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ORIGINAL RESEARCH

PAIN, FUNCTION, AND STRENGTH OUTCOMES FOR MALES AND FEMALES WITH PATELLOFEMORAL PAIN WHO PARTICIPATE IN EITHER A HIP/CORE- OR KNEE-BASED REHABILITATION PROGRAM

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ABSTRACT

Background: Hip exercise has been recommended for females with patellofemoral pain (PFP). It is unknown if males with PFP will benefit from a similar treatment strategy.

Hypotheses/Purpose: The purpose of this study was to compare improvements in pain, function, and strength between males and females with PFP who participated in either a hip/core or knee rehabilitation program. The directional hypothesis was that females would respond more favorably to the hip/core rehabilitation program and males to the knee program.

Study Design: Randomized-controlled clinical trial

Methods: Patients were randomly assigned to a six-week hip/core or knee rehabilitation program. Visual analog scale (VAS), Anterior Knee Pain Scale (AKPS), and hip and knee isometric strength were collected before and after subjects completed the rehabilitation program. Data were analyzed using an intention-to-treat basis. Separate mixed-model analyses of variance (ANOVA) with repeated measures were used to determine changes in VAS and AKPS and strength changes for subjects classified as treatment responders (successful outcome) and non-responders (unsuccessful outcome).

Results: Regardless of sex or rehabilitation group, VAS ($F_{1,181} = 206.5$; $p < .0001$) and AKPS ($F_{1,181} = 160.4$; $p < 0.0001$) scores improved. All treatment responders demonstrated improved hip abductor ($F_{1,122} = 6.6$; $p = 0.007$), hip extensor ($F_{1,122} = 19.3$; $p < 0.0001$), and knee extensor ($F_{1,122} = 16.0$; $p < 0.0001$) strength. A trend ($F_{1,122} = 3.6$; $p = 0.06$) existed for an effect of sex on hip external rotator strength change. Males demonstrated a 15.4% increase compared to a 5.0% increase for females. All treatment non-responders had minimal and non-significant ($p > 0.05$) strength changes.

Conclusion: On average, males and females with PFP benefitted from either a hip/core or knee rehabilitation program. Subjects with successful outcomes likely had hip and knee weakness that responded well to the intervention. These males and females had similar and meaningful improvements in hip extensor and knee extensor strength. Only males had relevant changes in hip external rotator strength. Clinicians should consider a subgroup of males who may benefit from hip extensor and external rotator exercise and females who may benefit from hip extensor exercise.

Level of Evidence: 2b

Keywords: Anterior knee pain, hip, rehabilitation, sex

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INTRODUCTION

Patellofemoral pain (PFP) is one of the most common and clinically challenging knee pathologies to manage.[1-3] Individuals with PFP report peripatellar and/or retropatellar pain exacerbated by activities like stair ambulation, jumping, and running that require loading on a flexed knee.[3] PFP is thought to result from abnormal patella tracking that increases lateral patellofemoral joint stress.[4,5]

Historically, clinicians believe that a delay in vastus medialis activation relative to the vastus lateralis can cause excessive lateral patellofemoral joint loading.[6,7] This theory has led to interventions designed to improve quadriceps function. While quadriceps exercise is important,[8] as many as 70% to 90% of individuals with PFP who complete rehabilitation have ongoing symptoms.[9-11]

Powers[12] has theorized that excessive hip adduction and/or internal rotation from hip weakness can lead to increased patellofemoral joint loading. This perspective has segued to investigations focusing on hip exercise.[13-15] While an important treatment strategy,[16] many hip exercises have been performed in weight bearing and most likely affected the knee muscles.

To address this concern, more recent investigations have compared the isolated effects of hip and quadriceps strengthening exercise on PFP.[17,18] A large scale, multicenter randomized-controlled clinical trial was conducted to compare pain, patient-reported function, and muscle performance in subjects with PFP who completed either a hip/core or knee strengthening program.[18] All subjects, *regardless of exercise group*, had significant improvements in pain, patient-reported function, and muscle performance.

Most studies that have examined the benefits of hip exercise on PFP have either excluded males[13-15,19] or included a relatively low number of males.[18] A main reason for excluding males has been strong evidence of a high prevalence of PFP in females[20,21] and associated hip weakness.[22,23] Although more prevalent in females, males develop PFP and limited data exist regarding patterns of hip and knee weakness in this cohort. Bolgla et al[24] compared isometric hip and knee strength in males with and without PFP. They found that males with PFP demonstrated significantly less knee extensor, *but similar hip* strength when compared to controls. These data highlighted that males with PFP may respond better to a knee-focused rehabilitation program, supporting the need for sex-specific interventions.[25] Additional studies are needed to make this determination.

The primary purpose of this study was to compare improvements in pain and patient-reported function between males and females with PFP who participated in either a hip/core or knee rehabilitation program. The secondary purpose was to compare changes in isometric hip and knee strength following rehabilitation. The directional hypothesis was that females would respond more favorably than males to the hip/core rehabilitation program and males would respond more favorably to the knee program.

METHODS

Study Design

This study was a secondary analysis of cross-sectional data from a larger randomized-controlled clinical trial[18] comparing outcomes in subjects with PFP who participated in either a six-week hip/core or knee strengthening rehabilitation program. For the current study, separate 2 (male or female) X 2 (hip/core or knee program) X 2 (baseline and post-rehabilitation) mixed-model analyses of variance (ANOVA) with repeated measures on time were used to determine any interaction effect between sex and exercise group on the primary variables of pain and patient-reported function.

Separate 2 (male or female) X 2 (baseline and post-rehabilitation) mixed-model ANOVAs with repeated measures on time were used to determine changes in the secondary variables of hip and knee isometric strength. The purpose of this analysis was to identify any interaction effect of sex on treatment response (i.e., treatment success or nonsuccess) based on strength changes. Subjects were grouped as either responders (treatment success) or non-responders (treatment nonsuccess) based on recommendations from Crossley et al.[26] Responders were defined *a priori* as follows: at least a 2-cm decrease in visual analog scale (VAS) score for pain and/or at least an 8-point improvement in the Anterior Knee Pain Scale (AKPS) score.[18,26] Subjects who did not meet any of these criteria were classified as non-responders.

Subjects

One hundred eighty-five subjects were included for this analysis. Subjects were recruited from a sample of convenience in the following geographic areas: Augusta, GA; Calgary, AB, CA; Chicago, IL; and Milwaukee, WI. Inclusion and exclusion criteria were consistent with those previously described.[27-31] Briefly, subjects were recreationally-active (exercised a minimum of 30 minutes three times a week for at least 6 months prior) and between the ages of 18 and 35 years. Additional inclusion criteria were an insidious onset of PFP for at least 1 month, self-reported pain during activity of at least 3-cm on a 10-cm VAS, and pain during activities that required loading on a flexed knee (e.g., running, jumping, squatting, or stair ambulation). Exclusion criteria included a history of back or lower extremity pathology (including patella tendinopathy, patella instability, and/or iliotibial band stress syndrome) other than PFP. The most affected extremity was used for subjects with bilateral symptoms (N = 88).[32] Subjects were randomly assigned to exercise group and examiners were blinded to subject group assignment. All subjects signed an informed consent document provided by each individual site's Institutional Review Board prior to participation.

Outcome Measures

Pain

Pain was assessed using a 10-cm VAS. The extreme left side of the VAS stated "no pain" whereas the extreme right side stated "worse pain imaginable." Subjects drew a perpendicular line on the scale at the position that best described their pain during activity over the previous week. The distance from the left side (e.g. no pain) of the VAS to the vertical mark made by the subject was measured to the nearest 1/10th of a centimeter and used for statistical analysis. The VAS for pain during activity over the prior week has represented a reliable, responsive, and valid instrument for assessing pain in individuals with PFP.[26]

Function

Function was assessed using the Anterior Knee Pain Scale (AKPS), a 100-point patient-reported outcome measure that assesses 13 domains of knee function for individuals with PFP.[33] A low score suggests significant knee dysfunction where as a higher score signifies no disability. The AKPS has represented a reliable, responsive, and valid instrument for assessing function in individuals with PFP.[26] The composite score on the AKPS was used for statistical analysis.

Isometric Hip and Knee Strength

Isometric hip abductor, hip extensor, hip external rotator, and knee extensor strength was assessed using a hand-held dynamometer and stabilization straps using methods previously described.[15,29,32,34,35] Peak force measures were recorded in kilograms and expressed as a percentage of body mass (%BM). The average of three trials was used for statistical analysis.

Rehabilitation Protocol

A random number generator was used to assign subjects to either the hip/core or knee program, a sequence that was used at each research site. All subjects met with a trained rehabilitation specialist up to three times a week over a six-week period. The rehabilitation specialist supervised all exercises sessions and progressed the subjects based on their feedback and symptoms (e.g., pain, swelling, crepitus). Subjects were instructed to perform the exercises at least six times a week (e.g., a subject who attended three supervised sessions completed at least three additional sessions independently at home) and used Theraband® (The Hygenic Corp, Akron, OH) for resistance. Resistance was based on a subject's ability to complete 10 repetitions of the exercise with good form but feeling challenged to complete the last three repetitions. Subjects performed all exercises bilaterally.

For the hip/core program, subjects initially performed non-weight bearing exercises designed to target the hip muscles and activate the core muscles (Table 1).[18] They then progressed to weight bearing exercises. While subjects indirectly activated the quadriceps during the weight bearing exercises, the exercises were designed to specifically target the hip and core muscles. The knee program had a similar progression (Table 2).[18] Subjects initially performed non-weight bearing knee extensor exercises and progressed to weight bearing. While some of the exercises indirectly activated the hip muscles, they also were designed to primarily target the knee extensors. Subjects were not given any verbal cue to activate the core during the knee extensor weight bearing exercises.[18]

Table 1. *Hip/core Exercise Protocol[18] (reproduced with permission from the Journal of Athletic Training, National Athletic Trainers' Association, Carrollton, TX)*

Week	Exercise	Sets, No.	Repetitions or Seconds, s
1	Hip abduction - standing	3	10
	Hip external rotator - standing	3	10
	Hip external rotator - seated	3	10
2	Hip abduction - standing	3	10
	Hip internal rotator - standing	3	10
	Hip external rotator - standing	3	10
3	Hip abduction - standing	3	10 (with stronger band)
	Hip internal rotator - standing	3	10 (with stronger band)
	Hip external rotator - standing	3	10 (with stronger band)
	Balancing 2 feet-Airex[a] pad	3	30-45 sec
4-6	Hip extension @ 45^{o} - standing	3	10-15
	Hip internal rotator - standing	3	10-15
	Hip external rotator - standing	3	10-15
	Balancing 1 foot-Airex[a] pad	3	45-60 sec

[a] Airex AG, Sins, Switzerland.

Table 2. *Knee Exercise Protocol[18] (reproduced with permission from the Journal of Athletic Training, National Athletic Trainers' Association, Carrollton, TX)*

Week	Exercise	Sets, No.	Repetitions or Seconds,
1	Isometric quadriceps setting	3	10
	Knee extensions -standing	3	10
	Double-legged, one-quarter squats	3	10
2	Isometric quadriceps setting	3	15
	Double-legged, one-half squats	3	15
	Terminal knee extension with Theraband[a]	3	15
	Double-legged, one-quarter squats	3	30 s
3	Double-legged, one-half squats	3	10
	Single-legged, one-quarter squats	3	10
	Double-legged, one-quarter squats	3	10
	Terminal-knee extension with Theraband[a]	3	10 (with stronger band)
4	Single-legged, one-half squats	3	10
	Forward, one-quarter lunges	3	10
	Lateral step-down (4-in [3.6-cm] step)	3	10
	Forward step-down (4-in [3.6-cm] step)	3	10
	Double-legged, one-half wall squats	3	30 s
5-6	Double-legged wall squats (to maximum 90^{o} knee flexion)	3	45-60 s
	Lateral step-down (6-10-in [5.6-9.6-cm] step)	3	15
	Forward step-down (6-10-in [5.6-9.6-cm] step)	3	15
	Forward one-half full lunge (to maximum 90^{o} knee flexion)	3	15
	Single-legged one-half full lunge (to maximum 90^{o} knee flexion)	3	15

[a] TheraBand, Hygenic Corp, Akron, OH.

Statistical Analysis

An intention-to-treat analysis, using a conservative method where missing data were replaced with the last score carried forward, was used. Separate Chi-square analyses were conducted to determine if any between-group differences existed with respect to demographic data as well as baseline pain (VAS score) and patient-reported function (AKPS score). Separate mixed-model 2 (sex) X 2 (rehabilitation group) X 2 (time) ANOVAs with repeated measures on time were used to determine differences in the primary variables (VAS and AKPS scores). Separate mixed-model 2 (sex) X 2 (time) ANOVAs with repeated measures on time also were used to determine differences in the sec-

Table 3. *Mean ± (standard deviation) of demographic data for subjects who completed either a hip/core- or knee-based rehabilitation program.*

	Hip/Core (N = 105)	Knee (N = 80)	*p*-value[a]
Sex, Female	73 (69.5%)	51 (63.7%)	0.41
Age, y	29.4 (0.7)	29.3 (0.9)	0.47
Mass, kg	67.0 (1.3)	71.1 (1.7)	0.68
Height, cm	170.0 (1.0)	171.2 (1.0)	0.41
VAS[b], cm	5.2 (0.2)	5.0 (0.2)	0.59
AKPS[c], points	75.1 (1.0)	76.2 (1.0)	0.52
Knee, Right	57 (54.3%)	38 (47.5%)	0.27

[a] Chi-square statistic
[b] 10-cm visual analog scale for average pain during activity for the prior week
[c] 100-point Anterior Knee Pain Scale

ondary variables (hip and knee isometric strength) for subjects classified as treatment responders. The same analyses were conducted for treatment non-responders. Effect sizes (Cohen's *d*) were calculated and interpreted as follows: 0.20 (small); 0.50 (medium); and 0.80 (large).[36] All statistical analyses were conducted using IBM SPSS Version 23.0 (IBM SPSS, Inc, Armonk, NY) at the 0.05 level of significance.

RESULTS

Both groups were equal with respect to demographics, pain, and function (Table 3). One-hundred-twenty-four patients (67%) met the *a priori* definition for treatment success (responders). Eight-eight females (71%) and 36 males (59%) responded favorably; 36 females (29%) and 25 males (41%) responded unfavorably. For the primary variables (pain and patient-reported function), a significant reduction in VAS ($F_{1,181}$ = 206.6; $p < 0.0001$; Table 4) and improvement in AKPS ($F_{1,181}$ = 160.4; $p < 0.0001$; Table 4) scores occurred regardless of sex or rehabilitation group. These differences also had large effect sizes (Cohen's *d*) exceeding 0.80 (Table 4).

For the secondary variables (isometric hip and knee strength), male and female responders exhibited improved hip abductor ($F_{1,122}$ = 6.6; p = 0.007), hip extensor ($F_{1,122}$ = 19.3; $p < 0.0001$), and knee extensor ($F_{1,122}$ = 16.0; $p < 0.0001$) strength (Table 5). While a similar pattern occurred for the hip external rotators ($F_{1,122}$ = 13.7; $p < 0.0001$), a trend for an interaction between sex and time ($F_{1,122}$ = 3.6; p = 0.06) existed. Males had small-to-medium effect sizes for changes in isometric hip extensor (Cohen's *d* = 0.36) and external rotator (Cohen's *d* = 0.38) strength (Table 5). Effect sizes for changes in female isometric hip and knee strength ranged from 0.15 to 0.28 (Table 5). No significant changes existed for males or females classified as non-responders ($p > 0.05$; Table 5). Their effect sizes were small, ranging from -0.05 to 0.18 (Table 5).

DISCUSSION

The primary purpose of this study was to compare improvements in pain and patient-reported function between males and females with PFP who participated in either a hip/core or knee rehabilitation program. The directional hypothesis was that females

Table 4. *Mean ± (standard deviation) for pain and patient-reported function before and after completion of either a hip/core or knee rehabilitation program. All subjects, regardless of group or sex, exhibited similar improvements in visual analog scale (VAS) and Anterior Knee Pain Scale (AKPS) scores.*

	Baseline		6-week		% Change		Cohen's *d*	
	Male N = 61	Female N = 124	Male	Female	Male	Female	Male	Female
VAS[a], cm								
Hip/Core	5.0 (1.7)	5.3 (1.7)	2.6 (2.4)	2.4 (2.2)	48.1%	54.7%	1.15	1.48
Knee	4.4 (1.5)	5.3 (1.6)	2.0 (2.1)	2.8 (2.3)	54.5%	47.2%	1.32	1.26
AKPS[a], points								
Hip/Core	76.3 (9.5)	74.5 (10.1)	86.6 (13.8)	87.9 (9.6)	13.5%	18.0%	0.87	1.36
Knee	78.0 (8.8)	75.2 (9.6)	87.1 (10.4)	87.0 (11.3)	11.7%	15.7%	0.95	1.13

[a] $p < 0.0001$

Table 5. *Mean ± (standard deviation) for isometric force measures (% body mass) for responders and non-responders, regardless of intervention assignment.*

	Baseline		6-week		% Change		Cohen's *d*	
	Male	Female	Male	Female	Male	Female	Male	Female
Responders	N = 36	N = 88						
Non-Responders	N = 25	N = 36						
Hip Abductors								
Responders[a]	38.8 (13.0)	32.2 (10.6)	41.0 (13.6)	34.6 (10.7)	5.7%	7.4%	0.16	0.23
Non-Responders[b]	39.2 (10.4)	33.8 (11.7)	40.4 (9.9)	34.0 (11.6)	3.1%	0.6%	0.12	0.02
Hip Extensors								
Responders[c]	27.4 (10.6)	22.1 (9.8)	31.4 (11.5)	25.0 (11.4)	14.6%	13.1%	0.36	0.27
Non-Responders[b]	31.8 (10.9)	23.6 (11.7)	31.3 (11.1)	25.2 (12.4)	-1.6%	6.8%	-0.05	0.13
Hip External Rotators								
Responders	13.0 (5.7)	12.0 (4.1)	15.0 (4.9)	12.6 (3.9)	15.4%	5.0%	0.38	0.15
Non-Responders[b]	14.1 (3.4)	11.6 (4.0)	14.7 (3.1)	12.0 (4.5)	6.0%	3.4%	0.18	0.09
Knee Extensors								
Responders[c]	44.9 (16.0)	37.4 (13.9)	50.0 (14.9)	41.3 (14.3)	11.4%	10.4%	0.33	0.28
Non-Responders[b]	47.5 (14.7)	39.7 (18.5)	47.8 (15.1)	40.5 (17.4)	0.6%	2.0%	0.02	0.04

[a] Significant increase in strength regardless of sex; $p = 0.007$

[b] No change in strength regardless of sex; $p > 0.05$

[c] Significant increase in strength regardless of sex; $p < 0.0001$

would respond more favorably than males to the hip/core rehabilitation program and males would respond more favorably to the knee program. This hypothesis was not supported as males and females had similar improvements in pain and patient-reported function regardless of intervention. Based solely on these findings, patients with PFP may benefit from a hip/core or knee program regardless of sex.

Although 124 (67%) subjects responded favorably to treatment, one-third of subjects did not. It was noteworthy that only 36 (29%) females responded unfavorably compared to 25 (41%) males. Different patterns of strength gains between males and females who responded favorably or unfavorably may explain this disparity (Table 5).

Isometric Hip and Knee Strength Changes

Hip Abductor Strength

Overall, all subjects made minimal, if any, improvements in isometric hip abductor strength. Although female responders showed the greatest gain, the increase was only 7.4% compared to 5.7% for male responders. Differences for male and female non-responders were even smaller. This pattern suggested that hip abductor strength improvement was not clinically important and not necessarily as important as previously thought.[37]

Another reason may be that subjects had no hip abductor weakness. Researchers have reported isometric hip abductor weakness in females with PFP ranging from 22.5%BM[29] to 29.0%BM.[38] On average, all females in our study had values exceeding 30%BM, suggesting no hip abductor weakness. The same reason most likely explained the difference noted in males. Although baseline strength measures for male responders (38.8%BM) and non-responders (39.3%BM) were slightly less than reported controls (40.0%BM),[29] the difference was negligible. Interestingly, all males, regardless of treatment effect, had average hip abductor strength similar to reported controls[24] after completing rehabilitation.

Hip Extensor Strength

More meaningful comparisons in hip extensor strength occurred between responders and non-responders. Hip extensor strength improved 14.6% and 13.1% for male and female responders, respectively, compared to -1.6% and 6.8% for male and female non-responders. It was noteworthy that baseline values for male and female responders were 16% and 7% less than male and female non-responders. This finding suggested that responders exhibited hip extensor weakness that improved with rehabilitation and achieved strength values similar to reported controls.[24]

Unlike isometric hip abductor strength values, more limited data exist for hip extensor strength for females with and without PFP. Robinson and Nee[34] reported strength values of 23%BM and 48%BM for females with and without PFP. Although none of our females achieved strength gains similar to Robinson and Nee controls, female responders almost had a two times greater (13.1% versus 6.8%) percentage increase in hip extensor strength than non-responders. Like males, these females may have represented a cohort with hip extensor weakness that improved with rehabilitation.

Hip External Rotators

The most interesting comparison was hip external rotator strength changes. Though not significant, a trend ($F_{1,122}$ = 3.6; p = 0.06) for an interaction between sex and strength gains existed for responders. Male responders had an 8% lower baseline value than non-responders that increased by 15.4%. This strength increase also had the highest effect size (Cohen's d = 0.38) of all other strength measures and exceeded values for reported controls (14.3%BM).[24] Like hip abductor and extensor strength changes, this cohort most likely had weakness that improved with rehabilitation.

Unlike males, female responders had a modest 5.0% increase in hip external rotator strength. This increase also was over 2.5 times less compared to the 13.1% strength increase observed for the hip extensors. This finding suggested that hip external rotator strength may be less important for females than males. This result also aligned with the importance of hip extensor function in females with PFP during running and a single-leg step-down task.[31,39]

Knee Extensors

Knee extensor strength patterns between responders and non-responders were similar to the hip extensors. Knee extensor strength improved 11.4% and 10.4% for male and female responders, respectively, compared to 0.6% and 2.0% for male and female non-responders. Baseline values for male and female responders both were 6% less than male and female non-responders. This finding suggested that responders exhibited knee extensor weakness that improved with rehabilitation. At the end of rehabilitation, only male responders had strength values similar to reported controls.[24] Post-rehabilitation knee extensor strength for female responders exceeded non-responders. All females, regardless of treatment response, had higher strength values than reported controls.[40]

Clinical Implications

Although a very common problem, PFP has been one of the most clinically challenging pathologies to manage because of its multifactor nature. Its complexity has led to emerging evidence aimed at identifying clinical subgroups to direct treatment.[41,42] Findings from the current study have provided preliminary data for a possible effect of sex on treatment development and implementation.

Interestingly, hip abductor strength gains did not appear as important as previously thought. However, responders could have experienced improvements in neuromuscular factors. A certain cohort of subjects could have alterations in gluteus medius, vastus medialis and/or lateralis onsets or amplitudes during functional activities that improved with rehabilitation.[27,43,44]

The most compelling finding was the pattern of change with hip extensor and hip external rotator strength. While male and female responders experienced similar hip extensor strength gains, only male responders had meaningful hip external rotator strength increases. This result suggested that male responders exhibited both hip extensor and hip external rotator strength deficits that improved with rehabilitation. Therefore, interventions that target the hip external rotators may be more beneficial for males than females. Finally, all male and female responders exhibited baseline knee extensor weakness compared to non-responders. The fact that responders benefited from either exercise program further highlighted the importance of exercise and quadriceps function.[45]

Limitations

This study was not without limitations. First, isometric hip and knee strength, instead of other measures such as eccentric strength and muscle endurance, were assessed. Isometric strength was assessed because data were collected at multiple study sites and the methods used had established reliability.[29,46] Other measures of muscle function may have provided additional insight. Second, pain, patient-reported function, and strength changes may have resulted from improved muscle neuromuscular activity in the tested muscles. This determination could not be made since electromyographic data were not collected. Finally, this study did not have a control group to know if subjects would have improved without treatment. Van Linschoten et al[47] reported superior short- and long-term outcomes for patients with PFP who participated in supervised exercise compared to patients who received a "wait-and-see" approach of rest and activity modification. Others also have reported both short- and long-term benefits with rehabilitation exercises.[17,48] For these reasons, a control group most likely would have provided minimal, if any, additional information.

CONCLUSION

This study was the first to examine between-sex differences for individuals with PFP who participated in either a hip/core or knee rehabilitation program. Nearly 70% of subjects had improved pain, patient-reported function, and strength after completing either program. Responders exhibited lower baseline strength measures for most muscle groups compared to non-responders. This comparison suggested that those with PFP had weakness and responded to either intervention. When prescribing exercises, clinicians should consider that males may benefit more from hip extensor and external rotator exercises and females to hip extensor exercise. It was noteworthy that one-third of subjects did not respond favorably to either intervention. This finding further supported the need to identify subgroups of patients that may benefit from other intervention strategies. While researchers recently have examined this issue,[41,42] ongoing studies that consider sex influences are needed to advance the treatment of individuals with PFP.

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