1999

Plantar Fasciitis: Etiology and Treatment

Scott Ackman
University of North Dakota

Follow this and additional works at: https://commons.und.edu/pt-grad
Part of the Physical Therapy Commons

Recommended Citation
https://commons.und.edu/pt-grad/2

This Scholarly Project is brought to you for free and open access by the Department of Physical Therapy at UND Scholarly Commons. It has been accepted for inclusion in Physical Therapy Scholarly Projects by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinebyousif@library.und.edu.

by

Scott Ackman
Bachelor of Science in Physical Therapy
University of North Dakota, 1998

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
1999
This Independent Study, submitted by Scott Ackman in partial fulfillment of the requirements for the Degree of Master of Physical therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and hereby approved.

Michelle Labrecque
(Faculty Preceptor)

Peggy Mehr
(Graduate School Advisor)

Thomas Mort
(Chairperson, Physical Therapy)
PERMISSION

Title Plantar fasciitis: Etiology and treatment.

Department Physical Therapy

Degree Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in his/her absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this Independent Study Report or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature

Date 11-6-98
**TABLE OF CONTENTS**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Figures</td>
<td>v</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vi</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>vii</td>
</tr>
<tr>
<td>Abstract</td>
<td>viii</td>
</tr>
<tr>
<td>Chapter I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Chapter II ANATOMY</td>
<td>6</td>
</tr>
<tr>
<td>Chapter III ETIOLOGY</td>
<td>18</td>
</tr>
<tr>
<td>Chapter IV TREATMENT</td>
<td>23</td>
</tr>
<tr>
<td>Chapter V EVALUATION AND REHABILITATION</td>
<td>34</td>
</tr>
<tr>
<td>Chapter VI SUMMARY</td>
<td>38</td>
</tr>
<tr>
<td>References</td>
<td>40</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Anatomy of the plantar fascia</td>
<td>7</td>
</tr>
<tr>
<td>2.</td>
<td>Superior view of the midtarsal joint</td>
<td>11</td>
</tr>
<tr>
<td>3.</td>
<td>Superior view of the subtalar joint</td>
<td>12</td>
</tr>
<tr>
<td>4.</td>
<td>Sagittal view of the subtalar joint</td>
<td>12</td>
</tr>
<tr>
<td>5.</td>
<td>Forefoot valgus and compensated forefoot valgus</td>
<td>14</td>
</tr>
<tr>
<td>6.</td>
<td>Windlass</td>
<td>14</td>
</tr>
<tr>
<td>7.</td>
<td>The effect of toe extension on arch height</td>
<td>15</td>
</tr>
<tr>
<td>8.</td>
<td>Straight, semi-curved and curved shoe lasts</td>
<td>30</td>
</tr>
<tr>
<td>9.</td>
<td>Heel and forefoot alignment. Normal, forefoot varus and compensated forefoot varus</td>
<td>36</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Differential diagnosis for heel pain</td>
<td>3</td>
</tr>
<tr>
<td>2. Complete list of etiological factors associated with plantar fasciitis</td>
<td>22</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

I would like to thank my mom and dad for their unconditional love and support. A special thanks to Becky Shomler for the illustrations that appear on page 14, 30 and 36.

To my friends and faculty, it has been an enjoyable and unforgettable three years, best of luck in the future.
ABSTRACT

Plantar fasciitis is a common cause of inferior heel pain in athletes and non-athletes. The diagnosis for plantar fasciitis is relatively simple due to the distinct nature of the subjective findings. Despite the simplicity of the diagnosis, a thorough history and objective evaluation are essential in order to identify possible etiological factors. The etiology of plantar fasciitis is multifactorial with no one factor present in all cases. Many treatment methods for plantar fasciitis are currently practiced. It is important to note no one treatment method was found to be successful in all cases of plantar fasciitis. In general, research supported the use of orthotics, iontophoresis, ice and home exercise. Research did not justify the use of phonophoresis, low dye taping or heel cups to treat plantar faciitis. The key to treatment of plantar fasciitis is successfully identifying the etiological factors and designing a rehabilitation program that treats those factors.
Chapter I
INTRODUCTION

Wood first described plantar fasciitis in 1812, but until twenty years ago it was a relatively unknown diagnosis. The change in prominence in the past twenty years is due in large part to the increase in fitness awareness in the 1970's. Plantar fasciitis is commonly reported in basketball players, dancers and in long distance runners. Plantar fasciitis represents approximately 10% of the injuries diagnosed in runners today. The scope of plantar fasciitis is not limited to athletes alone, however, it is common in all walks of life. Non-athletes who develop plantar fasciitis tend to stand for extended periods during the day or are overweight. The military also reports a significant number of recruits suffer from plantar fasciitis during basic training.

Plantar fasciitis is inflammation of the plantar fascia which results from increased tensile strain on the plantar fascia. The increased strain causes micro tearing of the plantar fascia near its insertion on the calcaneus. The micro tears in the fascia will grow larger if the increased strain continues and eventually form large nodules. The fascial overload may cause the formation of bone spurs on the calcaneus. Plantar fasciitis is classified as an overuse injury and is an excellent example of the pathological process. Tissue pathology occurs when the demands placed on the tissue are greater than what the tissue was designed to withstand. Overuse injuries develop through the summation of many small
forces that occur with repetitive activities, as compared to traumatic injuries which are caused by one large force. It is estimated one half of all sports related injuries in children and adults are overuse injuries.\textsuperscript{6}

Plantar fasciitis is the most common cause of inferior heel pain.\textsuperscript{7} Plantar fasciitis is a relatively simple diagnosis due to the distinct nature of the patient’s subjective information. A classic presentation of plantar fasciitis involves pain in the inferior heel that worsens in the morning or after periods of prolonged inactivity. The pain will subside after the tissue warms up. The warm up period may consist of heel cord and plantar fascia stretches or simply taking a few steps. The pain may reoccur after prolonged periods of standing or walking.\textsuperscript{3,4,8,12} The symptoms have a gradual onset and usually take two to three months to develop into a problem that requires treatment. Kwong\textsuperscript{9} suggests in acute cases of plantar fasciitis that pain is limited to the insertion of the plantar fascia on the calcaneus, but in chronic cases the pain extends distally along the entire course of the plantar fascia. Nodules may also be present in chronic cases.\textsuperscript{9} The only significant objective finding is tenderness to palpation of the plantar fascia near its insertion on the medial calcaneal tubercle.\textsuperscript{3,4,8,12}

Plantar fasciitis may be the most common diagnosis accompanying inferior heel pain, but it is not the only possible diagnosis. Numerous differential diagnoses exist for inferior heel pain. Complete rupture of the plantar fascia, compartmental syndrome, calcaneal fracture, tarsal tunnel, and achillies tendonitis are all common causes of heel pain.\textsuperscript{10,11,12} All of these causes are in some way distinguishable from plantar fasciitis (Table 1).
<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Location</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plantar Fasciitis</strong></td>
<td>Medial Heel and Arch</td>
<td>Gradual Onset&lt;sup&gt;3,4,8,12&lt;/sup&gt; Morning Pain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May improve with activity&lt;sup&gt;3,4,8,12&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Complete Rupture of the Plantar Fascia</strong></td>
<td>Medial heel and Arch</td>
<td>Traumatic Onset</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feeling of pop in the arch&lt;sup&gt;7,10&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Swelling&lt;sup&gt;7,10&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arch may swell into a convex shape&lt;sup&gt;7,10&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Presence of residual nodule after swelling subsides&lt;sup&gt;10&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Calcaneal Fracture</strong></td>
<td>Calcaneus</td>
<td>Traumatic onset.  &lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Central plantar ecchymosis within 24 – 48 hours.  &lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Achilles Tendonitis</strong></td>
<td>Posterior aspect of calcaneus</td>
<td>Gradual Onset&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dull Ache&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Worsens when cold or contracted&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May improve with activity&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Compartment Syndrome</strong></td>
<td>Central Compartment</td>
<td>Traumatic&lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Constant Pain&lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Massive Swelling&lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased Sensation&lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Tarsal Tunnel</strong></td>
<td>Medial Heel and Arch</td>
<td>Burning dyasaethesias&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nocturnal Pain&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased symptoms with activity&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive Tinel's Sign&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Systemic</strong></td>
<td>Foot</td>
<td>Bilateral foot pain&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Common in younger patients&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RA, Spondylitis, Reiter’s syndrome&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Table 1-Differential Diagnoses for heel pain.

Plantar fasciitis is caused by a multitude of anatomical and environmental factors. Anatomical factors are simply problems with functional or anatomical
biomechanics. They include excessive pronation, cavus foot and decreased muscular flexibility.\textsuperscript{3,13,14} Environmental factors focus on problems caused by the individual's activities. Errors in training intensity, duration, and equipment are examples of environmental factors associated with plantar fasciitis.\textsuperscript{3} The etiological factors are well known. However, the interaction between environmental and anatomical factors can create a muddled picture. Therefore, singling out one cause for each person can prove difficult. No one anatomical or environmental factor is necessary or sufficient for the development of plantar fasciitis. All of these factors can, and do, contribute to the development of plantar fasciitis. The constant among the etiological factors is that all of the factors increase the tensile strain on the plantar fascia to pathological levels.

The treatment options for plantar fasciitis can be divided into four categories. Modalities, biomechanical corrective devices, surgical release, and home exercises have all proven effective in the treatment of selective cases of plantar fasciitis. Several modalities are used for the treatment of plantar fasciitis such as ice, iontophoresis, and phonophoresis.\textsuperscript{4,10,15} Orthotics, low dye taping and heel cups are all examples of biomechanical corrective devices.\textsuperscript{16,17,18} Surgery involves cutting of the plantar fascia to release excess tension.\textsuperscript{19} Night splints and a home exercise program also may be included to stretch or strengthen surrounding tissue.\textsuperscript{8,9} All of the options have advantages and disadvantages, but none of the aforementioned treatment methods will be effective in all cases of plantar fasciitis.
Physician's and Physical Therapist's today are well versed in etiology and treatment options for plantar fasciitis, however, there are many misconceptions and differing of opinions about the effectiveness of each treatment. The purpose of this paper is to further educate medical professionals on all aspects of plantar fasciitis. The goal of this paper is to crystallize the causes and treatments of plantar fasciitis, allowing clinicians to better understand the etiology of treatment.
CHAPTER II
ANATOMY AND BIOMECHANICS

Biomechanical principles and anatomical relationships play key roles in the development of plantar fasciitis. Thus, a basic knowledge of these two elements is required to fully understand plantar fasciitis.

The plantar fascia is embedded deep into the tissues of the plantar aspect of the foot and consists of a strong band of collagen fibers (Figure 1). The majority of the fibers run in a longitudinal direction originating from the medial tubercle of the calcaneus.\textsuperscript{11} The plantar fascia is thick and narrow near its origin but becomes thinner and broader as it extends distally.\textsuperscript{20} At its origin the plantar fascia consists of medial, lateral and central bands. It is important to note there is a differing of opinion on the exact definition of the plantar fascia. In some circles it is considered to be synonymous with the plantar aponeurosis.\textsuperscript{11} However, in other texts the plantar fascia is not considered to be synonymous with the plantar aponeurosis. In these texts the plantar aponeurosis is considered to consist of the central band only.\textsuperscript{11} For the purposes of this paper, the plantar aponeurosis will be considered only the central band and the plantar fascia will be considered all three bands.

The plantar aponeurosis is the most complex of the three portions of the plantar fascia.\textsuperscript{20} The plantar aponeurosis divides into five bands just proximal to the metatarsal joints.\textsuperscript{11,20} As each band moves distally they divide into
the dermis of the skin near the ball of the foot. The five deep components split again forming medial and lateral septa which border the flexor tendons and act to separate them from the lumbricales. The septa of the deep components blend with several structures including the plantar pads of the metatarsal phalangeal joints, fibrous flexor sheaths, interosseous fascia, and the periosteum at the base of the proximal phalangeals. The medial and lateral septa to the first digit also attach to the medial and lateral sesamoid bones and to the deep fascia of the flexor hallucis brevis. The blend of flexor tendons and deep components with the transverse metatarsal ligaments form a series of arches. The tendons of the short and long flexor tendons pass through these arches. Spaces are created between the five processes, and allow the lumbricales, digital vessels and nerves to become superficial. The five processes of the plantar aponeurosis are bound together by the transverse fasciculi. The fasciculi increase the strength of the plantar aponeurosis.
The three portions of the plantar fascia are continuous. The three are, however, distinguishable due to the presence of two vertical intramuscular septa. The intramuscular septa separate the plantar aponeurosis from the medial and lateral bands of the plantar fascia. The medial and lateral bands of the plantar fascia are broader and thinner than the central band and cover the medial and lateral sides of the sole respectively. The medial band of the plantar fascia covers the under surface of the abductor hallucis tendon. Originating from the flexor retinaculum, the medial band blends with the deep fascia medially and the central band laterally. The lateral band of the plantar fascia covers the under surface of the abductor digiti minimi. It originates from the lateral process of the calcaneal tuberosity and inserts on the base of the 5th metatarsal.

The muscles of the plantar surface of the foot can be divided into three groups or into four layers. The anatomy of the plantar musculature and its relationship to the plantar fascia is easiest understood by dividing the plantar musculature into four layers. The four layers of muscles are distinguishable due to the presence of transverse septa. The transverse septa branch from the previously mentioned vertical intramuscular septa and act as a border between each of the four layers. The plantar fascia covers the under surface of the first, most superficial, layer. The first layer consists of the abductor hallucis, flexor digitorum brevis, and the abductor digiti minimi. The flexor digitorum brevis originates from the medial calcaneal tubercle and the plantar fascia. The origin of the flexor digitorum brevis is just distal to the origin of the plantar fascia on the medial calcaneal tubercle. The plantar fascia also serves as part of the origin
for both the abductor hallucis and abductor digiti minimi. The second layer of plantar muscle consists of the lumbricales and the quadratus plantae. The flexor hallucis brevis, adductor hallucis and the flexor digiti minimi brevis make up the third layer of muscle. The fourth and deepest layer of the plantar musculature consists of the dorsal and plantar interossei.\textsuperscript{20,22}

The plantar nerves are often involved with inferior heel pain which makes a brief anatomical description necessary.\textsuperscript{7} The tibial nerve divides into the medial and lateral plantar nerves posterior to the medial malleolus. The medial plantar is the larger of the two branches and provides motor and sensory information to the foot. The medial plantar nerve runs through the heel by passing underneath the proximal end of the abductor hallucis.\textsuperscript{23} The nerve then runs distally between the abductor hallucis medially and flexor digitorum brevis laterally. The medial plantar nerve concludes near the base of the metatarsals when it divides into motor and sensory branches.\textsuperscript{23} The motor branches of the medial plantar nerve innervate the abductor hallucis, flexor digitorum brevis, flexor hallucis brevis and the medial most lumbricales.\textsuperscript{20,22,23} The cutaneous branches of the medial plantar nerve provide sensory information for the medial three and a half digits. The lateral plantar nerve enters the heel deep to the abductor hallucis and runs distally and laterally between the 1\textsuperscript{st} and 2\textsuperscript{nd} layers of the plantar muscles.\textsuperscript{23} The lateral plantar nerve concludes by dividing into superficial and deep branches. The superficial branches provide sensation to the lateral one and a half digits. Deep and superficial branches provide motor
innervation to the adductor hallucis, flexor digiti minimi brevis, dorsal interossei, plantar interossei, abductor digiti minimi, quadratus plantae and the 2nd – 4th lumbricales.22,23

The biomechanics of the foot are extremely complex. A basic understanding of biomechanical principles is crucial to understanding the etiology and treatment of plantar fasciitis. The foot performs several diverse functions acting as a shock absorber, stabilizer, torque converter, and accommodating to differing terrain.24 The foot also acts to propel the body forward.24 Complex biomechanical relationships make it possible for the foot to perform all of these functions. An attempt will be made to include only the biomechanics pertinent to plantar fasciitis with the most important structures being the midtarsal joint, subtalar joint, and 1st ray.

The midtarsal joint is a saddle joint consisting of two separate articulations and separates the rearfoot from the forefoot. The first articulation occurs between the talus, calcaneus and the navicular. The second articulation occurs between the calcaneus and the cuboid. The joint is supported by the talocalcaneonavicular and calcaneocuboid ligaments. Dynamically the joint is supported by the plantar fascia.24 The joint has a longitudinal and an oblique axis. The longitudinal axis is positioned approximately 9 degrees medial to the sagittal plane and the oblique axis is positioned approximately 57 degrees medial to the sagittal plane25 (Figure 2). The longitudinal axis, which roughly parallels the subtalar axis, allows for half of the pronation and supination to occur. The oblique axis, which roughly parallels the ankle joint, allows for dorsiflexion and
plantarflexion. The orientation of the two joint axis will change as the position of the subtalar joint changes. Consequently, the interaction of the subtalar and midtarsal joints has a profound affect on the functional capabilities of the foot.

The subtalar joint exists at the junction between the calcaneus and the talus. The main function of the subtalar joint is to act as a torque converter. The joint "converts" tibial rotation occurring in the transverse plane to displacement of the rearfoot which occurs in the frontal plane. The joint is supported by two major ligaments; the calcaneofibular laterally and internally by the interosseous talocalcaneal. The axis of motion for the subtalar joint is situated roughly 23 degrees medial to the sagittal plane and 42 degrees superiorly from the transverse plane (Figures 3 and 4). The axis is described as running through the foot beginning inferior, posterior and lateral moving to superior, anterior and medial. The positioning of the joint axis allows for only two motions to take place. The first motion is pronation and the second is supination, both of which are triplanar motions. Approximately one half of the pronation and supination occurs at the subtalar joint. Pronation involves a combination of eversion, dorsiflexion, and abduction. In a closed chain environment pronation will
manifest itself as the talus adducting and plantarflexing on the stable calcaneus. Essentially the talus moves down and in.\textsuperscript{24} The amount of pronation that occurs depends on the position of the hindfoot, subtalar mobility and bone configuration of the midfoot.\textsuperscript{26} Pronation at the subtalar joint causes the two planes of the midtarsal joint to move closer to parallel. This movement unlocks the forefoot and allows for an increase in foot mobility. Pronation results in a flattening of the longitudinal arch.\textsuperscript{27} The plantar fascia acts to stabilize the foot and control the flattening of the arch during pronation.\textsuperscript{26}

Supination consists of inversion, plantar flexion, and adduction. Supination will be manifested with the talus dorsiflexing and abducting when the calcaneus is fixed.\textsuperscript{24} Supination of the subtalar joint causes the two joint axis to approach a perpendicular orientation and results in the forefoot becoming locked. The locking of the forefoot increases foot stability and improves its ability to act as a lever for push off. However, locking at the midtarsal joint decreases the foot's ability to act as a shock absorber.\textsuperscript{24}

The 1\textsuperscript{st} ray is very important in the biomechanics of the foot. The 1\textsuperscript{st} metatarsal and medial cuneiform comprise the 1\textsuperscript{st} ray, which runs from proximal,
plantar and medial to distal, dorsal and lateral. The movements around the axis are triplanar. The first triplanar motion involves dorsiflexion, adduction, and inversion. The second triplanar motion involves plantarflexion, abduction, and eversion.

The forefoot is very complex biomechanically due to the existence of the 1st-5th rays. The interaction between the five can dramatically affect the function and position of the midtarsal and subtalar joints. Flexion of the 1st ray will lead to a slightly lesser degree of flexion of the 2nd ray. The same applies for flexion of the 5th ray and 4th ray. The 1st and 5th rays can also interact to cause a twist in the forefoot. The twist is caused by opposite movements of the 1st and 5th rays. Flexion of the 1st ray accompanied by extension of the 5th ray is referred to as a pronation twist or forefoot valgus. Extension of the 1st ray and flexion of the 5th ray is a supination twist or forefoot varus. The forefoot twist is important because of the effect it has on the standing foot. Ordinarily the heel and metatarsal heads will all rest in the same horizontal plane. However, if a pronation forefoot twist (forefoot valgus) is present when the foot touches the ground, only the medial side of the forefoot will be in contact with the ground (Figure 5). The foot will be unstable because the lateral aspect of the foot is not in contact with the ground. The foot can compensate in three ways to achieve stability. First, it can achieve stability by simply un-twisting the forefoot. If the twist will not undo (i.e. forefoot malalignment exists) the second method of correction occurs which involves supination of the forefoot on the midtarsal joint until the metatarsal heads are horizontal. If neither of the above two options can
take place the third way the metatarsal heads can become horizontal is if the entire heel supinates.²⁸ The last scenario would present as forefoot valgus corrected by compensatory rearfoot varus (Figure 5).

The functions of the plantar fascia have been discussed in context with the biomechanics of the foot. The methods by which the plantar fascia reinforces the longitudinal arch and acts as a secondary restraint to arch descent is often compared to a windlass.²⁵-²⁷

In addition to the two functions mentioned above the plantar fascia will help with the extension of the 1st metatarsal phalangeal joint. This action will cause the three following effects: raise the arch, cause the calcaneus to invert, and laterally rotate the tibia.²¹ The method by which the plantar fascia and 1st metatarsal phalangeal joint accomplish this is described by Hicks as the windlass effect²¹ (Figure 6).
As mentioned previously in Chapter Two, part of the plantar aponeurosis inserts into the plantar pad. The plantar pads articulate with the five metatarsal heads. The plantar pad slides freely underneath the head of the metatarsal when flexion or extension occurs at the metatarsal phalangeal joints. Toe extension results in the plantar pad moving anterior to the head of the metatarsal. The movement of the plantar pad increases the tension present in the plantar fascia. Hicks described this effect as if the drum of the windlass was wound one quarter turn which tightens the cable (fascia). The functional length of the plantar fascia is shortened by about 1 cm. The plantar fascia does not change length. In order to achieve the change in distance, the head of the 1st metatarsal moves proximally towards the calcaneus (Figure 7). Hicks confirmed the plantar fascia was strong enough to do this and found the plantar aponeurosis capable of withstanding 1.7 – 3.4 times the body weight. To confirm his suspicions Hicks cut the plantar aponeurosis and found the arch raising mechanism to disappear. Essentially the windlass effect states extension of the metatarsal joint will cause the metatarsal joint to move closer to the calcaneus. However, it is noted with equal toe extension the 1st ray will approximate the most and the 5th ray will approximate the least. Thus, extension of the metatarsal will cause forefoot pronation.

Figure 7-The effect of toe extension on arch height as demonstrated by radiographic tracing. J Anatomy.
The functional biomechanics of the foot and tensile strain on the plantar fascia change as the body proceeds through the gait cycle. The constant changes that take place make a basic understanding of gait cycle terminology essential. The gait cycle is divided into eight distinctive phases: initial contact, loading response, mid-stance, terminal stance, pre-swing, initial swing, mid-swing, and terminal swing. Initial contact occurs when the heel contacts the ground. Loading response occurs when the weight of the body is transferred onto the outstretched limb. Mid-stance occurs when the body is centered over a single limb. Terminal stance exists after the body progresses past the single limb. The body enters the pre-swing phase when the limb is unloaded. Pre-swing is the second phase of double limb support. The initial swing initiates when the thigh begins to advance as the foot clears the floor. Mid-swing begins when the foot clears the ground. The last phase of the gait cycle is terminal swing which occurs when the extended limb is prepared for initial contact. At initial contact the subtalar joint is supinated, but it moves quickly into pronation as the body progresses through the gait cycle. At initial contact the longitudinal axis of the midtarsal joint is supinated while the oblique axis is pronated. The 1st ray is dorsiflexed and inverted. Tension in the plantar fascia increases from initial contact to midstance. Maximal pronation of the subtalar joint occurs when the center of gravity passes over the stance leg. This results in flattening of the longitudinal arch, which increases the tension of the plantar fascia. This occurs roughly 40% of the way through the stance phase. At the midtarsal joint the longitudinal axis is
maximally supinated and the oblique axis of the midtarsal joint is pronated. The subtalar joint begins to supinate as the body moves from midstance to terminal stance. The 1st ray begins to plantarflex and evert as the body progresses from mid to terminal stance.

Maximal supination of the subtalar joint occurs between terminal stance and preswing. The longitudinal axis of the midtarsal joint is fully pronated, which allows the forefoot to stay in contact with the ground for push off. Toe extension during push off results in a peak of plantar fascia tension. The oblique axis of the midtarsal joint has progressed to full supination at preswing. The 1st ray is fully plantarflexed and everted at the time of preswing.
CHAPTER III
ETIOLOGY

Countless etiological factors are associated with and contribute to the development of plantar fasciitis. However, no factor by itself has been proven to cause plantar fasciitis. A number of studies have been published in an attempt to outline specific causes or predisposing factors of plantar fasciitis. Unfortunately, the studies conclusions tend to contradict each other. This chapter will simplify the etiology of plantar fasciitis into three basic categories: functional biomechanical deficits, anatomical biomechanical deficits and environmental considerations.

Functional biomechanical deficits are associated with muscle length or strength imbalances in the foot and ankle. Restricted motion of the 1st metatarsal phalangeal joint (MTP) is widely considered to have an adverse effect on the function of the plantar fascia. Decreased 1st MTP motion limits the ability of the plantar fascia to stabilize, tighten and elevate the longitudinal arch. This results in an increased risk of injury. Creighton found a significant difference between passive flexion and extension in runners with plantar fasciitis and runners without plantar fasciitis. First MTP active extension was also found to be significantly different when comparing runners with and without plantar fasciitis. The average plantar fasciitis sufferer lacked 16 degrees of active extension and 22 degrees of passive extension when compared to the asymptomatic group.
Decreased dorsiflexion ROM, increased plantarflexion ROM and plantarflexion strength deficits are related to plantar fasciitis. Kibler found deficits in dynamic ankle range of motion to exist in 38 of 43 subjects studied with plantar fasciitis. The deficits in dynamic motion ranged from 17% to 38% when compared to a control group. Analysis of passive ankle range of motion revealed 37 of 43 subjects with plantar fasciitis could not dorsiflex past five degrees from neutral on their affected side or had a deficit of greater than ten degrees from the unaffected side. The theory behind tight calf muscles as a contributing cause of plantar fasciitis is well understood. A tight gastroc soleus complex results in a valgus heel position at heel strike which restricts the midfoot's ability to supinate and dorsiflex. Ten degrees of dorsiflexion are needed for the foot and ankle to maintain proper biomechanics during the gait cycle.

Kibler found 37 of 41 subjects with plantar fasciitis had peak torque deficits in plantar flexion. The strength deficits alter the biomechanics of the foot resulting in decreased efficiency in force production and shock absorption. Kibler concluded functional pronation of the hindfoot results, which leads to an increase strain on the plantar fascia. Together these two factors increase the tensile strain on the plantar fascia enough to cause pathology.

Messier and Warren mention an increase in plantarflexion range of motion as a possible factor in the development of plantar fasciitis. Warren found people with plantar fasciitis tend to have greater than 60 degrees of plantar flexion. She theorizes increased plantar flexion allows the runner more time to "impart backforces on the ground."
Numerous anatomical biomechanical deficits have been cited as possible contributors to plantar fasciitis. However, only two are consistently mentioned. Overpronation has for a long time been considered the number one anatomical factor in plantar fasciitis. Pronation is a compensatory movement caused by malalignment of the heel and forefoot or leg and heel. Pronation leads to flattening of the longitudinal arch, which increases tensile strain on the plantar fascia. Patient's with plantar fasciitis tend to have an increased amount of pronation when compared to normative data. The other anatomical biomechanical factor is cavus foot, which is an overly supinated foot. As mentioned previously supination results in the foot becoming rigid which diminishes its ability to absorb shock. The decreased ability of the foot to act as a shock absorber increases the tensile strain on the plantar fascia. The resulting strain contributes to the development of plantar fasciitis.

Environmental considerations make up the third and final class of etiological factors. These factors for the most part have little or nothing to do with the body but are dependent on what is done to the body. Training error is the most widely recognized environmental factor of plantar fasciitis. Errors in training can be due to duration, length or intensity. Logging an excessive amount of miles accounts for 29% of all training errors. According to a study done by Warren, runners' with plantar fasciitis tend to run more than 30 miles a week while asymptomatic runners run less than 30 miles per week. Interval workouts, running on hard surfaces, and running hills have also been associated with plantar fasciitis in runners. A study done by Jones and Warren concluded
when runners with plantar fasciitis tend to be taller, older, weigh more and have run for more years than runners without plantar fasciitis.

Weight plays a role in the development of plantar fasciitis. Wapner\textsuperscript{8} reported the subjects in his study with plantar fasciitis were on average 20 pounds over ideal weight.

None of the aforementioned factors are sufficient by themselves to cause plantar fasciitis. However, a review of the literature does implicate these factors in the development of plantar fasciitis. The factors discussed in Chapter Three are a partial list of etiological factors mentioned in the reviewed literature. These are the most consistently mentioned and the most pertinent to clinicians. (A complete list of all the factors mentioned is provided in Table 2)
Etiological Factors associated with Plantar Fasciitis.

**Anatomical Biomechanical Factors**

- Depressed or non-existent longitudinal arch.\(^{3,10,12,31}\)
- Overpronation at the subtalar joint.\(^{3,7,10,12,27}\)
- Increased height of the longitudinal arch or cavus foot.\(^{3,7,12,27,31}\)
- Leg length discrepancy.\(^{3,12,27,31}\)

**Functional Biomechanical Factors**

- Decreased 1\(^{st}\) metatarsal extension.\(^{14}\)
- Decreased plantar flexion strength.\(^3\)
- Tight gastocnemius/soleus complex (decreased ROM dorsiflexion).\(^{9,10,12,27,31}\)
- Increased plantar flexion ROM.\(^{27,30}\)
- Obesity.\(^{7,8,31}\)

**Environmental Factors**

- Changes in intensity or duration of exercise.\(^{3,7,10,12}\)
- Equipment changes.\(^{3,13}\)
- Worn out running shoes.\(^7\)
- Running on hard surfaces.\(^{10,13,18}\)
- Running Hills.\(^{10,13,18}\)
- Standing on hard or uneven surfaces.\(^7\)
- Standing for prolonged periods of time.\(^7\)

Reported tendencies when comparing plantar fasciitis sufferers to non sufferers. Plantar fasciitis sufferers tend to:

- Weigh more.\(^{31}\)
- Taller.\(^{31}\)
- Older.\(^{31}\)
- Run for a greater number of years.\(^{31}\)
- Run less miles per week.\(^{31}\)
- Slower training times.\(^{31}\)

Table 2-Etiological factors of plantar fasciitis listed in reviewed literature.
CHAPTER IV
TREATMENT OPTIONS

As previously mentioned in Chapter One, the treatment options for plantar fasciitis can be divided into four categories; modalities, biomechanical corrective devices, surgical release and home exercises. Modalities used in the treatment of plantar fasciitis include iontophoresis, phonophoresis and ice. Biomechanical corrective devices include orthotics, heel cups, shoes, and low dye taping. A home program can include, stretching, strengthening, and night splints. Surgical release is the final treatment option discussed. The following chapter explains the theories behind the aforementioned treatments and lists strengths and weaknesses of each treatment.

**Iontophoresis**

Iontophoresis is commonly used and is effective in the treatment of plantar fasciitis and other inflammatory conditions.\textsuperscript{32-34} First demonstrated by LeDuc in 1908, iontophoresis is a process in which ionized drugs are driven through intact skin by bipolar electrodes. The positive and negative electrodes create an electrical potential which pushes the ions through the skin. Positive ions are pushed through at the positive pole and negative ions are pushed through at the negative pole.\textsuperscript{4,32,33} Recommended treatment dosage for iontophoresis ranges from 40 mAmp minutes to 80 mAmp minutes. Dexamethasone sodium
phosphate, an anti-inflammatory, is commonly used in physical therapy as the negative ion. Lidocaine, an analgesic, is commonly used as the positive ion.\textsuperscript{4,33,34}

Iontophoresis has several advantages as a method of treatment for plantar fasciitis. It is a non-invasive and relatively painless way to administer anti-inflammatories to a specific location. Anti-inflammatory tissue concentrations have been found to be higher with iontophoresis as compared to oral anti-inflammatories. As shown by Gudeman\textsuperscript{4}, iontophoresis also increases the rate of initial healing which is beneficial in the athletic population.

Treatment of plantar fasciitis with iontophoresis also poses several disadvantages.\textsuperscript{4} The main disadvantage is iontophoresis does not correct the etiological factors that lead to plantar fasciitis. Iontophoresis only treats the symptoms, not the underlying cause. Direct injections provide a higher tissue concentration of anti-inflammatories than does iontophoresis. The effectiveness of iontophoresis is negatively correlated with age; the older the patient the less likely iontophoresis will be effective. Burning, redness and tingling at the site of the electrodes are relatively common.\textsuperscript{4,32,33}

**Phonophoresis**

Phonophoresis is another commonly used modality in the treatment of plantar fasciitis. Griffin\textsuperscript{35} demonstrated in 1967 that cortisol could be driven into muscle tissue with the use of ultrasound. The exact mechanism by which hydrocortisone is driven into the skin is unknown.\textsuperscript{15}
Studies have shown phonophoresis to be effective in the treatment of many inflammatory conditions. Epicondylitis, subdeltiod bursitis, and synovitis of small joints all respond favorably to treatment with phonophoresis. The same study found plantar fasciitis along with trochanteric bursitis and subscapular bursitis to respond poorly to phonophoresis. Poor outcome of plantar fasciitis treatment by phonophoresis has been attributed to the thickened epidermis present on the plantar aspect of the foot.

Although controversy exists over the effectiveness of phonophoresis in the treatment of plantar fasciitis, many clinicians use it and report positive results. There are several advantages to treating plantar fasciitis with phonophoresis. Unlike iontophoresis, phonophoresis drives the entire molecule into the skin. Phonophoresis also takes less time than iontophoresis and penetrates deeper into the skin.

The disadvantages of phonophoresis as a treatment modality are obvious. The main disadvantage is its questionable effectiveness. Phonophoresis also does not correct any etiological factors and only treats the symptoms. Phonophoresis can not be used in situations where ultrasound is contraindicated.

Ice

Ice is the most recognizable modality used in the treatment of plantar fasciitis. The key difference between ice and phonophoresis or iontophoresis is ice is usually applied outside the clinic. Ice is classified as a modality but it could just as easily be listed under elements of a home program. The ability of ice to reduce inflammation is the main reason it is used in the treatment of plantar
fasciitis. Ice can be applied in several ways: ice massage, cold pack or chemical cold packs. The goal for each is to anesthetize the area. The time it takes to do this will differ for each application method.

As part of a traditional home program including stretching and strengthening, ice has been found to be effective in the treatment of plantar fasciitis.

The advantages of using ice as a treatment for plantar fasciitis are simple. It is an effective method of pain relief and acts as an anti-inflammatory. Ice is inexpensive and can be applied by the patient at home.

Like the other modalities, the main disadvantage of ice is it doesn't correct the problem, it only treats the symptoms. Some people may not tolerate cold well or may have contraindications to cold.

Orthotics

The foot functions most efficiently when the subtalar joint is in neutral. A neutral subtalar position puts the heel perpendicular to the distal one third of the leg. Therefore, excessive amounts of pronation or supination place an increased amount of stress on the ligaments, muscles and bones of the foot. Orthotics correct abnormal biomechanics by restoring the subtalar and midtarsal joints to their correct position. Orthotics also cushion the foot. Both functions of orthotics increase the efficiency of the foot and decrease stress on the surrounding tissue.

Several studies have found orthotics to be very effective in treating plantar fasciitis. Many running injuries are associated with alterations in kinematic
and kinetic factors; consequently orthotics tend to be especially helpful in runners.\textsuperscript{13,16,18} Rigid orthotics have been found to work well in long distance runners, in situations where more foot control is required, and for tall or obese people.\textsuperscript{13} Soft orthotics work well for competitive races, short distance runners and people who have cavus feet.\textsuperscript{13}

Orthotics have many advantages over other treatments for plantar fasciitis. The biggest advantage is their ability to restore normal foot biomechanics. James\textsuperscript{13} reports pronation in an abnormal foot will return to normal levels when an orthotic is used. Restoring normal biomechanics allows the foot to function more efficiently eliminating excessive and abnormal stress on the plantar fascia.

The disadvantages of treating plantar fasciitis with orthotics are mostly related to the demands they place on the Physical Therapist and the facility. Successful treatment of plantar fasciitis with orthotics is dependent on choosing the correct orthotic for each patient.\textsuperscript{18} Many types and styles of orthotics exist which can make fitting difficult. Casting materials and/or insoles with posting material are needed in order to provide temporary orthotics. Making orthotics requires the Physical Therapist to have a certain level of expertise.

Heel Cups

Heel cups are commonly used in the treatment of plantar fasciitis.\textsuperscript{38} Heel cups are thought to reduce the impact on the heel by cupping the soft tissue together. Heel cups also act to shift vertical impulses from the rearfoot to the
forefoot and midfoot. Some types of heel cups are made of viscoelastic material which helps further reduce impact force on the heel.

Although heel cups are commonly used, recent studies have questioned their usefulness. Nigg reports visco heels did not significantly change the vertical impact force on the heel. Katoh goes further by saying heel cups should be contraindicated in the treatment of plantar fasciitis. No patients in his study reported benefits from using heel cups. Plantar fasciitis patients have a longer heel contact time and shorter forefoot contact time. Nigg feels this response helps reduce tension on the plantar fascia thus providing a measure of pain relief. Heel cups, however, increase the time spent on the forefoot, which increases tension on the plantar fascia resulting in increased symptoms.

Despite questions about their efficacy, heel cups do have some value. Heel cups tend to work well when treating the elderly or people with fat pad atrophy.

The disadvantages of using heel pads are obvious. They have been found to have a negative effect on biomechanics which can lead to increased tension on the plantar fascia.

Low Dye Taping

Strapping the longitudinal arch is a commonly used method of stabilizing the arch. In addition to stabilizing the arch, taping can help control heel valgus, stabilize the first metatarsal head, decrease pronation and change the position of foot strike. The low dye method of taping will medialize heel strike forces, diminish the duration of forces on the midfoot and medialize forefoot forces. The
idea being this will diminish the strain on the plantar fascia and surrounding ligaments. A limited number of studies have been done on the validity of treating plantar fasciitis with low dye taping. The mechanical effects of low dye taping have been well studied, and the results of these studies have led to the use of low dye taping as a method of treating plantar fasciitis.  

Not enough research has been done on low dye taping to draw conclusions on its effectiveness as a method of treatment. Low dye taping is a temporary biomechanical solution; if it is found helpful an orthotic is usually prescribed. Moisture loosens the tape so low dye taping is not a good treatment choice for people who exercise. To produce results the patient must learn to apply the tape.

Shoes

Footwear may not be considered a form of treatment for plantar fasciitis but for runners the proper footwear plays a key role in the relief of symptoms. Matching foot type with shoe construction can do wonders for runners with plantar fasciitis. The type of last, construction, midsoles and heel counters all affect the function of the shoes (Figure 8). Generally speaking, a straight last (shape) offers more support and works well for pronators. Curved lasts allow for more flexibility and work well for supinators.  

The construction of the insole is also important when selecting shoes. A board last offers more stability making it well suited for pronators. A slip last tends to provide a better fit and is more flexible than a board last.
The make up of the midsole also affects shoe performance. Polyurethane is one type of material used in midsole construction. It is heavier and more durable than other midsole materials and works well for heavier people. Another type of midsole material is ethyl vinyl acetate (EVA). EVA is more spongy than polyurethane but not as durable making it a good choice for lighter weight people. The heel counters in running shoes should be firm and non deformable. The life of a running shoe tends to be 500 to 700 miles.

Exercise Program

A strong home exercise program is a key component of plantar fasciitis treatment. A traditional plantar fasciitis home program involves icing, stretching and strengthening the foot and ankle. Biomechanical principles are responsible for shaping the home program. A tight gastrocnemius-soleus complex and restricted 1st metatarsalphalangeal extension are regarded as etiological factors of plantar fasciitis. Consequently, stretching targets the gastronemius, soleus,
and plantar fascia. Strength deficits in the gastrocnemius-soleus complex, and foot intrinsics also play a role in plantar fasciitis. The presence of these etiological factors cause the inclusion of gastrocnemius and soleus strengthening in a home program.

The validity of treating plantar fasciitis with just a home exercise program has not been well researched. However, one study found home exercise programs to be an appropriate form of plantar fasciitis treatment.

Home exercise programs offer a relatively cheap form of plantar fasciitis treatment. Home programs also work on correcting functional biomechanical deficits. Essentially, the correction of these deficits can eliminate current symptoms and future reoccurrence.

Patient compliance plays a key role in the success of any home program. A home program will be unsuccessful if the patient does not comply. Home programs also do not provide immediate relief of symptoms so patients may quit the program before seeing the results.

Night Splints

The foot assumes a plantarflexed position during sleep regardless of sleeping position. This allows the gastroc soleus complex to contract through the night. The morning pain associated with plantar fasciitis is due to the tissue stretch that takes place with the first few steps. Night splints position the foot in 5-10 degrees of dorsiflexion, which does not allow the tissue to contract. No contraction during the night equals no stretch in the morning, essentially eliminating the morning pain.
Studies have found night splints to be an effective form of treatment for plantar fasciitis. Sharkey and Wapner\textsuperscript{8} reported 14 of 17 patients treated with night splints had complete resolution of plantar fascial symptoms.

Night splints are an advantageous treatment for plantar fasciitis for a couple of reasons. The first being night splints are a passive treatment and require the patient only to wear them. In cases where decreased dorsiflexion is an etiological factor, night splints will provide a passive stretch to the tissue throughout the night.

Night splints are not without their disadvantages. It takes most patients a few nights to become comfortable sleeping with night splints, and some patients never become comfortable. The effect of some types of night splints are limited due to them falling off or becoming unattached.

**Surgical Release**

Surgery for plantar fasciitis tends to be a last resort and is done in only 10\% of all cases.\textsuperscript{7} A longitudinal incision is made on the inferior surface of the heel to expose the plantar fascia.\textsuperscript{7,43} The plantar fascia is then cut and released from its insertion on the calcaneus.\textsuperscript{7,43}

Surgery tends to be a successful form of treatment for plantar fasciitis. Studies report patients experience complete relief of symptoms in 55\% - 90\% of cases.\textsuperscript{7,19,43} It is important to note most surgical cases involve patients whose symptoms have persisted for two or more years and conservative treatment has failed.\textsuperscript{7,19,43}
The high success rate of surgical treatment in tough cases is a definite advantage of this form of treatment.

Surgical treatment represents only a minority of the treated cases due to the high number of disadvantages associated with it. Longitudinal arch height diminishes and measurable flattening of the arch occurs with weight bearing after surgery.\textsuperscript{19} This results in a decrease in the foot's overall functional ability.\textsuperscript{19} Six to ten months are needed to fully recover from surgery which in most cases is much longer than conservative methods.\textsuperscript{7,19} Complications are also associated with surgery, including hypertrophic scar formation, neuromas, and heel pad swelling.\textsuperscript{19}
CHAPTER V
EVALUATION AND REHABILITATION

The key to successful management of plantar fasciitis is choosing the correct treatment plan for the patient's etiological factors. Due to the high number of treatment options and myriad of factors associated with plantar fasciitis this can be a difficult task. Therefore, the evaluative process becomes critical to successful management of plantar fasciitis. The evaluative process will reveal the etiological factors at work and allow the therapist to customize a treatment program accordingly.

As mentioned in Chapter One, the subjective findings of the evaluation are relatively distinct and consistent from person to person. Therefore, this portion of the evaluation tends to be simple and straightforward. As a review, plantar fasciitis patients tend to report pain being the worst in the morning or when initiating activity after prolonged periods of inactivity.\(^3,7,10,11,12\) Pain may also occur after prolonged periods of activity. Onset of symptoms is gradual beginning with a dull ache in the heel which worsens as the problem persists.\(^3,7,12\)

The subjective findings will be consistent from patient to patient, but the objective findings can be drastically different. This fact makes conducting a complete objective evaluation critical in the formation of a treatment plan. The aim of the objective evaluation should be to determine possible etiological factors. Specifically, the objective evaluation needs to determine the presence or
absence of abnormal foot and ankle biomechanics. The presence or absence of various biomechanical faults will indicate which treatment option or options should be selected. A thorough objective evaluation will include several basic tests. Forefoot-heel alignment, lower leg-heel alignment, ankle ROM, ankle strength, and 1st metatarsal ROM should all be tested. Positive or negative findings in these four areas will help the therapist narrow his or her treatment options and formulate a comprehensive treatment plan. Matching the findings with the treatment options will allow the therapist to take advantage of the strengths of each treatment modality.

The presence of over pronation and cavus foot as etiological factors make it essential to check leg-heel and forefoot-heel alignment. To check leg heel alignment the patient should be positioned in prone with the foot extending over the edge of the table. One mark should be over the insertion of the achilles tendon on the calcaneus. A second mark is made just distal to the first as close to the midline of the calcaneus as possible. Connect the two marks. Two more marks are made on the distal 1/3 of the tibia and connected. Finally, position the subtalar joint in neutral and compare the relationship between the lines. Parallel to eight degrees of varus is considered normal. If the varus is greater than eight degrees the patient has hindfoot varus. A less than parallel relationship indicates rearfoot valgus (Figure 9).

The patient is also positioned in prone to determine forefoot-heel alignment. The subtalar joint is positioned in neutral and the 1st metatarsal joint is loaded. While in this position a comparison is made between the vertical axis
of the heel and the plane from the 2nd through 4th metatarsal. The plane should be perpendicular to the vertical axis. If the 1st metatarsal is higher than the 5th metatarsal forefoot varus exists. If the 5th is higher than the 1st, forefoot valgus exists.\(^{44}\) If abnormalities in forefoot-heel and leg-heel alignments are revealed in non-weight bearing or in weight bearing, they need to be corrected.

![Diagram of normal forefoot alignment, forefoot varus, and compensated forefoot varus.](image)

Over pronation can be caused by several biomechanical abnormalities that are unrelated to the subtalar or midtarsal joints. Increased hip anteversion, genu varus, and genu valgus can all manifest as increased pronation.\(^{13,41}\) Therefore, it will be important to check for these abnormalities during the initial evaluation to eliminate them as possible causes of increased pronation. In cases where an anatomical biomechanical fault is present it will need to be corrected. Therefore, orthotics should be the foundation of any treatment program.

Limitations in dorsiflexion range of motion is consistently listed as an etiological factor of plantar fasciitis. Consequently, it is necessary to measure
dorsiflexion range of motion to detect any deficits that may exist. Ten to twenty degrees of dorsiflexion is considered normal. Less than five degree is considered to be a significant etiological factor. If deficits exist in dorsiflexion range of motion gastrocnemius and soleus stretching will need to be included in a home exercise program.

The presence of 1st metatarsal range of motion limitations as an etiological factor in plantar fasciitis make it necessary to include 1st MTP measurements in the objective evaluation. Normal passive range of motion for the 1st MTP is considered to be 70 degrees of extension and 45 degrees of flexion. Creighton's research showed patients with less than 45 degrees of passive flexion or marked restrictions in passive extension to be at risk for plantar fasciitis. Stretching of the 1st MTP should be included in cases where limitations of 1st MTP motion exist.

Evaluating gastrocnemius and soleus strength are also an important part of the objective evaluation. Deficits in gastrocnemius and soleus strength have been linked to plantar fasciitis. Including objective tests to measure strength can reveal or eliminate possible etiological factors. When strength deficits are present the inclusion of strengthening exercises in the home program are critical to a successful outcome.
CHAPTER VI

SUMMARY

Plantar fasciitis is the result of a simple inflammatory process. However, this is the only thing simple about plantar fasciitis. As noted throughout this paper, plantar fasciitis is caused by the interaction of several factors. Anatomical biomechanics, functional biomechanics and environmental factors all play a role in the development of plantar fasciitis. Generally speaking, plantar fasciitis begins gradually and initially symptoms are relieved with activity. It usually is several months until the patient seeks treatment.

There are a variety of treatment options for plantar fasciitis. Positives and negatives exist for all treatment options. As mentioned previously the key to successful treatment of plantar fasciitis is to be flexible and match etiological factors with treatment strengths. Conservative treatment is used and successful in the majority of cases. However, not all methods of conservative treatment are supported by scientific research. In general, research supported the use of orthotics, iontophoresis, ice and home exercise. Research did not justify the use of phonophoresis, low dye taping or heel cups to treat plantar fasciitis. Surgical release is a last resort and is used in a minority of cases.

Plantar fasciitis has been the subject of numerous literature reviews and studies over the past few years. However, there is still a lack of outcome studies. In the future, plantar fasciitis research should focus on treatment options and
measuring the effectiveness of each treatment. Combining this information with improved evaluative techniques will help solve some of the mystery of plantar fasciitis.
REFERENCES


