hypothesized that males with PFP would demonstrate less hip and knee strength than controls.

2. Methods

2.1. Design

This study was a secondary analysis of cross-sectional data for males with and without PFP from a larger randomized controlled trial (RCT) examining hip and core versus knee-muscle strengthening for the treatment of PFP (Ferber, Bolgla, Earl-Boehm, Emery, & Hamstra-Wright, 2014).

2.2. Subjects

Sixty-six males with PFP and 36 controls participated. Individuals between the age of 18–40 years were recruited via print media, media releases, university noticeboards, and practitioner referrals in the Calgary, AB, CA; Milwaukee, WI, USA; Augusta, GA, USA; and Chicago, IL, USA areas. Inclusion and exclusion criteria (Table 1) for males with PFP were based on prior studies (Boling et al., 2006).

Controls represented a sample of convenience. Inclusion criteria were: 1) recreationally active (e.g., exercised at least 30 min 3 days a week over the past 6 months), 2) no history of PFP, and 3) meeting none of the exclusion criteria (Table 1). All individuals who chose to participate signed an informed consent approved by the given investigation site's Institutional Review Board (University of Calgary Conjoint Health Research Ethics Board, University of Wisconsin–Milwaukee Institutional Review Board, Georgia Regents University Human Assurance Committee, and the University of Illinois at Chicago Institutional Review Board).

Table 1
Inclusion and exclusion criteria for males with patellofemoral pain (Boling et al., 2006).

Inclusion criteria (must meet 3 of the 5 and be recreationally-active)
Visual analog rating during activities of daily living over the previous week at a minimum of a 3 on a 10-cm scale
Insidious onset of symptoms unrelated to trauma for at least 4 weeks
Anterior knee pain during at least three of the following:
○ During or after activity
○ Prolonged sitting
○ Stair ascent or descent
○ During squatting
Pain with palpation of the patellar facets or pain during a step-down from a 20-cm box or double-legged squat
Recreationally-active (exercise at least 30 min a day 3 times a week for the past 6 months)
Exclusion criteria
Meniscal or other intra-articular pathology
Cruciate or collateral ligament laxity
Patellar tendon, iliotibial band, or pes anserine tenderness
Positive patellar apprehension sign
Osgood-Schlatter or Sinding-Larsen-Johanssen syndromes
Evidence of knee effusion
Hip or lumbar referred pain
History of recurrent patellar subluxation or dislocation
History of knee joint surgery
Non-steroidal anti-inflammatory drug or corticosteroid use within 24 h prior to testing
History of head injury or vestibular disorder within the last 6 months