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Review article

Postoperative weight-bearing restrictions and rehabilitation protocols after hip arthroscopy for femoroacetabular impingement: a systematic review

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ABSTRACT

Despite recent increased interest in hip arthroscopy for the management of femoroacetabular impingement (FAI), there is little evidence to guide weight-bearing recommendations and rehabilitation postoperatively. The primary objective of this study was to determine if sufficient evidence exists to recommend specific weight-bearing restrictions postoperatively. This study was registered with PROSPERO (CRD42021247741). PubMed, MEDLINE and Embase were searched on 3 March 2023 for Level I–IV studies including patients over the age of 18 years, with a minimum 1-year follow-up and reporting of a weight-bearing status, a patient-reported outcome measure (PROM) and a clinical outcome. Meta-analysis was precluded due to heterogeneity in the included studies, and a descriptive analysis was undertaken. Methodological quality and risk of bias were assessed with the methodological index for non-randomized studies (MINORS). Twenty-four studies including 2231 patients who underwent hip arthroscopy for treatment of FAI were included (follow-up interval 33.2 ± 24.7 months). Most articles (62.5%) were case series. There were seven terms describing weight-bearing recommendations, with 83% being some variation of 'partial weight-bearing'. Eight PROMs were reported, with 83% using the modified Harris Hip Score and 87.5% of studies reporting reoperation rates. Only 75% of studies reported rehabilitation protocols. The average MINORS score was 11.07 ± 1.10 out of 16 for non-comparative studies and 18.22 ± 1.48 out of 24 for comparative studies. The reporting of weight-bearing status, clinical outcomes, PROMs and rehabilitation parameters remains poor. At present, sufficient comparative evidence does not exist to make specific weight-bearing recommendation postoperatively.

INTRODUCTION

Femoroacetabular impingement (FAI) is a motion-related clinical disorder characterized by atypical morphology of the acetabulum and proximal femur causing abnormal bony contact and hip pain [1, 2]. It has been increasingly recognized as a common cause of hip pain and predisposing factor to the development of osteoarthritis in young people [1, 3]. Improving awareness of this clinical entity has led to an increase in diagnosis of FAI in the population over time [4]. It has been postulated that the increasing incidence of FAI may be due to a repetition injury on the open proximal femoral physis in young high-level athletes causing morphological changes to the hip joint [5–7].

The standard of care for treatment of symptomatic FAI that has not responded to non-operative treatment (e.g. education, activity modifications, rehabilitation and injections [8]) is hip arthroscopy, which includes procedures such as osteochondroplasty, labral debridement, repair and reconstruction [2, 9]. These treatments are supported by emerging high-quality evidence affirming the safety and efficacy of hip arthroscopy compared to non-operative approaches [10–12] as well as compared to traditional open approaches [13, 14]. This new evidence, combined with the increasing incidence in FAI, has led to a great increase in the rate of hip arthroscopy and associated literature [15–18].

Despite the growing popularity of hip arthroscopy, the literature is generally poor when it comes to outcome reporting [19], rehabilitation protocols and, specifically, early postoperative weight-bearing recommendations [20, 21]. A comprehensive review performed by Grzybowski *et al.* [21] in 2015 and a subsequent review with the same criteria by Bistolfi *et al.* [22] in 2021 found that the current literature lacks high-quality evidence to support specific weight-bearing recommendations postoperatively. A large scoping review by Reiman *et al.* [20] of 169 studies found that only 76% reported a weight-bearing status in their rehabilitation protocol and furthermore found wide variability in duration of weight-bearing restrictions based on the procedure performed (e.g. osteochondroplasty, labral repair, microfracture, etc.).

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In lieu of good evidence and with no consensus on postoperative physiotherapy protocols [2], the best available evidence is expert opinion. The most cited article in hip arthroscopy [23] and one of the first large case series describing the arthroscopic treatment of FAI limited their patients to 20 lbs of partial weight-bearing (PWB) for a period of 4 weeks and extended that to 6–8 weeks if microfracturing was performed [24]. This protocol has been widely adopted [25]; however, protocols describing both non-weight-bearing (NWB) [25, 26] and weight-bearing as tolerated (WBAT) in the immediate postoperative period have also been described [25, 27, 28]. To date, there is only one retrospective study that compared patients made NWB to those made PWB [29]. This study compared all patients prior to September 2013, who were made strictly NWB for the first 3 weeks postoperatively, with all patients from October 2013 onwards, who were allowed weight-bearing with crutches (PWB) for the first 3 weeks postoperatively. Although they noted no difference in patient-reported outcome measures (PROMs) or clinical outcomes at 2 years, the temporal nature of this study limits the conclusions that can be drawn.

Biomechanical studies suggest that labral repairs fixed with a minimum of two suture anchors are resistant to simulated full weight-bearing [30] and that variable repair techniques can be significantly stronger than needed to withstand the forces encountered during normal gait [31]. Despite that, few surgeons elect to allow WBAT in the immediate postoperative period. This may be attributed to the lack of clinical evidence affirming the safety of allowing WBAT immediately postoperatively.

The purpose of this review is to determine if sufficient evidence exists to recommend specific weight-bearing restrictions in the immediate postoperative period following arthroscopic hip procedures for the treatment of FAI. In addition, this review aims to describe the variability in the reporting and use of PROMs, clinical outcomes and rehabilitation protocols.

MATERIALS AND METHODS

A systematic review was conducted according to preferred reporting items for systematic reviews and meta-analyses [32]. This study was registered with PROSPERO international prospective register of systematic reviews [33] (registration number CRD42021247741) on 8 September 2022. A computer-assisted search of PubMed (1966 to present), MEDLINE (1946 to present) and Embase (1947 to present) databases was undertaken on 3 March 2023 by a single reviewer. The search strategy used the following terms; (((((((((femoroacetabular[Title/Abstract]) AND (impingement[Title/Abstract])) OR (FAI[Title/Abstract])) AND (hip[Title/Abstract])) AND (arthroscopy[Title/Abstract])) AND (rehabilitation[Title/Abstract])) NOT (knee[Title/Abstract])) NOT (shoulder [Title/Abstract])) NOT (ankle[Title/Abstract])) NOT (wrist [Title/Abstract]). Search results were uploaded into Covidence (Veritas Health Innovation, Melbourne, Australia). Titles, abstracts and full-text articles were reviewed independently by two investigators. Disagreement was resolved with a third reviewer via consensus.

Eligibility criteria

English language, Level I–IV studies of the results of hip arthroscopy for FAI including patients over the age of 18 years, with a minimum 1-year follow-up and reporting of a weight-bearing status, at least one PROM and at least one clinical outcome were included. Hip arthroscopy procedures included labral procedures (debridement, repair and reconstruction), osteochondroplasty (femoral and acetabular), loose body removal, articular cartilage debridement and repair, capsular repair and plication, iliopsoas release and ligamentum teres debridement. All references within included studies were evaluated for inclusion if missed by the initial search. Level V evidence reviews, non-English language, letters to the editor, technical papers, gray literature and bilateral surgical interventions were excluded. Duplicate studies were electronically identified and excluded. Duplicate subject populations within separate unique studies were not reported twice.

Surgical outcomes of interest were the specific PROMs, number of PROMs, reoperation rate (including repeat arthroscopy and conversion to total hip arthroplasty) and complication rate. Outcomes of interest for rehabilitation were postoperative range of motion restrictions, duration of restrictions and brace use.

Data extraction

Data extraction was completed blinded in duplicate, and a descriptive analysis of the included studies was undertaken. There were no disagreements on included studies. Categories of data extraction included (I) characteristics of included studies (number/age/sex of patients, study design and follow-up intervals), (II) description of weight-bearing status, (III) description of PROMs (number and type), (IV) description of clinical outcomes [reoperation rate (e.g. repeat arthroscopy and conversion to total hip arthroplasty (THA) and complication rate] and (V) description of rehabilitation protocols [brace use and postoperative range of motion restrictions (restrictions and duration)].

Methodologic quality

Methodological quality and risk of bias were assessed with the methodological index for non-randomized studies [34] (MINORS). MINORS criteria were applied to both comparative and non-comparative studies included in the review.

Synthesis

Meta-analysis was precluded due to heterogeneity in the included studies. Descriptive analysis was undertaken using Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA). Demographic information, postoperative weight-bearing status, PROMs, clinical outcomes and description of rehabilitation (specifically, postoperative range of motion restrictions and brace use) were collated and recorded in an Excel spreadsheet.

RESULTS

Study characteristics

Twenty-four studies, published between 2009 and 2021 were included (Fig. 1). There were 2231 patients included, with an average age of 34.2 ± 9.5 years and 50.1% ± 21.3% male. The

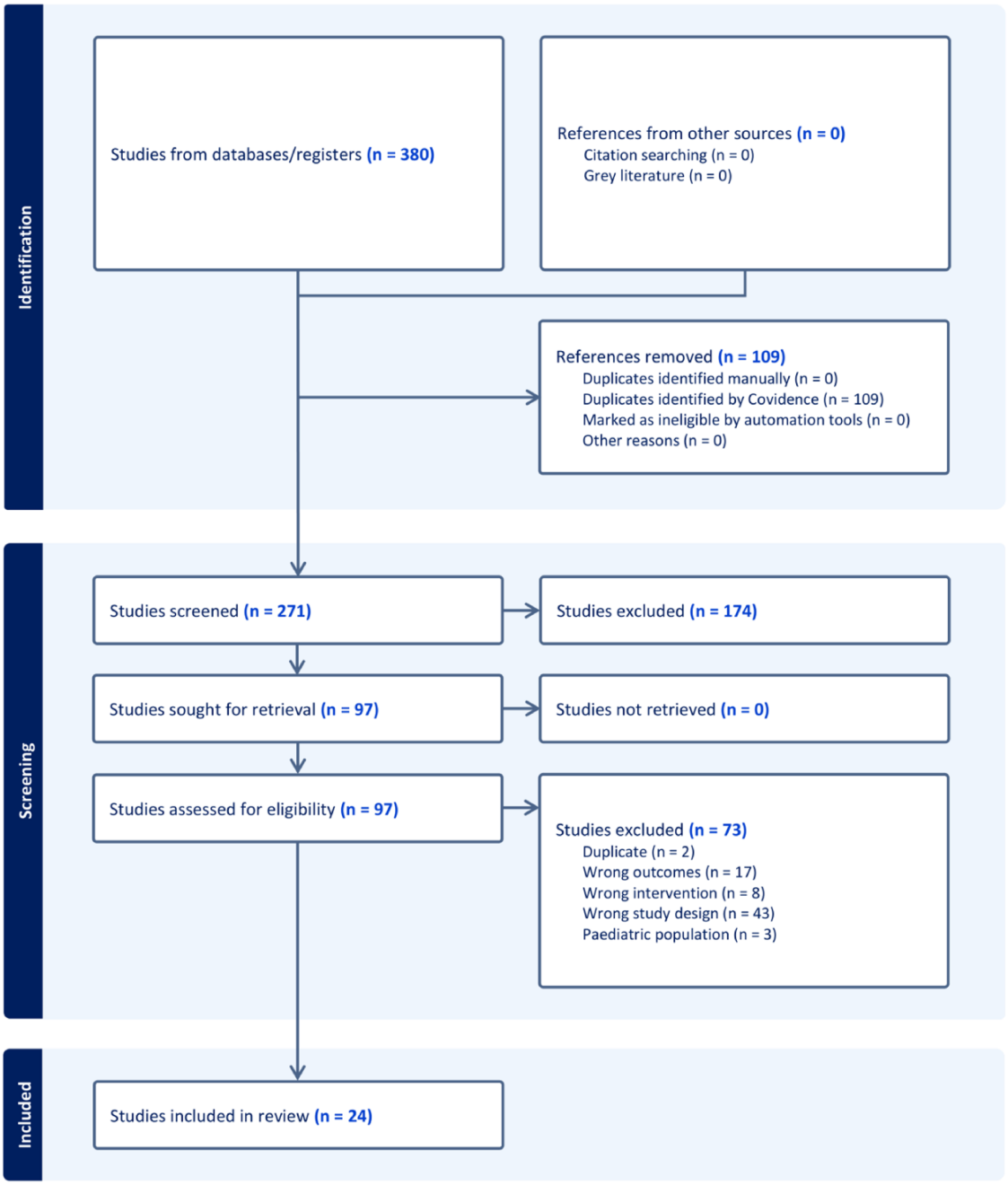

Fig. 1. Preferred reporting items for systematic reviews and meta-analyses diagram of the search process.

mean length of follow-up was 33.2 ± 24.7 months (Table I). There were 15 (62.5%) Level IV, 8 (33.3%) Level III and 1 (4.1%) Level II evidence studies included, for a total of 15 non-comparative and 9 comparative studies (Table I). Inclusion criteria were intentionally stringent (must include reporting of weight-bearing status, at least one PROM and at least one clinical outcome) to attempt to draw conclusions from the most thoroughly reported available evidence. The average MINORS score was 11.07 ± 1.10 out of 16 for non-comparative studies and 18.22 ± 1.48 out of 24 for comparative studies.

Weight-bearing descriptions

There were seven different terms used to describe postoperative weight-bearing restrictions. Two studies (8%) described NWB, two studies (8%) described WBAT and the remaining 20 studies 84% described some variation of PWB. Within PWB, one study (5%) described 'partial weightbearing', one study (5%) described 'weight-bearing limited', one study (5%) described 'touchdown weight-bearing', three studies (15%) described WBAT with crutches and the remaining 14 studies (70%) described 'flat-foot weight-bearing' (FFWB). Of the PWB studies, 15 studies (60%) specified a 20 lb maximum weight

Table I. ***Demographics***

Study	*Mean age, years*	*Male, %*	*Follow-up, mo*	*Weightbearing status*	*PROMs*	*Reoperation rate, %*	*MINORS*
Comparative							
Avnieli *et al.*	34.4	61.6	48	NWB versus PWB	mHHS, HOS ADL	0.0	18
Beck *et al.*	33.2	33.3	60	PWB	mHHS, HOS ADL, HOS Sport	3.4	18
Bolia *et al.*	28	57.1	78	PWB	mHHS, HOS ADL, HOS Sport	14.1	20
Chen *et al.*	30.1	64.5	24	PWB	mHHS, HOS Sport, iHOT, NAHS	22.6	20
Domb *et al.*	19.3	20.0	24	PWB	mHHS, HOS ADL, NAHS	10.0	19
Kierkegaard *et al.*	36.0	37.0	12	PWB	HAGOS Pain, Symptoms, QoL, PA, ADL, Sport	NR	16
Lall *et al.*	43.0	35.7	24	PWB	mHHS, HOS Sport, iHOT, NAHS	23.8	18
Lin *et al.*	43.1	25	120	PWB	mHHS, NAHS	29.3	16
Shibata *et al.*	21.0	50.0	12	PWB	mHHS, iHOT	2.5	19
							18.2
Non-comparative							
Cvetanovich *et al.*	33.3	39.4	24	PWB	mHHS, HOS ADL, HOS Sport	2.9	12
Degen *et al.*	22.5	100.0	16	PWB	mHHS, HOS ADL, HOS Sport, iHOT	0.0	11
Ferro and Philippon	43.7	47.8	30	PWB	mHHS	8.7	11
Flores *et al.*	36.2	47.2	24	PWB	mHHS, HOOS	0.74	12
Frank et al. (cycle)	30	38	24	PWB	mHHS, HOS ADL, HOS Sport	0.0	12
Frank *et al.* (yoga)	35	9.5	24	PWB	mHHS, HOS ADL, HOS Sport	0.0	12
Gao *et al.*	57.0	55.6	24	PWB	HHS, iHOT	3.7	11
Perets *et al.*	55.2	44.7	70	PWB	mHHS, HOS Sport, NAHS	29.1	10
Philippon *et al.* 2010 [35]	27.0	100.0	24	PWB	mHHS	7.1	9
Philippon *et al.* 2009 [24]	40.6	44.6	24	PWB	mHHS, HOS ADL, HOS Sport, NAHS	8.2	10
Riff *et al.*	34.7	41.0	24	PWB	mHHS, HOS ADL, HOS Sport	0.0	13
Sansone *et al.* 2015 [27]	25	82.0	12	WBAT	iHOT, HSAS, HAGOS Pain, Symptoms, QoL, PA, ADL, Sport	3.6	11
Sansone *et al.* 2017 [28]	37.0	66.0	24	WBAT	iHOT, HSAS, HAGOS Pain, Symptoms, QoL, PA, ADL, Sport	5.0	10
Sariali and Vandenbulke	36.0	50.0	36	PWB	mHHS, Oxford	10.6	12
Tijssen *et al.*	40.5	56.8	24	NWB	iHOT	NR	10
	34.2	**50.1**	**33.2**			**8.4**	**11.1**

Abbreviation: NWB, non-weight bearing, PWB, partial weight bearing, WBAT, weight bearing as tolerated; mHHS, Modified Harris Hip Score; HOS, Hip Outcome Score; iHOT, International Hip Outcome Tool; NAHS, Non-Arthritic Hip Score; HAGOS, Copenhagen Hip and Groin Outcome Score Pain; HOOS, Hip disability and osteoarthritis outcome score; HSAS, Hip Sports Activity Scale; Oxford, Oxford Hip Score; NR, Not reported.
Summary statistics, Mean of each column.

restriction through the operative limb, while one study (5%) specified a maximum of 30% body weight. Only five studies (21%) further specified weight-bearing recommendations specific to the procedures performed within hip arthroscopy (e.g. FFWB × 3 weeks for labral repair and NWB × 6 weeks for microfracture). Four of these studies described FFWB (20 lb maximum weight restriction) postoperatively for labral debridement, repair and osteoplasty, which ranged between 2 and 4 weeks in duration before advancing to WBAT. In the case of microfracturing, weight-bearing restrictions were more conservative, with as much as 4 weeks of NWB or 6–8 weeks of PWB before advancing to WBAT.

Range of motion restrictions and bracing

Only 75% of studies described their rehabilitation protocol. Early postoperative range of motion restrictions was reported in 71% of the studies, and the duration of restrictions was reported in 67% of studies. This was reported as a fixed number in 42% of studies or as a range in 21% of studies (range 2–12 weeks, median 3 weeks and average 4 ± 2 weeks) or as a full range of motion in the early rehabilitation phase in one study (4.2%). Postoperative bracing or orthosis was used in 46% of the included studies with the duration ranging from 10 days to 8 weeks.

PROM reporting

There were eight unique PROMs reported, with two PROMs, the Hip Outcome Score (HOS) and the Copenhagen Hip and Groin Outcome Score (HAGOS), each containing subscales utilized by one and three studies, respectively. The HOS subscales used were HOS-Activities of Daily Living (ADL) and HOS Sport, with the remaining elements of the PROM not used. The HAGOS subscales used included all subscales, which were Pain, Symptoms, ADL, Sport, Physical Activity (PA) and Quality of Life (QoL). The most used PROM was the modified Harris Hip Score (mHHS) in 83% of studies. There was an average of 2.25 ± 0.85 PROMs used per study with the most common number of PROMs used being two.

Clinical outcome reporting

Twenty-one (87%) studies reported their rate of reoperation. Of those, four studies (19%) reported no revision arthroscopy or conversions to THA. Of the remainder, 14 (67%) reported revision arthroscopy, 13 reported conversions to THA (62%) and one reported a peri-acetabular osteotomy (5%). Revision arthroscopy rates were 0–14.5% in the PWB group, 1–3.5% in the WBAT group and not reported in the NWB group. Conversion to THA rates were 0–29.3% in the PWB group, 0–4.1% in the WBAT group and not reported in the NWB group. The sole peri-acetabular osteotomy occurred in the PWB group.

Only 15 (62.5%) studies reported their complication rate. Of those, seven (46.7%) described having any complications at all. Six studies (40.0%) reported neuropraxias (four lateral femoral cutaneous nerve, one pudendal nerve and one undefined), four studies (26.7%) reported infections (three reported superficial and one reported deep), three studies (20.0%) reported deep vein thromboses and one study (6.7%) reported scrotal swelling.

DISCUSSION

This review looked to build on previous reviews [19–22] on rehabilitation after hip arthroscopy, especially as it pertains to early postoperative weight-bearing guidelines, range of motion restrictions including bracing and postoperative outcomes. Prior reviews demonstrated minimal evidence to support specific weight-bearing restrictions postoperatively and generally poor reporting of rehabilitation protocols. The most recent of these reviews [20] was published prior to the important retrospective case control study by Avnieli *et al* (2020). This paper represents the highest current level of comparative evidence for differing weight-bearing protocols. Considering that the comparison of weight-bearing protocols was not a core objective of the prior reviews, this can justify the need for a new analysis of narrower scope. Additionally, the most recent review focused only on the duration of weight-bearing and range of motion (ROM) restrictions. It did not examine the specific characteristics of those restrictions, which are essential for clinical integration. Using stringent inclusion criteria (requirement of weight-bearing status, clinical outcomes and PROMs), the most thoroughly reported literature in hip arthroscopy was analyzed to try to find evidence to support certain weight-bearing restrictions in the postoperative period. However, there was also no evidence to suggest that certain weight-bearing restrictions in the postoperative period were better than others.

Details in most studies were lacking, as most studies failed to describe their weight-bearing restrictions beyond one or two sentences. Furthermore, the terminology used differs greatly between studies, and what is implied by specific terms is often unclear. With five different terms describing 'partial weight-bearing' and only 54.1% of studies providing any type of loading guidance (20 lbs, 30% of body weight), it is difficult to compare methodology and outcomes across studies. Overall, 91.7% of the included studies suggested some form of protected weight-bearing (PWB or NWB) postoperatively, presumably in an attempt to protect the labral and capsular repairs [24, 35]. However, biomechanical studies have suggested that labral repairs can not only withstand the axial loads weight-bearing immediately [30, 31] but that activation of the hip flexor musculature to maintain NWB may also cause increased strain on the anterior hip capsule and compressive forces across the hip joint [36] that could be counter-productive for pain control and healing. It is possible that early weight-bearing and range of motion could actually be protective and lead to accelerated rehabilitation, as well as decrease disruption of ADLs in the early postoperative period. While direct comparisons between studies were impossible, it is interesting that the studies that employed WBAT [27, 28] had below average reoperation rates compared to the PWB and NWB studies (Table I). However, they used PROMs (HSAS and HAGOS) that almost no other studies used, and, importantly, they did not use the most popular PROM, the mHHS (Table I), which could have been the basis of comparison for PWB or NWB restrictions.

The most relevant clinical outcomes to weight-bearing status recommendations are the rate of repeat arthroscopy and conversion to THA, due to concerns about failure of repair and subsequent intra-articular damage. It has previously been shown that residual or unrecognized bony impingement, and not early

weight-bearing or noncompliance, is the leading cause of suture failure leading to eventual revision arthroscopy [37–39]. This, combined with biomechanical evidence that at least two-suture labral repairs are resistant to simulated WBAT [30, 31], suggests that concerns about early weight-bearing may be unwarranted. Unfortunately, due to heterogeneity in study characteristics and descriptions of weight-bearing status, no direct statistics could be performed comparing rates of reoperation to specific weight-bearing recommendations.

Variation in weight-bearing status based on the specific intraoperative procedures performed was only described in five studies. Generally speaking, weight-bearing restrictions were more permissive in purely labral procedures and more conservative in chondral or bony procedures, which is consistent with the literature [20, 25, 40, 41]. However, the scientific basis for this in the hip is unclear, as these recommendations originate from literature evaluating cartilage procedures in the knee [25].

In addition to considerations of postoperative weight-bearing recommendations, the range of motion restrictions was commonly identified in the early postoperative phases. Restrictions on hip flexion (to 90°) and extension (to 0°) were commonly recommended, while other planes of motion, including external rotation, abduction and adduction, were less consistently noted. This is likely due to biomechanical evidence suggesting increased anterior hip forces with excessive hip flexion or extension [36]. Limitations in external rotation have been considered as protective to capsular repairs, as failure has been noted in higher degrees of external rotation in cadaveric models [42]. Only one study indicated the full free range of motion during early rehabilitation, while it was unreported whether this included the immediate postoperative period [27]. While early ROM may have benefits such as decreased stiffness and adhesion formation, restrictions have been suggested especially in cases of capsular repair and plication for laxity and instability [41, 43]. Often in these situations of capsular laxity, a brace is prescribed (46% of included studies), although the type of brace, parameters and length of time are all matters of debate [41]. In fact, the literature on brace use is very limited. While rehabilitation-focused articles have made a case for specific protocols [40, 43–48], it seems that most surgical articles either are not adhering to or not reporting their use.

A secondary objective of this review was to evaluate outcome reporting and attempt to delineate the most relevant clinical outcome PROMs. Although eight unique PROMs were identified, 83% of studies included the mHHS, which is consistent with the prior literature, suggesting that it is the most commonly used PROM following hip arthroscopy [19, 49, 50]. This suggests that PROM usage in hip arthroscopy is fairly homogenous, compared, for example, to PROM use in the shoulder where there are 19 commonly used PROMs, with no one used in more than 27% of studies [51]. While a wide variety of clinical outcomes were deemed acceptable to meet inclusion criteria, the most reported was the reoperation rate (87.5%), above even reporting of complications (62.5%). It is possible that many studies omitted reporting of complications due to the low rate associated with this procedure [52] (53.3% of the included studies that reported complications had none). Reoperation rate is specifically important as one of the core rationales for performing hip arthroscopy is to prevent progression of osteoarthritis and the future need for THA. While the mid-term survivorship of hip arthroscopy for FAI is well described at near 80%, there are limited data on long-term survivorship [53], and thus, continued reporting is important.

Limitations

Only English language articles were included, which introduces a risk of language bias. Given that symptomatic FAI often occurs in adolescents and young adults, exclusion of studies with patients younger than 18 years decreased the number of studies included. However, this was done intentionally in order to decrease the overall heterogeneity of the population in this analysis. The available literature for arthroscopic treatment of FAI in adolescents [54–56] suggests that younger age does not have an influence on postoperative weight-bearing recommendations or rehabilitation protocols and therefore would not have changed the conclusions of this study. Additionally, because the quality of reporting is generally poor, it is difficult to determine if rehabilitation for most patients is truly inadequate or simply poorly reported.

CONCLUSION

The variability in reporting and heterogeneity in study outcomes precludes supporting any specific weight-bearing recommendation in the immediate postoperative period following hip arthroscopy for FAI. There is a lack of high-level evidence on weight-bearing postoperatively, and current practices are largely based on expert opinion. Future areas of research should include controlled trials evaluating the effect of different weight-bearing recommendations in the acute postoperative period.

SUPPLEMENTARY DATA

Supplementary data are available at *Journal of Hip Preservation Surgery* online.

DATA AVAILABILITY

Data are available within the article and its supplementary materials.

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CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Ganz R, Parvizi J, Beck M *et al.* Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop* 2003; **1**: 112–20.
2. Griffin DR, Dickenson EJ, O'Donnell J *et al.* The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. *Br J Sports Med* 2016; **50**: 1169–76.
3. Sankar WN, Nevitt M, Parvizi J *et al.* Femoroacetabular impingement: defining the condition and its role in the pathophysiology of osteoarthritis. *J Am Acad Orthop Surg* 2013; **21**: S7–15.
4. Hale RF, Melugin HP, Zhou J *et al.* Incidence of femoroacetabular impingement and surgical management trends over time. *Am J Sports Med* 2021; **49**: 35–41.

5. Stull JD, Philippon MJ, LaPrade RF. "At-risk" positioning and hip biomechanics of the Peewee ice hockey sprint start. *Am J Sports Med* 2011; **39**: 29–35.
6. Philippon MJ, Ho CP, Briggs KK *et al.* Prevalence of increased alpha angles as a measure of cam-type femoroacetabular impingement in youth ice hockey players. *Am J Sports Med* 2013; **41**: 1357–62.
7. Palmer A, Fernquest S, Gimpel M *et al.* Physical activity during adolescence and the development of cam morphology: a cross-sectional cohort study of 210 individuals. *Br J Sports Med* 2018; **52**: 601–10.
8. Wall PDH, Fernandez M, Griffin DR *et al.* Nonoperative treatment for femoroacetabular impingement: a systematic review of the literature. *PM R* 2013; **5**: 418–26.
9. Kelly BT, Williams RJ, Philippon MJ. Hip arthroscopy: current indications, treatment options, and management issues. *Am J Sports Med* 2003; **31**: 1020–37.
10. Femoroacetabular Impingement Randomized Controlled Trial (FIRST) Investigators, Ayeni OR, Karlsson J, Heels-Ansdell D *et al.* Osteochondroplasty and labral repair for the treatment of young adults with femoroacetabular impingement: a randomized controlled trial. *Am J Sports Med* 2021; **49**: 25–34.
11. Palmer AJR, Ayyar Gupta V, Fernquest S *et al.* Arthroscopic hip surgery compared with physiotherapy and activity modification for the treatment of symptomatic femoroacetabular impingement: multicentre randomised controlled trial. *BMJ* 2019; **364**: l185.
12. Griffin DR, Dickenson EJ, Wall PDH *et al.* Hip arthroscopy versus best conservative care for the treatment of femoroacetabular impingement syndrome (UK FASHIoN): a multicentre randomised controlled trial. *Lancet Lond Engl* 2018; **391**: 2225–35.
13. Matsuda DK, Carlisle JC, Arthurs SC *et al.* Comparative systematic review of the open dislocation, mini-open, and arthroscopic surgeries for femoroacetabular impingement. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2011; **27**: 252–69.
14. Zhang D, Chen L, Wang G. Hip arthroscopy versus open surgical dislocation for femoroacetabular impingement. *Medicine (Baltimore)* 2016; **95**: e5122.
15. Cvetanovich GL, Chalmers PN, Levy DM *et al.* Hip arthroscopy surgical volume trends and 30-day postoperative complications. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2016; **32**: 1286–92.
16. Palmer A, Malak T, Broomfield J. *Past and Projected Temporal Trends in Arthroscopic Hip Surgery in England Between 2002 and 2013*. Published 17 March 2016. Available at: https://bmjopensem.bmj.com/content/2/1/e000082. Accessed: 20 December 2022.
17. Montgomery SR, Ngo SS, Hobson T *et al.* Trends and demographics in hip arthroscopy in the United States. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2013; **29**: 661–5.
18. Bozic KJ, Chan V, Valone FH *et al.* Trends in hip arthroscopy utilization in the United States. *J Arthroplasty* 2013; **28**: 140–3.
19. Reiman MP, Peters S, Sylvain J *et al.* Prevalence and consistency in surgical outcome reporting for femoroacetabular impingement syndrome: a scoping review. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2018; **34**: 1319–28.e9.
20. Reiman MP, Boyd J, Ingel N *et al.* There is limited and inconsistent reporting of postoperative rehabilitation for femoroacetabular impingement syndrome: a scoping review of 169 studies. *J Orthop Sports Phys Ther* 2020; **50**: 252–8.
21. Grzybowski JS, Malloy P, Stegemann C *et al.* Rehabilitation following hip arthroscopy: a systematic review. *Front Surg* 2015; **2**: 21.
22. Bistolfi A, Guidotti C, Aprato A *et al.* Rehabilitation protocol following hip arthroscopy. A 2015 to 2020 systematic review. *Am J Phys Med Rehabil* 2020; **100**: 958–65.
23. von Glinski A, Yilmaz E, Goodmanson R *et al.* The impact of the 30 most cited articles on hip arthroscopy: what is the subject matter? *J Hip Preserv Surg* 2020; **7**: 14–21.
24. Philippon MJ, Briggs KK, Yen YM *et al.* Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction: minimum two-year follow-up. *J Bone Joint Surg Br* 2009; **91**: 16–23.
25. Rath E, Sharfman ZT, Paret M *et al.* Hip arthroscopy protocol: expert opinions on post-operative weight bearing and return to sports guidelines. *J Hip Preserv Surg* 2017; **4**: 60–6.
26. Tijssen M, van Cingel R, de Visser E *et al.* A clinical observational study on patient-reported outcomes, hip functional performance and return to sports activities in hip arthroscopy patients. *Phys Ther Sport Off J Assoc Chart Physiother Sports Med* 2016; **20**: 45–55.
27. Sansone M, Ahldén M, Jonasson P *et al.* Good results after hip arthroscopy for femoroacetabular impingement in top-level athletes. *Orthop J Sports Med* 2015; **3**: 2325967115569691.
28. Sansone M, Ahldén M, Jónasson P *et al.* Outcome after hip arthroscopy for femoroacetabular impingement in 289 patients with minimum 2-year follow-up. *Scand J Med Sci Sports* 2017; **27**: 230–5.
29. Avnieli IB, Vidra M, Factor S *et al.* Postoperative weightbearing protocols after arthroscopic surgery for femoroacetabular impingement does not affect patient outcome: a comparative study with minimum 2-year follow-up. *Arthrosc J Arthrosc Relat Surg* 2020; **36**: 159–64.
30. Koh JL, Gupta K. Evaluation of repair of the hip labrum under simulated full weight-bearing. *HIP Int* 2017; **27**: 104–9.
31. Hapa O, Barber FA, Başçı O *et al.* Biomechanical performance of hip labral repair techniques. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2016; **32**: 1010–6.
32. Moher D, Liberati A, Tetzlaff J *et al.*, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* 2009; **62**: 1006–12.
33. York CTu. *PROSPERO – International Prospective Register of Systematic Reviews*. Published online 2012. Available at: http://www.crd.york.ac.uk/PROSPERO/. Accessed: 5 May 2021.
34. Slim K, Nini E, Forestier D *et al.* Methodological index for non-randomized studies (minors): development and validation of a new instrument. *ANZ J Surg* 2003; **73**: 712–6.
35. Philippon MJ, Weiss DR, Kuppersmith DA *et al.* Arthroscopic labral repair and treatment of femoroacetabular impingement in professional hockey players. *Am J Sports Med* 2010; **38**: 99–104.
36. Lewis CL, Sahrmann SA, Moran DW. anterior hip joint force increases with hip extension, decreased gluteal force, or decreased iliopsoas force. *J Biomech* 2007; **40**: 3725–31.
37. Heyworth BE, Shindle MK, Voos JE *et al.* Radiologic and intraoperative findings in revision hip arthroscopy. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2007; **23**: 1295–302.
38. Cvetanovich GL, Harris JD, Erickson BJ *et al.* Revision hip arthroscopy: a systematic review of diagnoses, operative findings, and outcomes. *Arthrosc J Arthrosc Relat Surg* 2015; **31**: 1382–90.
39. Sardana V, Philippon MJ, Bedi A *et al.* Revision hip arthroscopy indications and outcomes: a systematic review. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2015; **31**: 2047–55.
40. Edelstein J, Ranawat A, Enseki KR *et al.* Post-operative guidelines following hip arthroscopy. *Curr Rev Musculoskelet Med* 2012; **5**: 15–23.
41. Enseki KR, Kohlrieser D. Rehabilitation following hip arthroscopy: an evolving process. *Int J Sports Phys Ther* 2014; **9**: 765–73.
42. Chahla J, Mikula JD, Schon JM *et al.* Hip capsular closure: a biomechanical analysis of failure torque. *Am J Sports Med* 2017; **45**: 434–9.
43. Wahoff M, Ryan M. Rehabilitation after hip femoroacetabular impingement arthroscopy. *Clin Sports Med* 2011; **30**: 463–82.
44. Voight ML, Robinson K, Gill L *et al.* Postoperative rehabilitation guidelines for hip arthroscopy in an active population. *Sports Health* 2010; **2**: 222–30.
45. Garrison JC, Osler MT, Singleton SB. Rehabilitation after arthroscopy of an acetabular labral tear. *N Am J Sports Phys Ther NAJSPT* 2007; **2**: 241–50.
46. Stalzer S, Wahoff M, Scanlan M. Rehabilitation following hip arthroscopy. *Clin Sports Med* 2006; **25**: 337–57.
47. Wilson KW, Kannan AS, Kopacko M *et al.* Rehabilitation and return to sport after hip arthroscopy. *Oper Tech Orthop* 2019; **29**: 100739.

48. Malloy P, Gray K, Wolff AB. Rehabilitation after hip arthroscopy: a movement control-based perspective. *Clin Sports Med* 2016; **35**: 503–21.
49. Polascik BA, Peck J, Cepeda N *et al.* Reporting clinical significance in hip arthroscopy: where are we now? *HSS J* 2020; **16**: 527–33.
50. Lindman I, Nikou S, Öhlin A *et al.* Evaluation of outcome reporting trends for femoroacetabular impingement syndrome- a systematic review. *J Exp Orthop* 2021; **8**: 33.
51. Padua R, de Girolamo L, Grassi A *et al.* Choosing patient-reported outcome measures for shoulder pathology. *EFORT Open Rev* 2021; **6**: 779–87.
52. Kowalczuk M, Bhandari M, Farrokhyar F *et al.* Complications following hip arthroscopy: a systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc Off J ESSKA* 2013; **21**: 1669–75.
53. Ruzbarsky JJ, Soares R, Johannsen A *et al.* Survivorship following hip arthroscopy: lessons learned from a comprehensive database. *Curr Rev Musculoskelet Med* 2020; **13**: 220–32.
54. Philippon MJ, Ejnisman L, Ellis HB *et al.* Outcomes 2 to 5 years following hip arthroscopy for femoroacetabular impingement in the patient aged 11 to 16 years. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2012; **28**: 1255–61.
55. Byrd JWT, Jones KS, Gwathmey FW. Arthroscopic management of femoroacetabular impingement in adolescents. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc* 2016; **32**: 1800–6.
56. Cvetanovich GL, Weber AE, Kuhns BD *et al.* Clinically meaningful improvements after hip arthroscopy for femoroacetabular impingement in adolescent and young adult patients regardless of gender. *J Pediatr Orthop* 2018; **38**: 465–70.