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CASE REPORT

TREATMENT OF DISTAL ILIOTIBIAL BAND SYNDROME IN A LONG DISTANCE RUNNER WITH GAIT RE-TRAINING EMPHASIZING STEP RATE MANIPULATION

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ABSTRACT

Background & Purpose: Iliotibial band syndrome (ITBS) is a common injury associated with long distance running. Researchers have previously described biomechanical factors associated with ITBS. The purpose of this case report is to present the treatment outcomes in a runner with distal ITBS utilizing running gait re-training to increase step rate above the runner's preferred or self-chosen step rate.

Case Description: The subject was a 36 year old female runner with a diagnosis of left knee ITBS, whose pain prevented her from running greater than three miles for three months. Treadmill video analysis of running form was utilized to determine that the subject had an excessive stride length, strong heel strike, decreased knee flexion angle at initial foot contact, and excessive vertical displacement. Cadence was 168 steps/minute at a preferred running pace of 6.5 mph. Treatment emphasized gait re-training to increase cadence above preferred. Treatment also included iliotibial band flexibility and multi-plane eccentric lower extremity strengthening.

Outcomes: The subject reported running pain free within 6 weeks of the intervention with a maximum running distance of 7 miles and 10-15 miles/week progressing to half marathon distance and 20-25 miles/week at 4 month follow up. Step rate increased 5% to 176 steps/minute and was maintained at both the 6 week and 4 month follow up. 5K run pace improved from 8:45 to 8:20 minutes/Km. LEFS score improved from 71/80 to 80/80 at 4 month follow up.

Discussion: This case demonstrated that a 5% increased step rate above preferred along with a home exercise program for hip strengthening and iliotibial band stretching, improved running mechanics and reduced knee pain in a distance runner.

Key Words: Gait retraining, iliotibial band band syndrome, running

Level of Evidence: 4-single case report

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INTRODUCTION/BACKGROUND

Iliotibial band syndrome (ITBS) is the second most common cause of knee pain in runners and the most common cause of lateral knee pain.[1] ITBS is an overuse injury that has traditionally been described as being caused by friction or rubbing of the distal portion of the iliotibial band (ITB) over the lateral femoral condyle with repeated flexion and extension of the knee.[2] It has been noted that this friction is greatest at 20-30 degrees of knee flexion which occurs during the early portion of the stance phase of running.[3] This theory has been challenged; however, and recent studies have focused on the frontal and transverse plane mechanics of the knee and lower extremity that may contribute to the development of this injury.[4,5] The attachments and function of the ITB in gait seem to support the frontal and transverse plane focus. The ITB originates at the fascial components of the gluteus maximus, gluteus medius, and tensor fascia latae muscles and has distal attachments at the lateral border of the patella, lateral patellar retinaculum, and Gerdy's tubercle.[5] The ITB functions to provide stability of the lateral hip and resists knee adduction and internal rotation during the stance phase of the gait cycle.

Noehren et al[5] compared a group of female distance runners with ITBS to healthy matched controls through instrumented gait analysis. They found that the ITBS group exhibited significantly greater hip adduction and knee internal rotation than the control group. They hypothesized that these combined motions created excessive strain to the ITB as it attempted to decelerate hip adduction and knee internal rotation causing compression of its distal aspect against the lateral femoral condyle.[5] Ferber et al[6] found a similar conclusion as they compared a group of female recreational runners with healthy controls and found that the ITBS group had higher peak hip adduction and knee internal rotation angles than the controls.[6] These results suggest that atypical hip and knee mechanics are the primary factors in the development of ITBS. Finally, Hamill et al[4] reported that runners with ITBS had a greater strain rate of the ITB during midsupport of running gait which may be indicative of rapid, excessive, or decreased control of adduction and internal rotation of the knee and lower extremity.[4]

While the results of research have been able to provide some very significant information to clinicians regarding potential biomechanical causes or reasons for ITBS in runners, literature on treatment interventions specific to runners has been lacking.[7,8] Fredericson et al[2] described a multiple phase approach to treatment of ITBS in runners. Their treatment approach utilized three phases. The acute phase focused on activity modification and reduction of inflammation, the subacute phase emphasized flexibility exercises, massage, basic hip abductor and external rotator strengthening, and the recovery and strengthening phase progressed to multi-planar functional hip abductor strengthening exercises. After these three phases of treatment they then progress to a return to running phase, but that phase is nonspecific in regards to recommending changes to running mechanics with the exception of a brief mention for a recommendation toward faster paced running that they suggest would increase knee flexion at foot contact and help avoid the zone of impingement of the ITB.[2] Baker et al[9] then updated this multi-phase ITBS treatment approach with a greater emphasis on correcting faulty hip and knee mechanics through stretching and strengthening exercises, but again did not specifically address running mechanics or running gait re-training in their program.[9]

There has been, however, an abundance of recent research on running mechanics and gait re-training although not specific to ITBS. One of the most significant areas of research in this area has been regarding step rate manipulation and its effects on running mechanics. Heiderscheidt et al[10] assessed the effects of cadence manipulation on both running mechanics and impact forces by increasing step rate above a runner's preferred by 5% and 10%. They found that key components of running mechanics were improved including decreased heel strike, decreased braking impulse, decreased step length, and decreased vertical excursion. There was also a significant reduction in impact forces when comparing a runner's preferred step rate to step rates 5% or 10% slower than preferred. They also found that there was a substantial reduction in mechanical work performed at the knee with as little as 5% increase in step rate.[10] Hobara et al[11] performed a similar analysis and their results also showed decreased impact forces when step rate was increased above preferred.[11] Chumanov et al[12] further found that the gluteus medius and maximus demonstrated increased firing during late swing phase in anticipation of loading that was greater as the step rate was increased above preferred. They hypothesized that this increased hip muscle activity may be beneficial for runners with knee pain.[12] Current researchers have suggested that landing closer to the center of mass, utilizing a slight forward lean, and more knee flexion at initial contact leads to reduced loading forces.[10,11]

The purpose of this case report is to present the outcome of an intervention for ITBS that emphasized gait re-training with step rate manipulation in addition to traditional treatment methods such as flexibility and hip abductor strengthening exercises. This case demonstrates how step rate manipulation led to the occurrence of the desired factors of running mechanics mentioned above that have been associated with decreased impact forces. The author's hypothesize that the observed improved running mechanics influenced loading forces and led to an outcome of pain free running.

SUBJECT HISTORY/REVIEW OF SYSTEMS

The subject was a 36 year-old professional female who had been a recreational runner for approximately three years and participated in road races including 5K, 10K, and half marathons. Without symptoms, the subject ran 15-20 miles per week on paved roads or trails wearing neutral running shoes. The subject's chief complaint was left lateral knee pain that occurred with running. Onset of a dull aching pain at the left lateral knee would typically occur prior to the three-mile distance resulting in a stop of the run. This pain had been present for three months initially presenting itself as a sharp pain that made the left knee feel like it was locking up near the end of a half marathon relay run. The subject also noted right great toe pain that had been present since it was bumped when slipping on stairs on a date after the initial onset of her knee pain.

The subject was initially seen by a non-surgical orthopedist and was given a diagnosis of left ITBS. At the time of this visit, knee radiographs were obtained and showed no abnormalities. The physician referred the patient to physical therapy for assessment of running mechanics and a therapeutic exercise program. Prior to coming to physical therapy the subject had not received any formal treatments. Independently, the subject rested from running, performed light stretching, and continued to participate in gym based strength training, which was not painful. The subject noted a past history of right ITBS that resolved with rest and stretching. The subject's goal was to return to running pain free with the intent to train and complete a half or full marathon.

Based on the information gathered from the physician's report and in the subject's history, this subject was deemed appropriate for physical therapy evaluation with an emphasis on assessing running mechanics and form. The plan for evaluation was to assess lower extremity alignment in weight bearing and non-weight bearing, functional biomechanics, walking gait, flexibility/range of motion, strength, and to perform video analysis of running form. Video running analysis was planned, to include assessment of running form from the rear, side, and front views. As part of the running analysis cadence (steps/minute) would be counted and calculated by the therapist. Special tests of the knee joint, palpation, and observation of the knee also would be performed to help rule out potential differential diagnosis. This subject was deemed an excellent candidate for this type of evaluation and the possible intervention of step rate manipulation due to the presence of pain only with running, a history suggestive of an overuse injury with a biomechanical component, and negative radiographs.

EXAMINATION

Prior to the physical examination the subject completed a visual analog scale (VAS) where 0 is no pain and 10 is the most pain possible, to assess the current level of pain. The subject's baseline pain at rest was 0/10, but with running up to three miles was rated at 4/10. The subject also completed the Lower Extremity Functional Scale (LEFS) to evaluate functional status with regards to knee symptoms. This self-assessment functional tool has been shown to be both valid and reliable.[13] The subject's score on the lower extremity functional scale was 71/80, with 80 representing maximum function. Scores were reduced on each of the running specific items within the LEFS, representing the deficit from maximum function.

Physical evaluation of the subject revealed palpation tenderness at the left distal ITB of the lateral left knee. Knee joint effusion was not present and knee range of motion was full and pain free. McMurray's test was negative for meniscal pathology and varus and valgus stress tests showed excellent stability and were symptom free. Ober's test was positive bilaterally, hamstring flexibility of 75/90 bilaterally and mild piriformis tightness on the involved side with a figure four test were also observed. Manual muscle testing of the hip abductors was 4/5 on the left and 4+/5 on the right. All other LE manual muscle tests were 5/5.

Weight bearing alignment at rest showed that the patient had average medial arch height, vertical calcaneus and slightly varus knees. Non-weightbearing assessment of alignment found a mild rearfoot varus, mild ankle equinus, and a flexible first ray and mid-foot. Walking gait analysis was performed in the clinic gym utilizing both real time observation as well as slow motion video analysis. Walking gait analysis was significant for contralateral pelvic drop (bilateral), a supinatory biased gait, and a medial heel whip most likely consistent with tight calves.

Functional strength and movement testing found that single leg balance was good (30 second single leg stance completed), but the subject had a mild tendency to lose balance in a pronatory direction. The Star Excursion Balance Test was completed using the Functional Testing Grid (Total Gym, San Diego, CA). Reaches were performed in the anterior, medial, and posterior-medial rotational directions. The focus of this testing was on the quality of motion rather than maximum distance. This testing provided very meaningful information as the subject showed excessive dynamic knee valgus (knee adduction, mid-foot pronation, and contralateral pelvic drop with lateral trunk lean) of the left leg greater than the right most notable with medial reaches (frontal plane). The subject attempted to compensate for a deficiency in controlling dynamic knee valgus by keeping the knee in a varus or abducted position. When the testing challenged the compensatory comfort zone, the lack of control of dynamic knee valgus was noted. This was suggestive of hip abductor and external rotator weakness.

Video running analysis was completed with the subject running on a treadmill. A brief warm up consisting of dynamic stretching (sagittal and frontal plane leg swings, 1 rep, 30 seconds each) and 5 minutes walking on the treadmill at 3.5 mph to acclimate to the treadmill were performed. The subject initiated running at a self-selected pace of 6.5 mph. The subject continued to run for several minutes and verbalized when a comfortable pace with typical form was reached. Digital video was then taken from the rear, side, and front views by the evaluating physical therapist (Sony DCR SX65) video camera (60 fps). Cadence was then assessed by counting each time the right foot hit the ground for 30 seconds and this number was then multiplied to calculate the total steps per minute at 168. Video was then viewed with the subject at both regular and slow motion speeds. The video was viewed on a 20 inch Vizio wall mounted flat screen monitor via a direct video camera connection (Figure 1).

Computerized video analysis was not performed to assess objective measures of running mechanics, but the following significant observations were made through repeated visual observation of the video in slow motion by utilizing the camera's slow motion viewing function. At initial contact the subject had a heel strike pattern. Initial foot contact was significantly in front of her center of mass. Her knee was

Figure 1. *Initial foot contact position before gait re-training. A.) Heel strike initial foot contact in front of the subject's center of mass. B.) Upright trunk posture C.) Lead knee extended at approximately 10 degrees at initial foot contact. D.) Center of mass line.*

near full extension (approximately 10 degrees knee flexion) and her trunk was upright and lacking a forward leaning posture. During mid-stance the subject had a contralateral pelvic drop, which was seen bilaterally and appeared equal in degree of motion. Through her gait cycle it was observed that she had significant and excessive vertical center of mass displacement. Finally, the subject had adequate knee separation and did not show crossing over beyond midline with her stride on either side.

It was determined that the subject's initial cadence may have been contributory to several variables (heel strike, initial contact out in front of her center of mass, and excessive vertical displacement). Each of these variables are known to be associated with increased impact forces on the LE and increased impact forces have been connected to running related injuries.[14,15,16,17] Multiple authors have described the relationship between vertical displacement of the center of mass, vertical impact forces, and step frequency.[10,11,18,19,20] These relationships have been explained through the spring-mass model. Farley et al[18] showed that as step frequency increased at a given speed that vertical displacement of the center of mass and vertical impact forces decreased.[18] Slower step frequencies at a given speed had the opposite effect.

The initial evaluation also revealed contralateral pelvic drop during running, which is linked to functional hip abductor weakness. Dynamic knee valgus during functional movement testing was also noted, confirming this diagnosis. This led to the primary intervention of running gait re-training with emphasis on step rate manipulation. The hypothesis was that if step rate was increased above her preferred rate by at least 5% that each of the variables above could be improved, impact forces could be decreased, and the stress on the iliotibial band could be reduced. This would hopefully allow the achievement of the primary physical therapy goal of pain free running. The plan was to also address the functional hip weakness with strengthening exercises and the ITB tightness with flexibility exercises as is typical with rehabilitation of this diagnosis.

INTERVENTION

The primary intervention was running gait re-training with step rate manipulation. It was determined during the video gait examination that the subject's running cadence was 168 steps per minute at a preferred running pace of 6.5 mph. Based on the research by Heiderscheidt et al.[10] it was determined that a goal would be to increase the subject's step rate by 5% or 8 steps per minute to 176 steps per minute. Heiderscheidt et al[10] showed that even a 5% increase in step rate above one's preferred rate could effectively reduce impact forces transmitted through the knees and improve running mechanics such as foot strike pattern, stride length, and vertical displacement. At the time of the subject's first physical therapy visit the running gait re-training was initiated. The subject was allowed to warm up and accommodate to the treadmill as stated in the examination. The subject then proceeded to run at a preferred pace of 6.5 mph. A metronome set to 176 beats per minute was then utilized to provide auditory feedback to increase step rate to match the beat of the metronome while still running at the 6.5 mph pace. The subject was also provided with simple verbal cues that included "run quietly" and "let your feet strike under your body as you fall forward". The subject was able to successfully achieve this cadence during the initial instruction. Instructions were given for practicing this running form at home with a goal of achieving 176 steps per minute with help of the metronome. The subject was asked to run 1-2 miles, three times per week with at least one rest day between running days so long as running was pain free. She was instructed to utilize constant auditory cueing from the metronome until she was able to easily and consistently match the cadence goal. At that point the auditory cueing from the metronome could be used intermittently to check compliance and then could be removed completely once consistent compliance was confirmed. Noehren et al[21] found that it took approximately eight training sessions to assume new running mechanics from visual feedback with initial feedback being used constantly and then gradually taken away in later sessions. This case utilized a similar model with auditory cueing.[21]

The first visit also consisted of instruction on a home exercise program that included a wall ITB stretch (Figure 2) to be performed 3 times daily for 3 sets of 20 seconds on each leg. The subject was instructed to perform theraband resisted (at ankles)

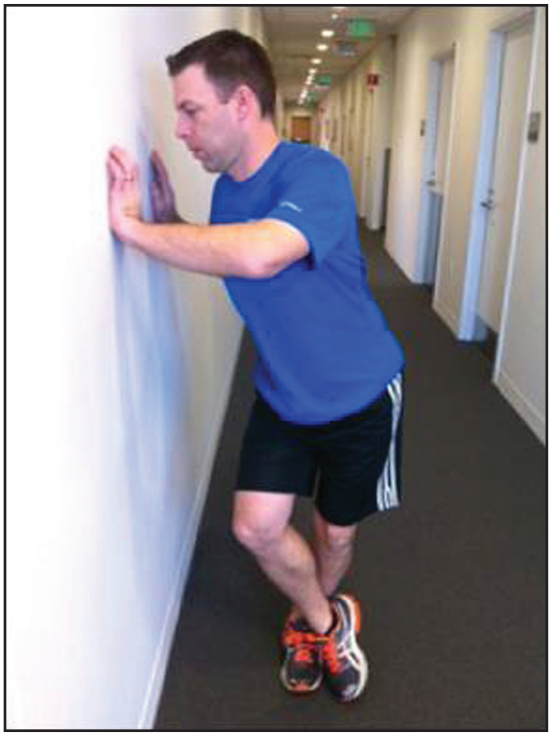

Figure 2. *Wall iliotibial band stretch.*

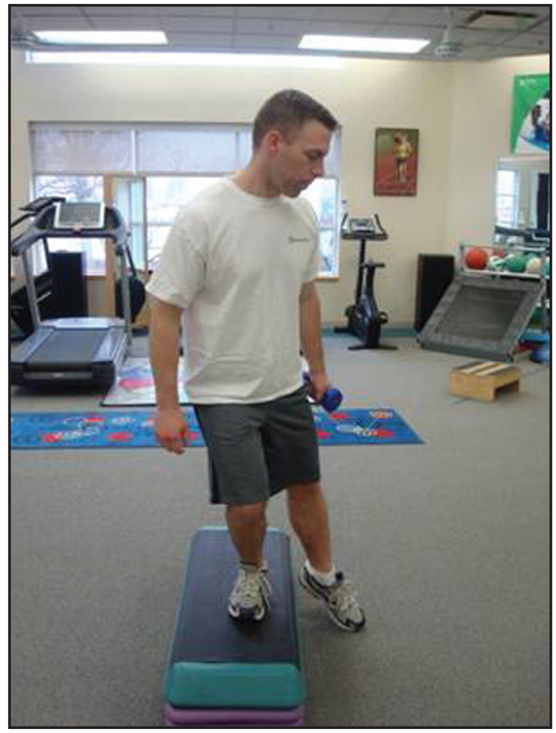

Figure 4. *Eccentric step-down (posterior-medial direction shown).*

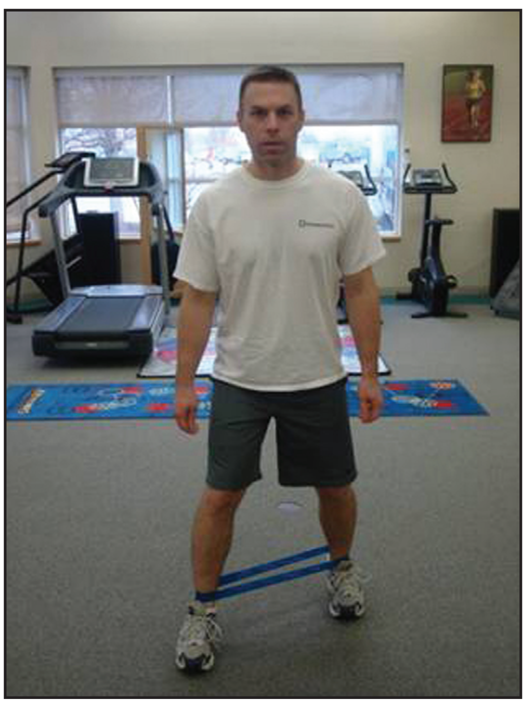

Figure 3. *Band resisted side-stepping and forward-backward walking.*

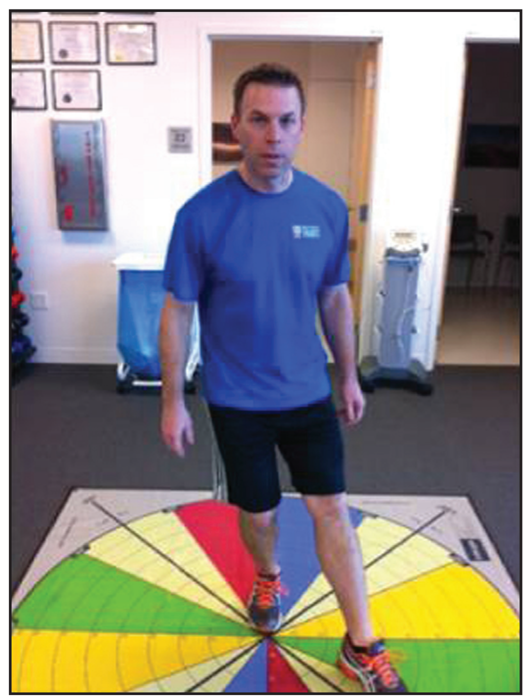

Figure 5. *Star excursion balance and reach (anterior-medial direction shown).*

side-stepping and forward and backward walking (Figure 3) for dynamic hip abductor strength. Single leg eccentric control exercises that included the star excursion balance and reach in the anterior-medial rotation, medial, and posterior-medial rotation directions (Figure 4) were issued. These same motions were also to be performed off of a 6-inch step with a toe touch in each plane of motion (Figure 5). These single leg eccentrics were to be performed for 1-2 sets of 10 repetitions three times per week with at least one rest day between each session. Handouts were issued with instructions. Ice massage for five minutes to the lateral knee was recommended as needed if pain should occur.

Follow up visits were conducted at four weeks and six weeks following the initial evaluation. These visits consisted of re-assessment of running form, including a second video taken at four weeks. Step rate was verified and reinforced with a metronome at each visit. Home exercises were reviewed to assess progress and to verify correct performance. During these visits the subject was also given guidance for the progression of the home running program which consisted of a 10% increase in total mileage per week so long as running was pain free. Home strengthening and flexibility exercises were continued as initially instructed throughout this time period. Formal discharge from physical therapy occurred after the six week follow up visit. The subject was brought back, however, at four months following initial evaluation to assess whether changes in running form and step rate had been maintained. Video was also taken at the four-month post evaluation visit to verify long-term compliance with these changes.

OUTCOMES

At four weeks after the initial evaluation the subject reported compliance with all recommendations and had been successful running up to 3.5 miles without knee pain. At that time running mechanics were re-assessed with video. Cadence was assessed at 176 steps per minute without the use of a metronome. Foot strike was a mid-foot strike pattern. Initial foot contact was now directly beneath her shoulder (foot strike almost directly under her center of mass) with her trunk leaning forward slightly rather than the upright posture at initial evaluation (Figure 6). Vertical displacement was visually observed to be minimal and much less than at the time of initial evaluation. These improved running mechanics that were visualized presented an assumption of decreased impact forces present with running. Pelvic drop was now absent as compared to the contralateral pelvic drop seen at the first visit. Hip abduction strength was improved to 4+/5 on the left. More importantly, the subject demonstrated improved ability to control dynamic valgus of the left LE with the Star Excursion Balance Test although there were still mild deficits (excessive knee adduction-frontal plane motion).

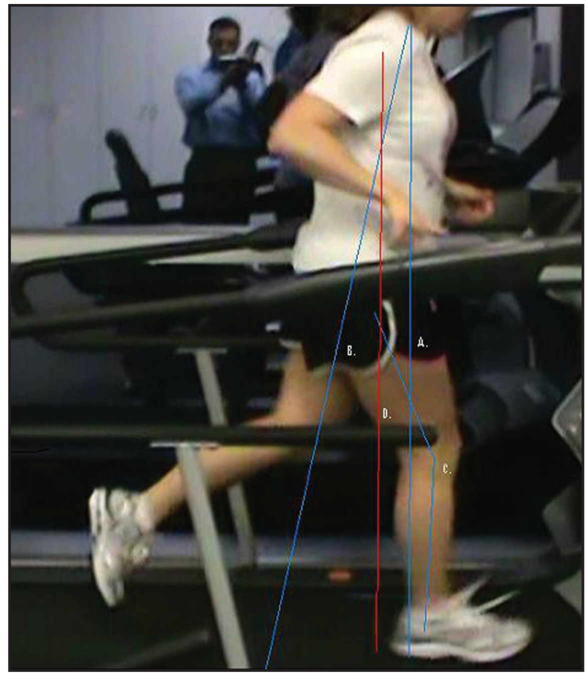

Figure 6. *Initial foot contact position after gait re-training. A.) Midfoot strike pattern closer to the subject's center of mass. B.) Mild forward trunk lean posture. C.) Lead knee extended at approximately 20 degrees at initial foot contact. D.) Center of mass line.*

At six weeks follow up the subject reported feeling great and had no knee pain with running now up to seven miles. Comfort was reported with the new running form with an improved feeling of strength. Running form was assessed again visually on the treadmill at 6.5 mph. Cadence was verified at 176 steps per minute and form was near ideal and consistent with changes seen on video at the four week follow up (Figure 7). Strength was also improved with hip abduction manual muscle test 5/5 bilaterally. Star Balance Excursion Test showed excellent control of knee motion and lower extremity loading with reaches in the anterior, medial, and posterior-medial rotation directions to test all three planes of motion.

At the four month follow up the subject reported a successful progression of running distance to 13.1 miles without knee pain (Figure 8). Weekly training mileage had been advanced to 25 miles per week. Cadence had remained consistent at 176 steps per minute. Hip abduction strength remained 5/5 bilat-

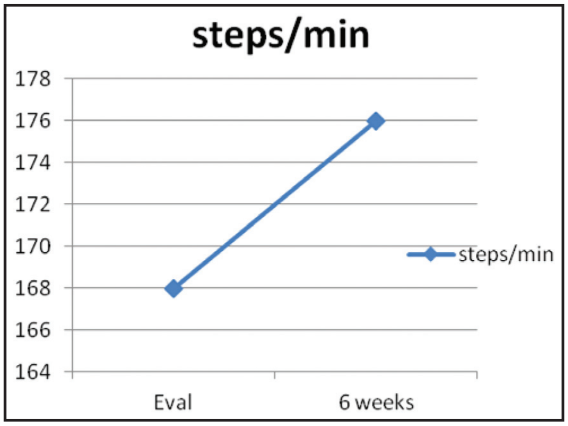

Figure 7. *Cadence (steps/minute) at initial evaluation and 6 week follow up visit.*

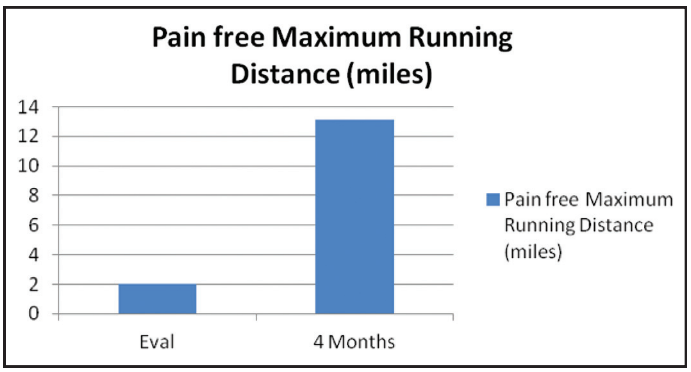

Figure 8. *Pain-free maximum running distance (miles) at initial evaluation and the 4 month follow up visit.*

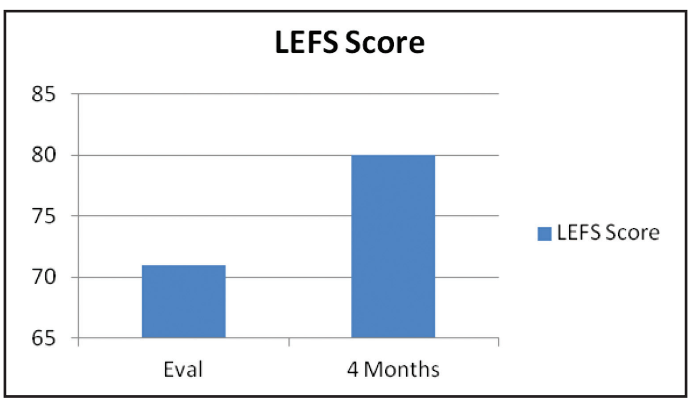

Figure 9. *Lower Extremity Functional Scale (LEFS) score at initial evaluation and 4 month follow up visit.*

erally. Star Balance Excursion Test showed excellent control of knee motion in the frontal plane and excellent control of loading in all planes. LEFS score was improved to 80/80 as compared to 71/80 at initial evaluation with running related items now showing no deficits (Figure 9). The subject also noted that

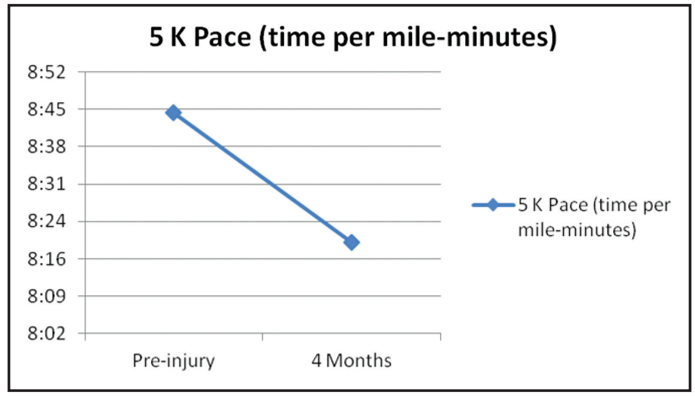

Figure 10. *5 Kilometer run pace pre-injury and at the 4 month follow up visit.*

her 5 kilometer running pace had improved from a 8:45 per mile pace to a 8:20 per mile pace, but it is unclear whether this was at all related to the increased step-rate and improved running mechanics or was related to training (Figure 10).

DISCUSSION

This case report presents running gait re-training as a primary treatment intervention for the rehabilitation of a runner with distal ITBS. This subject was able to successfully return to pain free running and to maintain that success up to a four month follow up period. Central to this success was a transformation of running form through gait re-training emphasizing increasing step rate 5% above the subject's preferred rate. This simple increase in step rate, achieved initially with help from a metronome, was able to improve running mechanics and components of faulty running form that may contribute to ITBS. The metronome was only used during her first month of rehabilitation as she was able to successfully progress from constant auditory cueing, to intermittent, to no auditory cueing at all while maintaining her new cadence. As running form improved with the achievement of an increased cadence, the subject was able to run greater distances and progress overall mileage without pain.

Heiderscheidt et al[10] showed that just a 5% increase in step rate above preferred significantly reduced total work at the knee, reducing the total amount of joint loading. This increased step rate also shortened stride, decreased the amount of heel strike, reduced vertical displacement, and reduced the peak hip adduction and internal rotation angles.[10] These characteristics are all factors that could contribute to ITBS as researchers have recently shown that the peak hip adduction angle and knee internal rotation angles are characteristic of runners with ITBS.[4,5] Impact forces also may magnify hip adduction and knee internal rotation angles as the body works to decelerate loading forces. Running also may produce fatigue with repetition and as one fatigues these faulty mechanics may worsen.[22,23] Improving running form via a step rate increase of 5% addressed and improved running mechanics. These improvements likely led to a reduction of impact forces and faults that may be central to the cause of this injury.

It should be noted that the subject of this case did also improve hip abductor strength, which has been described in the literature as being an important component of the treatment of ITBS.[2,9,24] Theoretically, improving hip abductor strength could help to decrease the peak hip adduction and knee internal rotation angles through improved ability to decelerate these motions. The literature, however, has not shown an abundance of evidence that traditional treatment focusing on hip abductor strengthening and movement training exercises alone is successful in altering running mechanics. In fact, Willy et al[25] showed that a hip abductor strengthening program had no significant effect on running mechanics.[25] Ferber et al.[26] compared runners with ITBS and healthy controls. They expected the increased hip adduction position associated with ITBS to result in increased demands on the hip abductor muscles. They found, however, that the hip abductor moment was the same between groups and suggested that the timing of muscle activation may be more important than the magnitude of muscle activation.[26] Chumanov et al[12] measured muscle activity of the lower extremity in runners at their preferred step rate, +5%, and +10%. They found that there was an increase in muscle activity, especially of the gluteus maximus and gluteus medius, in anticipation of foot-ground contact.[12] This pre-activation of muscle activity at higher step-rates is thought to enhance muscle activity during the loading response and to regulate leg stiffness. This is also consistent with research by Farley et al[18] who described an increase in leg stiffness at higher step rates at a given speed.[18] It is likely that improved strength played a role in the rehabilitation of this patient, but improved muscle activation timing through an increased step rate was also probably related to her success.

CONCLUSION

Gait re-training with step rate manipulation may be an important and practical intervention for the treatment of distal ITBS in runners. This case report provides evidence that when combined with traditional strengthening of the hip abductors and ITB flexibility exercises, increasing step rate above preferred rate could improve running mechanics and contribute to the successful return of a runner to pain free distance running. Future research may be helpful to isolate the effects of step rate manipulation versus other interventions such as hip abductor strengthening or other gait re-training methods in order to further define the relative importance of cadence manipulation in the rehabilitation of runners with ITBS.

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