KORNELIA KULIG, PT, PhD, FAPTA[1] • **JOHN M. POPOVICH, JR,** DPT, PhD[2]
LISA M. NOCETI-DEWIT, DPT, OCS, ATC[3] • **STEPHEN F. REISCHL,** DPT, OCS[4] • **DONG KIM,** BS[5]

Women With Posterior Tibial Tendon Dysfunction Have Diminished Ankle and Hip Muscle Performance

Persons with acquired flatfoot deformity demonstrate impaired walking performance, as indicated by slower walking speed and frequent reports of foot pain during activity and at rest.[25,29] There is no doubt that acquired flatfoot deformity is accompanied by some level of tibialis posterior tendon dysfunction. The tibialis posterior functions to create a rigid foot segment by stabilizing the midfoot[37] and assists in generating energy, by the plantar flexors in terminal stance, to produce successful propulsion.[41] Laboratory studies confirm that persons with acquired flatfoot deformity demonstrate decreased and delayed activation of the tibialis posterior muscle, often resulting in prolonged pronation during the latter stance phases of walking gait,[21,30,32] and decreased functional strength (ie, single-limb heel rise performance) of the ankle.[2] Prolonged pronation likely overloads the posterior tibialis tendon, resulting in localized degenerative changes, impaired muscle strength capacity, and pain. In the presence of flatfoot deformity, the result is typically increased hindfoot eversion,[16,17] increased transverse plane foot motion,[28,29,38] inefficient propulsion during locomotion,[32] and diminished plantar flexion moment.[28,32]

STUDY DESIGN: Controlled laboratory study using a cross-sectional design.

OBJECTIVES: To characterize ankle and hip muscle performance in women with posterior tibial tendon dysfunction (PTTD) and compare them to matched controls. We hypothesized that ankle plantar flexor strength, and hip extensor and abductor strength and endurance, would be diminished in women with PTTD and this impairment would be on the side of dysfunction.

BACKGROUND: Individuals with PTTD demonstrate impaired walking abilities. Walking gait is strongly dependent on the performance of calf and hip musculature.

METHODS: Thirty-four middle-aged women (17 with PTTD) participated. Ankle plantar flexor strength was assessed with the single-leg heel raise test. Hip muscle performance, including strength and endurance, were dynamometrically measured. Differences between groups and sides were assessed with a mixed-model analysis of variance.

RESULTS: Females with PTTD performed significantly fewer single-leg heel raises and repeated sagittal and frontal plane non–weight-bearing leg lifts, and also had lower hip extensor and abductor torques than age-matched controls. There were no differences between sides for hip strength and endurance measures for either group, but differences between sides in ankle strength measures were noted in both groups.

CONCLUSION: Women with PTTD demonstrated decreased ankle and hip muscle performance bilaterally. *J Orthop Sports Phys Ther 2011;41(9):687-694. doi:10.2519/jospt.2011.3427*

KEY WORDS: *acquired flatfoot deformity, PTTD, walking*

The actions of the hip extensors and abductors are essential during walking. The hip extensors absorb energy created by ground reaction forces during the early stance phase of gait,[3,41] and this necessitates adequate strength, power, and control. If any of these components are deficient, other joints in the lower extremity may compensate. The hip abductors function to prevent a frontal plane pelvis drop during stance in gait,[3] a role that, if impaired, may have kinematic consequences of a dropped pelvis, possibly followed by increased femoral adduction and internal rotation. This altered position of the femur likely influences distal joints and, potentially, lower extremity mechanics. Indeed, diminished hip performance has been documented

[1]Associate Professor of Clinical Physical Therapy, Jacquelin Perry Musculoskeletal Biomechanics Research Laboratory, University of Southern California, Division of Biokinesiology and Physical Therapy, Los Angeles, CA. [2]PhD candidate (at time of study), Jacquelin Perry Musculoskeletal Biomechanics Research Laboratory, University of Southern California, Division of Biokinesiology and Physical Therapy, Los Angeles, CA. [3]Adjunct Instructor of Clinical Physical Therapy, University of Southern California, Division of Biokinesiology and Physical Therapy, Los Angeles, CA. [4]Adjunct Associate Professor of Clinical Physical Therapy, University of Southern California, Division of Biokinesiology and Physical Therapy, Los Angeles, CA. [5]Student, Temple University, School of Podiatric Medicine, Philadelphia, PA. The experimental protocol of this study was approved by the University of Southern California Institutional Review Board. Address correspondence to Dr Kornelia Kulig, University of Southern California, Division of Biokinesiology and Physical Therapy, 1540 East Alcazar Street, CHP 155, Los Angeles, CA 90089-9006. E-mail: kulig@usc.edu

TABLE 1 Participant Characteristics, Activity Level, Function, Pain, and Foot Morphology*

	Control (n = 17)	Posterior Tibial Tendon Dysfunction (n = 17)	*P* Value
Age, y	50.7 ± 5.5	52.1 ± 7.5	.534
Height, m	1.66 ± 0.06	1.65 ± 0.05	.577
Mass, kg	74.4 ± 16.6	82.0 ± 18.5	.218
BMI, kg/m²	26.9 ± 5.9	29.5 ± 6.3	.196
Physical activity level (MET)	48.9 ± 11.2	42.2 ± 13.8	.130
6-minute walk test, m	571.5 ± 72.3	497.1 ± 89.6	.016
Pain after 6-minute walk test (0-100 mm)	1.2 ± 3.1	22.9 ± 23.8	.005
Arch index†	0.221 ± 0.042	0.158 ± 0.027	<.001

Abbreviations: BMI, body mass index; MET, metabolic equivalent.
**Values are mean ± SD.*
†Navicular height (mm) over the truncated foot length (mm). Arch index data were collapsed by side, as there was no significant main effect for side (P = .261); however, there was a significant group main effect (P<.001, F = 31.624, df = 1).

in persons with knee pathologies.[18] However, the same has not been established for persons with foot and ankle problems.

Therefore, the purpose of this study is to characterize ankle and hip muscle performance in women with posterior tibialis tendon dysfunction (PTTD), and to compare them to matched controls. We hypothesized that ankle plantar flexor strength and hip muscle strength and endurance would be diminished in women with PTTD, and that this impairment would be greater on the side of the dysfunction.

METHODS

Participants

Two groups of participants were recruited and consented prior to enrollment in the study. Seventeen females with unilateral early stage PTTD (9 had symptoms on the right), between the ages of 43 and 66 years, comprised the experimental group, and 17 pain-free, age-matched females served as a control group. The groups were similar in terms of age, height, and body mass (**TABLE 1**). In general, both groups consisted of professionally active females. Only females were studied because of the higher incidence of PTTD in females compared to males,[13,15] and to avoid combining genders, which would have introduced an unknown factor not accounted for in a study with a small sample size. Participants in the PTTD group were recruited from orthopaedic clinics in the Los Angeles area, and participants in the control group were recruited by verbal or written communications in the same geographical region. The protocol for this study was approved by The Institutional Review Board of the University of Southern California.

Potential participants with PTTD were screened through medical history and physical examination by a surgeon and a licensed physical therapist. Those who met the following criteria were enrolled into the experimental group: (1) pain located along the medial ankle, either superior to the medial malleolus or inferior to the medial malleolus towards the navicular, (2) pain reproduced on palpation of the posterior tibialis tendon, (3) flattened and abducted midfoot posture during standing, and (4) absence of rigid foot deformity, as determined by passive joint testing. Potential participants were excluded if they had any of the following conditions: fixed foot deformities, previous foot surgery, or cardiovascular, neurovascular, peripheral vascular, or musculoskeletal pathology that might have limited participation in the study.

Instrumentation, Questionnaires, and Functional Tests

Plantar flexion performance, bilaterally, was assessed by the number of successful and complete single-leg heel raises performed. The single-leg heel raise task is considered a clinical test of plantar flexor strength[22,27] and posterior tibialis muscle function.[17]

Bilateral hip extensor and hip abductor isometric strength and endurance were assessed using the PrimusRS dynamometer (BTE Technologies, Hanover, MD). In healthy participants, the test-retest reliability assessed by ICC for hip strength was 0.87 (extension) and 0.80 (abduction), and for hip endurance was 0.88 (extension) and 0.27 (abduction).

Pain, stiffness, functional difficulty, and activity limitations were assessed with the Foot Functional Index-revised, which is a self-reported questionnaire.[6] Each question is scored on a Likert scale, with 1 representing no pain/stiffness/difficulty/limitation and 6 the most painful/stiff/difficult/limiting. The foot pain category, comprised of 11 questions, assessed the level of pain during various conditions, such as standing without shoes. Eight questions assessed the severity of foot stiffness experienced in different situations. Twenty questions comprised the functional difficulty category, in which participants indicated their level of difficulty performing functional activities, such as maintaining balance. Nine questions determined the amount of limitation in recreational activities. Nineteen questions addressing aspects such as embarrassment and personal concerns were included in the personal category. Discrete category scores and composite scores were each calculated and recorded. The Foot Functional Index-revised is a valid and reliable measure.[6]

Physical activity was assessed using the physical activity scale, a 24-hour, self-administered activity questionnaire.[1] This self-reported questionnaire assesses activity level on a day selected by the participant to represent an average day in the past week. The physical activity scale has been reported to be a reliable and valid measure.[1] The results are presented in metabolic equivalent value (MET) according to task.

Functional walking performance was assessed using the 6-minute walk test (6MWT), a measure of the distance that a person can walk at a comfortable, purposeful, self-selected pace in 6 minutes. Normative values have been established in persons aged 20 and above,[11,14,36] and this test has been used in determining physical fitness levels in individuals with obesity.[26] The reliability of the 6MWT has been reported to be 0.94 to 0.96.[36]

Foot pain perceived immediately after the 6MWT was assessed using a visual analog scale (VAS). This scale allows participants to mark their level of pain along a 100-mm line, with endpoints of 0 (no pain) and 100 (worst pain imaginable). The VAS has been determined to be a valid and reliable measure.[8,34]

Procedures

Prior to testing, each procedure was carefully explained. First, potential participants were contacted by phone to review the inclusion and exclusion criteria. Following the phone call, participants were personally screened, and each participant's age, height, body mass, navicular height, and truncated foot length were recorded. The navicular height and truncated foot length were used to calculate arch index.[40] Each participant was asked, and readily answered, the question "Which leg would you stand on to kick a ball?" In the control group, the limb that was used to stand on was deemed the dominant limb for between-group comparisons with the involved side of the PTTD group. A systems screening of current and past medical and surgical history was then reviewed and recorded.

All testing, performed in the order listed below, took place at the Musculoskeletal Biomechanics Research Laboratory at the University of Southern California.

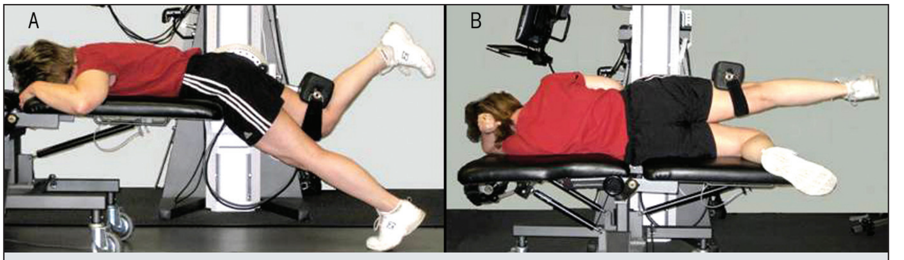

FIGURE 1. Hip muscle performance (strength and endurance) testing position using BTE dynamometer. (A) Hip extension, (B) hip abduction.

Plantar flexor performance was performed with bare feet. Hip strength and endurance were performed on the involved and noninvolved lower extremities. The 6MWT was performed indoors.

Ankle Plantar Flexor Strength Evaluation To evaluate plantar flexor strength, participants were instructed to stand on 1 limb, maintain the stance limb's knee in extension, and maximally raise their heel using light hand support for balance.[22,27] The test was terminated when the participant's stance knee flexed or excessive weight was put through the supporting hand, or the height of the heel raise was diminished. Testing of the contralateral limb followed.

Hip Extensor Strength Evaluation To determine the peak isometric hip extensor torque, participants were positioned in prone, with bilateral lower extremities off the edge of the dynamometer's testing table. The hip was positioned in 30° of flexion and the knee was flexed to 90° (**FIGURE 1A**). The axis of rotation of the dynamometer was aligned with the center of the hip joint in the sagittal plane. The lever arm was attached to a resistance pad positioned slightly superior to the popliteal space. Participants performed a 5-second isometric contraction for each strength-testing assessment. To facilitate a maximal effort, participants received verbal encouragement. A total of 3 trials were collected for each limb. A 1-minute rest was given between each trial. Peak torque values, obtained by averaging trials, were extracted, normalized to body weight (Nm/kg), and used as an outcome measure for hip extensor strength.

Hip Abductor Strength Evaluation For hip abductor isometric torque testing, participants were placed in sidelying on the dynamometer's testing table (**FIGURE 1B**). The target hip was positioned on the ceiling side of the table and in a neutral position (0° flexion, 0° abduction, 0° transverse plane rotation). The axis of the dynamometer was aligned with the center of the hip joint in the frontal plane. The lever arm was attached to a resistance pad, which was positioned at the participant's lateral femoral epicondyle of the lower extremity being tested. Participants performed a 5-second isometric contraction. To facilitate a maximal effort, participants received verbal encouragement. A total of 3 trials were collected for each limb. A 1-minute rest was given between each trial. Peak torque values, obtained by averaging trials, were extracted, normalized to body weight (Nm/kg), and used as an outcome measure for hip abductor strength.

Hip Extensor Endurance Evaluation To evaluate hip extensor endurance, participants were positioned as they were for the hip extensor strength testing. The dynamometer was set in the isotonic mode at 10% of each participant's body mass, and participants were instructed to move against the resistance as many times as they were able, at a rate of 25 repetitions per minute. To encourage participants to meet the preset torque and rate of repetition, the investigator provided verbal encouragement, using a firm and rhythmical voice: "up-down, up-down…" The test was terminated if the participant was unable to maintain a minimum of 50% power, as determined by the range of motion and rate, or until volitional failure. A 2- to 3-minute rest was provided prior to performing the endurance test on the contralateral limb. The number of successful repetitions, with the predetermined criteria, was used as the outcome measure for hip extensor endurance.

Hip Abductor Endurance Evaluation To evaluate hip abductor endurance, participants were positioned as they were for the hip abductor strength testing. The dynamometer was set in the isotonic mode, at 10% of each participant's body mass, and the participants were instructed to move against resistance as many times as they were able, at a rate of 25 repetitions per minute. The investigator provided verbal encouragement to meet the preset torque and rate of repetition, using a firm and rhythmical voice: "up-down, up-down..." The test was terminated if the participant was unable to maintain a minimum of 50% power, as determined by the range of motion and rate, or until volitional failure. A 2- to 3-minute rest was provided prior to performing the endurance test on the contralateral limb. The number of successful repetitions, with the predetermined criteria, was used as the outcome measure for hip abductor endurance.

Walking Performance To evaluate walking performance, participants were instructed to walk in their shoes at a self-selected but goal-oriented pace for 6 minutes back and forth along a 137-m hallway. Verbal reassurance was provided every 180 m to promote optimal effort. The distance covered in 6 minutes was measured and recorded.

Sample Size Determination

A sample size of 32 participants (16 women per group) was determined via power analysis on preliminary data from 16 participants (8 per group). To detect difference between groups, a *t* test sample size was performed based on an alpha level of .05 and power values of 0.8.

Statistical Analyses

A 2-way (group by side) mixed-model analysis of variance was performed to determine if arch index, ankle plantar flexor strength, and hip strength and endurance measures differed between the 2 groups and between sides. For these analyses, the dominant limb and nondominant limb in the control group were treated as the involved and uninvolved limbs, respectively. Independent *t* tests were performed to determine if the 6MWT, pain following the 6MWT, and self-reported questionnaires differed between groups. Statistical analyses were performed using SPSS statistical software (SPSS Inc, Chicago, IL), with significance level of $P \leqslant .05$.

TABLE 2 Foot Functional Index-revised*

Foot Functional Index	Control (n = 17)	Posterior Tibial Tendon Dysfunction (n = 17)	*P* Value
Pain†	11.8 ± 2.3	25.4 ± 7.8	<.001
Stiffness‡	9.1 ± 1.7	16.4 ± 6.8	<.001
Limitation§	8.6 ± 1.4	16.0 ± 10.3	.010
Difficulty‖	20.5 ± 1.2	44.8 ± 16.4	<.001
Social¶	20.4 ± 3.1	42.1 ± 16.4	<.001
Total#	70.4 ± 5.7	144.6 ± 46.6	<.001

**Values are mean ± SD.*
†No pain, 11 points; worst pain, 66 points.
‡No stiffness, 8 points; worst stiffness, 48 points.
§No limitations, 9 points; worst limitations, 54 points.
‖No difficulty, 20 points; worst difficulty, 120 points.
¶No issues, 19 points; worst issues, 114 points.
#Lowest (best) index, 67; highest (worst) index, 402 points.

RESULTS

Demographic, Morphologic, Functional, and Disability Group Comparisons

The groups were similar in age, height, body mass, body mass index, and 24-hour physical activity. There was no interaction between group and side for arch index (*P* = .841). There was no significant main effect for side (*P* = .261). However, there was a significant main effect for group (*P*<.001, F = 31.624, *df* = 1), which indicated that individuals with PTTD had flatter feet, in general, than controls. Individuals with PTTD walked significantly (*P* = .016) shorter distances in 6 minutes than controls (mean ± SD, 497.1 ± 89.6 versus 571.5 ± 72.3 m). The participants with PTTD experienced significantly (*P*<.005) more pain after the 6MWT (mean ± SD VAS score, 22.9 ± 23.8) than controls. Discrete and composite scores on the Foot Functional Index-revised were significantly higher in individuals with PTTD as compared to their age-matched controls (**TABLE 2**).

Ankle Plantar Flexor Strength Evaluation

There was no interaction between group and side for ankle plantar flexor strength (*P* = .345). There was a significant main effect for group (*P*<.001, F = 22.329, *df* = 1) and main effect for side (*P*<.001, F = 19.266, *df* = 1), indicating that individuals with PTTD performed fewer repetitions than controls, and that both groups performed fewer repetitions on the involved (or dominant) limb. On average, females with PTTD exhibited lower (63.1%) ankle plantar flexor strength, when compared to the control group (mean collapsed across sides ± SD, 7.4 ± 3.9 versus 20.1 ± 10.3, respectively) (**FIGURE 2**).

Hip Extensor Strength Evaluation

There was no significant interaction for hip extensor torque between group and side (*P* = .496), nor was there a significant main effect for side (*P* = .779). There was a significant main effect for group (*P* = .012, F = 7.189, *df* = 1). Females with PTTD generated significantly less (33.8%) peak normalized isometric hip

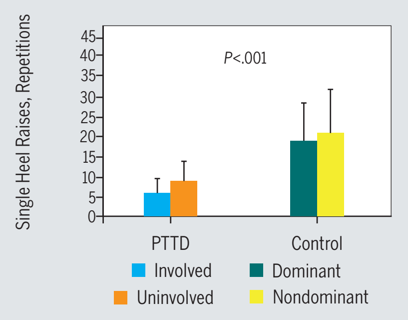

FIGURE 2. Calf performance in single-leg heel rises for both sides and both groups. Error bars denote ±1 SD. There was a significant main effect for side (*P*<.001) and group (*P*<.001), indicating that both groups performed fewer repetitions on the involved (or dominant) limb and that individuals with posterior tibial tendon dysfunction (PTTD) performed fewer than the control participants.

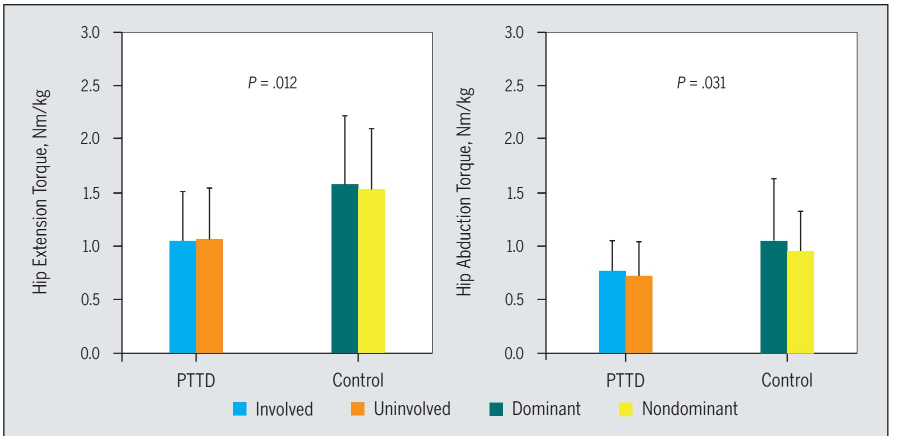

FIGURE 3. Hip muscle performance (A) extensor and (B) abductor torque, normalized to body mass, for both sides and both groups. Error bars denote ±1 SD. Abbreviation: PTTD, posterior tibial tendon dysfunction.

extensor torque than the control group (mean collapsed across sides ± SD, 1.05 ± 0.46 versus 1.55 ± 0.60 Nm/kg of body mass, respectively) (**FIGURE 3A**).

Hip Abductor Strength Evaluation

There was no significant interaction for hip abductor torque between group and side (*P* = .576), nor was there a significant main effect for side (*P* = .220). There was a significant main effect for group (*P* = .031, F = 5.116, *df* = 1). Individuals in the PTTD group generated significantly less (28.4%) hip abductor torque, when compared to the control group (mean collapsed across sides ± SD, 0.74 ± 0.3 versus 1.03 ± 0.59 Nm/kg of body mass, respectively) (**FIGURE 3B**).

Hip Extensor Endurance Evaluation

There was no significant interaction for hip extensor endurance between group and side (*P* = .940), nor was there a significant main effect for side (*P* = .835). There was a significant main effect for group (*P* = .028, F = 5.331, *df* = 1). Females with PTTD exhibited less (38.5%) hip extensor endurance, as measured by the number of repetitions performed at 10% of body weight, when compared to the control group (mean collapsed across sides ± SD, 28.8 ± 12.9 versus 46.9 ± 28.7 repetitions, respectively) (**FIGURE 4A**).

Hip Abductor Endurance Evaluation

There was no significant interaction for hip abductor endurance between group and side (*P* = .274), nor was there a significant main effect for side (*P* = .490). There was a significant main effect for group (*P* = .028, F = 5.339, *df* = 1). Females with PTTD exhibited less (27.1%) hip abductor endurance, measured by the number of repetitions performed at 10% of body weight, when compared to the control group (mean collapsed across sides ± SD, 17.2 ± 7.7 versus 23.6 ± 8.1 repetitions, respectively) (**FIGURE 4B**).

DISCUSSION

Women with PTTD demonstrated impaired bilateral ankle plantar flexor and hip extensor and abductor performance, when compared to age-matched controls. This did not support our secondary hypothesis that the ipsilateral ankle and hip would be weaker. Consistent with our previous work, significant deficits were evident for women in the PTTD group in total walking distance and reported pain after the walking test.[25]

Ankle plantar flexor strength was significantly lower in women with PTTD than in controls (7 versus 20 single-leg heel raises, respectively), accounting for a 63% deficit, which is often seen in otherwise healthy older adults.[4,10,33] Ankle plantar flexor power during walking is the greatest predictor of step length and walking velocity in older adults,[4,20] and in individuals with chronic venous insufficiency.[39] Along with the study's finding of decreased ankle plantar flexor power bilaterally, women with PTTD had a 33.8% deficit of maximum torque of the hip extensors. If the assumed[10,33] compensatory resources from the hip are not readily available when walking for a prolonged period, secondary to weakness, new, less adaptable walking patterns may develop, resulting in mechanical overload of 1 or more regions, decreased walking capacity, and preponderance for developing new symptoms.

Women with PTTD demonstrated impaired bilateral hip extensor performance, including strength and endurance, and bilateral hip abductor strength and endurance. This was contrary to our secondary hypothesis of unilateral impairment on the side of PTTD. Bilateral weakness of the ankles and hips may suggest disuse, and disuse is typically associated with decreased activity level. However, that was not supported by the results of the self-reported 24-hour physical activity scale. It is plausible, however, that women with PTTD adjusted to these impairments by doing the same activities but slower, to adapt to their condition or to avoid eliciting or increasing painful symptoms. It is worth noting that aver-

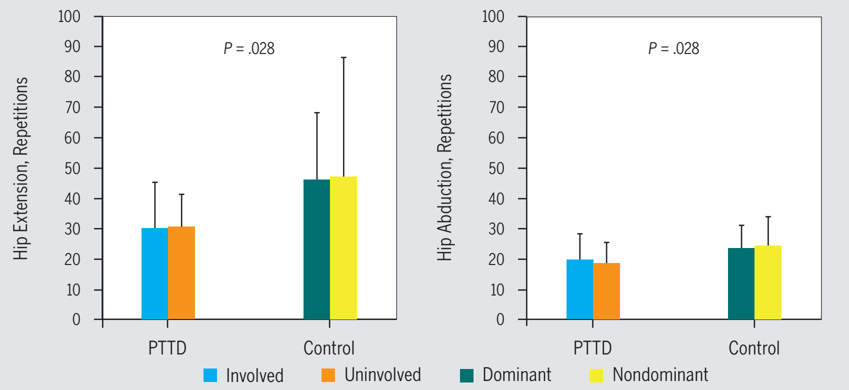

FIGURE 4. Hip muscle performance (A) extensor and (B) abductor endurance, measured in number of repetitions at 10% body mass resistance, performed in the isotonic mode, for both sides and both groups. Error bars denote ±1 SD. Abbreviation: PTTD, posterior tibial tendon dysfunction.

aged pain scores following the 6MWT were low, and that some participants with PTTD did not report pain. Chang et al[9] identified muscle strength, instead of pain, as the primary predictor of walking velocity in older adults. If the women had adjusted their walking velocity for multiple years, then general disuse might be the most likely cause of bilateral hip and calf muscle function deficits found in this population.

Stability of the pelvis in the frontal plane is essential for the single-limb stance phases of gait and effective propulsion. This action is largely controlled by the hip abductors.[3] In individuals with hip abductor weakness, a contralateral pelvic drop is typically observed during gait and other dynamic or static single-limb activities, though it is not the only compensation available. Individuals with PTTD demonstrated a 30% deficit in peak hip abductor production. When combined with deficiencies in hip extensor strength, the summative effect would be a reduction of hip external rotation moment, which might result in increased transverse plane motion of the femur. We hypothesize that the alterations in hip muscle performance, combined with the collapsed posture of the lower extremity, may result in undesirable lower extremity posture during single-limb stance, likely loading the hip and foot/ankle disproportionately.

The collapsed foot posture often seen in persons with PTTD is typically a result of chronic overuse. Interestingly, though symptomatic on one side, these women, compared to the control group, had a lower arch index on both sides, suggesting that the early stages of PTTD may not differentiate foot posture between sides. This chronic dysfunction and localized pathology often promotes further weakness of the posterior tibialis. The collapsed foot posture exacerbates the dysfunction by increasing the length of the tendon, altering the length-tension relationship, which affects the muscle's strength-producing capabilities. As the pathology progresses, increased hindfoot eversion[16] and midfoot abductus ("too many toes sign")[19] develop and contribute to the flatfoot deformity. The change in hindfoot position alters force production of the calf musculature, resulting in localized weakness and ineffective control of anterior tibial progression. If the entirety of the leg alignment is altered from the foot position, it is plausible that hip musculature may not be in an optimal position to capably produce force. Static postures of pronation have been shown to alter the position of the pelvis and joints of the lower extremity.[23,31] Therefore, it is plausible that alterations in the posterior tibialis muscle or tendon may increase demand on the frontal plane controllers of the hip, especially when a particular activity level is maintained. Though the original pathology may be localized to the posterior tibialis tendon, alterations of the frontal and transverse plane controllers of the hip may perpetually increase the demand on the posterior tibialis by ineffectively controlling the rate of femoral and tibial internal rotation, resulting in increased rate and/or duration of foot pronation.

There are few studies that suggest a relationship between foot and ankle pathology and hip muscle performance. Alterations in hip extensor and abductor electromyographic patterns following ankle injury have been documented,[5,7] and individuals with chronic ankle sprains have been shown to have diminished hip abductor strength on the involved side.[12] Snyder et al[35] investigated the effect of hip abductor and external rotator strengthening on rearfoot mechanics in runners. Following a 6-week hip strengthening intervention, there were significant decreases in eversion ROM and rearfoot inversion moment. This finding implies a functional cause-and-effect relationship between the hip and foot/ankle regions.

There are several limitations to this study. First, women between 43 and 66 years of age, with and without PTTD, were studied. This reflects the higher incidence of PTTD in females within this age range.[24] Thus the conclusions of the present study can only be applied to middle-aged women with early PTTD. Secondly, we chose to measure hip extensor and abductor performance via dynamometry, which is a performance measure not consistently used in the clinical setting. Thus reproduction of our results may not be as easily achieved with conventional manual muscle testing or handheld dynamometry. On the other hand, we used a clinical method to assess plantar flexor strength instead of dynamometry. Like all clinical performance tests, the single-heel raise test is prone to error related to the investigator's instruction and the participant's understanding and willingness to perform. We do feel, however, that both methods used in this study rendered valid results for the undertaken comparisons. Our between-side statistical comparison scheme did not match with self-identified leg dominance, as the majority of participants identified the right leg as the kicking leg and, in the PTTD group, 9 women had symptoms on the right and 8 on the left. However, this issue does not undermine the conclusion drawn from our study, as there was no difference in strength between sides.

Further research should be directed towards implementing an exercise regimen targeting not only the pathological tissue and joint (the posterior tibial tendon and foot and ankle, in this instance), but the hip musculature as well, so as to assess its impact on functional status measures, such as walking distance and strength, and pain levels. The influence of hip muscle performance and foot and ankle pathology and its effect on unilateral tasks is the focus of our further research. Furthermore, in individuals with PTTD compared to age-matched controls, kinematic analysis of transverse plane motion during gait and hip extensor and abductor torque production capabilities would be a future area of investigation.

CONCLUSION

The results of this study demonstrate significant differences of ankle plantar flexor strength, as well as bilateral hip extensor strength, bilateral hip extensor endurance, bilateral hip abductor strength, distance walked during the 6MWT, and pain after the 6MWT, in females with early stages of PTTD as compared to age-matched controls. These findings suggest that pathology in the foot/ankle is accompanied by diminished performance of the hip musculature. Clinical assessment of both regions and sides is suggested, and comprehensive treatment of this patient population is recommended. ◉

KEY POINTS

FINDINGS: Women with PTTD had decreased ankle plantar flexor strength, decreased walking distance in 6 minutes, decreased hip extensor muscle strength and endurance, and decreased hip abductor muscle strength and endurance, when compared to age-matched controls. A significant difference was not noted between groups in subjective activity level.

IMPLICATION: Evaluation of women with PTTD should include assessment of bilateral plantar flexor and hip extensor and abductor performance, as impairment may contribute to decreased activity and limited participation.

CAUTION: This study was performed only on middle-aged women with early stage PTTD.

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