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Effects of a hip brace on biomechanics and pain in people with femoroacetabular impingement

Nicolas R.A. Newcomb[a], Tim V. Wrigley[a], Rana S. Hinman[a], Jessica Kasza[c], Libby Spiers[a], John O'Donnell[b], Kim L. Bennell[a,*]

[a] Department of Physiotherapy, Centre for Health, Exercise and Sports Medicine, University of Melbourne, Australia
[b] Hip Arthroscopy Australia, Australia
[c] Department of Epidemiology and Preventive Medicine, Monash University, Australia

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ABSTRACT

Objectives: This study evaluates whether hip bracing in patients with femoroacetabular impingement (FAI) (a) immediately reduces range of hip internal rotation, flexion, adduction, and pain during functional tasks; and (b) improves patient-reported outcomes when worn daily over 4 weeks.
Design: Within-participant design followed by a case series.
Methods: Twenty-five adults with symptomatic FAI underwent 3D kinematic assessment with and without a hip brace during single-leg squat, double-leg squat, stair ascent, and stair descent. A subset of this population (n = 17) continued to wear the brace daily for 4-weeks. A linear mixed statistical model was used to assess pain and kinematic differences between the braced and unbraced conditions at baseline testing. Patient-reported outcomes (NRS pain, iHot-33 and HAGOS questionnaires) at 4-weeks were compared to baseline using paired t-tests.
Results: Bracing resulted in significant but small reductions in peak hip flexion ranging between 5.3° (95% CI 0.8°–9.7°) and 5.6° (95% CI 1.1°–10.0°), internal rotation ranging between 2.5° (95% CI 0.6°–4.4°) and 6.4° (95% CI 4.5°–8.2°), and adduction ranging between 2.2° (95% CI 0.5°–3.8°) and 3.3° (95% CI 1.6°–5.0°) during all tasks, except flexion during single-leg squat, compared with the unbraced condition; pain was not significantly improved with the brace. Bracing over four weeks did not significantly change patient-reported outcomes.
Conclusions: Bracing subtly limited impinging hip movements during functional tasks, but did not immediately reduce pain or improve patient-reported clinical outcomes after 4 weeks in a young adult cohort with long-standing FAI.

1. Introduction

Femoroacetabular impingement (FAI) is a common cause of groin pain and functional limitation, especially in athletes involved in acceleration-type sports.[1,2] Specific morphologies of the femoral head (cam) and acetabulum (pincer), or frequently a combination of the two, predispose the patient to symptomatic impingement of the femoral head and neck against the acetabular rim. This can eventually lead to chondral damage and hip osteoarthritis.[3,4]

The symptoms of FAI include hip stiffness and varying degrees of sudden sharp or slow onset anterior groin pain, which are commonly provoked by activities involving hip flexion, adduction and/or internal rotation placing the hip into an impinging position.[5–7] Although the repetitive hip overloading common in acceleration sports frequently aggravates FAI-related pain and functional limitation, symptoms outside of sport are also common; in particular, during protracted periods of sitting, climbing stairs, and squatting.[8–10]

The goals of treatment for FAI are to relieve pain, improve function and allow return to usual activity. Operative treatment, either open or arthroscopic, aims to improve hip morphology and repair damaged tissue, and has progressed steadily in sophistication and volume over the past decade.[11,12] Conservative treatments such as medication, rehabilitation focused on strength, neuromuscular control and range of motion, and activity modification also play a role in FAI management, but are under-researched, despite being a prerequisite for surgical intervention.[11–13] An orthotic device to

* Corresponding author.
E-mail address: k.bennell@unimelb.edu.au (K.L. Bennell).

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limit impinging hip movements during provocative activities may be a useful self-administered adjunctive treatment for FAI.

There has been limited research investigating hip bracing as a conservative treatment for FAI prior to surgery. Although large motion-limiting braces are available for post-surgical use, these are designed to restrict abduction and generally stabilize the hip, rather than restrict impingement movements.[14] While no known brace has specifically been designed for conservative management of FAI, it is plausible that a hip brace which restricts impinging movements could mitigate symptoms in patients with the condition.

A single case study demonstrated that a light-weight strap, which was originally designed to prevent internal rotation in people with patellofemoral pain,[15] immediately reduced pain, hip internal rotation, and hip adduction during running, step-down, and drop jump tasks in an FAI patient.[16] Another study using the same strap and involving 8 FAI patients, but reported in abstract form only, evaluated kinematic change during walking, jogging and stair-climb tasks. Results revealed small, immediate task-dependent reductions in adduction, flexion and internal rotation during brace-wear.[17] While these preliminary results are promising, further research is needed to confirm the role of hip bracing for patients with FAI.

The primary aim of this study was to evaluate the immediate effects of a hip brace on hip kinematics and pain in young adult patients with FAI. We hypothesized that the brace would immediately reduce hip pain and peak hip internal rotation, adduction and flexion angles compared to an unbraced condition during several tasks likely to provoke symptoms. A secondary exploratory aim was to investigate the effects of daily brace-wear on hip pain and other patient-reported outcomes over four weeks.

2. Methods

To investigate immediate bracing effects, a within-participant design was used. To investigate effects of daily brace use in a subgroup of participants, an observational study design was used.

Twenty-five young adult participants aged 18–35 years old were recruited via a sports physician and an orthopedic surgeon (JO). Participants were eligible if they had been diagnosed with FAI based on clinical and radiological findings. These included a history of groin/hip pain or stiffness in daily and/or sports activities, a positive FADIR (flexion, adduction, internal rotation) test, with or without a positive FABER (flexion, abduction, external rotation) test,[6–8] as well as the presence of cam and/or pincer morphology on imaging as reported by an experienced radiologist.[18] Participants were also required to report pain of ≥3 out of 10 on an 11-point numeric pain rating scale (NRS) during activities that involved impingement-type movements.

Exclusion criteria were any current pathology other than FAI that interfered with movement, a history of lower limb surgery, or self-reported hip osteoarthritis. Bilateral FAI, being relatively common,[19] was not excluded; the more symptomatic limb was chosen as the test leg.

The study was approved by the University of Melbourne Human Research Ethics Committee. All participants provided written informed consent.

Demographic information was collected online and included age, sex, weight, height and duration of symptoms. To describe participants' level of sporting activity, we used the Hip Sports Activity Score (HSAS).[20,21] This provides a global assessment of sports activity measured on a 0–8 scale (0 = no sports activity, 8 = elite-level participation in one or more acceleration-type sports).

Pain during kinematic testing, as well as overall pain in the past week at baseline and four weeks (in the subgroup wearing the brace for four weeks) were assessed using an 11-point NRS (0 = "no pain", 10 = "worst pain imaginable"). Two validated patient-reported outcome questionnaires were also administered at baseline and four weeks. The International Hip Outcome Tool (iHOT-33) measured hip-related quality-of-life via a visual analogue scale (0–100 score range, where higher scores indicate better quality-of-life).[22] The Copenhagen Hip and Groin Outcome Score (HAGOS) assessed hip and groin disability in six subscales using five-point Likert scales (normalized to 0–100, where higher scores represent better outcomes).[23] Patient-perceived global ratings of overall, pain-specific, and function-specific change from baseline were assessed after four-weeks on a 7-point Likert scale (0 = "much worse", 6 = "much better").

The test brace was a S.E.R.F. Strap (**S**tability thru **E**xternal **R**otation of the **F**emur, Don Joy Orthopaedics, Inc, Vista, CA).[15] It consists of light-weight, thin, elastic material and utilizes a 3-point hip-leg anchor around the pelvis, distal thigh and proximal tibia with an oblique strap wrapping around the thigh.[15] The line of action of the oblique strap pulls the hip into external rotation and abduction. The brace was fitted by a physician researcher (NN) according to the brace's instruction manual. For each participant, tension was applied to the oblique strap to achieve maximum passive hip external rotation while standing. Two velcro markers were placed on the strap ensuring participants could self-apply the brace daily with the same tension as was applied at fitting. Participants then acclimated to the brace by practicing the kinematics testing tasks.

Each participant performed stair ascent and descent, constrained and unconstrained squat, and single-leg squat tasks in both braced and unbraced conditions. Test condition (braced or unbraced) was randomized according to a permuted block randomization protocol. Within each condition, performance of groups of tasks (squatting tasks and stair-related tasks) was similarly randomized.

Tasks were performed according to published biomechanics protocols for FAI.[16,24,25] For stair tasks, participants ascended two steps, paused in neutral stance, turned, paused again and then descended. For double-leg squats, participants squatted to their maximum depth, holding this position for 3 s before returning to standing. Constrained squats required the heels to be planted and the shoulders to be positioned directly above the knees while unconstrained squats did not. For the single leg squat, participants stood sideways on the first step and lowered themselves by a distance that was 10% of their height. Each task was repeated until achieved 3 times successfully. Further detail is provided in the Supplementary material.

Kinematics testing employed a 12-camera motion analysis system (Vicon MX, Oxford, UK) sampling at 120 Hz. Two OR6-6-2000 floor-embedded force plates (AMTI Inc., Watertown, MA, USA), and a first-step-mounted 9286AA force plate (Kistler, Switzerland) were sampled in synchrony with the cameras by Vicon Nexus 1.8.5 at 1200 Hz, and used to identify the foot contact phases of the tasks. Reflective markers were applied to the lower limbs and bare feet according to Besier et al.[26] Functional knee joint centers were derived from the helical knee axis.[26] Estimation of the hip joint center position from pelvic markers were in accordance to the Harrington et al. regression equations.[27,28] Detail regarding marker placement is provided in the Supplementary material.

Kinematic data were sampled and assessed over the course of the entire squatting process for all squat tasks, and during the stance phase of the braced leg on the first step for the stair tasks. Marker trajectories and ground reaction forces were low-pass filtered at 6 Hz using a 2nd order, dual-pass Butterworth filter. Derivation of segment technical and anatomic coordinate systems, and segment kinematics, were programmed in Vicon Body Language (Vicon, Oxford, UK).[26] The primary hip joint kinematic

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