Journal of Science and Medicine in Sport 19 (2016) 696–701

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Isometric and isokinetic hip strength and agonist/antagonist ratios in symptomatic femoroacetabular impingement

Laura E. Diamond[a,*], Tim V. Wrigley[a], Rana S. Hinman[a], Paul W. Hodges[b], John O'Donnell[c], Amir Takla[d], Kim L. Bennell[a]

[a] The University of Melbourne, Centre for Health, Exercise and Sports Medicine, Department of Physiotherapy, School of Health Sciences, Australia
[b] The University of Queensland, Centre of Clinical Research Excellence in Spinal Pain, Injury & Health, School of Health & Rehabilitation Sciences, Australia
[c] St Vincent's Hospital, Australia
[d] Ivanhoe Sports & Physiotherapy Clinic, Hip Arthroscopy Australia, Australia

ARTICLE INFO

Article history:
Received 30 June 2015
Received in revised form
18 September 2015
Accepted 7 October 2015
Available online 22 October 2015

Keywords:
Femoroacetabular impingement
Hip strength
Hip joint

ABSTRACT

Objectives: This study investigated isometric and isokinetic hip strength in individuals with and without symptomatic femoroacetabular impingement (FAI). The specific aims were to: (i) determine whether differences exist in isometric and isokinetic hip strength measures between groups; (ii) compare hip strength agonist/antagonist ratios between groups; and (iii) examine relationships between hip strength and self-reported measures of either hip pain or function in those with FAI.
Design: Cross-sectional.
Methods: Fifteen individuals (11 males; 25 ± 5 years) with symptomatic FAI (clinical examination and imaging (alpha angle >55° (cam FAI), and lateral centre edge angle >39° and/or positive crossover sign (combined FAI))) and 14 age- and sex-matched disease-free controls (no morphological FAI on magnetic resonance imaging) underwent strength testing. Maximal voluntary isometric contraction strength of hip muscle groups and isokinetic hip internal (IR) and external rotation (ER) strength (20°/s) were measured. Groups were compared with independent *t*-tests and Mann–Whitney *U* tests.
Results: Participants with FAI had 20% lower isometric abduction strength than controls ($p = 0.04$). There were no significant differences in isometric strength for other muscle groups or peak isokinetic ER or IR strength. The ratio of isometric, but not isokinetic, ER/IR strength was significantly higher in the FAI group ($p = 0.01$). There were no differences in ratios for other muscle groups. Angle of peak IR torque was the only feature correlated with symptoms.
Conclusions: Individuals with symptomatic FAI demonstrate isometric hip abductor muscle weakness and strength imbalance in the hip rotators. Strength measurement, including agonist/antagonist ratios, may be relevant for clinical management of FAI.

1. Introduction

Femoroacetabular impingement (FAI) is a morphological hip condition that can cause hip/groin pain and impaired performance in young, often active adults.[1] FAI can result when the proximal femur abuts against the acetabular rim, frequently leading to joint stiffness, structural damage (typically labral tears or chondral lesions), and hip osteoarthritis.[1] FAI is common in athletes who move repetitively through hip flexion, adduction and internal rotation.[2] Although strength testing is recommended during physical examination of patients with hip pain,[3] little is known regarding hip strength in individuals with symptomatic FAI.

Muscle weakness has been associated with other hip pathologies, including osteoarthritis.[4] However, only one study has assessed isometric strength in a symptomatic FAI population, reporting deficits across the hip adductor, abductor, flexor, and external rotator muscles.[5] Evaluation of strength, as well as agonist/antagonist strength ratios, in participants with FAI and control participants who have undergone imaging to ensure an absence of asymptomatic morphological FAI are necessary to provide further insight into this issue. Though hip muscle weakness in asymptomatic FAI is not well defined, this remains an important consideration as a recent review of 26 studies shows a prevalence of asymptomatic FAI at 50–55% in athletes.[6]

* Corresponding author.
E-mail address: lauraem@student.unimelb.edu.au (L.E. Diamond).

http://dx.doi.org/10.1016/j.jsams.2015.10.002
1440-2440/

Although it may be reasonable to predict strength deficits and/or imbalances as a result of mechanisms such as pain/reflex inhibition, attenuated muscle activation, or atrophy in symptomatic FAI, there is limited supporting evidence. Nevertheless, rehabilitation programs, including those following arthroscopic surgery for FAI, promote hip muscle strengthening.[7,8] Further, non-surgical treatment for FAI (including strength training) is endorsed within the literature, despite weak supporting evidence[9], and unknown long term outcomes.[10] Increased understanding of the nature and extent of strength deficits in symptomatic FAI is necessary to aid development of conservative treatments, including preoperative programs with the potential to improve surgical outcomes.

No study has examined dynamic hip rotation strength (e.g. isokinetic) in symptomatic FAI. Assessment of strength through range in this condition is important given that reduced hip rotation range of motion (ROM) is reported in FAI.[11] The functional potential of the external rotator muscles is highest during single-leg weight bearing activities that require pelvic and trunk rotation,[12] highlighting their importance during sports such as ice hockey[13] and ballet,[14] where symptomatic FAI has been identified.[2] The external rotators may be especially important in individuals with FAI as these muscles could play a role in augmenting hip stability[15] and avoiding impinging positions.

The purpose of this study was to compare isometric and isokinetic hip muscle strength between individuals with symptomatic FAI and an asymptomatic control group with no evidence of morphological FAI. It was hypothesized that: (i) isometric and isokinetic hip strength measures would differ between groups; (ii) hip strength ratios would differ between groups; and (iii) an association would exist between hip strength, and self-reported measures of hip pain or function in people with symptomatic FAI.

2. Methods

This exploratory study used a convenience sample of participants who were concurrently enrolled in a separate invasive intramuscular electromyography study. For this research, individuals aged 18–35 years diagnosed with “cam” type or combined (“cam” and “pincer”) FAI, were recruited from the surgical records of the study orthopaedic surgeon (JO). Fifteen participants were included; all had tested positive for a clinical impingement test,[1] and had definitive signs of FAI on imaging ((X-ray and/or magnetic resonance imaging (MRI)); alpha angle >55° (cam FAI), and lateral centre edge angle >39° and/or positive crossover sign (combined FAI)).[16,17] All participants were scheduled for arthroscopic surgery, and were to have persistent hip/groin pain and activity limitation for at least 3 months. Participants diagnosed with bilateral FAI were tested on the more symptomatic side. Potential participants were excluded if they had: (i) only pincer type FAI; (ii) any history of hip surgery; (iii) moderate or severe radiographic osteoarthritis, as determined by the treating physician; (iv) lower limb injury/pain sufficient to limit function in the preceding month; or (v) other forms of arthritis, diabetes, cardiac circulatory conditions that limit everyday activities.

Fourteen asymptomatic healthy control participants, comparable to the FAI group with respect to age, sex, leg dominance, and activity level (Tegner Activity Scale), with no history of hip and/or groin pain were recruited from the community. Control participants underwent a hip MRI to ensure they did not have morphological FAI, using a 3-Tesla MR scanner (Siemens Magnetom Trio syngo MR B17) and a 16-channel body coil (coupled with a Siemens Spine array). Alpha angle was measured in the oblique sagittal plane;[16] lateral centre edge angle was measured in the coronal plane.[18] The localizer sequence was used to correct for pelvic obliquity where required.[18] Measurements were made using OsiriX imaging software (©Pixmeo SARL, Switzerland) and the Orthopaedic Studio v1.2 Plugin (Spectronic AB, Helsingborg, Sweden). Eligible participants had alpha angle <50° and lateral centre edge angle <40°.[16,17]

All participants provided written informed consent and the study was approved by the institutional medical research ethics committee.

Maximal voluntary isometric contraction strength of hip internal rotation, external rotation, extension, abduction, adduction, and flexion (in that order) muscle groups was measured by a single tester with a hand-held dynamometer (Lafayette Manual Muscle Tester 01160/01163/01165; Lafayette Instrument Company, Indiana. USA). Participants performed two maximal efforts (3–5 s duration) with a 30-s rest between. Additional measurements were taken if poor stabilization occurred or if participants failed to achieve a maximum effort. Participants received standardised verbal encouragement to contract maximally. The mean of the two valid measures were converted to torque (N m) by multiplying by the lever arm length (distance between approximate joint axis of rotation and the point of force application), and normalised to body mass (N m/kg).[19]

Isometric hip abduction/adduction strength was measured in supine with the hips in neutral position and belts over the hips and contralateral thigh. The dynamometer was positioned proximal to the lateral femoral condyle (abduction) or medial femoral condyle (adduction). Reliability of hip abduction strength measures in hip osteoarthritis was previously established in our laboratory using the same method (intraclass correlation coefficient (ICC) 0.84; 95% CI 0.55–0.94).[19] Reliability in healthy individuals, using a slight variation is ICC 0.93 (95% CI 0.73–0.98).[20]

Isometric hip flexion was measured in supine with the test-leg hip and knee flexed to 90°. The participant was stabilised with belts as above; the dynamometer was positioned 5 cm proximal to the patella border. Reliability in healthy individuals is ICC 0.94 (95% CI 0.76–0.99).[20] For hip extension strength, participants were prone with the knee flexed to 90°, with belts over the lower back and contralateral thigh. The dynamometer was positioned on the central point of the heel, in line with the shank. Reliability using the same method was previously reported in healthy individuals (ICC 0.89; standard error of the mean 0.126).[21]

Isometric hip internal and external rotation was measured in prone with the hips in neutral position and knee flexed to 90°, and stabilization belts over the lower back and contralateral thigh. The dynamometer was positioned proximal to the medial malleolus (external rotation) and lateral malleolus (internal rotation). Reliability of hip internal (ICC 0.89; 95% CI 0.60–0.97) and external rotation (ICC 0.99; 95% CI 0.93–1.00) using the same method in healthy individuals has been established.[20]

Concentric isokinetic hip internal rotation (IR) and external rotation (ER) strength was measured with a KinCom 125-AP isokinetic dynamometer (Chattecx, Chattanooga, TN). Participants lay prone with the hip in neutral and the test leg knee flexed to 90°. The dynamometer arm was aligned through the long axis of the femur with the axis of rotation at the approximate hip joint centre. The distal thigh was stabilized with a custom clamp; the shank was strapped to the dynamometer pad superior to the lateral malleolus. The lower trunk was secured to the dynamometer chair with a strap (Supplementary material Fig. 1). Range of motion limits were individualised based on the range for ER and IR that could be achieved with minimal pain, in order to reveal any patient-specific limitations to the muscle-force producing range of motion. Participants completed three maximal, continuous, reciprocal, isokinetic contractions of the hip rotator muscles at an angular velocity 20°/s, starting in ER. Initial and terminal acceleration/deceleration were set to ‘medium’. Peak force measures were converted to torque and normalised to body mass (N m/kg). Gravitational torque