12-2018

A Barefoot Running Program For A College Lacrosse Player With Chronic Exertional Compartment Syndrome: A Case Report

Erica Mazzarelli
University of New England

University of New England
Department of Physical Therapy
PTH 608/708: 2018 Case Report Template

Name: Erica Mazzarelli Abbreviated (Running) Title: A Barefoot Running Program for a College Lacrosse Player with Chronic Exertional Compartment Syndrome: A Case Report

Please use this template, as clearly outlined both in blackboard and the syllabus, by entering the necessary information into each section under the appropriate headers as assigned and submitting to blackboard for the assigned due dates. The format consists of a full traditional case report using the CARE guidelines.

Once a section is complete and has been graded, you may delete the instructions provided in grey. Feel free to work ahead as your case allows, but only assigned sections will be graded by the due dates. Please start by adding your name above and in the header, and once you develop your title, a "running" or abbreviated title. Name the file to include your last name for submission to BB. This same template will be used for PTH708, and will be completed throughout the fall.

All sections should be in **black text, size 12-font, Times New Roman, and double-spaced with proper grammar and punctuation. Track changes must be switched OFF**. Any assignments submitted in unacceptable condition as determined by the faculty will be returned to the student for resubmission in three days for a maximum score of 80%.

All case reports are written **in *past tense***, so ensure that your submissions are past tense. No patient initials are necessary; please refer to your case subject as "patient" throughout the manuscript.

Academic Honesty:

You may use any resources at your disposal to complete the assignment. You may not communicate with other UNE students to obtain answers to assignments or share sources to submit. Proper citations must be used for referencing others' published work. If you have questions, please contact a PTH608 course instructor. Any violation of these conditions will be considered academic dishonesty.

By entering your name, you are affirming that you will complete ALL the assignments as original work. Completing an assignment for someone else is unethical and is a form of academic dishonesty.

Student Name: Erica Mazzarelli *Date:* *6/27/18*

By typing your name here, it is representative of your signature.

A Barefoot Running Program for a College Lacrosse Player with Chronic Exertional Compartment Syndrome: A Case Report

Erica Mazzarelli, BS

Doctor of Physical Therapy (DPT) student

Department of Physical Therapy, University of New England, 716 Stevens Ave, Portland, ME

The patient gave consent to participate in this case study by signing an informed consent form allowing the use of medical information and photography obtained for this report and received information on the institution policies regarding the Health Insurance Portability and Accountability Act.

Acknowledgments to Kirsten Buchanan, PhD, PT, ATC for assistance with case report conceptualization and Emily Marotta, DPT for supervision, assistance, and guidance with patient care.

Keywords: chronic exertional compartment syndrome, barefoot running, female college lacrosse player

ABSTRACT

Background and Purpose

Although barefoot running has been investigated for anterior and lateral exertional compartment syndrome, a specific barefoot running program aimed at altering running mechanics has not been determined for posterior exertional compartment syndrome for a college lacrosse player. The purpose of this case report was to examine the effects of adopting a forefoot running pattern through a barefoot running program in a 20-year-old college lacrosse player with posterior chronic exertional compartment syndrome (CECS) in conjunction with a comprehensive physical therapy program.

Case description

The patient was a 20-year-old female college lacrosse player who presented to physical therapy with a 9-month history of bilateral, posterior lower leg pain, which was brought on by running on pavement, up hills, and longer than 5-10 minutes. The patient reported extreme tightness and throbbing in the posterior lower leg and numbness and tingling into the feet while running on pavement and long distance runs greater than 1 mile. The patient was seen 1-2x/week for twelve weeks.

Outcomes

DF ROM improved from lacking 16° to lacking 8° on the right and lacking 12° to lacking 4° on the left. All hip and ankle strength improved from 4-4+/5 to 5/5 throughout. The LEFS improved from 9% disability to 5% disability. The patient's running tolerance improved from 1 min shod to 12 min barefoot before experiencing tightness in her legs.

Discussion

Barefoot running, in conjunction with manual therapy, lower extremity (LE) stretching, strengthening, and stabilization exercises was found to be effective at improving running

tolerance for a female college lacrosse player. Future research should investigate the efficacy of barefoot running programs and appropriate timelines for progression in patients with posterior CECS.

Abstract Word Count: 275

Word Count: 3336

----------PART ONE BEGINS HERE----------

INTRODUCTION/BACKGROUND and PURPOSE

The cause of chronic exertional compartment syndrome (CECS) is somewhat of a mystery. In a literature review by Schubert, multiple factors were cited. It could be due to "muscle hypertrophy, fascial thickness or stiffness, stimulation of fascial sensory stretch receptors, decreased venous return, microtraumatic muscular injuries, and clinical myopathies".[1] It could also be due to limitation in strength, range of motion (ROM), flexibility, endurance, flawed motor control, a rapid increase in training volume, frequency, and intensity.[1] CECS is diagnosed via intercompartmental pressure testing. Compartment syndrome is considered if the compartment pressure is 15 mmHg before exercise and 30 mmHg post exercise.[2] The anterior compartment of the lower leg is most commonly affected by CECS (42.5%), followed by the lateral compartment (35.5%), and the deep posterior (18.9%) and superficial posterior (3%) compartments.[2] Females and athletes playing at competitive levels are more likely to develop CECS.[2] Lacrosse was found to be one of the top three sports with the most cases of CECS.[2]

Although a fascia release is recommended, it was proposed CECS can be managed conservatively first for 6-8 weeks before a fasciotomy may be necessary.[3] It was recommended CECS can be managed with activity modification, pressure, rest, ice, compression, and elevation (PRICE), ROM, and soft tissue mobility, stretching, joint mobilizations, neurodynamic

mobilizations, strengthening, taping, orthotics, NSAIDs, and biomechanical analysis.[1]

Barefoot running has been researched extensively as running shoes have evolved and running injuries have become more widely examined over the last few decades. Running barefoot has been found to alter foot strike from a rearfoot pattern to a midfoot or forefoot pattern.[4] Barefoot running has been shown to decrease ground reaction force (GRF), [4,5] increase stride frequency, decrease stride length, and decrease peak pressure under the heel, midfoot, and hallux compared to standard running shoes.[5] Lower impact loads may reduce impact-related running injuries and decrease stress on the surrounding musculature.

A case series, done by Diebal et al, applied a 6-week forefoot running program to two patients with CECS of the anterior and lateral compartments.[6] After the 6-week intervention, the subjects were able to increase running tolerance to 5 km (3 miles) and decrease intercompartmental pressure at rest and after running 0.8 km (0.5 miles).[6] The protocol included initial training drills and eventual inclusion of forefoot interval running of 0.25 km followed by a two-minute walking interval, with the running intervals gradually progressed.[6] Another study of ten patients with anterior CECS also benefited from a forefoot running intervention, which decreased intracompartmental pressures and pain, increased running tolerance, and successfully avoided surgery.[7]

While there has been some limited research investigating a barefoot running protocol on patients with anterior and lateral compartment syndrome, there has not been any studies investigating their protocol in posterior CECS. Therefore, the purpose of this case report was to examine the effects of adopting a forefoot running pattern through barefoot running training in a 20-year-old college lacrosse player with posterior compartment CECS in conjunction with a comprehensive physical therapy program.

CASE DESCRIPTION

Patient History and Systems Review

The patient was given a verbal explanation of the study protocol and expected outcomes and provided with written informed consent before testing and video recording. The patient was a 20-year-old female college lacrosse player who presented to physical therapy with a 9-month history of bilateral lower leg pain, which was brought on by running on pavement, up hills, and with long-distances. The patient reported extreme tightness and throbbing in the posterior lower leg and numbness and tingling into the feet while running on pavement and with long distance runs greater than 1 mile. The patient reported the tightness and 8/10 pain on the Numeric Pain Rating Scale (NPRS) after 5-10 minutes of running on pavement in running shoes and after 15-20 minutes of running on turf in cleats. She reported having to sit down to relieve the pain, which would subside within 5-10 minutes, the pain would not subside with static standing.

Upon returning home from college, she saw an orthopedic doctor who diagnosed her with exertional compartment syndrome and referred her to physical therapy. The patient's main concern was her ability to continue playing lacrosse at a collegiate level without pain or discomfort in her lower legs. She reported her lacrosse coach strongly suggested bilateral fasciotomies, however, she and her mother agreed on an initial conservative approach for symptom management. The patient reported taking two 400 mg ibuprofen as needed after lacrosse practice or games. She reported she had not needed to take any medication within the past month as she had not been running.

The patient rated her overall health as very good. Significant medical history reported by the patient included a history of right ankle sprains and left sided atrophy, weakness, and decreased stability caused by Lyme disease which had since been treated six years ago. It is worthy to note she had been seen by a physical therapist for her diagnosis of Lyme disease for left sided lower

extremity (LE) atrophy, weakness, and balance disturbances. At that time treatment sessions included strength training, neuromuscular re-education, which included stability and balance training, and LE and cardiovascular endurance training. After pharmacological treatment for Lyme disease and physical therapy, she had returned to gymnastics and sport with normalized strength 10 weeks later after the Lyme diagnosis. All other history, comorbidities, or genetic information was unremarkable.

Examination – Tests and Measures

During the initial examination, lower extremity ROM and manual muscle testing (MMT) were performed (Table 2). Goniometry was used to measure joint ROM as it has good intrarater reliability.[8] MMT was chosen as a reliable and valid measure for the assessment of the musculoskeletal system.[9]

Navicular drop (ND) was tested as it is a reliable and valid measure of subtalar joint position and an objective measure of pronation.[10,11] For the ND test, the patient was in standing and the navicular tuberosity was marked. The patient was guided to move her foot into subtalar neutral by the therapist who was palpating the navicular. Then the patient was instructed to relax her feet and the excursion of the two points was measured. A measurement of less than 10 mm is considered normal and greater than 15 mm excessive pronation and is considered abnormal.[12,13] A ND of greater than 10 mm has been reported in competitive runners experiencing exercise-related leg pain (ERLP) and runners with a ND of >10 mm have 4 times greater odds of experiencing ERLP.[13] The Lower Extremity Functional Scale (LEFS) was used to assess lower extremity (LE) dysfunction at initial evaluation due to its reliability and responsiveness to change.[14] The Numeric Pain Rating Scale (NPRS) was used to quantify pain experienced after or

during running. A score of zero represents no pain experienced by the patient and a score of ten being the worst pain.[15]

Three physical therapy sessions after the initial examination, a functional walking and running gait analysis was conducted on a commercial grade treadmill (Startrac, Core Health & Fitness, Vancouver, Washington) using video recording. Although observational gait analysis has been found to be only slightly to moderately reliable, it is a convenient and inexpensive way to evaluate gait.[16,17] Walking and running gait analysis were performed before starting the barefoot running program. The patient began walking at a self-selected pace of 3 miles per hour (mph) for three minutes. She then ran at a self-selected pace of 5.5 mph for 1 minute then a 3-minute cool down walk at 3 mph.

Clinical Impression: Evaluation, Diagnosis, Prognosis

At the initial evaluation, the patient's impairments were consistent with exertional compartment syndrome. The patient had limitations in ROM, MMT, and had pain, numbness, and tingling into the feet with running more than 10 minutes which resolved with rest. Prior to physical therapy, she was assessed by an orthopedic surgeon. The gold standard for CECS diagnosis is intracompartmental pressure measurement before exercise and 1-5 minutes after exercise.[18] However, the patient did not undergo this testing until after she was discharged, which revealed elevated intracompartmental pressures in the posterior compartments bilaterally. Differential diagnoses included: medial tibial stress syndrome, stress fracture, peroneal nerve entrapment, popliteal nerve entrapment syndrome, and claudication.[18]

The patient was a good candidate for the case report as she was motivated to continue playing lacrosse at a collegiate level and wanted to manage her symptoms conservatively. Her ICD-10 medical diagnosis was M79.A21, nontraumatic compartment syndrome of right lower

extremity and M79.A22, nontraumatic compartment syndrome of left lower extremity. Her ICD-10 PT diagnosis was M79.661, pain in right lower leg and M79.662, pain in left lower leg.

Non-operative management of CECS has mixed reviews in the existing literature and patients may continue to experience persistent symptoms with exercise after conservative management lasting 6 weeks to years.[3,19] However, in case reports studying the effects of forefoot running on CECS, reduction of symptoms and improved running tolerance were reported by 6 weeks.[6,7] The patient had many positive prognostic factors including her high level of motivation to return to sport, avoid surgery, her familiarity with exercise, compliance with her home exercise program (HEP), age, and ability to rest for the summer before returning to college to play lacrosse.

No additional referrals or consultations were considered or needed for the patient. If progress was not being made with physical therapy and the intervention, a referral back to her orthopedic physician for MRI or a specialist for intracompartmental pressure testing may have been warranted.

The decision was made to proceed with the chosen plan of care incorporating barefoot running training to influence a forefoot running pattern to decrease GRF, stride length, and contact with the ground time.[5] Joint mobilizations were performed to improve talocrural mobility. Soft-tissue massage and stretching of the gastrocnemius and soleus were implemented to improve ROM and decrease pain. Lower extremity strengthening and neuromuscular re-education such as balance training were also introduced. ROM, MMT, running testing, and observational gait analysis were re-tested at the end of 4 weeks to assess progress in mobility, strength, and running tolerance. Short- and long-term goals for physical therapy are listed in Table 3.

----------PART TWO----------

Intervention

Coordination, communication, documentation, patient related instruction

Following the initial evaluation (IE), a plan of care (POC) was established. Coordination and communication with her orthopedic doctor were established to share the patient's progress. The IE was documented using an electronic medical record system (EMR). In addition to the EMR, the patient's POC, including exercises, was documented on hand-written flow sheets to track progress and measurements.

During the IE, the patient was educated on the evaluation findings, her condition, possible prognosis, the importance of regaining ankle ROM and LE strength, and her HEP. The HEP was demonstrated by the therapist and patient to ensure proper form. The patient was given pictures and written instructions of the exercises, which included sets, repetitions, frequency, and duration of rest periods. The patient was also given a green theraband (The Hygenic Corporation, Akron, OH) tied in a circle for clamshells. An outline of the HEP is demonstrated in Table 4.

Procedural interventions

The patient was seen 1-2x/week for twelve weeks for 1 hour. The patient missed 1 session due to family obligations. The interventions included barefoot running training on a treadmill, manual soft tissue and joint mobilizations, stretching, strengthening, and stabilization exercises. Ice was also used at the end of each session for both legs. The patient was compliant with her HEP.

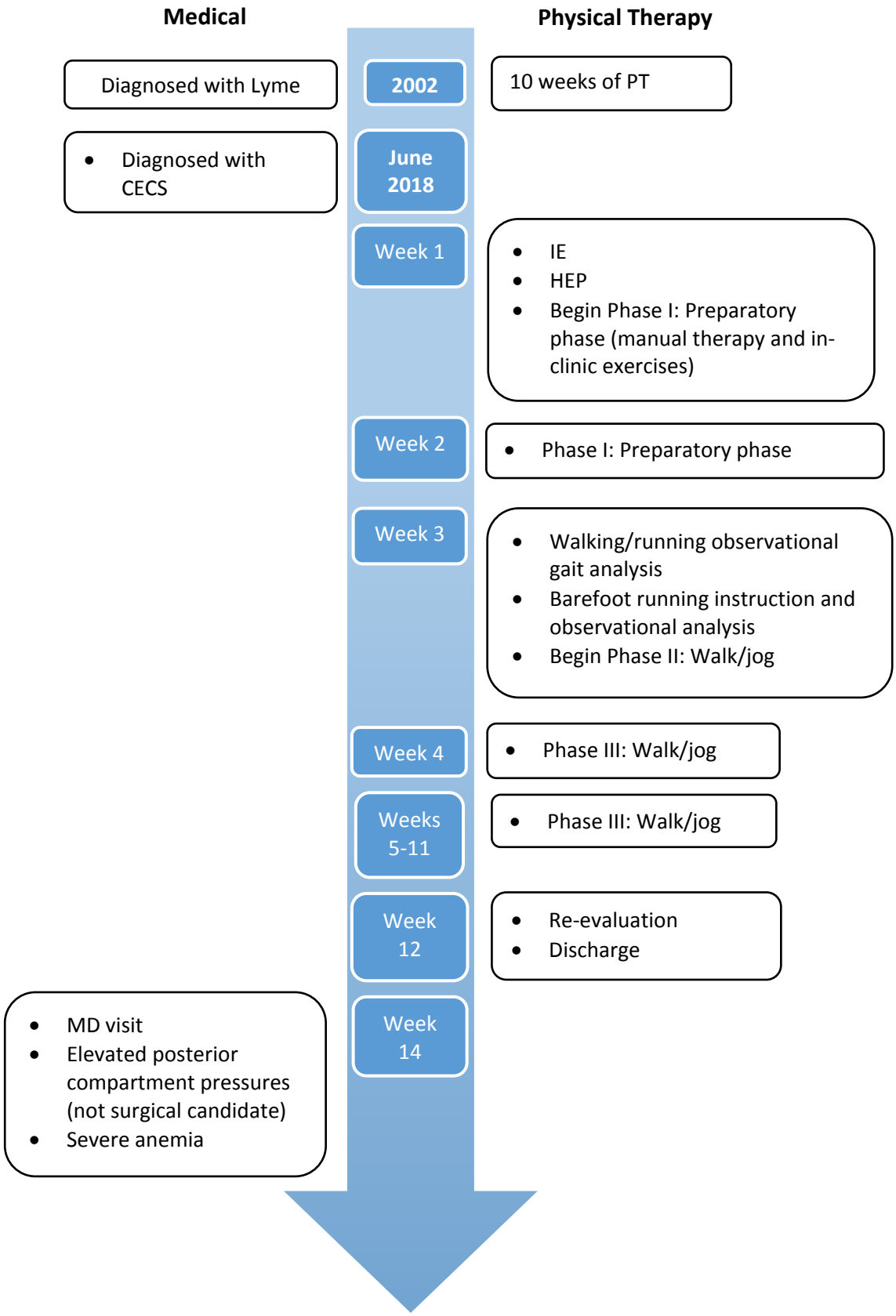
The barefoot running training was used to promote a forefoot strike to decrease GRF, stride length, and contact time with the ground to decrease compartment pressures and, therefore,

reduce pain with running.[5] Before initiating the barefoot running program, the patient completed a 2-week preparatory stretching and strengthening phase to address any ROM limitations, muscular imbalances or strength deficits. During week 3, the patient was introduced to barefoot running and was instructed verbally and visually to land "quietly" on the ball or front of the foot, increase step frequency, and decrease stride length.[6] She was provided visual feedback using a video recording cellphone (iPhone 5s, Apple). The next session she demonstrated barefoot running on a treadmill and her barefoot running technique was analyzed. The patient was given a barefoot running schedule (Table 5) to perform outside of the clinic, which was adapted from a presentation by Rothschild given at the FPTA annual conference.[20] Instructions for the program included: perform the running on a treadmill or track, transition back to shoes if pain is experienced and finish the running as prescribed, do not proceed to the next workout without pain, and cross-train or run in shoes on rest days. The patient would begin the PT session with either the prescribed running according to the program or with a 10-minute bike warmup if the running was already performed for that day. After the warmup, soft tissue and joint mobilizations were performed followed by stretching, strengthening, and stabilization exercise. Each session was ended with ice for 10 minutes on her gastrocnemius bilaterally. This chronology of the interventions was chosen so the patient's symptoms could be managed if she experienced increased pressure or tightness with the barefoot running intervention. Please see Appendix 1 for a timeline of the patient's medical and physical therapy timeline of care.

Soft tissue mobilizations were used to reduce myofascial restrictions posteriorly in the gastrocnemius and soleus, anteriorly in the tibialis anterior, and laterally in the peroneals. Anterior-posterior joint mobilizations of the talocrural joint were performed to improve dorsiflexion ROM.[21] Manual stretching of the gastrocnemius and soleus were performed in 30 second intervals, which has been found to elicit the greatest change in ROM.[22] Stretching of the

gastrocnemius and soleus were performed using a slant board. After stretching, strengthening and stabilization exercises were performed focusing on strengthening hip abductors, gluteals, quadriceps, hamstrings, and gastroc/soleus complex. In the clinic, banded exercises such as clamshells, 3-way hip kicks, and side steps were performed with a miniband (Perform Better, West Warwick, RI). Stabilization exercises, such as single leg stance, were performed on an airex pad (Airex, New York, NY) and a rockerboard (Fitterfirst, Calgary, AB, Canada) was utilized for double leg balance both anterior/posterior and laterally. An outline of all exercises can be found in Table 6.

TIMELINE


Medical
Physical Therapy
Diagnosed with Lyme
2002
10 weeks of PT
Diagnosed with CECS
June 2018
Week 1
IE
HEP
Begin Phase I: Preparatory phase (manual therapy and in-clinic exercises)
Week 2
Phase I: Preparatory phase
Week 3
Walking/running observational gait analysis
Barefoot running instruction and observational analysis
Begin Phase II: Walk/jog
Week 4
Phase III: Walk/jog
Weeks 5-11
Phase III: Walk/jog
Week 12
Re-evaluation
Discharge
Week 14
MD visit
Elevated posterior compartment pressures (not surgical candidate)
Severe anemia

OUTCOMES

After 10 weeks of barefoot running, LE strengthening, stretching, and manual therapy, the patient improved running tolerance, palpable tenderness, ROM, MMT, and LEFS. The patient's running tolerance improved from 1 minute shod with 5/10 pain to 12 minutes barefoot before experiencing tightness and pain in her calves which she rated 6-7/10 on the NPRS. At the IE, the patient experienced tightness or tenderness with palpation in her soleus, gastrocnemius, tibialis anterior, tibialis posterior, and peroneals. These restrictions were eliminated at discharge. The patient improved her DF ROM from 16° to 8° on the right, and 12° to 4° on the left. At the IE, MMT testing indicated slight weakness in her hips bilaterally, which was more pronounced with left hip flexion and abduction. Initial MMT testing also revealed weakness in all directions of the right ankle. At discharge, MMT of the hips and ankles improved to 5/5 bilaterally. The patient's excursion with the ND test was measured to be 6 mm and 8 mm on the right and left respectively, which was a normal amount of excursion and did not change after the intervention. The LEFS improved from 9% disability to 5% disability, which was associated with a 3-point improvement. This was not statistically significant as the minimally clinically important difference (MCID) is 9 points. The results of all tests and measures at IE and discharge can be found in Table 2.

During and after running observational gait analysis, she reported tightness and discomfort in both lower extremities and 5/10 pain on the NPRS. While walking she demonstrated a longer stride length with the right leg than the left. During running, she presented with a heel strike running pattern and an audible foot slap bilaterally. She also demonstrated increased transverse plane motion and internal rotation of the hips and knees at contact, which continued throughout the stance phase. This was thought to be due to the patient's high-arched, rigid foot which

prevented pronation early in stance and caused LE IR in the second half of stance as compensation, possibly due to weakness of the external rotators of the hips.

All short-term goals were met, and two long-term goals were not met. At the conclusion of this report, the patient was not able to run for 15 minutes without tightness or pain. Her LEFS still showed minor disability and she still experienced 6-7/10 pain with running. Patient short- and long-term goals can be found in Table 3.

Following the conclusion of this case report, the patient was seen by her orthopedic surgeon for compartmental pressure testing. The results revealed her posterior compartment pressure levels were elevated bilaterally, but not enough for surgical intervention. Further blood testing revealed severe anemia and the patient received subsequent treatment for the deficiency.

DISCUSSION

This case report investigated the use of a barefoot running program for a female college lacrosse player with posterior CECS in conjunction with a conventional physical therapy program. The purpose of the barefoot running program was to modify running mechanics to alter stride length and rate and decrease ground reaction forces.[4,5] While studies have examined barefoot running for individuals with anterior and lateral CECS,[6] none have examined this intervention in posterior CECS.

The 10-week barefoot running intervention did improve running tolerance, however, it did not improve tightness and pain with running. The patient did not finish the entire protocol due to tightness and pain in her lower legs and was only able to run up to 12 minutes. In the case report by Diebal et al, one subject with bilateral anterior and lateral CECS, who was assigned a barefoot running program along with “focused training drills”, was successful in improving running tolerance from 0.5 miles to 3 miles without any tightness or pain.[6] However, the study

had a different running protocol than the one performed in this case report and the subject presented with anterior and lateral CECS.

There may be many reasons as to why the patient did not see improvements in tightness and pain with barefoot running. One limitation is the lengthy adaptation time of modifying running mechanics. Although the patient was seen 2x/week for 12 weeks and was very compliant with her running program, possible adaptations and positive effects of altering running mechanics may take longer than anticipated. In addition, the barefoot running protocol that was used in this report has not been validated or supported by research. Furthermore, the patient's underlying anemia may have been a contributing factor to her running intolerance. Barefoot running, or running with a forefoot strike pattern, may have also put excessive stress on the posterior compartments, which could have aggravated the musculature and surrounding tissue. A walking and running observational gait analysis should have been completed at discharge to evaluate any changes in walking or running form; however, it also may have been too early in the program to see significant changes. A strength of this case report was the improvement seen in most other measures, such as palpable tenderness, ROM, and MMT. This may be due to the comprehensive nature of the physical therapy program.

A barefoot running program may be an effective way of altering faulty or inefficient running mechanics in individuals with lower extremity running injuries but may take an extensive period of time to see significant changes. Future research should investigate appropriate timelines and progression for barefoot running interventions. Studies should also explore barefoot running interventions for individuals with posterior CECS.

REFERENCES

1. Schubert AG. Exertional compartment syndrome: Review of the literature and proposed rehabilitation guidelines following surgical release. *Int J Sports Phys Ther*. 2011;6(2):126-141.

2. Davis DE, Raikin S, Garras DN, Vitanzo P, Labrador H, Espandar R. Characteristics of patients with chronic exertional compartment syndrome. *Foot Ankle Int*. 2013;34(10):1349-1354. doi: 10.1177/1071100713490919

3. Rajasekaran S, Hall MM. Nonoperative management of chronic exertional compartment syndrome: a systematic review. *Curr Sports Med Rep*. 2016;15(3):191-198. doi: 10.1249/JSR.0000000000000261

4. Hamill J, Russell EM, Gruber AH, Miller R. Impact characteristics in shod and barefoot running. *Footwear Science*. 2011;3(1):33-40. doi: 10.1080/19424280.2010.542187

5. Squadrone R, Gallozzi C. Biomechanical and physiological comparison of barefoot and two shod conditions in experienced barefoot runners. *J Sports Med Phys Fitness*. 2009;49(1):6-13.

6. Diebal AR, Gregory R, Alitz C, Gerber JP. Effects of forefoot running on chronic exertional compartment syndrome: a case series. *Int J Sports Phys Ther*. 2011;6(4):312.

7. Diebal AR, Gregory R, Alitz C, Gerber JP. Forefoot running improves pain and disability associated with chronic exertional compartment syndrome. *Am J Sports Med*. 2012;40(5):1060-1067. doi: 10.1177/0363546512439182

8. Konor MM, Morton S, Eckerson JM, Grindstaff TL. Reliability of three measure of ankle dorsiflexion range of motion. *Int J Sports Phys Ther*. 2012;7(3):279-287.

9. Cuthbert SC, Goodheart GJ. On the reliability and validity of manual muscle testing: a literature review. *Chiropr & Osteopat*. 2007;15:4. doi:10.1186/1746-1340-15-4

10. Sell KE, Verity TM, Worrell TW, Pease BJ, Wigglesworth J. Two measurement techniques for assessing subtalar joint position: a reliability study. *J Orthop Sports Phys Ther.*

1994;19(3):162-167. doi: 10.2519/jospt

11. Mueller MJ, Host JV, Norton BJ. Navicular drop as a composite measure of excessive pronation. *J Am Podiatr Med Assoc*. 1993;83(4):198-202. doi: 10.7547/87507315-83-4-198

12. Meininger AK, Koh JL. Evaluation of the injured runner. *Clin Sports Med*. 2012;31(2):203-215. doi: 10.1016/j.csm.2011.11.002

13. Bennett JE, Reinking MF, Rauh MJ. The relationship between isotonic plantar flexor endurance, navicular drop, and exercise-related leg pain in a cohort of collegiate cross-country runners. *Int J Sports Phys Ther*. 2012;7(3):267.

14. Watson CJ, Propps M, Ratner J, Zeigler DL, Horton P, Smith SS. Reliability and responsiveness of the lower extremity functional scale and the anterior knee pain scale in patients with anterior knee pain. *J Orthop Sports Phys Ther*. 2005;35(3):136-146. doi: 10.2519/jospt.2005.35.3.136

15. White D. Musculoskeletal Examination. In: O'Sullivan SB, Schmitz TJ, Fulk GD. Physical Rehabilitation. 6th 402 ed. Philadelphia: F.A. Davis Company; 2013;128-130.

16. Eastlack ME, Arvidson J, Snyder-Mackler L, Danoff JV, McGarvey CL. Interrater reliability of videotaped observational gait-analysis assessments. *Phys Ther*. 1991;71(6):465-472.

17. Krebs DE, Edelstein JE, Fishman S. Reliability of observational kinematic gait analysis. *Phys Ther*. 1985;65(7):1027-1033.

18. Tucker AK. Chronic exertional compartment syndrome of the leg. *Curr Rev Musculoskelet Med*. 2010;3(1-4):32-37. doi: 10.1007/s12178-010-9065-4

19. Van der Wal WA, Heesterbeek PJC, Van den Brand JGH, Verleisdonk EJMM. The natural course of chronic exertional compartment syndrome of the lower leg. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(7):2136-2141.

20. Rothschild, C. Barefoot running: Current evidence and transition strategies. Presented at;

FPTA Annual Conference; Daytona Beach; 2012.

21. Green T, Refshauge K, Crosbie J, Adams R. A randomized controlled trial of a passive accessory joint mobilization on acute ankle inversion sprains. *Phys Ther*. 2001;81(4):984-94.

22. Page P. Current concepts in muscle stretching for exercise and rehabilitation. *Int J Sports Phys Ther*. 2012;7(1):109-119.

TABLES and FIGURES

Table 1: Systems Review

	Initial Evaluation	**Discharge**
Cardiovascular/Pulmonary	Not impaired	Not impaired
Musculoskeletal	Impaired: Passive hip external rotation 90% limited bilaterally. All other hip and knee passive and active ROM within functional limits. ROM impairments of bilateral ankles Gross symmetry: bilateral forefoot varus, high arched feet, Haglund's deformity left calcaneus.	Impaired: Bilateral ankle active ROM impaired Gross symmetry: bilateral forefoot varus, high arched feet, Haglund's deformity left calcaneus.
Neuromuscular	Not impaired	Not impaired
Integumentary	Not impaired	Not impaired
Communication	Not impaired	Not impaired
Affect, Cognition, Language, Learning Style	Not impaired	Not impaired

Table 2: Tests & Measures

Tests & Measures	**Initial Evaluation Results**	**Discharge Results**
Right ankle ROM	DF: lacking 16° PF: 80° Soleus DF: 12°	DF: lacking 8° PF: 80° Soleus DF: 5°

	INV: 20° EV: 15°	INV: 20° EV: 15°
Left ankle ROM	DF: lacking 12° PF: 80° Soleus DF: 10° INV: 23° EV: 15°	DF: lacking 4° PF: 80° Soleus DF: 0° INV: 23° EV: 15°
Right hip strength	Flexion: 4+/5 Extension: 4+/5 Internal rotation: 4+/5 External rotation: 4+/5 Abduction: 4+/5	Flexion: 5/5 Extension: 5/5 Internal rotation: 5/5 External rotation: 5/5 Abduction: 5/5
Left hip strength	Flexion: 4/5 Extension: 4+/5 Internal rotation: 4+/5 External rotation: 4+/5 Abduction: 4/5	Flexion: 5/5 Extension: 5/5 Internal rotation: 5/5 External rotation: 5/5 Abduction: 5/5
Right knee strength	Flexion: 5/5 Extension: 5/5	Flexion: 5/5 Extension: 5/5
Left knee strength	Flexion: 5/5 Extension: 5/5	Flexion: 5/5 Extension: 5/5
Right ankle strength	DF: 4/5 PF: 5/5 INV: 4/5 EV: 4/5	DF: 5/5 PF: 5/5 INV: 5/5 EV: 5/5
Left ankle strength	DF: 4+/5 PF: 5/5 INV: 4+/5 EV: 4+/5	DF: 5/5 PF: 5/5 INV: 5/5 EV: 5/5
Navicular drop	Right: 6 mm Left: 8 mm	Right: 6 mm Left: 8 mm
Palpation	Tightness and tenderness to palpation in soleus, gastrocnemius, tibialis anterior, tibialis posterior, and peroneals	No palpable tenderness No restrictions palpated
Lower Extremity Functional Scale (LEFS)	73/80, 9% deficit	76/80, 5% deficit
Running tolerance	1 min with shoes (8/10 pain)	12 min barefoot (6-7/10 pain)

Dorsiflexion (DF), plantarflexion (PF), inversion (INV), eversion (EV)

Table 3: Patient Goals

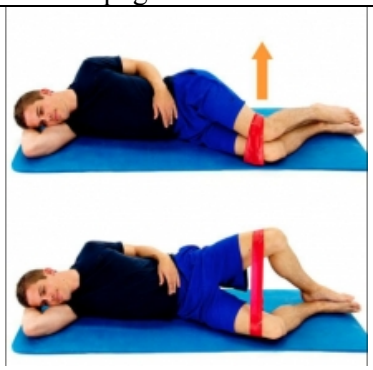
Time Frame	Goal
Short term: 8 weeks	Patient will improve ankle DF by 8-10 degrees to improve joint mobility and LE

	biomechanics.
	Patient will have minimal to no palpable tightness in the gastrocnemius/soleus complex to improve soft tissue mobility and LE biomechanics.
	Patient will be able to tolerate 5 minutes of running with no complaints of tightness or pain in lower leg.
Long term: 12 weeks	Patient will improve hip and ankle strength to 5/5 throughout to allow appropriate hip, knee, and ankle position while running and sport activities.
	Patient will be able to tolerate 15 minutes of running with no complaints of tightness or pain in lower leg.
	Patient will improve LEFS score to 80/80 and a NPRS to 0/10 with running to return to play lacrosse.

Dorsiflexion (DF), lower extremity (LE), lower extremity functional scale (LEFS), numeric pain rating scale (NPRS)

Table 4: Home Exercise Program

Exercise	Parameters	Diagram
Gastrocnemius Stretch with Towel (long-sitting)	R and L LE: 30 sec hold Repetitions: 3 Sets: 1 Frequency: twice per day	 www.hep2go.com
Gastrocnemius stretch (standing)	R and L LE: 30 sec hold Repetitions: 3 Sets: 1 Frequency: twice per day	 www.hep2go.com

Soleus stretch (standing)	R and L LE: 30 second hold Repetitions: 3 Sets: 1 Frequency: twice per day	 www.hep2go.com
Gluteus bridges	R and L LE: 3 second hold Rest 30 sec between each set Repetitions: 10 Sets: 2 Frequency: once every other day	 www.hep2go.com
Clamshells	R and L LE: with green theraband Repetitions: 10 Sets: 2 Frequency: once every other day	 www.hep2go.com

460

461 **Table 5: Barefoot Running Intervention Timeline**

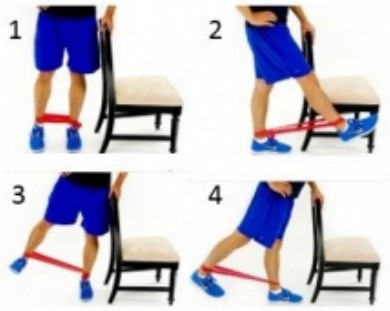
Day	Activity	
Phase I: Preparatory Phase Weeks 1-2		
Phase II: Weeks 3-4		
1	Walk 30 min	
2	Walk 9 min/jog 1 min (x3)	
3	Rest	
4	Walk 8 min/jog 2 min (x 3)	
5	Walk 7 min/jog 3 min (x3)	
6	Rest	
7	Walk 6 min/jog 4 min (x3)	

8	Walk 5 min/jog 5 min (x3)	
9	Rest	
10	Walk 4 min/jog 6 min (x3)	
11	Walk 3 min/jog 7 min (x3)	
Phase III: Weeks 5-7 - 3 days/week		
12	Jog 12 min	Re-evaluation
13	Rest	
14	Jog 15 min	
15	Rest	
16	Jog 17 min	
17	Rest	
18	Jog 20 min	
19	Rest	
20	Jog 20 min	
21	Rest	
Phase IV: Week 7-8 – 4 days/week		
22	Jog 25 min	
23	Rest	
24	Jog 25 min	
25	Rest	
26	Jog 30 min	
27	Rest	
28	Jog 30 min	
29	Jog 30 min	
30	Rest	

462

463 **Table 6: In-clinic Exercises**

Exercise	Parameters	When added	Diagram
Slantboard calf stretch (straight leg)	R and L LE at same time: 3 minutes	2nd visit	 www.hep2go.com

Squats	Repetitions: 10 Sets: 2	2nd visit	 www.hep2go.com
Single leg stance (SLS) on airex	R and L LE: 30 second balance Repetitions: 3	2nd visit	 www.hep2go.com
3-way hip kicks with green miniband	R and L LE Repetitions: 10 Sets: 2	2nd visit	 www.hep2go.com
Step up 8-inch step with leg drive	R and L LE Repetitions: 10 Sets: 2	3rd visit	 www.hep2go.com

Side step with miniband	R and L LE 10 feet one way Repetitions: 2 laps	3rd visit	 www.hep2go.com
Goblet squat with 8-pound weight	Repetitions: 20 Sets: 2	4th visit	 www.hep2go.com
Step down 8-inch step	R and L LE Repetitions: 10 Sets: 2	4th visit	 www.hep2go.com
Rockerboard (front and side)	30 second balance Repetitions: 3	6th visit	 www.hep2go.com

Agility drills (light jog)	Side shuffle 20 feet each side Cross over front 20 feet each side Cross over back 20 feet each side Grapevines 20 feet each side	7th visit	 www.womensrunning.com

464

465 **CARE Checklist**

466 ***Final Parts One & Two, PTH708:*** Completed for the final submission to document the locations of key case report components.

CARE Content Area	Page
1. **Title** – The area of focus and "case report" should appear in the title	2
2. **Key Words** – Two to five key words that identify topics in this case report	2
3. **Abstract** – (structure or unstructured) a. Introduction – What is unique and why is it important? b. The patient's main concerns and important clinical findings. c. The main diagnoses, interventions, and outcomes. d. Conclusion—What are one or more "take-away" lessons?	3-4
4. **Introduction** – Briefly summarize why this case is unique with medical literature references.	4
5. **Patient Information** a. De-identified demographic and other patient information. b. Main concerns and symptoms of the patient. c. Medical, family, and psychosocial history including genetic information. d. Relevant past interventions and their outcomes.	6-7
6. **Clinical Findings** – Relevant physical examination (PE) and other clinical findings	7-9
7. **Timeline** – Relevant data from this episode of care organized as a timeline (figure or table).	13
8. **Diagnostic Assessment** a. Diagnostic methods (PE, laboratory testing, imaging, surveys). b. Diagnostic challenges. c. Diagnostic reasoning including differential diagnosis. d. Prognostic characteristics when applicable.	8-9
9. **Therapeutic Intervention** a. Types of intervention (pharmacologic, surgical, preventive). b. Administration of intervention (dosage, strength, duration). c. Changes in the interventions with explanations.	10-12
10. **Follow-up and Outcomes** a. Clinician and patient-assessed outcomes when appropriate. b. Important follow-up diagnostic and other test results. c. Intervention adherence and tolerability (how was this assessed)? d. Adverse and unanticipated events.	14-15

11. **Discussion** a. Strengths and limitations in your approach to this case. b. Discussion of the relevant medical literature. c. The rationale for your conclusions. d. The primary "take-away" lessons from this case report.	15-16
12. **Patient Perspective** – The patient can share their perspective on their case.	
13. **Informed Consent** – The patient should give informed consent.	2

467