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Research article

Conservative management acutely improves functional movement and clinical outcomes in patients with pre-arthritic hip pain

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ABSTRACT

Conservative management for individuals with pre-arthritic hip pain is commonly prescribed prior to consideration of surgical management. The purpose of this study is to determine if patients with pre-arthritic hip pain will improve their functional movement control and clinical outcome measures following the implementation of physical therapy and a home-exercise programme. Information was retrospectively collected on consecutive patients and included: demographics, diagnosis, initial and follow-up evaluation of the single leg squat test (SLST) and step-down test (SDT), and patient-reported outcome measures. An independent *t*-test and one-way analysis of covariance were performed for continuous patient-reported outcome measures and a Fisher's exact test was performed for patient satisfaction. Forty-six patients (31 female and 15 male) diagnosed with pre-arthritic hip pain were included. A total of 30 patients improved their functional movement control during performance of the SLST, whereas 31 patients improved performance of the SDT. There was a statistically significant difference between patients that improved and did not improve ($P \leq 0.017$). Patients with pre-arthritic hip pain who improved their functional movement control following a prescribed rehabilitation intervention are likely to report less pain and greater functional ability in their daily and sports-related activities. This study supports conservative management to acutely improve outcomes for patients with pre-arthritic hip pain.

INTRODUCTION

Pre-arthritic hip pain is defined as pathologies associated with the intra-articular structures of the hip joint in the absence of severe degenerative joint disease and includes femoroacetabular impingement (FAI), dysplasia, structural instability, acetabular labral tears, chondral lesions and ligamentum teres tears.[1–3] Abnormal hip motion and muscle function have been shown in patients with pre-arthritic hip pathologies.[1,3,4] Hip arthroscopy is commonly used to treat these conditions with positive outcomes[5,6]; however, it is unknown whether improvements in hip motion and muscle function can lead to positive outcomes following a trial of conservative management.

On examination patients with FAI and chondrolabral pathology commonly present with decreased hip flexion, adduction, abduction and internal rotation ROM and decreased strength with hip flexion, abduction, adduction and external rotation, as well as altered balance and proprioception.[7–11] These neuromuscular deficits can result in impaired functional control of the hip, pelvis and lumbosacral spine.[9,10,12,13] Physical performance during dynamic movements can be defined as an individual's 'functional movement control'.

Conservative management addresses deficits in functional movement control through strength and stabilization exercises of the hip and lumbopelvic musculature that may contribute to the subjects symptoms.[14] Structural deformities combined with impaired functional movement control may ultimately lead to chondrolabral injury that result in functional limitations during daily and sports-related activities.[8,13]

Pre-arthritic hip pain is diagnosed from a combination of diagnostic imaging (i.e. X-ray, magnetic resonance imaging, magnetic resonance arthrogram) and a comprehensive clinical examination.[1,2,15] Patient-reported outcome measures (PROs) and functional performance testing are commonly included in a comprehensive clinical examination.[1,15] Functional performance tests combine the assessment of range of motion, strength and proprioception to evaluate functional movement patterns that are associated with more complex activities.[16,17] These tests are used to identify neuromuscular deficiencies that limit functional movement control during dynamic activity.[16] Two frequently performed lower extremity functional performance tests are the single leg squat test (SLST) and step-down test (SDT).[18,19] The SLST and SDT account for several deviations in hip, pelvis and trunk performance that are considered important when assessing individuals for neuromuscular deficiencies associated with pre-arthritic hip pain.[9,20] While clinicians commonly utilize these tests in the evaluation of subjects with lower extremity pathologies, the SLST and SDT have only recently been shown to be reliable and valid in evaluating subjects with pre-arthritic hip pain.[21,22]

Prior to consideration of surgical intervention, a trial of conservative management is commonly recommended to address neuromuscular deficiencies in the surrounding hip musculature.[1,8,13] These management strategies are prescribed to try and improve strength and dynamic stabilization of the hip and lumbopelvic musculature that may contribute to the patients symptoms.[14] Structural deformities combined with impaired functional movement control may ultimately lead to chondrolabral injury that result in functional limitations during daily and sports-related activities.[8,13] It is unknown whether improvements in hip motion and muscle function can occur with a conservative treatment and produce positive outcomes in patients diagnosed with pre-arthritic hip pain. The purpose of this study is to determine if patients with pre-arthritic hip pain will improve their functional movement control and clinical outcome measures following the implementation of physical therapy and a home-exercise programme. The hypothesis of this study is that patients that improve their functional movement control during performance of the SLST and SDT will have better clinical outcomes than those that do not improve.

MATERIALS AND METHODS

Subjects

Patients were clinically diagnosed and conservatively treated by the secondary investigator (JJC) for pre-arthritic hip pain from chondrolabral lesions caused by FAI, dysplasia and/or structural abnormalities. To be included in the current study patients must have had evaluations for both the initial and follow-up test performance of the SLST and SDT, along with completion of at least 4 weeks of physical therapy and a standardized home-exercise programme between evaluations. Since this was a retrospective study, subjects were consecutive patients that had follow-up assessment of the SLST and SDT at a 4-week or longer-time interval. Patients who did not have a follow-up evaluation of the SLST and SDT were not included in the current study. All patients and parents/guardians (when applicable) approved and signed the written informed consent and authorization to disclose protected health information established under the Allegheny Singer Research Institute-Institutional Review Board.

Functional testing and home-exercise programme

The standardized protocols for administering both the SLST and SDT for patients with pre-arthritic hip pain were established from previously published studies.[21,22] Three trials of the SLST and SDT for the affected extremity were evaluated for six criteria including: (i) overall impression of the trials (including balance and evaluation of the arm strategy), (ii) posture or movement of the trunk, (iii) posture or movement of the pelvis, (iv) hip joint movement and posture, (v) knee joint movement and posture and (vi) depth of squat.[23–26] Each repetition was graded as 'positive for deviation' with a 1 or 'negative for deviation' with a 0, for all six criteria. Repetitions were given a total score of 0–6, with 0 being 'negative for any deviation' and 6 being 'positive for all deviations'. The lowest score of the three repetitions was taken for both the initial and follow-up evaluation of the SLST and SDT. Improvement (yes/no) was assessed as any decrease in total score from the initial to follow-up evaluation.

All patients performed a rehabilitation intervention focused on patient education, activity modification, limitation of aggravating factors, an individualized physical therapy programme and a home-exercise programme. Supervised physical therapy was provided by the rehabilitation specialist of the patients choosing 1 day a week. The home-exercise programme distributed to the patients was from a previously performed literature review.[14] Participants completed four exercises of the home-exercise programme on the week-days when they were not participating in the individualized physical therapy intervention. The patients were instructed to cycle through the 12-total exercises during the week, while not repeating an individual exercise on back-to-back days.

Procedure

All data in the current study were retrospectively collected from a secure cloud-based software storage program and was previously prospectively collected as part of the routine clinical care for patients with pre-arthritic hip pain. The research data for the current study were de-identified so that patients could not be identified, directly or through identifiers linked to the patients. Demographic information was collected from the initial evaluation and included: age, gender, height, weight, body mass index (BMI), side of involved hip, duration of symptoms (DOS) and intra-articular diagnosis. The following PROs were collected for each patient at the initial and follow-up clinical evaluation: visual analogue scale score for pain (VAS; 0–10); hip outcome score (HOS) for limitations in activities of daily living (HOS-ADL; 0–100) and sports-related activities (HOS-SRA; 0–100); per cent global rating for activities of daily living (%—ADL; 0–100); and per cent global rating for sports-related activities (%—SRA; 0–100). Patient satisfaction (yes/no) was collected from the follow-up clinical evaluation.

Statistical analysis

A one-tail, independent *t*-test and a one-way analysis of covariance (ANCOVA) were performed for each continuous PROs score (VAS, HOS-ADL, HOS-SRA, %—ADL, %—SRA). The *t*-tests determined whether the mean change in PROs was significantly different between patients that improved and those that did not improve their functional movement control during performance of the SLST and SDT. The ANCOVA determined whether the post-rehabilitation intervention PROs were significantly different between patients that improved and those that did not improve. A Fisher's exact test was performed for patient satisfaction to determine whether a significant relationship was present between the PROs and patients that improved and those that did not improve. All statistical analysis was performed with a *a priori* alpha set of $P < 0.05$. All data were analysed using a common statistical software program (IBM SPSS Statistics, Version 23, Armonk, NY, USA).

Power analysis

To determine the sample size needed for this study, a power analysis (G*Power 3.1.9.2, Universität Dusseldorf, Dusseldorf, Germany) was performed based on a one-tail *t*-test with the difference between two independent means. The estimated effect size (Cohen's *d*) of 0.80 was based on Cohen's[27] reporting of a large effect size for an independent *t*-test calculation. The determination to estimate a large effect size was founded from Martin and Philippon's[28] evaluation of responsiveness for the HOS-SRA. Their study reported a large effect size (Cohen's $d = 1.5$) for the difference between a 'change' group and 'stable' group, 7 months after hip arthroscopy for individuals with pre-arthritic hip pain.[28] A large effect size was also shown for differences in the HOS-SRA score between patients with pre-arthritic hip pain that were graded as 'passing' or 'failing' during performance of both the SLST and SDT.[21] The difference in HOS-SRA scores of individuals that 'passed' and 'failed' for the SLST and SDT demonstrated large effect sizes of Cohen's $d = 1.13$ and Cohen's $d = 1.41$, respectively. Also included in this power analysis calculation was an alpha error probability = 0.05, power value = 0.80 and an allocation ratio (N2/N1) = 1, to produce a sample size of at least 42.

RESULTS

Subjects

Forty-six patients consecutively diagnosed and referred for conservative management were retrospectively included in this study. This population included 31 female and 15 male patients with a mean age of 30 ± 12 years (mean ± SD), height of 170.7 ± 9.2 cm, weight of 74.3 ± 14.7 kg and BMI of 25.5 ± 4.2. These physically active patients reported an average of 10 ± 10 months for DOS relating to their pre-arthritic hip pain prior to the initial clinical evaluation. They were evaluated and diagnosed with one or more of the following pathologies: 46 with acetabular labral tears (100%), 21 with FAI (46%, 18 cam and 3 pincer deformities), 13 with structural instability (28%), 9 with chondral deformities (20%), 8 with dysplasia (17%) and 2 (4%) with ligamentous teres pathology. Following the completion of physical therapy and a home-exercise programme, patients were evaluated at an average of 8 ± 3 weeks from their initial consultation.

A total of 30 patients improved and 16 did not improve their functional movement control during performance of the SLST, while 31 improved and 15 did not improve performance of the SDT. The average age, height, weight, BMI and DOS for those that improved and did not improve their functional movement control for both the SLST and SDT are reported in Table I. The ratios for gender and the involved extremity for each group are also reported in Table I. There was no statistical difference between patients that improved and those that did not improve their functional movement control during

Table I. Mean and standard deviations for age, height, weight, BMI, DOS and the ratios of gender and the involved extremity

	SLST Mean ± SD		*SDT Mean ± SD*		*Total Mean ± SD*
	Improved	*Did not improve*	*Improved*	*Did not improve*	
Age	30 ± 12.2	29 ± 12.0	29 ± 11.9	32 ± 12.3	30 ± 12
Height (cm)	171.4 ± 8.5	169.3 ± 10.4	171.6 ± 9.1	168.7 ± 9.3	170.7 ± 9.2
Weight (kg)	75.9 ± 15.7	71.4 ± 12.4	74.3 ± 15.5	74.6 ± 13.4	74.3 ± 14.7
BMI	25.8 ± 4.7	24.9 ± 3.2	25.1 ± 4.2	26.3 ± 4.5	25.5 ± 4.2
DOS (months)	7.5 ± 8.3	13.2 ± 12.0	7.9 ± 8.8	12.7 ± 11.8	10 ± 10
Gender (female:male)	20:10	11:5	20:11	11:4	31:15
Extremity (right:left)	16:14	8:8	14:17	10:5	24:22

BMI, body mass index; DOS, duration of symptoms; SLST, single leg squat test; SDT, step-down test; SD, standard deviation.

performance of the SLST and SDT for age (SLST $P = 0.676$; SDT $P = 0.419$), height (SLST $P = 0.472$; SDT $P = 0.313$), weight (SLST $P = 0.336$; SDT $P = 0.942$), BMI (SLST $P = 0.485$; SDT $P = 0.390$) and DOS (SLST $P = 0.064$; SDT $P = 0.124$). The mean change for the continuous PROs of those that improved and did not improve is presented in Table II, while the 2 × 2 contingency table for patient satisfaction is provided in Table III. The decision for surgical intervention for those that improved and did not improve is provided in Table IV.

Statistical results

A one-tail, independent *t*-test was performed to explore the effect of the physical therapy and home-exercise programme on the mean change for each continuous PROs. There was a statistically significant difference ($P \leq 0.022$) between individuals that improved and those that did not improve their functional movement control with results presented in Table V. An ANCOVA was performed to explore the effect of the physical therapy and home-exercise programme on the post-rehabilitation continuous PROs score. There was a statistically significant difference ($P \leq 0.012$) between patients that improved and those that did not improve with the results presented in Table VI. A Fisher's exact test was performed to explore the effect of the physical therapy and home-exercise programme on the relationship between patient satisfaction and those patients that improved and did not improve. There was a statistically significant relationship ($P < 0.001$) between those patients that improved and those that did not improve with the results presented in Table VII.

DISCUSSION

The main finding from the current study was that the majority of patients referred for conservative management of pre-arthritic hip pain were able to improve their functional movement control over an average 8-week timeframe. Prior to the current study, it was unclear if patients with pre-arthritic hip pain could improve their functional movement control, and if they did, would it improve their patient-reported clinical outcomes. In confirming the hypothesis, the current study demonstrates the potential benefit of physical therapy and a home-exercise programme to acutely improve patient clinical outcome measures. If subjects improved their functional movement control, they were likely to report less pain and greater functional ability in their daily and sports-related activities following physical therapy and a home-exercise programme. In addition, a significant number of patients who improved their functional movement control had greater satisfaction with the prescribed rehabilitation intervention, than those that did not improve.

All patients were initially evaluated with a mean score of 4.5 ± 0.9 (mean ± SD) and 5.3 ± 0.9 positive deviations for the SLST and SDT, respectively. Patients that improved their functional movement control demonstrated a mean of 3.0 ± 1.0 and 3.6 ± 1.3 positive deviations, while those that did not improve demonstrated a mean of 4.6 ± 1.0 and 5.3 ± 1.0 positive deviations during

Table II. Mean change of continuous PROs from initial to follow-up evaluation

	SLST		*SDT*	
	Mean ± SD		*Mean ± SD*	
	Improved	*Did not improve*	*Improved*	*Did not improve*
VAS	−1.9 ± 2.4	−0.2 ± 1.7	−1.9 ± 2.3	−0.1 ± 1.6
HOS-ADL	9.7 ± 14.8	−1.4 ± 7.7	9.2 ± 14.4	−1.0 ± 9.5
HOS-SRA	15.9 ± 21.7	−2.4 ± 16.5	14.9 ± 21.6	−1.6 ± 18.0
%—ADL	14.2 ± 27.8	−9.5 ± 17.4	13.2 ± 24.7	−9.0 ± 26.0
%—SRA	22.0 ± 34.4	3.1 ± 14.7	19.6 ± 33.8	6.9 ± 20.0

PROs, patient-reported outcome measures; SLST, single leg squat test; SDT, step-down test; VAS, visual analogue scale for pain; HOS-ADL, hip outcome score for activities of daily living; HOS-SRA, hip outcome score for sports-related activities; %—ADL, per cent global rating for activities of daily living; %—SRA, per cent global rating for sports-related activities.

Table III. Patient satisfaction with the rehabilitation intervention and standardized home-exercise programme

	SLST		*SDT*	
Patient satisfaction	*Improved*	*Did not improve*	*Improved*	*Did not improve*
Yes	28	3	27	4
No	2	13	4	11

SLST, single leg squat test; SDT, step-down test.

Table IV. Surgical decision following the rehabilitation intervention and home-exercise programme

	SLST		*SDT*	
Surgery	*Improved*	*Did not improve*	*Improved*	*Did not improve*
Yes	7	12	8	11
No	23	4	23	4

SLST, single leg squat test; SDT, step-down test.

performance of the SLST and SDT, respectively. Those patients that improved their functional movement control demonstrated a mean improvement of nearly two deviations for both the SLST and SDT, while those that did not improve demonstrated the same number of positive deviations and in some cases an increase in deviations.

Most PROs utilized in the assessment of non-arthritic hip pain do not assess for a patients reported pain level.[29]

Table V. Summary table for one-tail independent t-tests for mean change in continuous PROs

	SLST *t-value (P-value)*	*SDT* *t-value (P-value)*
VAS	−2.587 (0.007)*	−2.583 (0.007)*
HOS-ADL	2.780 (0.004)*	2.459 (0.009)*
HOS-SRA	2.955 (0.003)*	2.553 (0.007)*
%—ADL	3.100 (0.002)*	2.811 (0.004)*
%—SRA	2.088 (0.022)*	1.338 (0.094)

PROs, patient-reported outcome measures; SLST, single leg squat test; SDT, step-down test; VAS, visual analog scale for pain; HOS-ADL, hip outcome score for activities of daily living; HOS-SRA, hip outcome score for sports-related activities; %—ADL, per cent global rating for activities of daily living; %—SRA, per cent global rating for sports-related activities.
*Significant at $P < 0.05$.

The VAS is commonly used to assess pain in the orthopaedic settings, including hip arthroscopy. A recent study demonstrated a minimal clinically important difference value of −1.5 between patients that self-rated as 'normal' and those as 'abnormal' for VAS pain score 1-year post-hip arthroscopy.[30] The current study demonstrated a mean decrease in reported pain levels of -1.9 ± 2.4 and -1.9 ± 2.3 for patients that improved their functional movement control during performance of the SLST and SDT, respectively. This improvement was significantly greater than the -0.2 ± 1.7 and -0.1 ± 1.6 decrease in reported pain levels for those that did not improve their functional movement control during performance of the SLST and SDT, respectively. Patients that improved their

Table VI. Summary table for one-way ANCOVA for post-rehabilitation continuous PROs

	SLST F-*value* (P-*value*)	*SDT* F-*value* (P-*value*)
VAS	11.879 (0.001)*	9.997 (0.003)*
HOS-ADL	9.558 (0.003)*	6.966 (0.012)*
HOS-SRA	10.668 (0.002)*	7.273 (0.010)*
%—ADL	19.158 (0.000)*	13.741 (0.001)*
%—SRA	10.643 (0.002)*	6.206 (0.017)*

PROs, patient-reported outcome measures; SLST, single leg squat test; SDT, step-down test; VAS, visual analog scale for pain; HOS-ADL, hip outcome score for activities of daily living; HOS-SRA, hip outcome score for sports-related activities; %—ADL, per cent global rating for activities of daily living; %—SRA, per cent global rating for sports-related activities.

*Significant at $P < 0.05$.

Table VII. Summary table for Fisher's exact test for patient satisfaction

	SLST P-*value*	*SDT* P-*value*
Patient Satisfaction (Yes or No)	<0.001*	<0.001*

PROs, patient-reported outcome measures; SLST, single leg squat test; SDT, step-down test.

*Significant at $P < 0.05$.

functional movement control not only reported statistically less pain, but also a clinically meaningful decrease in pain than those that did not improve.

The HOS is a commonly used self-reported outcome measurement that accounts for limitations in activities of daily living and sports-related activities and has shown evidence of reliability, validity and responsiveness for those with FAI and labral pathologies.[28,31–33] The current study demonstrated a clinically meaningful change of 9.7 ± 14.8 and 9.2 ± 14.4 on the HOS-ADL for those subjects that improved their functional movement control for the SLST and SDT, respectively.[27,28] In comparison, those patients that did not improve their functional movement control for the SLST and SDT reported a mean change of -1.4 ± 7.7 and -1.0 ± 9.5 on the HOS-ADL, respectively. A clinically meaningful change of 15.9 ± 21.7 and 14.9 ± 21.6 was also shown on the HOS-SRA for those patients that improved their functional movement control for the SLST and SDT, respectively.[27,28] In comparison, those patients that did not improve their functional movement control for the SLST and SDT reported a mean change of -2.4 ± 16.5 and -1.6 ± 18.0 on the HOS-SRA, respectively. Patients who improved their functional movement control not only reported statistically significant improvements in their activities of daily living and sports-related activities, but also demonstrated a clinically meaningful increase in function compared to those that did not improve.

Patient satisfaction should be included in all clinical evaluations, particularly with the recent emphasis on reporting patients perspectives on improvements in their overall quality of life.[34,35] During the follow-up evaluation and prior to the assessment of performance for the SLST and SDT, each patient was asked, 'Are you satisfied with the rehabilitation intervention and home-exercise program that we have provided?' Patients were asked to answer with a response of 'yes' or 'no'. A significant number of patients that improved their functional movement control for the SLST (93%, 28/30) and SDT (87%, 27/31) responded that they were satisfied with the prescribed rehabilitation intervention and home-exercise programme, while a significant number of those that did not improve for the SLST (81%, 13/16) and SDT (73%, 11/15) reported that they were not satisfied. It should be noted that 19% (3/16) and 27% (4/15) of patients who did not improve their functional performance during the SLST and SDT were still satisfied with the prescribed intervention, respectively. In these cases, it may be that the patients were satisfied with their treatment, even though they did not improve their functional movement control.

There are limitations to the current study that need to be considered when interpreting the results. Although data collection was prospective, data review was retrospective and introduces potential investigator bias. Caution should be exercised when generalizing the results of the current study to patients with other lower extremity and hip-specific disorders, including those with osteoarthritic changes. The conclusions of the current study should only be applied to patients with diagnosed pre-arthritic hip pain from chondrolabral lesions caused by FAI, dysplasia and/or structural abnormalities. These subjects were diagnosed and conservatively treated for these pathologies by a board-certified orthopaedic surgeon with a specialty in arthroscopic hip preservation surgery. While several subjects in the current study demonstrated extra-articular conditions associated with the lower extremity and surrounding hip structures, their primary diagnosis was attributed to intra-articular conditions of the hip. Therefore, the results should not be generalized to all painful conditions of the hip and lower extremity. The methodology utilized in the current study may not be the only viable options for administration of the SLST and SDT during assessment of subjects with non-arthritic hip pain. Different techniques for test performance as well as differing landmarks for the visual evaluation criteria could be utilized with effectiveness. Other functional performance tests may also be beneficial in the evaluation of patients diagnosed with non-arthritic hip pain associated with intra-articular conditions of the hip. Similarly, the prescribed rehabilitation intervention may not be the only option for conservative management of subjects with pre-arthritic hip pain. Compliance for the rehabilitation intervention was self-reported by each patient and should be considered a limitation of this study. It should also be noted that each patient received a different rehabilitation intervention and therefore some individuals could have received a better rehabilitation protocol than others, depending on the specific physical therapist and/or athletic trainer. The addition of the SLST and SDT to the comprehensive clinical evaluation of non-arthritic pain could be utilized, with the goal of identifying functional limitations present that might predispose an individual to choosing surgical intervention or a return to normal activities. However, there was no follow-up on these subjects who chose not to undergo surgery. Therefore, although subjects chose not to undergo surgery at the follow-up evaluation, they may have chosen surgical intervention later if their symptoms returned. Long-term follow-up studies regarding the effectiveness of conservative management with physical therapy is needed. Future research is needed to understand the long-term effects of improving functional movement control on pain and function during daily and sports-related activities for subjects diagnosed with pre-arthritic hip pain.

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CONFLICT OF INTEREST STATEMENT

The authors report the following potential conflicts of interest or sources of funding: JJC is a board member of the International Society for Hip Arthroscopy, is a paid consultant for Arthrex, and has patents with and recieves royalties from Arthrex and Breg.

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