Movement Pattern Training in People with Intra-articular, Prearthritic Hip Disorders

NCT02913222

9-29-2016

RESEARCH STRATEGY

A. Significance: Effective treatment of PAHD needed to improve function and prevent or delay hip OA

Intra-articular, prearthritic hip disorders (PAHD) present as hip joint pain and loss of joint function with no radiographic evidence of osteoarthritis.[18, 48] Associated diagnoses include femoroacetabular impingement, hip dysplasia, labral tears and chondral lesions. PAHD result in substantial hip dysfunction in young adults leading to significant limitations in walking, sitting and standing,[10, 11, 44] thus restricting their ability to work or complete everyday tasks. Without proper management, PAHD may progress to hip osteoarthritis (OA),[3, 24, 38, 49] a leading cause of reduced quality of life and loss of function for older people.

Current evidence in the treatment of PAHD is limited.[2, 4, 41, 53] The preponderance of literature is related to surgical interventions and is primarily observational. There are no published clinical trials to compare surgical to nonsurgical treatment outcomes. Despite this evidence gap, the number of surgical procedures to treat PAHD has grown exponentially[9, 39] before clinical trials have established the superiority of surgery over other treatment options. Rehabilitation provides a relatively inexpensive alternative to surgery, yet controversy exists regarding its effectiveness. Some authors believe rehabilitation can improve function in people with PAHD,[13, 33] however others state that surgery is the best option.[28, 30] This controversy may contribute to continued growth in the number of surgeries performed, with the potential for surgery to become standard treatment prior to rigorous investigation of treatment options. Our long term goal is to develop effective treatment strategies, surgical and nonsurgical, for people with PAHD that will improve function and prevent or delay the onset of OA.

Rehabilitation targeted at modifying abnormal movement patterns may lead to improved function and reduced pain in people with PAHD. Abnormal movement patterns, such as excessive hip adduction (Fig. 1), may create altered mechanical stresses on the hip joint structures, resulting in subsequent injury. Kumar et al[36] recently reported that excessive hip adduction motion during functional testing may be associated with articular cartilage damage in the hip joint. In our previous work investigating PAHD, we noted that increased hip adduction during a single leg squat was associated with lower patient-reported function. *(See Preliminary studies)*. Given these novel findings, rehabilitation to optimize lower extremity movement patterns during functional tasks would be an appropriate approach for people with PAHD.

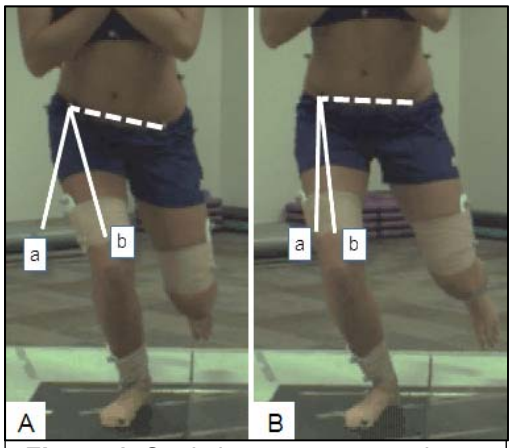


Figure 1. Static images representing hip motion during single leg squat. Hip adduction is represented as the angle between line (a) drawn perpendicular to the pelvis (dashed line) and line (b) bisecting the thigh. **A.** Abnormal movement pattern demonstrating excessive hip adduction **B.** Reduced hip adduction after MPT.

Movement pattern training (MPT) is an innovative rehabilitation approach with the goal to reduce stresses on the hip joint by optimizing the biomechanics of functional tasks. The key element of MPT is *task-specific instruction* to correct abnormal movement patterns during daily and fitness activities. In our previous study, we assessed the feasibility of using MPT in addition to hip strengthening for the treatment of PAHD.[21] **After participating in treatment, people with PAHD were able to reduce hip adduction during functional tasks**[21] **and this reduction was associated with improved patient-reported function *(See Preliminary studies)***. Surprisingly, hip muscle strength did not improve after treatment, nor was strength associated with functional improvement or hip adduction reduction, raising questions about the relationship among hip strength, hip-specific function and lower extremity movement patterns in people with PAHD. Although no studies have reported the use of MPT in patients with PAHD, similar approaches have been used in low back pain,[27, 32, 50, 52] anterior cruciate ligament tear prevention,[29, 47] and patellofemoral pain.[43] If determined to be effective in the rehabilitation of PAHD, MPT may also serve a role in injury prevention and post-surgical rehabilitation. Additionally, we believe MPT can be feasibly implemented into community practice with minimal training and equipment. We have successfully implemented MPT in our current clinical practice.

B. Innovation: Novel treatment using movement pattern training to improve function

The novel theoretical concept of the proposed study is that a person's movement pattern may contribute to the development and persistence of pain related to PAHD. The Physical Stress Theory[40] states that repetitive or prolonged stresses may result in tissue injury if the tissue's capacity to accept stress is exceeded. The Movement System Impairment Theory[46] builds upon the Physical Stress Theory by stating that

mechanical hip pain is the consequence of repeated use of *abnormal movement patterns* during daily activities. Abnormal movement patterns may create altered mechanical forces on joint structures, thus changing the location and magnitude of stress to specific joint tissues, such as the articular cartilage and acetabular labrum.[46] Repeated loading of hip joint with altered mechanical forces may contribute to cumulative tissue stress, micro-trauma, pain and potentially osteoarthritis.[15] Until the abnormal movement pattern is modified, the hip pain may persist or recur. We have reported extensively on the Movement System Impairment Theory in people with low back pain.[26, 27, 31, 32, 50, 51]

We will assess the effect of MPT on correcting abnormal movement patterns, reducing pain and improving function in people with PAHD. This *approach is innovative* by focusing treatment on modifying abnormal movement patterns that may contribute to altered stresses on the hip joint structures, instead of the traditional approach of focusing rehabilitation on isolated physical impairments, such as muscle weakness[14] and limited joint flexibility.[13, 14] Impairment-based treatment may improve the body's overall capacity, however may not improve hip biomechanics. For example, lower extremity strengthening exercises may increase the muscle's force production capability, however this increased force production capability may not result in improved quality of movement during daily tasks. In this proposal, we will perform a multicenter, feasibility RCT to compare the efficacy of our novel treatment strategy, MPT, to standard, impairment-based rehabilitation.

C. Approach

Overview of the team and the approach

In the future trial, we will need large, generalizable samples that would be difficult, if not impossible, to recruit at one site. Therefore two sites, Washington University and University of Pittsburgh, will participate in the feasibility RCT. Drs. Harris-Hayes and Fitzgerald will serve as principal investigators (PI). The Steering Committee will include the PIs and Drs Clohisy and Schechtman (*See Project Leadership Plan).*

Washington University, Study Coordinating Center: The Study Coordinating Center (Harris-Hayes, Director) will oversee personnel training, protocol implementation, data collection and follow-up. Dr. Harris-Hayes is an orthopedic physical therapist with a Master's of Science in Clinical Investigation. As part of her training (K23HD067343), she successfully completed an exploratory trial to assess the feasibility of MPT in the treatment of PAHD. Washington University provides substantial infrastructure to support this project (*See Facilities and Other Resources*). Our multidisciplinary hip group (*See letters Clohisy, Nepple, Prather, Hunt*) has substantial expertise in PAHD and experience in participant recruitment for clinical research. The Data Coordinating Center (Schechtman, director) will administer the study, perform scientific oversight, ensure quality control and perform data analysis.

University of Pittsburgh: The Physical Therapy – Clinical and Translational Research Center (PT-CTRC) (Fitzgerald, Director) will oversee study implementation at the University of Pittsburg site. Dr. Fitzgerald will also guide Dr. Harris-Hayes in developing and implementing methods to optimize treatment fidelity among treatment providers. Methods he has used successfully in his previous RCTs will be used in the proposed study. Dr. Fitzgerald is an experienced investigator and recognized expert in OA,[16] who has conducted multiple RCTs examining the effectiveness of rehabilitation related to lower extremity disorders.[1, 17, 45] The PT-CTRC provides significant infrastructure to perform multicenter clinical trials including access to potential participants, facilities, equipment and support for new investigators (*See Facilities and Other Resources*).

Timeline: We have developed a Manual of Procedures to facilitate consistency in participant recruitment, protocol implementation and data collection across sites. We are developing training modules to optimize the treatment providers' adherence to study protocol. The study planning phase will include a pretrial meeting of the Steering Committee and onsite training of study personnel. Methods for the proposed study, described below, were optimized in the previous study, therefore we will initiate participant recruitment within one month of study start. Recruitment will proceed for 17 months (months 2-18) with the last follow-up being completed by month 21. The last 3 months will be used for data analysis and study close-out.

Preliminary studies supporting the approach

Aim 1: Participant adherence: Based on the previous study (K23), we are confident we will meet recruitment and retention goals of the project. In the study, we randomized 35 people with PAHD into an immediate treatment group (n=18) or a wait-list control group (n=17). The treatment group participated in 6 sessions of MPT. Overall retention rate was 91%; 2 in the treatment group and 1 in the wait-list group did not return after baseline testing. Treatment adherence was high; 15 of 16 who participated in treatment attended all supervised sessions and 1 attended 5 of 6 sessions. Additionally, 89% of those in the treatment group reported

completing their home program at least once per day. Using methods optimized in the previous study, we anticipate similar adherence in the proposed study.

Aim 2: Post-treatment improvement in outcomes: In our previous study (K23), we used patient-reported outcomes and 3D motion analysis to assess post-treatment improvement in function and lower extremity movement patterns respectively. We noted, with baseline assessment, that increased hip adduction motion during a single leg squat, may be associated with lower patient-reported function, quantified using the modified Harris Hip Score (r = -0.28, *P* = 0.08) (*unpublished data)*. Compared to wait-list control, those who participated in MPT demonstrated improved post-treatment function[21] (Fig. 2) that was associated with a reduction in hip adduction (r = -0.60, p=0.001) (Fig. 3). Additional preliminary data suggests these post-treatment improvements in function are maintained up to 12 months after treatment.[20] These preliminary results suggest that MPT may be an effective treatment approach for people with PAHD, however comparison to standard rehabilitation is needed.

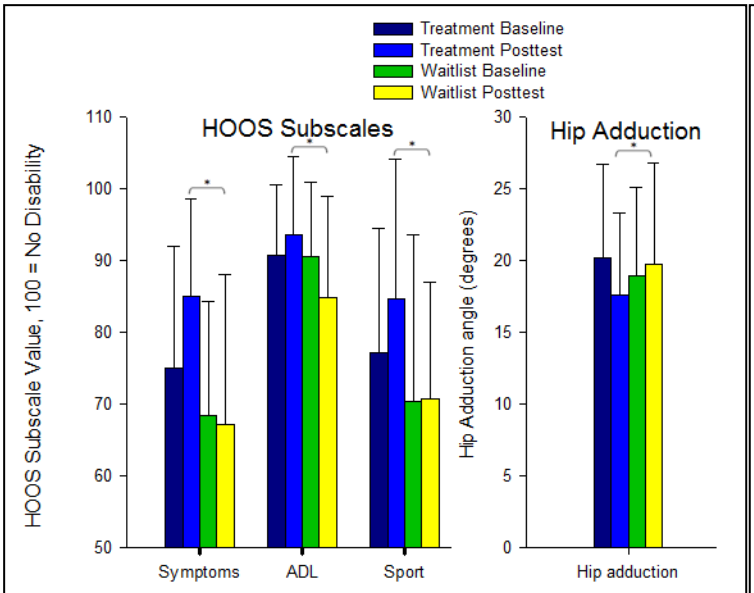


Figure 2. Treatment outcomes at baseline and post-treatment comparing those who received movement pattern training compared to those randomized to a waitlist. *p<0.05.

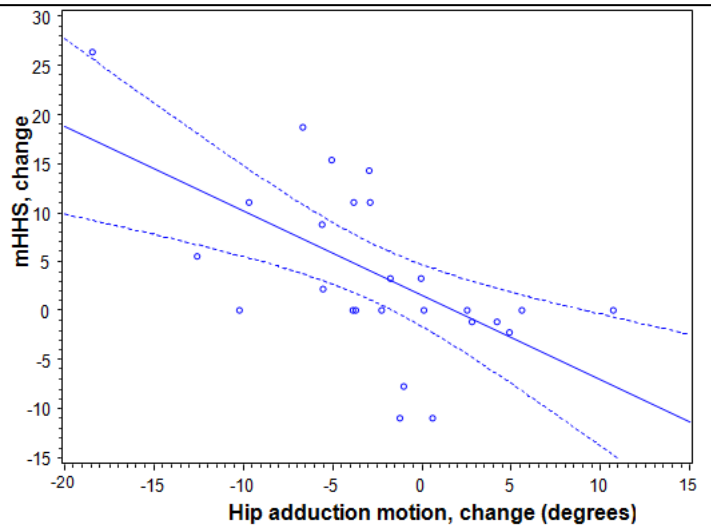


Figure 3. Association between change in function (modified Harris Hip Score (mHHS)) and change in hip adduction motion (r = -0.60, p=0.001). Improved function was associated with a reduction in hip adduction motion. Plot represents the linear regression (solid line) with 95% CI (dashed lines).

Experimental approach

Participant Recruitment: 46 participants will be enrolled. To be enrolled, participants must 1) be 15-40 years old, 2) report deep hip joint or anterior groin pain, confirmed upon physical exam, 3) report pain ≥ 3/10 and present ≥ 3 months and 4) demonstrate functional limitation with modified Harris Hip Score <90. Exclusion criteria include 1) previous hip surgery, fracture, pelvic/hip infection, or pain due to high impact trauma, 2) inflammatory disease, e.g. rheumatoid arthritis, gout and 3) neurological involvement affecting balance.

General Procedures

Aim 1: Participant adherence and treatment fidelity: Participant adherence to treatment sessions will be documented by the treatment providers. Participants will complete daily logs of home program performance. To optimize retention, participants will be contacted at regular intervals by the site-specific research coordinator. Any barriers to study participation will be documented and addressed. To optimize treatment fidelity among study personnel, we will use training methods established by Dr. Fitzgerald. We also will use the treatment fidelity framework developed by the NIH's Behavioral Change Consortium.[7, 8] Treatment providers will be contacted monthly to identify barriers to treatment fidelity. Booster sessions to review key components of study protocol will be provided at months 9 and 15.

Aim 2: Post-treatment improvement in outcomes (Fig. 4): Informed consent will be obtained prior to testing. Participants will complete self-report questionnaires and participate in movement pattern assessment. Participants will then be randomized into 1 of 2 treatment groups, movement pattern training (MPT) or standard rehabilitation (Control). Both groups will participate in 10 supervised sessions and perform a home program

within a 12 week time frame. At13 weeks after enrollment, participants will return for testing to assess post-treatment improvements
in primary and secondary outcomes.

Specific Procedures (Aims 1 and 2)
Primary outcome – Function: At pre-treatment and post-treatment testing, participants will complete the Hip disability and Osteoarthritis Outcome Score (HOOS),[42] a reliable and valid[34] hip-specific, patient reported outcome measure. Basic demographic, medical history and medication use will also be collected. (Appendix 1). All questionnaire responses will be collected and managed using Research Electronic Data Capture (REDCap*, See Facilities and Other Resources*) system hosted at Washington University. We will use the tailored design method of survey procedures, used in our previous study, to motivate participants to respond.[12]

Minimum important change (MIC) for HOOS subscales has not been established for patients undergoing non-surgical management for PAHD. Using values established for people who have undergone arthroscopic surgery,[34] the MIC values for HOOS subscales of ADL and Symptoms are 6 and 9 respectively. In our **preliminary work,** statistically significant differences exceeding MIC were found in HOOS ADL and Symptoms, with those participating in MPT demonstrating greater improvement at follow up compared to those in the wait-list group (Fig. 2).

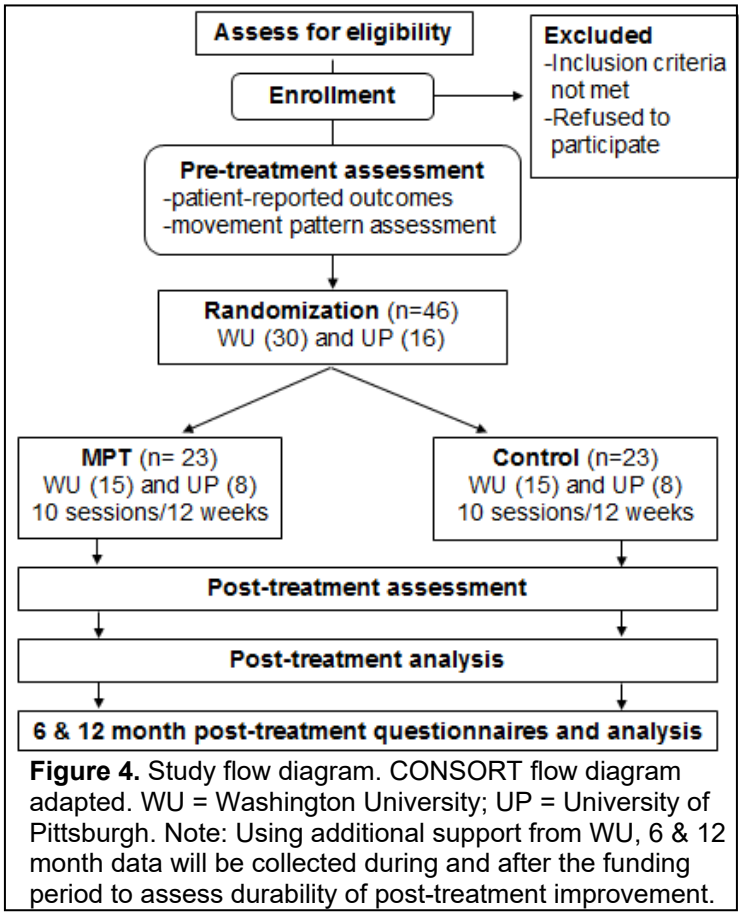


Figure 4. Study flow diagram. CONSORT flow diagram adapted. WU = Washington University; UP = University of Pittsburgh. Note: Using additional support from WU, 6 & 12 month data will be collected during and after the funding period to assess durability of post-treatment improvement.

Secondary outcome – Movement pattern: We will use a digital camera to acquire 2D hip motion while participants complete tasks of varying difficulty: step down, single leg squat, drop vertical jump. Markers will be placed on anatomical landmarks of the pelvis and thigh to assist with hip angle measurement. Previously published procedures[25] for camera placement and participant positioning will be used to optimize between-site data collection and reduce the effect of projection angles on the 2D measures. Participants will practice each movement prior to testing. We will then collect 3 trials of each movement. Commercially available software will be used to measure peak hip adduction motion. All measurements will be completed by trained personnel at Washington University, who will be blinded to treatment group.

In our **preliminary work**, we used 3D kinematic methods to quantify hip motion during the single leg squat. For the current study, we chose to use a 2D method that can be easily replicated with simple equipment in the clinical setting. To assess our ability to predict 3D peak hip adduction angle using our proposed 2D method, we used digital videos synchronized to the 3D kinematic data collection. Using data from 12 randomly selected participants, we found the correlation between 2D and 3D peak hip adduction to be high ($r = 0.85$, $P < 0.001$). Test-retest reliability of our 2D method is excellent ($ICC_{3,3} = 0.996$); standard error of measurement of 0.47°.

Randomization: Participants will be randomized to 1 of 2 treatment groups in a 1:1 ratio stratified by sex and HOOS Symptoms quartile (as determined from the preliminary data) within each site. Within each stratum, participants will be allocated using a variable block size so that the desired allocation ratio will be maintained at intervals throughout the recruitment process. Randomization sequences will be generated a priori using a formal probability model and will be elicited from the data capture system. Given the nature of the intervention, it is not possible to blind the treatment providers or participants to treatment assignment. Study personnel performing the assessments or the movement pattern measurements will be blinded to group assignment.

Treatment: Treatment for both groups will include 10 supervised sessions over 12 weeks. After randomization,

scheduling for participants, the treating physical therapists will be trained and tested in standardized procedures for both treatment arms. Both treatment arms will include assessment of patient goals, patient education and instruction in a home program. Patient education will focus on patient-specific tasks, identified by the participant to be symptom-producing. Based on participant responses during our **preliminary work,** patient-specific tasks included work-related and fitness activities, such as running, cycling and swimming. Participant independence and adherence will be documented (Appendix 2).[22] A brief description of the treatment approaches are provided below.

Movement pattern training (MPT) (Appendix 3): Focus will be on task-specific training to improve lower extremity movement patterns during basic functional tasks, such as sit to stand and stair negotiation, and reported patient-specific tasks. Patient education will include instruction in abnormal movement patterns and methods to optimize their movement pattern during each task. Exercises will include repeated practice of functional tasks using optimized movement patterns. Verbal cues and visual aids, such as a mirror, will be used to assist the participant. Based on the participant's performance, the difficulty of the task-specific activities will be progressed by varying the repetitions performed, increasing the load or changing the support surface. The home program will consist of repeated practice of tasks performed during supervised sessions.

Standard rehabilitation (Control) (Appendix 4): Focus will be on progressive lower extremity and trunk strengthening and lower extremity flexibility. Patient education will include instruction to modify intensity, frequency or duration of patient-specific tasks. Using current clinical practice guidelines[14] and previous reports,[6, 53] strengthening and flexibility exercises will be prescribed and progressed by varying the repetitions performed or increasing the load. The home program will include exercises performed during supervised sessions.

Post-treatment assessment: Participants will return for questionnaire completion and movement pattern assessment immediately after treatment. We will compare pre-treatment measures to post-treatment measures of both treatment groups to assess change in functional ability (HOOS) and movement patterns. Additionally, participants will complete a questionnaire developed to determine barriers to treatment adherence and to assess 1) treatment receipt, *'did the participant receive the treatment as intended'* and 2) treatment enactment, *'was the participant able to successfully implement their new skills'*.[7, 8] To assess sustained effects of treatment, participants enrolled at the Washington University site will return for questionnaire completion and laboratory testing 1-2 years after treatment

Additional measures: We will collect additional measures, to assist in the future trial development. To assess the feasibility of using PROMIS, the NIH-funded Patient-Reported Outcomes Measurement Information System for people with PAHD, we will use the computer-adapted version of the physical function and mobility domains. Using previously reported methods,[23] we will assess hip muscle strength pre- and post-treatment. Finally, using additional funding from Washington University (*See letter, Earhart*), participants will complete study questionnaires, electronically administered, 6 and 12 months after treatment to assess durability of post-treatment improvement.

Sample size considerations: With a sample size of 46 (23/group), the 95% confidence bounds (CBs) around our overall rates of adherence and retention will be between 78% and 96%, meaning that estimates will be within 9% of the true rate. The within site and within group estimates of adherence will be within 13% of the true rate. These calculations assume that the observed rates will be at least 90%, which is reasonable to expect based on our preliminary data. Aim 2 will estimate intervention effect sizes and as such, the study is not designed to generate definitive results. However, with at least 20 participants/group completing pre- and post-testing, the study will have 80% power to detect large effect sizes of 0.9 or above, with 95% CBs between 0.27 and 1.53. We note that preliminary data for the primary outcomes indicate that approximately 50% of the variance in change is explained by the pre-treatment value, and thus power and precision will be increased by including this covariate in the analyses.

We anticipate no problems enrolling sufficient participants for this feasibilty study. We were able to enroll 3-5 participants per month during our previous study. To improve our likelihood of meeting recruitment goals, we have added the University of Pittsburgh site and established collaborations with additional healthcare providers in St. Louis. We have also removed the restriction from the previous study for body mass index (previously <30 kg/m^2 required for kinematic testing). Support from the Data Coordination Center (Schechtmen, Director) will assist in optimizing retention rate and patient follow-up. Additionally, we will provide compensation of $25/hour to offset travel effort and costs related to the testing sessions and treatment will be provided at no charge.

Statistical Analysis: The primary data analyses for Aim 1 will be descriptive, and include reporting the rate of recruitment, screening, and enrollment for all potential participants considered for the study; and reasons for non-enrollment. Adherence, retention, and fidelity rates will be categorized using the specified thresholds and reported with 95% CBs. Uncategorized rates will be compared between sites and groups by Wilcoxon's test. Aim 2 will generate estimates of effect sizes. We will report change between pre-and post-treatment with 95% CBs. Inferential analyses will compare the change in response to treatment using analysis of covariance (ANCOVA) where change is the dependent variable and the pre-treatment value is the covariate. Accounting for variation in pre-treatment function will increase the precision of the between-group comparisons and also adjust the treatment effect estimates for possible imbalances between groups. If statistical assumptions are not satisfied, transformations will be explored or nonparametric covariance analyses[35] will be used.

Data Management and Quality Control: Study data will be electronically captured using the REDCap system hosted in a limited access data center managed by the Data Coordinating Center. Additional quality control programs will verify that study identification numbers are accurately labeled, evaluate consistency over time, and check for incomplete or overdue data. Routine reporting will monitor recruitment and retention, overall quality, and protocol deviations. Throughout the study, standardization of procedures across sites will be ensured by dynamic training and monitoring that includes site visits and remote auditing.

Limitations and Alternative Approaches: We have proposed this feasibility RCT to assess the ability to perform a multicenter RCT. Multicenter studies have unique challenges, however we believe this is a strength of our study by allowing us to achieve large, generalizable samples. We have developed a team with individual strengths that, when brought together, will optimize our ability to successfully complete this project and subsequent studies. Although a new investigator, Dr. Harris-Hayes has demonstrated her capability to lead a project by completing an exploratory RCT (*manuscript in review*) during her K23 training grant. Drs. Fitzgerald and Schechtman are experienced investigators, with significant experience implementing multicenter studies. Dr. Clohisy is well-recognized for his clinical expertise in PAHD and has an established research agenda with the goal of improving patient outcomes through investigation of nonsurgical and surgical treatment strategies.

Given our preliminary data, we expect those receiving MPT will report improved function after treatment. It is possible those receiving the standard rehabilitation will report similar improvements. Although unexpected, this finding would be important to demonstrate that nonsurgical management may be an option for people with PAHD. Study data will then be used to guide the development of future improved treatment strategies. If we find similar improvements in both groups, it is likely some participants will respond favorably to the treatment approach they received, while others remain unchanged or possibly worsen. Secondary analysis of patient-specific factors and movement pattern assessment may identify subgroups of people with PAHD who would respond to different types of treatment.[5]

We did not include imaging in this study. Imaging would provide useful information about bony abnormalities[19, 37] and structural disease associated with PAHD, however would be cost-prohibitive for this feasibility study. In our **preliminary work,** we did not find an association between patient-reported function and bony abnormalities. We therefore chose to focus on the abnormal movement pattern in this study. Imaging to assess bony abnormalities and structure disease will be included in the future, definitive trial.

Significance and future directions: Information from the current study regarding the participants' ability to adhere to treatment, the treatment providers' ability to adhere to the treatment protocol and effect size estimates will guide the future, large RCT. Should the feasibility study indicate that modifications are needed, these will be made prior to the large RCT. Feedback from study participants and the treatment providers will be used to improve participants adherence and treatment fidelity. The future RCT will include assessment of patient-reported function and movement patterns from the proposed study and bony abnormalities. A better understanding of the association among these factors and treatment prognosis will help us develop improved treatment strategies and to better match treatment to patients.

Intra-articular, prearthritic hip disorders result in significant limitations in the young adult and are likely precursors to osteoarthritis. MPT is an innovative treatment approach with the potential to optimize treatment outcomes, nonsurgical and surgical, for people with PAHD. Further, MPT may provide a strategy for injury prevention, particularly those injuries of insidious nature. Ultimately this work will lead to better overall outcomes, reduced healthcare cost and reduced patient burden.

Appendix 3: Movement Pattern Training Protocol

3.1 Task-specific instructions

- **Handouts provided to participants to reinforce performance of task-specific modifications during daily activities.**

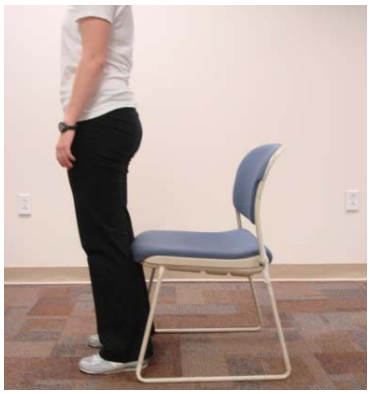
3.2 Progression table for task-specific training

- **Provides overview of progression for task-specific training.**

Appendix 3.1

Sitting Down From Standing Position

1. Stand with knees touching back of chair, feet hip-width apart.



2. Bend at your hips and knees while simultaneously contracting your thighs to slowly lower yourself onto the chair.

3a. Keep your knees aligned with your feet.

3b. Don't allow knees to roll in. Squeezing your buttocks will prevent your knees from coming together.

4. Sit down onto the front of the chair and scoot to back of chair

If can't bend hip past 90 degrees, straddle feet so the _____ foot is back and the _____ foot is forward.

Standing Up From Sitting Position

1. Position your feet hip-width apart and far enough under you so there is a good bend at your knees.

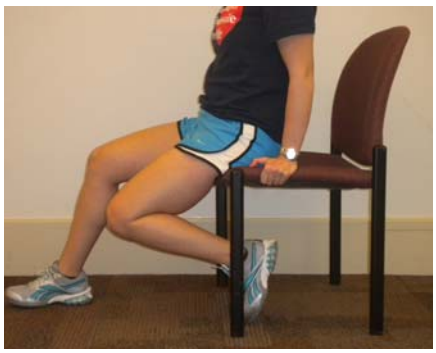
2. Scoot to the front of the chair. Position your feet slightly behind your knees.

3. Use your thighs and buttocks to lift your body up off the chair while shifting weight forward. Avoid pulling your knees back to meet your body.

4. Keep the knees aligned with the toes. Do not allow the knees to roll in.

5. Final position of your knee should be relaxed with a slight bend.

If you can't bend hip past 90 degrees, straddle feet so the _____ foot is back and the _____ foot is forward.



Walking

Focus on moving in a heel to toe fashion, keeping feet hip width apart. Avoid pivoting on a fixed foot.

Try to let your heel land softly on the ground. Contract your seat muscles as the heel hits the ground to align knee over foot.

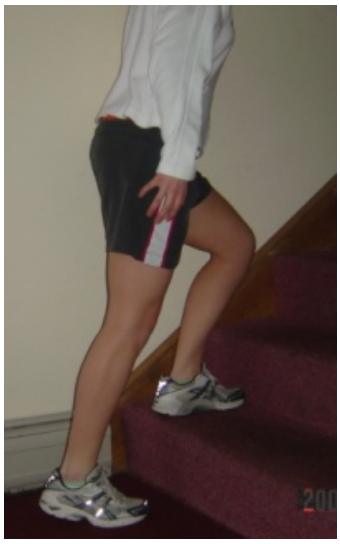
Avoid completely straightening your leg from the point your heel hits the ground to the point where your toes leave the ground; always have a bend in your knee.

__decrease speed
__decrease stride length

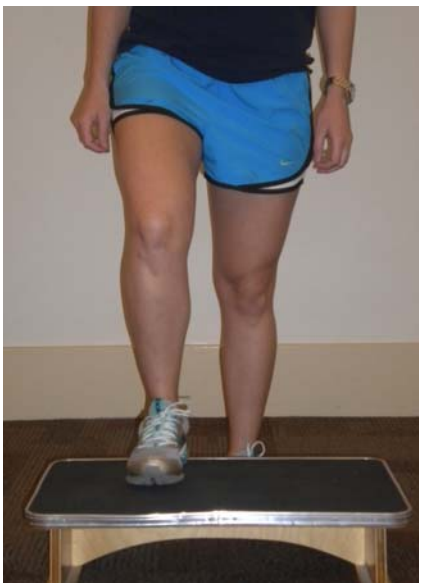
Make sure you "lift your heel" to help make pushing off with your toes easier. Taking slightly shorter steps can also help.

Ascending Stairs

Lean forward and use your thigh and buttock to move your body forward onto the next stair. Avoid pulling your knee back to meet the body. Instead propel the body forward on to the next stair.

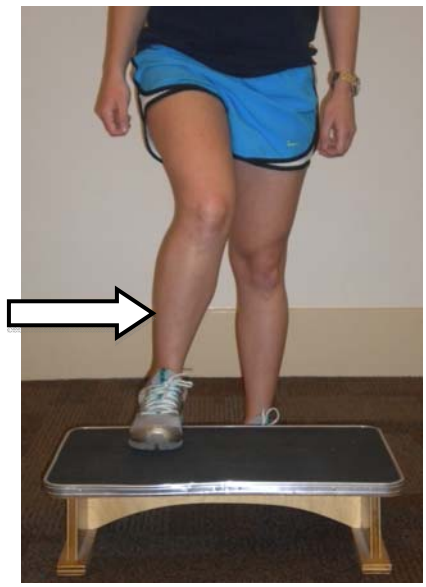


Squeeze your buttock to prevent your knee from turning inward.



Correct

Don't let your knee roll in or your pelvis tilt.



Incorrect

Note: If ascending stairs is painful, use a handrail or step up each step with your non-painful leg first

Descending Stairs

Lean forward and bend your standing leg to slowly lower yourself onto the next stair.

Squeeze your buttock to prevent your knee from turning inward.

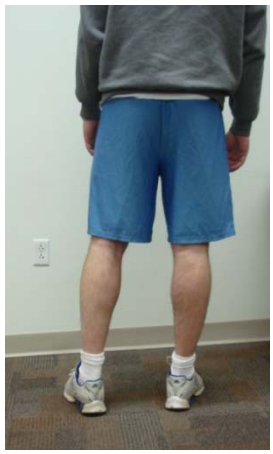
Correct

Don't let your knee roll in or your pelvis tilt.

Incorrect

Note: If descending stairs causes pain, lead each stair's descent with the painful hip.

Weight Shifts



Weight shifting with unilateral gluteal contraction of the stance limb
Purposes:
•To improve the performance of the hip external rotator and abductor muscles.
•To prevent compensatory movements of the hip, pelvis, and spine.
•To prevent the thigh from turning inward.

1. Stand with both feet relatively close together.
2. Shift your weight to one leg.
3. Tighten your buttock muscle on the side of your stance leg.
4. Repeat to the opposite leg.
5. Alternate the weight shift from one leg to the other.
6. Keep your pelvis level and trunk upright.
7. Do not let your opposite hip drop.
8. Do not let your knee turn inward.
9. You may place your hands on your pelvis to monitor your motion.

Repeat 10-20 times on each leg. Perform 2 sets.

*this exercise may be used frequently throughout the day to improve contraction and reduce pain.

Single leg stance

Single leg stance
Purposes:
•To improve the performance of the hip external rotator and abductor muscles.
•To prevent compensatory movements of the hip, pelvis, and spine.

1. Stand with both feet relatively close together and knees “unlocked”
2. Shift your weight to one leg and tighten your buttock muscle on the side of your stance leg.
3. Lift your opposite leg in front of you as if marching in place.
4. Repeat to the opposite leg.
5. Keep your pelvis level and trunk upright.
6. Do not let your opposite hip drop or knee turn inward.
7. You may place your hands on your pelvis to monitor your motion.

*Optional: Hold onto countertop for balance

Repeat 10-20 times. Perform 2 sets.

Single Leg Squat

Lean forward and bend your standing leg to slowly lower yourself and return to the starting position.

Squeeze your buttock to prevent your knee from turning inward. Keep your trunk in the upright position.

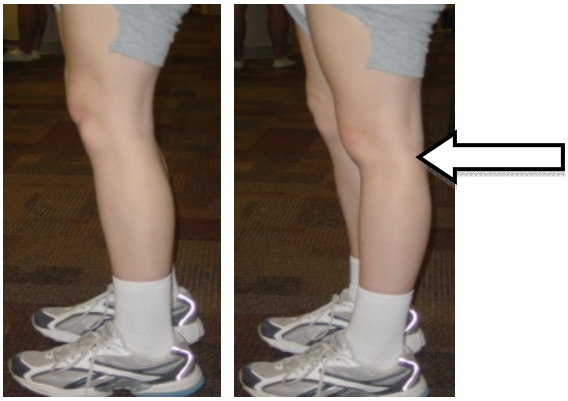
Correct

Don’t let your knee roll in or your trunk bend to the side.

Incorrect

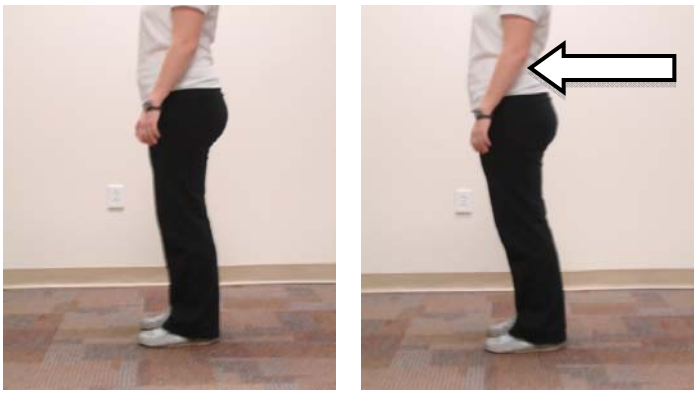
Standing

Don't stand with your knees locked. Allow there to be a slight bend in your knees.



Correct Incorrect

Don't stand with your hips swayed forward or your shoulders swayed back behind your hips.

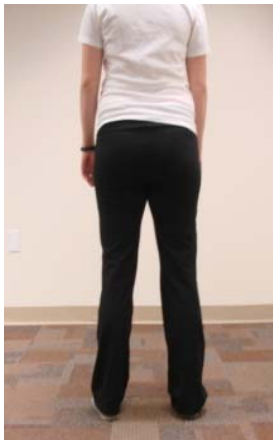


Correct Incorrect

Don't stand with weight on one leg:

Incorrect

Instead, stand with equal weight on both legs with your feet hip width apart:



Correct

Avoid standing for prolonged periods.

__Allow feet to point out if femoral retroversion
__Allow feet to point in if excessive femoral anteversion

Sitting

Position yourself so that your knees are aligned with your feet. While sitting, your feet should be supported (flat on the floor). Back rest should be supportive.

Your therapist may instruct you to sit with your hips higher than your knees. You may need to raise your chair or use a pillow or wedge in your chair.

Don't sit with your knees higher than hips.

Don't rest feet on toes pulled underneath chair.

Don't sit in a "W" position

Don't cross your legs in any of the following positions:

(a) Leg around thigh.

(b) Thigh over thigh.

(c) Ankle over knee

(d) Sitting on one leg

Sleeping

When sleeping on your side, use pillows between your knees

to keep your legs parallel to the floor:

Incorrect

Correct

Avoid extreme hip flexion or rotation:

Incorrect

Incorrect

Additional instructions:

_____ When sleeping on your stomach, place a pillow under your hips.
_____ When sleeping on your back, place a pillow under your knees.
_____ When sleeping on your side, you may reduce pressure on your hip by
_____placing towel rolls above and below the hip bone.
_____ a towel roll under the waist.

Appendix 3.2

Task-specific training progression

Task - Movements	Level 1	Level 2	Level 3	Level 4	Level 5
1. Sit to Stand Stand to Sit*	1. Regular seat height	1. Regular seat height with resistance	1. Lower seat height with resistance	1. Varying seat height with resistance	1. Varying seat height with increased resistance
2. Walking/Running**	2. Patient-preferred speed	2. Patient-preferred speed, increase time	2. Fast-walk	2. Walk-Run (if patient goal), otherwise increase time walking	2. Run (if patient goal), otherwise increase time walking
3. Ascending stairs*	3. 6-8” step up	3. 6-8” step up with resistance	3. 6-8” step up with resistance	3. 8-10” step up	3. 8-10” step up with resistance
4. Descending stairs*	4. 6-8” step down	4. 6-8” step down with resistance	4. 6-8” step down with resistance	4. 8-10” step down	4. 8-10” step down with resistance
5. Single leg activities	5. Weight shift	5. Single leg stance with hold	5. Single leg squat with hand support	5. Single leg squat	5. Single leg squat with resistance
6. Patient-specific tasks	Tasks will be identified by the participant during their baseline assessment. Activities typically include work-related activities such as standing and sitting or fitness/sport activities. Tasks will be practiced and progressed in difficulty based on participant performance. For example, see walking above for progression to running. Cycling mechanics will be observed and modified; progression will include increase in time and speed.				
Task - Position					
1. Standing 2. Sitting 3. Sleeping	Participant will be provided instruction during the initial 2 visits. Each activity will be assessed during follow up visits, until the participant is independent in the task. To be independent in the task, the participant must verbalize and demonstrate proper performance.				

*Parameters: Perform 2-4 sets, 8-12 reps 1x/day. Resistance can be provided with theraband, ankle weights or weight equipment. Participant is progressed to the next level when they can perform 3 sets of 8-10 repetitions with ease and demonstrating good mechanics at the hip and knee.

**Walking/Running Parameters: Participants will be progressed to the next level when they can perform with good mechanics at the hip and knee and report no worsening of their symptoms.

Appendix 4: Standard Rehabilitation Protocol

4.1 Exercise instructions

- **Provides exercise instructions given to participant. Pictures are also provided to assist with independent performance of home program.**

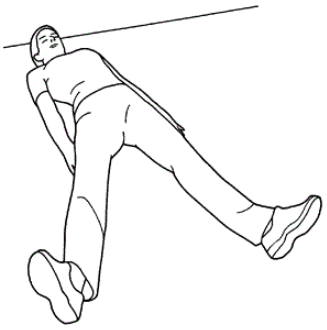
4.2 Progression table for exercise

- **Provides overview of exercise progression.**

Appendix 4.1

(All exercises printed with permission)

Hip Abductors – Level 1

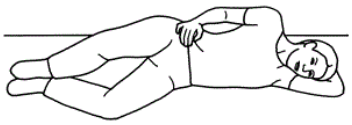


Hip Abduction in Supine
Purpose: To improve performance of hip abductor muscles.

1. Lay on your back with your legs straight and close together.
2. Contract your buttock muscle to slide your leg out to the side.
3. Return your leg to the starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Hip Abductors – Level 2



Hip Abduction in Side Lying with Knee Flexed
Purpose: To improve the performance of the hip abductor muscles.

1. From side lying, bend both hips and knees.
2. Lift top knee towards the ceiling while keeping your ankles together.
3. Return top knee to starting position.

Perform 2-4 sets, 8-12 reps 1x/day

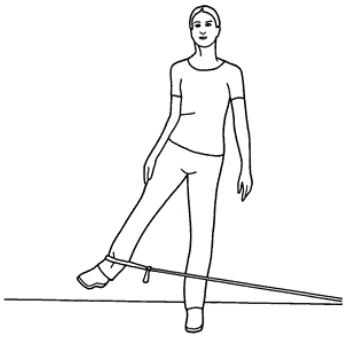
Hip Abductors – Level 3

Hip Abduction in Side Lying with Hip Extended
Purpose: To improve the performance of the hip abductor muscles.

1. Lying on your side, bend the bottom hip and knee.
2. Straighten your top hip and knee.
3. Lift top leg towards ceiling.
4. Return leg to starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Hip Abductors – Level 4 and 5



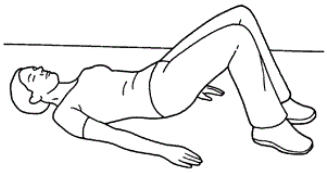
Hip Abduction in Standing with Resistance
Purpose: To improve the performance of the hip abductor muscles.

1. From standing, lift your leg out to the side.
2. Return leg to the starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Level 5: Increase resistance

Hip Extensors – Level 1

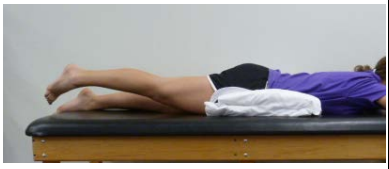


Bridge
Purpose: To improve the performance of the hip extensors.

1. Lay on your back with knees bent.
2. Squeeze glutes and lift hips off of the table.
3. Return hips to starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Hip Extensors – Level 2

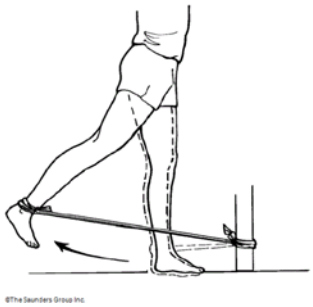


Hip Extension—Prone with Knee Extended
Purpose: To improve the performance of the hip extensors.

1. Squeeze the gluteal muscle and raise thigh off the floor as you lift toward the ceiling.
2. Slowly lower leg back down and relax.

Perform 2-4 sets, 8-12 reps 1x/day

Hip Extensors – Level 3



Hip Extension—Standing with Resistance
Purpose: To improve the performance of the hip extensors.

1. Bring the ankle behind the body.
2. Slowly return back to start position.

Perform 2-4 sets, 8-12 reps 1x/day

Progression: Increase resistance.

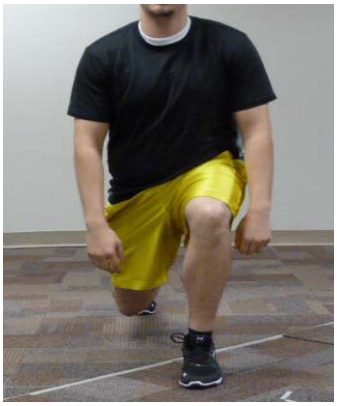
Hip Extensors – Level 4

Squat
Purpose: To improve the performance of the hip extensors.

1. Stand with both feet shoulder width apart.
2. Perform a squat. Keep your back straight as you "sit" back.
3. You may place your arms in front of you to maintain balance.

Perform 2-4 sets, 8-12 reps 1x/day

Hip Extensors – Level 5



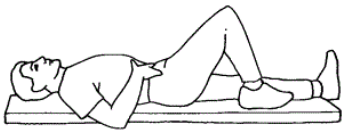
Lunges
Purpose: To improve the performance of the hip extensors.

1. Stand with feet shoulder width apart. Step forward into a lunge, keeping your knee straight in front of you. Push back to start position with front leg.
2. Your knee should never pass your toes.

Perform 2-4 sets, 8-12 reps 1x/day

Progression: hold weights in hands while performing the lunge.

Hip Flexors – Level 1

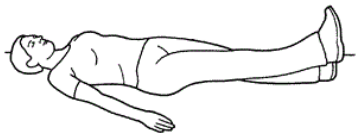


Hip Flexion- Supine Position
Purpose: To improve the performance of the hip flexors.

1. Lay on your back with legs straight.
2. Slide one heel up towards your trunk keeping your heel on the table.
3. Return heel back to starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Hip Flexors – Level 2 and 3

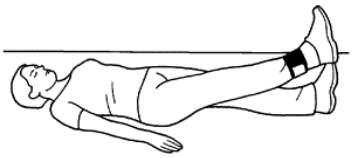


Hip Flexion- Supine Position
Purpose: To improve the performance of the hip flexors.

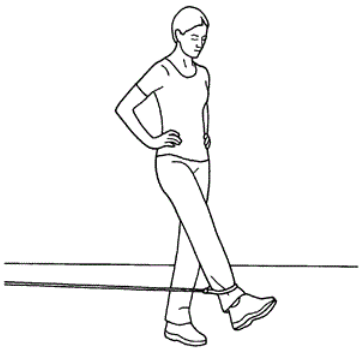
1. Lay on back with one leg straight and one leg bent.
2. Lift the straight leg towards the ceiling.
3. Return leg to starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Level 3: Add resistance/weight.



Hip Flexors – Level 4 and 5



Hip Flexion- Standing Position with Resistance
Purpose: To improve the performance of the hip flexors.

1. From standing, bring leg straight in front of you.
2. Return leg to starting position

Perform 2-4 sets, 8-12 reps 1x/day

Level 5: Increase resistance.

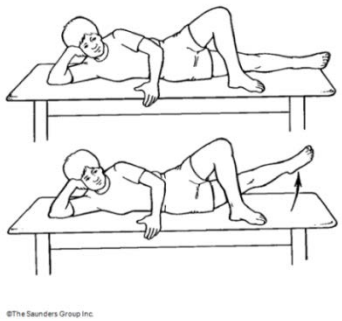
Hip Adductors – Level 1

Hip Adduction—Sitting
Purpose: To improve the performance of the hip adductors.

1. Sit with knees slightly apart.
2. Place hands on the inside of your knees.
3. Squeeze the thighs together, but resist the motion with your hands.
4. Hold for 5 seconds, then slowly relax.

Perform 2-4 sets, 8-12 reps 1x/day

Hip Adductors – Level 2 and 3



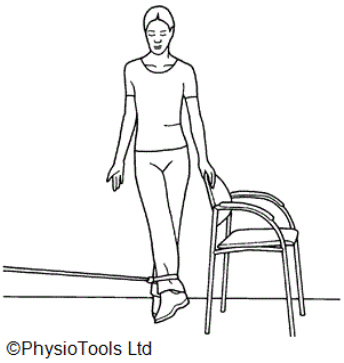
Hip Adduction—Side Lying
Purpose: To improve the performance of the hip adductors.

1. Lie on side with bottom leg straight.
2. Bend the knee of the top leg over the bottom leg.
3. Raise the bottom leg up toward the ceiling.
4. Slowly lower back down.

Perform 2-4 sets, 8-12 reps 1x/day

Level 3: Use resistance with this exercise.

Hip Adductors – Level 4 and 5



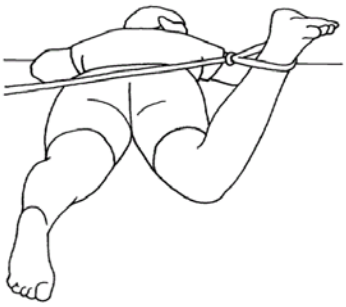
Hip Adduction in Standing with Resistance
Purpose: To improve the performance of the hip abductor muscles.

1. From standing, lift your leg across your body.
2. Return leg to the starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Level 5: Increase resistance.

Hip Internal Rotators – Level 1 and 2



Hip Internal Rotation—Prone
Purpose: To improve the performance of the hip internal rotators.

1. Lay on your stomach and bend your knee.
2. Rotate your hip by allowing the foot of the bent knee to move away from your other leg.
3. Return slowly back to the start position.

Perform 2-4 sets, 8-12 reps 1x/day

Level 1: no resistance

Level 2: may use theraband with increasing resistance to progress this exercise.

Hip Internal Rotators – Level 3+

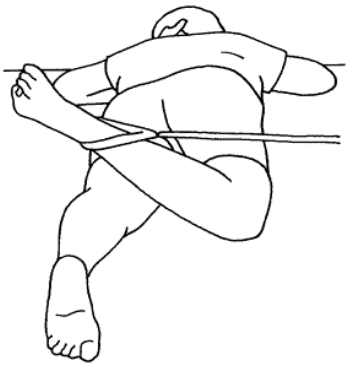
Hip Internal Rotation—Sitting
Purpose: To improve the performance of the hip internal rotators.

1. Sit at the edge of a table or chair with feet hanging above the floor.
2. Rotate your hip by allowing the foot of one leg to move away from your other leg.
3. Return slowly back to the start position.

Perform 2-4 sets, 8-12 reps 1x/day

Level 4 and above: Increase resistance of theraband with this exercise.

Hip External Rotators – Level 1 and 2



Isometric Hip ER in Prone
Purpose: To improve the performance of the hip external rotator muscles.

1. Lay on your stomach and bend your knee.
2. Rotate your hip by allowing the foot of the bent knee to move toward your other leg.
3. Return slowly back to the start position.

Perform 2-4 sets, 8-12 reps 1x/day

Level 1: no resistance

Level 2: may use theraband with increasing resistance to progress this exercise.

Hip External Rotators – Level 3+

Hip ER in Sitting
Purpose: To improve the performance of the hip external rotator muscles.

1. While keeping your thigh on the supporting surface, rotate your hip so that your foot moves in toward the other leg.
2. Return leg slowly to starting position.

Perform 2-4 sets, 8-12 reps 1x/day

Level 4 and above: Increase resistance of theraband with this exercise.

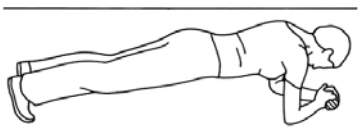
Trunk – Level 1

Plank – On Knees
Purpose: To improve trunk stability.

1. Lying face down, support your body weight on your forearms and knees.
2. Tighten your stomach muscles while keeping your neck and back straight.
3. Your trunk should not rotate and the back should remain flat from shoulders to hips. Do not hike hips in the air.

Perform 2-4 sets, 30-60 second holds 1x/day

Trunk – Level 2

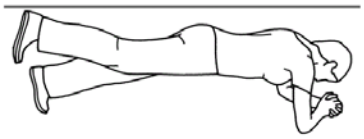


Plank – On Toes
Purpose: To improve trunk stability.

1. Lying face down, support your body weight on your forearms and toes.
2. Tighten your stomach muscles while keeping your neck and back straight.
3. Your trunk should not rotate and the back should remain flat from shoulders to hips. Do not hike hips in the air.

Perform 2-4 sets, 30-60 second holds 1x/day

Trunk – Level 3



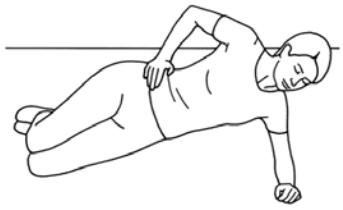
Plank on Toes with Leg Lift

Purpose: To improve trunk stability with limb movement.

1. Lying face down, support your body weight on your forearms and toes.
2. Tighten your stomach muscles while keeping your neck and back straight.
3. Your trunk should not rotate and the back should remain flat from shoulders to hips. Do not hike hips in the air.
4. Lift on leg back up into the air.

Perform 2-4 sets, 30-60 second holds 1x/day

Side Trunk – Level 1



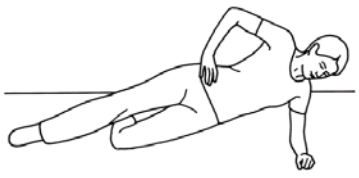
Side Plank – On Knees

Purpose: To improve trunk stability.

1. Lie on your side with your knees bent.
2. Support your body weight on your forearm and knees.
3. Tighten your stomach muscles while keeping your neck and back straight.
4. Your trunk should not rotate and the back should remain flat from shoulders to hips. Do not hike hips in the air.

Perform 2-4 sets, 30-60 second holds 1x/day

Side Trunk – Level 2



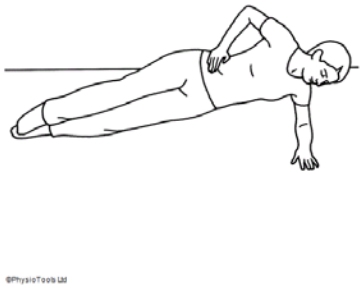
Side Plank – On One Knee

Purposes: To improve trunk stability.

1. Lie on your side with your bottom knee bent and the top one straight.
2. Support your body weight on your forearm and knee.
3. Tighten your stomach muscles while keeping your neck and back straight.
4. Your trunk should not rotate and the back should remain flat from shoulders to hips. Do not hike hips in the air.

Perform 2-4 sets, 30-60 second holds 1x/day

Side Trunk – Level 3



Side Plank – Legs Straight
Purpose: To improve trunk stability.

1. Lie on your side with both legs straight.
2. Support your body weight on your forearm and feet.
3. Tighten your stomach muscles while keeping your neck and back straight.
4. Your trunk should not rotate and the back should remain flat from shoulders to hips. Do not hike hips in the air.

Perform 2-4 sets, 30-60 second holds 1x/day

Flexibility – Hamstring Stretch

Doorway Hamstring Stretch
Purpose: To improve the flexibility of the hamstrings.

1. Lie on your back near a doorway
2. Keeping your knee straight, bring your leg up along the door frame.
3. You should feel the stretch in the back of your thigh.
4. Make sure your lower leg stays flat on the floor.
5. Stretch to the point of feeling tightness or slight discomfort.

Hold 30 secs, 2-4 reps (can adjust hold and reps, but should accumulate 60 sec of stretch total), perform 1x/day

Flexibility – Calf Stretch

Calf Stretch – Standing
Purpose: To improve the flexibility of the calf muscles.

1. Standing with feet staggered/ one foot in front of the other.
2. Lean forward with hands on the wall, keeping the back foot in contact with the ground.
3. If you keep the back knee straight you are stretching the gastroc muscles. If you bend the back knee slightly, you are stretching the soleus.
4. Hold for 30 seconds, then slowly shift weight back to normal standing.
5. Stretch to the point of feeling tightness or slight discomfort.

Hold 30 secs, 2-4 reps (can adjust hold and reps, but should accumulate 60 sec of stretch total), perform 1x/day

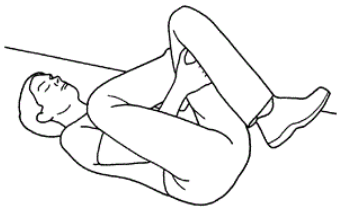
Flexibility – Hip Flexors Stretch

Hip Flexors Stretch – Kneeling/Standing
Purpose: To stretch the hip flexor muscles.

1. Get into the kneeling/standing position with one leg in front of the other.
2. Keeping back upright, lean weight forward towards front leg.
3. Hold stretch for 30 seconds, then repeat for the other leg.
4. Stretch to the point of feeling tightness or slight discomfort.

Hold 30 secs, 2-4 reps (can adjust hold and reps, but should accumulate 60 sec of stretch total), perform 1x/day

Flexibility – Piriformis Stretch



Piriformis Stretch
Purpose: To improve the flexibility of the piriformis.

1. Lying on your back with knees bent.
2. Cross the ankle of the leg to be stretched over the other knee. Put your arms around the thigh as shown.
3. Bring your thigh towards your stomach. Feel the stretch in your buttock.
4. Stretch to the point of feeling tightness or slight discomfort

Hold 30 secs, 2-4 reps (can adjust hold and reps, but should accumulate 60 sec of stretch total), perform 1x/day

Appendix 4.2

Exercise progression

Target Muscles – Strength	Level 1	Level 2	Level 3	Level 4	Level 5
1. Hip Abductors*	1. Hip Abd[a] in supine	1. Hip Abd in side lying with knee flexed	1. Hip Abd in side lying with hip extended	1. Hip Abd in standing with resistance	1. Hip Abd in standing; progress resistance
2. Hip Extensors*	2. Bridges	2. Hip Ext[b] in prone	2. Hip Ext in standing with resistance	2. Squats	2. Lunge
3. Hip Flexors*	3. Heel slide	3. Straight leg raise	3. Straight leg raise with resistance	3. Hip Flex[c] in standing with resistance	3. Hip Flex in standing; progress resistance
4. Hip Adductors*	4. Hip Add[d] isometrics in sitting	4. Hip Add in side lying	4. Hip Add in side lying with resistance	4. Hip Add in standing with resistance	4. Hip Add in standing; progress resistance
5. Hip Internal Rotators*	5. Hip IR[e] in prone	5. Hip IR in prone with resistance	5. Hip IR in sitting with resistance	5. Hip IR in sitting; progress resistance	5. Hip IR in sitting; progress resistance
6. Hip External Rotators*	6. Hip ER[f] in prone	6. Hip ER in prone with resistance	6. Hip ER in sitting with resistance	6. Hip ER in sitting with resistance	6. Hip ER in sitting with resistance
7. Trunk**	7. Plank on knees	7. Plank on toes	7. Plank on toes with leg lift		
8. Side Trunk**	8. Side plank on knees	8. Side plank on one knee	8. Side plank legs straight		
Target Muscles – Flexibility					
1. Hamstrings 2. Calves 3. Hip Flexors 4. Piriformis	Hold 30 seconds 2-4 reps (can adjust hold and reps, but should accumulate 60 seconds of stretch total), perform 1x/day				

[a]Abd = Abduction, [b]Ext = Extension, [c]Flex = Flexion, [d]Add = Adduction, [e]IR = Internal Rotation, [f]ER = External Rotation

*Strength Parameters: Perform 2-4 sets, 8-12 reps 1x/day. Resistance can be provided with theraband, ankle weights or weight equipment. Participant is progressed to the next level of exercise when they can perform 3 sets of 8-10 repetitions independently and with ease.

**Trunk Parameters: Perform 2-4 sets, 30-60 second holds 1x/day.