



A descriptive analysis of the relationship between leg alignment and Achilles tendonitis
by Anne Gerard Courtney

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Physical Education

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Abstract:

A study was conducted to investigate the relationship between lower extremity alignment and the achilles tendonitis syndrome in Bozeman, Montana residents who are known to exercise on a regular basis. Selected measures describing the alignment of the lower extremity of 29 subjects were taken. Data were collected and organized into three groups: Group I - no achilles tendonitis; Group 2 - past achilles tendonitis; and Group 3 - present achilles tendonitis. The data were analyzed by a t-test of means and F-ratio of variance.

A significant difference was found in eversion and dorsiflexion with the leg straight using the t-test for Group 1 - no achilles tendonitis and Group 3 - present . achilles tendonitis. The F-ratio was applied to these two groups and a significant difference was found in external rotation with the hip flexed.

Group 1 - no achilles tendonitis and Group 2 - past achilles tendonitis were found to have significant differences in means in inversion and forefoot varus and a significant difference in variance using the F-ratio in forefoot varus.

Inversion, eversion and forefoot varus were measurements found to be significantly different between Group 2 -past achilles tendonitis and Group 3 - present achilles tendonitis using the t-test of means. The F-ratio between these two groups found external rotation with the hip flexed to be significantly different.

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A DESCRIPTIVE ANALYSIS OF THE RELATIONSHIP BETWEEN
LEG ALIGNMENT AND ACHILLES TENDONITIS

by

ANNE GERARD COURTNEY

A thesis submitted in partial fulfillment
of the requirements for the degree

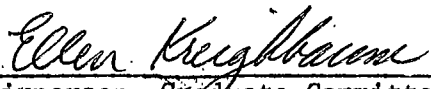
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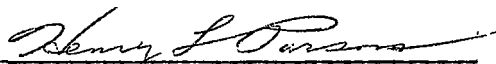
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ABSTRACT

A study was conducted to investigate the relationship between lower extremity alignment and the achilles tendonitis syndrome in Bozeman, Montana residents who are known to exercise on a regular basis. Selected measures describing the alignment of the lower extremity of 29 subjects were taken. Data were collected and organized into three groups: Group 1 - no achilles tendonitis; Group 2 - past achilles tendonitis; and Group 3 - present achilles tendonitis. The data were analyzed by a t-test of means and F-ratio of variance.

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Chapter 1

INTRODUCTION

Achilles tendonitis has plagued distance runners and marathoners for years, with numerous types of treatments yielding varying amounts of relief to victims of this overuse syndrome. In a study by Dr. Richard Schuster in Runner's World magazine, it was found that 17.5 percent of the runners suffered from achilles tendonitis (N = 1600) (2). Dr. Sheehan, a cardiologist and running expert, states that a muscular and structural cause for achilles tendonitis can be noted. A Grecian foot or Morton's foot with a short big toe, Hagland's deformity or bump on either side of the back of the heel, or signs of an unstable heel and presence of abnormal strain cord comprises structural causes for achilles tendonitis (30). Dr. John Pagliano states that excessive twisting of the heel bone (calcaneus) can cause rotation of the calcaneus and since the achilles tendon is attached to the back of this bone, it becomes stretched beyond it's normal length. (34).

The biomechanical explanations for injury to the achilles tendon has led to the advancement of a preventative-type treatment, orthotics or shoe inlays. The premise of orthotics as stated by podiatrists who have developed and advocated this treatment, is that without proper foot alignment, the foot strikes the ground

improperly and the entire leg works improperly. When that odd shock is absorbed 1,000 times a mile, there is trouble at most vulnerable points (13). The foot doesn't function properly as a shock absorber or lever for the propulsion phase of the gait. Orthotics correct the improper alignment so that the foot meets the ground within the norms. The treatment has in practice given relief to a large number of runners as described by one runner:

I was a one-man disaster area: tibial varum, cavus arch, equinus foot, recto-calcaneal exaotosis of the heels and a bunch of other words I didn't understand. He put elastic inserts in my shoes - "golden arches" they came to be called. In my case they had to be done and I'm glad I found the podiatrist when I did.
(34:31)

Recently increasing numbers of theories have been formulated as to the use of rigid or soft orthotics and the merit of orthotics is becoming more widely accepted by runner, podiatrists and doctors. However, research is limited in this area as stated by Dr. Rob Roy McGregor, a Boston podiatrist, in a personal letter: "I think your subject is fascinating and not-a-well-understood one." (20)

The following study was done in order to determine if there is any relationship between leg alignment, flexibility, and range of motion measurements and those people who have the over-use syndrome of achilles tendonitis. The results will give partial data to support or disallow the premise of orthotics in treatment and prevention of achilles tendonitis.

Statement of the Problem

Generally, the purpose of this study was to examine the possibilities of a relationship between leg alignment, flexibility, and range of motion measures of the leg, and the absence, past or present history of achilles tendonitis. The prediction of achilles tendonitis from an occurrence of certain abnormal alignment characteristics was examined.

Specifically this study measured the degrees of motion of inversion and eversion at the subtalar joint, forefoot varus and valgus, flexion at the ankle joint with the knee extended and straight, hip rotation with the hip extended and flexed, hamstring flexibility, frontal plane position of the tibia and subtalar joint in neutral position and static angle of gait, calcaneal position to the floor with the subtalar joint in neutral position and static angle of gait. The fourteen alignment measures were compared to those who have had no history of achilles tendonitis, a past history of achilles tendonitis, or presently suffer from achilles tendonitis. The possibility of prediction of the occurrence of achilles tendonitis from specific leg alignment factors or a general alignment trend was examined.

Hypotheses

Null Hypotheses. It was hypothesized that there would be no

significant difference between fourteen lower extremity alignment factors and the absence or presence (past or recent) history of achilles tendonitis. Each of these groups of achilles tendonitis subject could not be individually described by leg-alignment examinations. In addition, there would be no significant difference between the occurrence to non-occurrence of achilles tendonitis and any of the alignment, flexibility, or range of motion measures.

Alternative Hypotheses. It was hypothesized that there would be a significant difference between fourteen leg-alignment, flexibility, and range of motion measurements and the absence, past or present history of achilles tendonitis. Each group could be described independently by leg-alignment measures, and the prediction of achilles tendonitis could be made from specific alignment measure or a general trend of leg-alignment.

The hypothesis would be individually accepted at .05 level of significance.

Definition of Terms

These terms were defined by Root (24) unless otherwise noted.

Abduction. Abduction is the movement of part of the foot away from the mid-line of the body.

Acute Achilles Tendonitis. Acute achilles tendonitis is the inflammation of the tendon or its sheath where pain is usually

present only with prolonged running and subsides with rest. Pain may also be noted while walking up stairs. Tenderness on examination is limited to a small area, usually located one to two inches above the heel bone (4). Achilles tendonitis is the inflammation of the smooth fibrous cord or its lining (sheath) that connects the calf muscles to the back of the heel.

Adduction. Adduction is the movement of part of the foot towards the midline of the body.

Ankle Equinus. Ankle equinus is the structural limitation of the ankle joint dorsiflexion.

Chronic Achilles Tendonitis. Chronic achilles tendonitis is the classification of tendonitis in which the area of tenderness is larger than acute or sub-acute, and the tendon is often thickened and nodular (4).

Compensation. Compensation is the change of a structure, position or function of one part in attempt by the body to adjust to deviations of structure, position or function of another part.

Dorsiflexion. Dorsiflexion is the motion of the toes toward the anterior part of the lower leg.

Eversion. Eversion is the movement in which the plantar surface of the foot or part of the foot's plantar surface is tilted to face away from the midline of the body.

Inversion. Inversion is the movement in which the plantar

surface or part of the foot's plantar surface is tilted so that it faces towards the midline of the body.

Leg Alignment. Leg alignment is the range of motion measurements of the subtalar joint and mid-tarsal joint, hip joint, and hamstring flexibility, and calcaneal and tibial alignment with the subtalar joint in neutral and static angle of gait positions.

Midtalar Joint. The midtalar joint is composed of two articulations; the tauls and navicular foot-bone articulation and the calcaneus and cuboid foot-bone articulation.

Normal foot. Normal foot is a term which represents a set of circumstances whereby the foot will function in a manner which will not create adverse physical responses in the individual.

Plantarflexion. Plantarflexion is the motion of the toes away from the anterior part of the lower leg.

Pronation. Pronation is the simultaneous motion of the foot in the direction of abduction, eversion, and dorsiflexion. The foot moves away from the body's midline, the plantar surface faces outward, and the toes move away from the anterior surface of the lower leg.

Sub-acute Achilles Tendonitis. Sub-acute tendonitis is the inflammation of the tendon or its sheath in which pain is present when beginning to run and worsens when the subjects sprints. Findings are the same as acute, except that crepitus (grating sensation

or sound) may be noted on active dorsiflexion and plantarflexion of the foot (4).

Subtalar joint. The subtalar joint is composed of three articulation (connections) between the talus and calcaneus foot bones.

Supination. Supination is the simultaneous movement of the foot in the direction of adduction, inversion, and plantarflexion. The foot moves towards the midline of the body, the plantar surface turning inward, and the toes moving away from the anterior surface of the lower leg.

Valgus. Valgus is the everted structural position of the foot or part of the foot.

Varus. Varus is the inverted structural position of a foot or part of a foot.

Delimitations

The study was delimited to subjects selected from a questionnaire (see Appendix B) completed by Bozeman, Montana residents who exercise regularly during the 1976-1977 school year, and the absence, past or present history of achilles tendonitis.

Limitations

The study was limited by the researcher and the instrument used in collecting the alignment factors. The dial on the biometer donated by Dr. Robert Phillips (23) had to be reglued during data

collection. Also the dial was only on one side of the tool, so that when the opposite foot was measured, the tool was inverted and reversed so that the dial was read in a different position.

Age, sex and types of exercise were not held constant. The time of measurement and the activity before the measurements were taken was not controlled. Some subjects had previously experienced the leg-alignment procedures and therefore might have relaxed more during this testing time. The medical history, diagnosis and classification of the subjects as compiled by the researcher further limited the study. The number of people presently experiencing achilles tendonitis was limited, as the population of the town and particularly those who are distance runners is small, yielding a finite number of present achilles tendonitis subjects. The difference of range of motion measurement between static angle of gait and running will further limit this study.

Chapter 2

REVIEW OF RESEARCH AND RELATED LITERATURE

Review of Research

The study was patterned after Lilletvedt's A Descriptive Analysis of Foot Alignments and their Correlation to Shin Splints

(18). The alignment measurements techniques for the examination, data collection, and statistical treatment were similar in this study. Lilletvedt found a positive correlation, significant at the .05 level, between six alignment measurements and the grouping of those with shin splints. The alignment measures varied significantly from the control group, those without shin splints. The alternative hypothesis was accepted for six measurements, and these same measurements were also accepted as significant, at the .05 level, of predicting the occurrence of shin splints.

Several hypotheses have been formulated about the relationship of the foot and leg alignment abnormalities and the occurrence of the overuse syndrome of achilles tendonitis. In a letter from Snook he postulates:

Some correlation might exist between alignment of the leg and tenosynovitis in the peroneal and posterior tibial tendons, as these tendons have to work around the corner because of the anatomical position behind the malleoli. The achilles tendon however pulls in a straight line and I personally feel that it is merely a result of a tear in the substance of the tendon due to

shortening. (33)

Sheehan has listed leg problems associated with foot weaknesses and deviation, as achilles tendonitis, stress fractures and runner's knee (15:68). Achilles tendonitis is classified as an overuse syndrome and Subotnick describes leg alignment abnormalities as a causative agent.

This overuse syndrome is a combination of over-training plus feet and legs that have intrinsic or extrinsic imbalance. Intrinsic deformities are those in the foot structure itself. Extrinsic deformities places feet at an improper angle to the running surface. The feet contact the surface and support the whole body during running, and problems arise from shin splints to achilles tendonitis. (35:37)

Jesse hypothesizes that regardless of secondary acquired causes of foot deviations and weakness, the underlying cause is muscular imbalance at birth that is furthered by human failing in the development and maintenance of maximum strength potential of foot muscles and ligaments (15:65). A study was conducted on the effects of prolonged pronation and there was found to be electromyographic evidence that prolonged pronation causes various muscle groups to remain contracted (35:49).

Several studies have been performed on treatment methods for achilles tendonitis. Snook (31) did a case study on four subjects who didn't respond to conservative treatment of achilles tendonitis. Symptoms varied between cases, but all cases did not

seem to experience these symptoms if exercise was discontinued. All went through conservative treatment of rest, cold applications, followed by heat therapy, anti-inflammatory medicine, and casting. Because of poor responses, surgery was performed to separate fibrous adhesions between the sheath and cord. Snook advocates this type of surgery for those who are athletes, as achilles tendonitis doesn't seem to be a problem unless exercise is continued, and these athletes didn't respond to conservative treatment. A similar case study was done by Clancy and Brand (4) on four subjects, one having the condition in both legs. Again the subjects received treatment of rest, heel lifts, anti-inflammatories, and one subject was casted. Because of re-occurrence of achilles tendonitis surgery was performed. Upon examination of sheaths and tendons, it was found that the sheaths had thickened and holes were found in the membranes. Tendons had tears that ranged from microscopic to macroscopic. Clancy felt that at the time of major tearing of the tendon, it was chronically degenerative and inflamed and this suggests it was not normal at the time of rupture. The blood supply to the achilles tendon was believed to be a critical factor in the development of the small and large percentages of the structural rupture. Blood comes through the mesotendon and goes to specific areas but significant amounts go through the muscle and tendon junction. This alteration of blood supply was felt to

contribute to the subsequent large tears to a person with chronic achilles tendonitis. Surgery to release chronically inflamed tendon sheaths and decrease the inflammatory reaction, and increase the blood supply, would decrease chances of macroscopic tears to a chronic achilles tendonitis condition.

In relation to the treatment of achilles tendonitis, another study was done by Mackie, Golden, Foss and Cockrell (5) on steroid drug therapy and its contribution to achilles tendon ruptures in rabbits. It was hypothesized that steroids weaken tendons, thus increasing its chance of rupture. Conclusions showed that the tendon's weight changed, but there were no significant changes in the mechanical properties to indicate they would be ruptured more easily.

Research studies have been done in specific sport areas. Leech summarized causes and treatment of achilles tendonitis in skiers. A skier, thrown forward in a sudden deceleration fall with the heel piece failing to relieve can receive a rupture or tear to the achilles tendon, as the boot holds the foot immobile and the body continues forward. In addition, the skier's boot pressure on the rear of the heel can cause irritation and inflammation to the tendon or surrounding tissue. Also, the heel is raised in a ski boot, and when the skier changes to flat shoes, stretching of the achilles tendon may occur (17). Therefore,

from these factors, the skier is prone to achilles tendonitis. Glick and Katch (12) research musculoskeletal injuries in joggers. Out of 120 joggers, twelve were reported to have injuries to their achilles tendon, with four of the cases forced to stop jogging. Glick comments, in his study, on the importance of postural control, which is related to lower leg alignment:

The position of the pelvis is a key to postural control in running. Therefore any style of running as swayback, places the pelvis in a bad position and may cause stresses on various body parts. Since most of the joggers were novice runners, improper techniques may cause episodes of pain in the back, hips and feet that otherwise might not have occurred. (12:84)

Sinning and Forsyth (10) also did a study on running, in which the lower limb was examined at different running velocities. It was discovered that the range of ankle joint movement remains constant at all running velocities. Movement patterns of knee extension and ankle plantar flexion and hip extension on the support phase of running varied with different speeds. It was found that the greatest contributor to the increase in speed came from step length and frequency.

Review of Related Literature

Description of the Achilles Tendon. The achilles tendon is a strong, smooth, closely-packed fibrous tissue, whitish in color that attaches the triceps surae muscle (calf muscle) to the

tuberosity of the heel. This connective tissue lacks elasticity and when stretched, loses power, regaining power when shortened again. If an achilles tendon is shortened, as by wearing of high heels or heel lifts built into most ski boots, dorsiflexion is limited and that condition is called ankle equinus. Tendons are subjected to constant movement and friction with other tissues.

A sheath or paratendon, is a tube-shaped structure of fibrous connective tissue that encloses the tendon. It's lined with a synovial membrane of one to two layers of synovial lining cells that are very vascular with many small vessels. Synovium, a clear viscous fluid, is secreted by the synovial membrane. Providing a moist surface, the synovial membrane enables the tendon to move easily, almost frictionless, in the tendon sheath. In a healthy tendon, there is free play between the tendon and its sheath.

Classification and Description of Achilles Tendonitis. Achilles tendonitis can be classified into three groups; complete rupture, partial rupture, and tendonitis inflammation. In a complete rupture, the tendon may be torn apart, ruptured or cut. This tendon is very strong and isn't usually torn, even by injuries forceful enough to break bones or tear muscles. Occasionally an injury could occur where the tendon is pulled away from the bone. The tendon may become inflamed and is most commonly swollen close to where it attaches to the bone.

Tendonitis or tenosynovitis is where the tendon sheath becomes inflamed. There are two forms of this, "wet" type, where there is over-production of the synovium and a swollen tendon results, or "dry" type in which a creaking sound or sensation (crepitus) is present when the tendon is moved. Usually there is free play between the tendon and its sheath, but sometimes they adhere, adding to the "dry" type of tenosynovitis. If the inflammation is near the attachment to the heel, it's close to the tendon-bursa. The tendon-bursa is a small smooth sack which acts as a buffer. Easy sliding action of the tendon over rougher bone is attained by the smooth slippery qualities of the bursa. With the inflammation of a tendon, secondary bursitis could occur with the subsequent irritation of the bursa.

A partial rupture is a milder microscopic rupture. There may be varying degrees of ruptures and it can only be assessed if the rupture is in the most posterior aspect. Because of the decreased blood supply to the tendon, the danger of an incomplete or partial rupture is that the tendon is unable to repair itself, as an injury is repaired by the paratendon and surrounding fatty tissue (27:48-49).

Symptoms of a complete rupture are swelling, black and blue discoloration within 24 hours, the foot is weakened in plantar-flexion and there will be acute pain just above the heel. In strain or overuse inflammation, there will be point tenderness and some

swelling present. Often pain will only occur at the onset of exercise and subside with the continuation of exercise. Sometimes pain will be noticed throughout the exercise period, but will subside with rest. There may be slight tenderness along the heel cord. Tenderness is often localized in one specific area. Crepitation and thickening of the tendon or its sheath are some other symptoms that might go along with this condition.

Gait Analysis and Related Foot Function. Before examining causes and treatment of achilles tendonitis, the mechanics of running were discussed so leg-alignment abnormalities that are hypothesized to attribute to achilles tendonitis would be understood. The stance phase, 65 percent of the complete running motion, and the swing phase, 34 percent of the total motion, comprise the running gait. The stance phase begins with heel strike into mid-stance and ends with the toe-off. On heel strike the limb is slightly externally rotated at the hip and the foot is abducted. Immediately after heel strike the limb rotates inwardly on the planted foot, with rotation occurring at the subtalar joint. This inward rotation causes the foot to pronate the subtalar joint, thus becoming a mobile adapter. The limb externally rotates during mid-stance so that the foot supinates at the subtalar to become a rigid lever for the propulsion toe-off phase to the next heel strike (35:122).

Inter-relationship between the subtalar joint, transverse plane

rotations of the lower extremity and sagittal plane rotation of the pelvis suggest an interdependence between foot function (35:49). The foot position of the stance phase will be examined in order to relate its connection of limb action in running.

The subtalar joint functions as a universal joint beneath the ankle joint. Because the ground disallows the foot to internally or externally rotate, the subtalar joint takes over this motion by inverting or everting (35:41). During heel strike the foot is a pronated "mobile adapter" to take care of any variance in supporting surfaces or body position above the foot. Limited adaptation of the foot is related to the range of motion at the subtalar joint, i.e., the greater the pronation, the greater the mobility. During the toe-off (propulsion) phase, the subtalar joint must supinate to enable the foot a rigid lever for propulsion. The ability of the foot to be an adapter and lever is due to the locking mechanism of the midtarsal joint. Pronation at subtalar joint unlocks the midtarsal and allows adaptation, while supination at subtalar locks the midtarsal to form a lever for propulsion (7:826).

The following graph summarizes the motion of the leg and foot in a closed-kinetic chain reaction as the foot is planted on the ground (35:122).

Phase	contact (heel strike)	mid-stance	propulsion
	25 percent	50 percent	25 percent
leg motion	internal rotation	external rotation	
motion of foot at subtalar	pronation	supination	
foot position	supination neutral	pronation neutral	supination

Causes of Achilles Tendonitis. A strain to the achilles tendon often results from the lack of coordination between agonists and antagonists following an ankle strain or excessive dorsiflexion (9). A rupture can occur from muscle action or cutting by an external object. In skiing it can happen when the body is thrown forward "in a sudden decreased velocity fall and the heel piece fails to release." (17:31-22) Ryan states that:

The achilles tendon seldom ruptures in younger and lighter athletes, but may do so in the older and heavier athletes. When its tensile strength is suddenly exceeded by a combination of weight, leverage, and aging of the tendon from previous subclinical strain.

Over stress can lead to an overuse syndrome in which the gradual accumulation of microscopic trauma in which minor injury can become progressively more severe. Over stress can come from foot structure itself or deformity when the bend in the leg places the calcaneus in an everted or inverted position so that it is not perpendicular to the running surface (35:37). These small tears

can cause inflammation which may cause secondary bursitis as mentioned previously. Small tears usually heal themselves but in many sports the performer does not allow the time necessary for complete repair before restressing the tendon. Overuse can also cause inflammation of the tendon synovial sheath.

A shortened achilles tendon could be caused by high heeled shoes, which leads to inflexibility. Sheehan discusses the effects of inflexibility:

Inflexibility of the achilles tendon can lead to tendonitis and it worsens any biomechanical problem in the foot. It also overbalances muscles in the shin and limits their tolerance for stress. A short achilles tendon, gastroc, hamstring muscle, unstable heel, inverted heel, weak arch, or extensive use of the toe flexors may lead to the development of achilles tendonitis. (6:106)

With a tight gastrocnemius and soleus muscle, the leg is prevented from easily moving 10 degrees over the foot and an unusual strain is put on the achilles tendon (34:12).

Another cause discussed by Sheehan is a weak foot or structural problems described as Grecian foot or Morton's foot with a short big toe and Hagland's deformity which is a bump on either side of the back of the heel. Also a sign of an unstable heel presents an abnormal strain on the heel cord (30). Dr. Subotnick describes the structural cause of heel movement that can lead to achilles tendonitis as an irritation of the tissue overlying the

tendon as it passes over the calcaneus (34:18). The structural deviations of an extra high arch and bowed legs have been found to cause achilles tendonitis as it places the foot in prolonged pronation and an unusual angle of pull is put on the achilles tendon (34:22).

Jumping and leaping are activities that cause tears in the achilles tendon. Increased training, speed work, hills and rundown shoes are other precipitators of problems. With 5,000 footstrikes on each foot every hour, millimeters of shoe wear can affect the foot (30). Dr. Subotnick states changes in routine of workouts often generates problems such as low to high mileage, grass to dirt to roads, and slow to fast training (34:20).

Treatment of Achilles Tendonitis. Conservative treatment for strain and inflammation usually consist of rest and discontinuation of exercise, with the time period of rest being determined by the extent of the damage. Cold packs are applied when injuries are first noticed and anti-inflammatory (phenalbetazone) medicine is often administered. Casting or strapping techniques are used to restrict the range of motion reducing stress and limiting dorsiflexion. Hydro-therapy and diathermy have also been employed. With diathermy three to four times a day, an apparatus generates a current ranging from 10,000 to 100,000,000 cycles per second, depending on the use of short or long wave machines. The effect is an intensive heating of the deep tissues, and the body responds by vasodilation

of the capillaries and increased blood circulation and removal of by-products in the area heated (21:218).

Chronic inflammation of the sheath and tenosynovitis is being treated by some doctors with surgery to released adhesions between the tendon and sheath. Ruptured tendons are treated most commonly with cold pressure bandages, followed by treatment similar to strains and inflammation. In the case of complete severence, the tendon must be surgically repaired. The tendon is taped to shorten it and limit dorsiflexion (31). The heel cord must be stretched out properly by heel cord exercises before the athlete starts serious running (33).

Dr. Sheehan states that doctors are saying things no less revolutionary than what Copernicus told us 500 years ago . . . the foot is the center of the runner. When the calcaneus isn't perpendicular during heel strike, or the forefoot isn't parallel to the heel during mid-stance phase, and the subtalar doesn't invert two times as much as it everts, then the foot places an odd shock on the limb. This shock is taken 1,000 times a mile, making it very possible there will be injury including the achilles tendon (13:16). Orthotics, made of plastic and molded around the neutral foot position, are a form of treatment for achilles tendonitis. Orthotics can aid in treatment and prevention of this overuse syndrome by treating gait abnormalities and placing the foot in the proper functioning position (35:49). Shoe construction can also aid in prevention and

correction of this problem. The shoe should have heel height and width to reduce the strain to the back of the legs and reduce instability and heel support with a counter around the back of the upper to further stabilize the heel. The shoe should have a flexible forefoot so that it can bend from the ball of the foot forward for the propulsion phase of the gait (34:23).

The normal foot is described as:

1. During function, the foot places no undue stress on itself or on joints of the ankle, knee, and hip (34:7).
2. The calcaneus and lower leg are perpendicular to the ground (34:7).
3. The forefoot is parallel to the heel when the subtalar joint is in neutral position.
4. A plumbline from the hips will fall through the thigh and lower leg, and medial to the heel (34:7).
5. At the subtalar joint, there should be twice as much inversion as eversion (15:34).
6. The hip should never have more internal rotation than external rotation and the zero position is the point where the internal and external rotation are the same number of degrees (15:131).
7. At the ankle joint, a minimum of 10 degrees of dorsiflexion is necessary for normal locomotion (15:34, 131).

8. The hamstring muscle group must be at least 12 degrees from vertical when the subject is lying back, hip flexed at 90 degrees (23).

Chapter 3

METHODS AND PROCEDURES

Instrumentation

A biometer developed by Phillips (23) was employed to collect data for this study (Figures 1-6). This instrument was similar to the instrument used by Lilletvedt and she describes the instrument as:

an instrument that consisted of a number of protractor like devices and was capable of measuring body positions and/or segmental movements in terms of degrees. The instrument could be broken apart so that various protractors within the instrument could be used to take the various measurements. Figure , although not truly a part of the biometer, was used to establish the plane position of the forefoot in relationship to the rearfoot and so was required during the examination. (18:17)

Face validity of the instrument was accepted.

Data Collection Techniques

Pictorial description of the measurement techniques of the lower extremity alignment are illustrated in Figures 7 through 24. A detailed description of the methods used may be obtained from the author or Phillips (23).

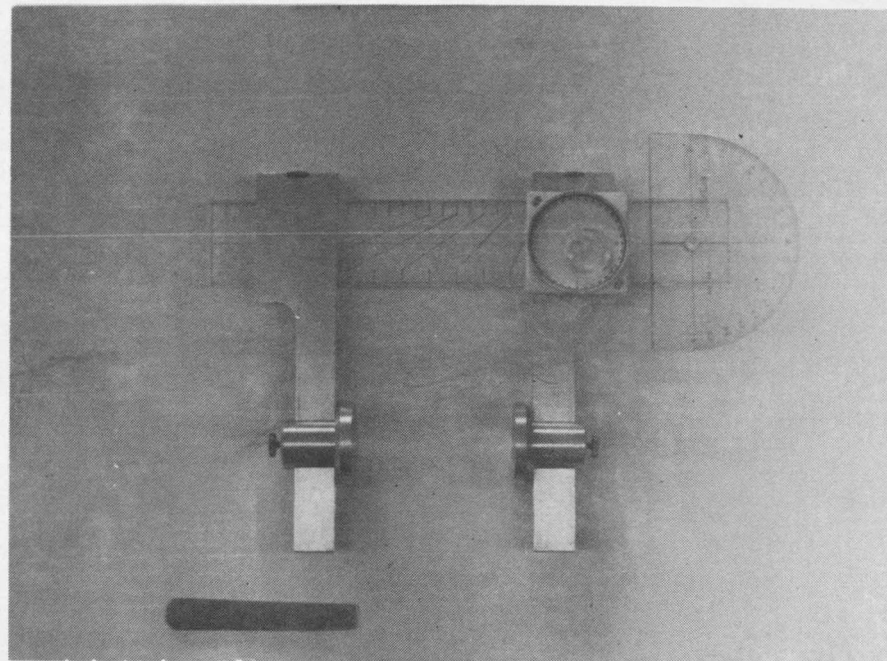


Figure 1. Assembled instrumentation required to conduct a complete biomechanical examination of the lower extremity

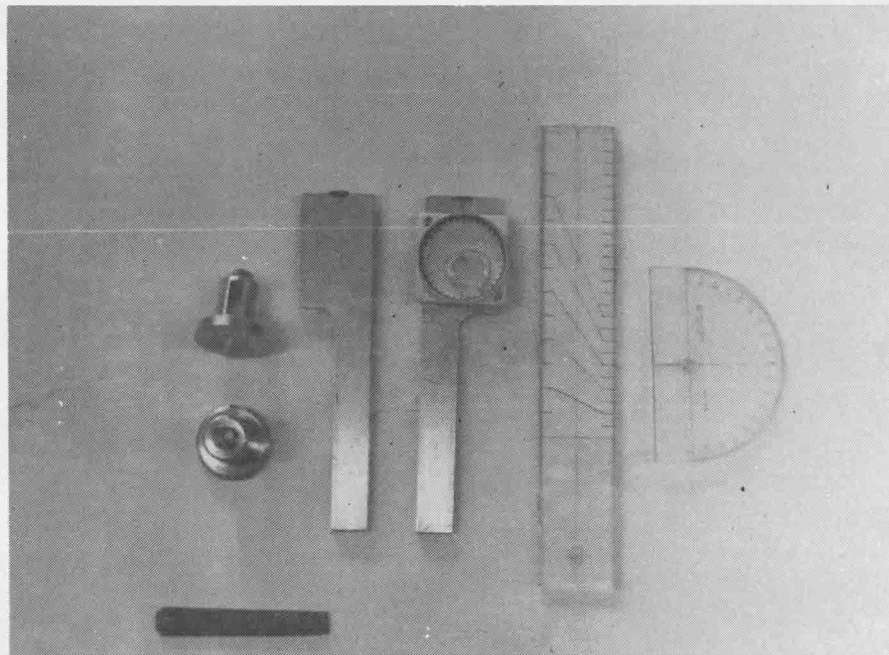


Figure 2. Disassembled instrumentation required to conduct a complete biomechanical examination of the lower extremity

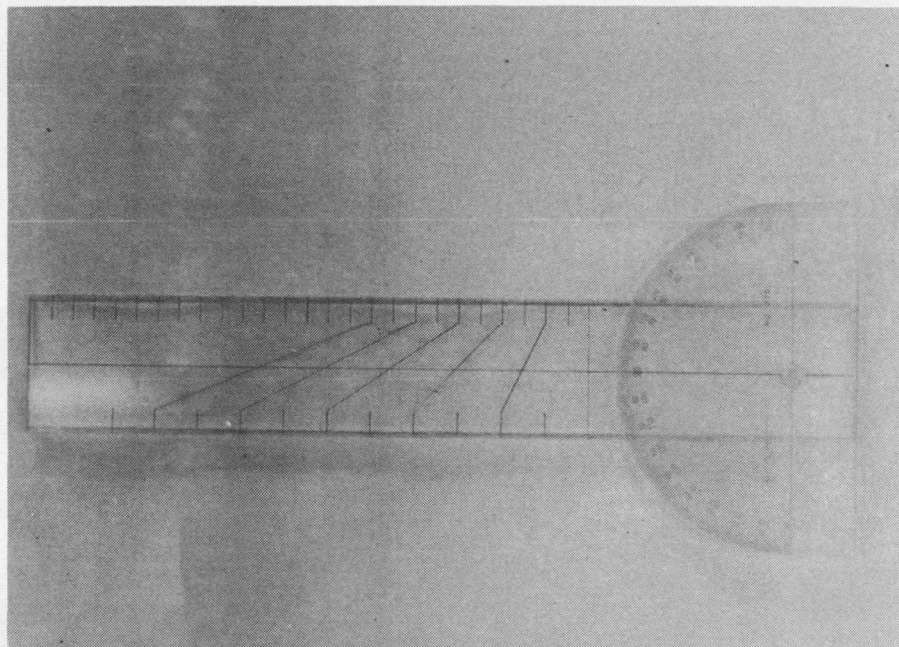


Figure 3. Instrumentation required to bisect the calcaneus and tibia, and measure inversion and eversion at the subtalar joint.

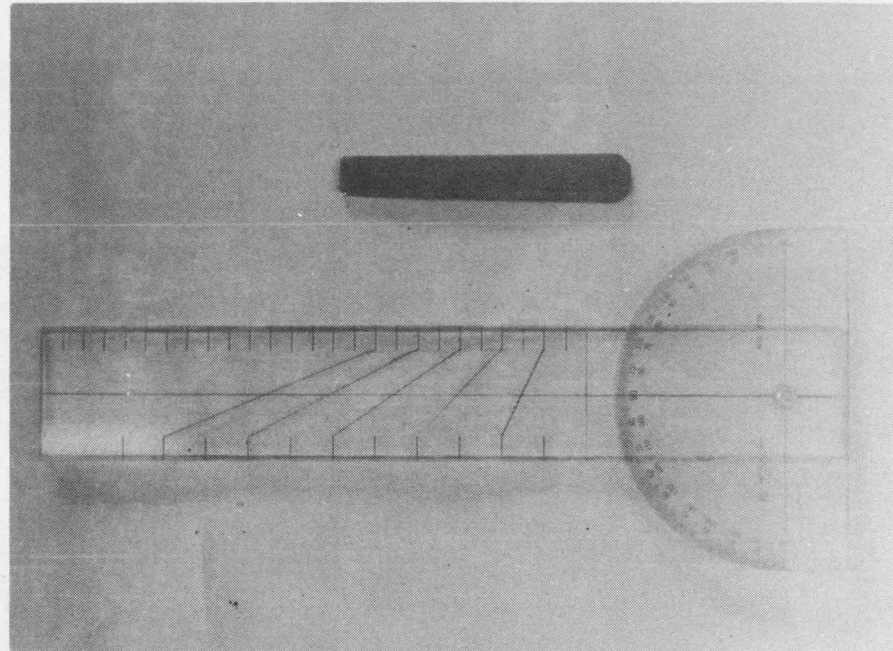


Figure 4. Instrumentation required to measure internal and external rotation of femur with the hip both flexed and extended.

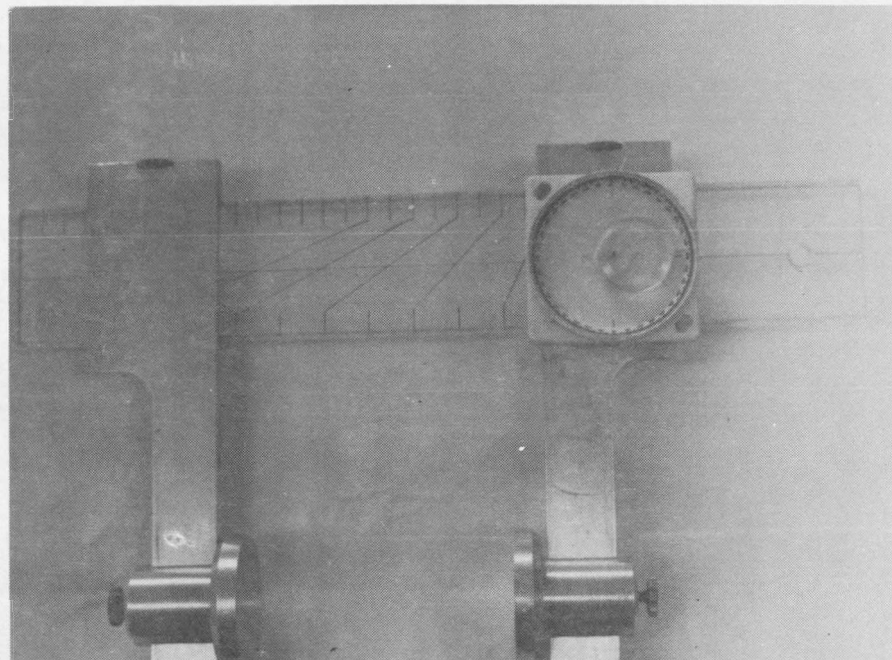


Figure 5. Instrumentation required to measure internal and external rotation of the femur with the hip both flexed and extended.

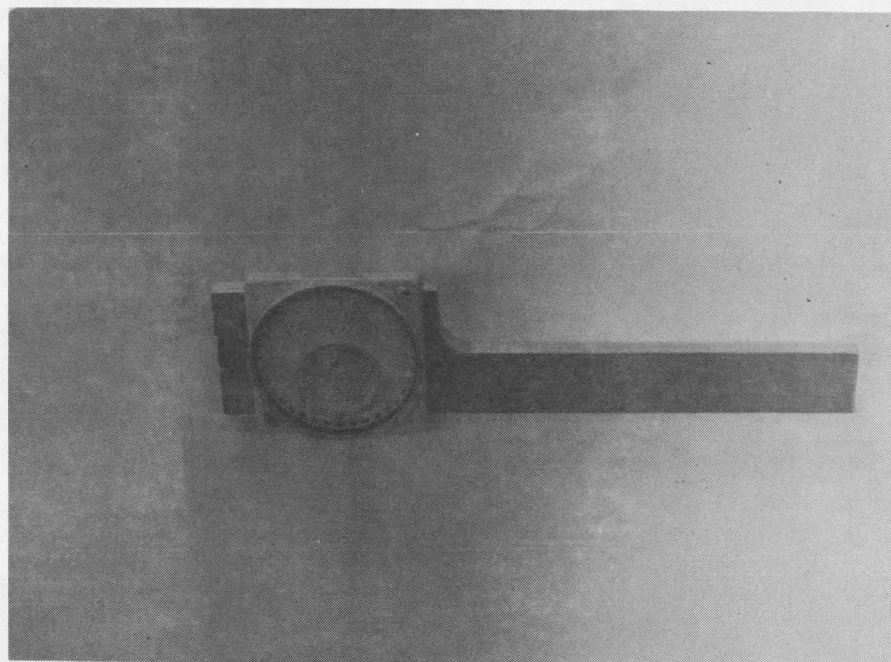


Figure 6. Instrumentation required to measure dorsiflexion and hamstring flexibility, position of both tibia and calcaneus with subtalar joint both static and neutral

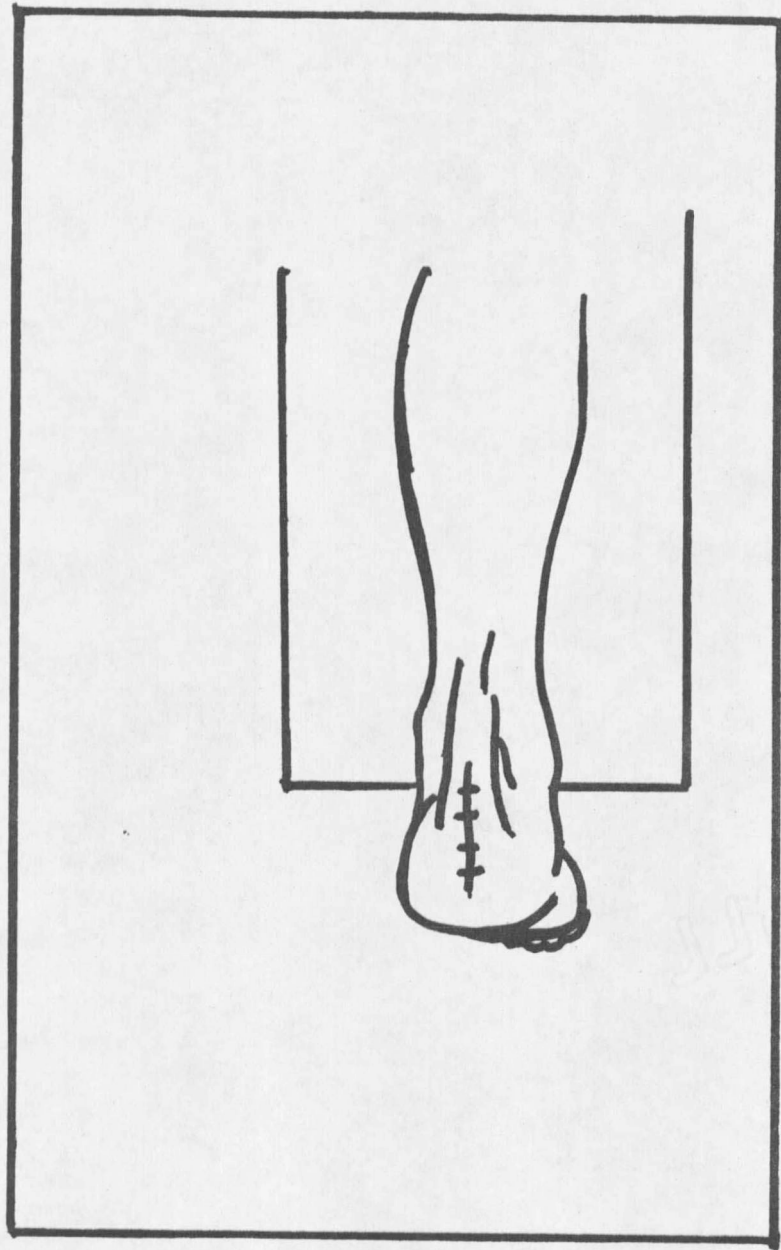


Figure 7. Line bisecting the calcaneus (18:25)

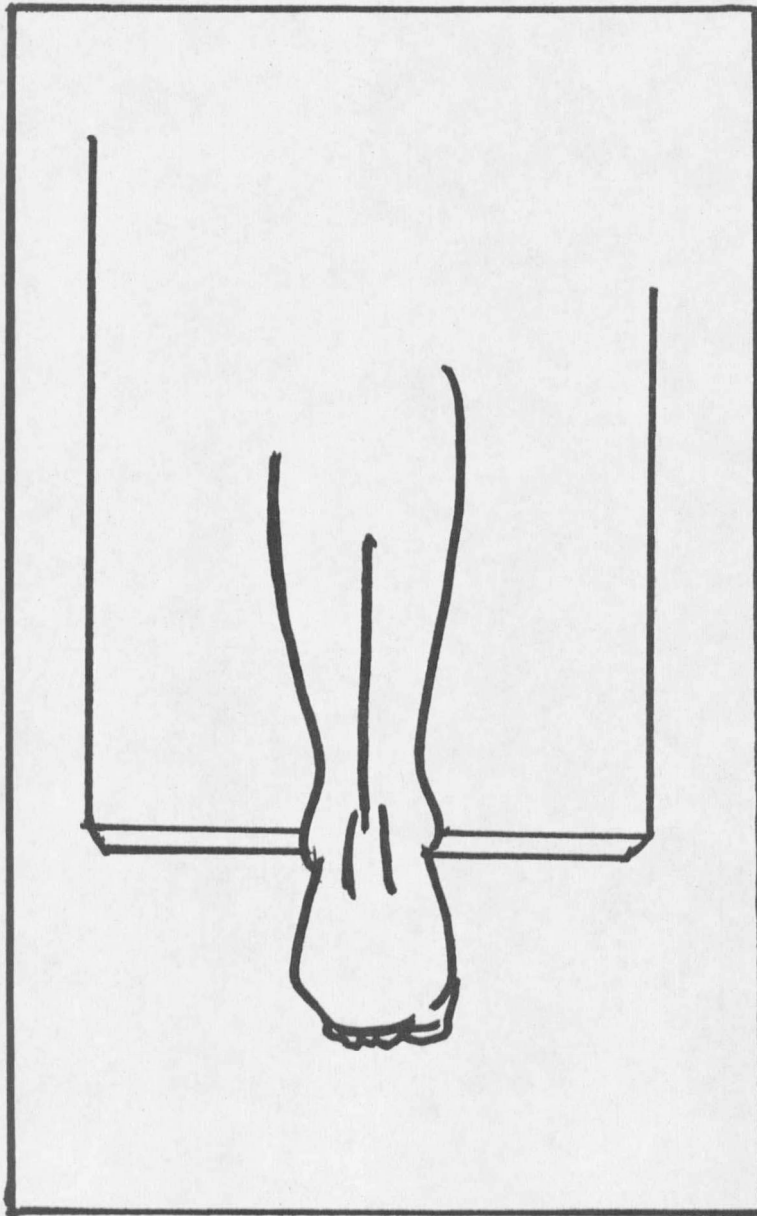


Figure 8. Line bisecting the distal one third of the leg (18:27)

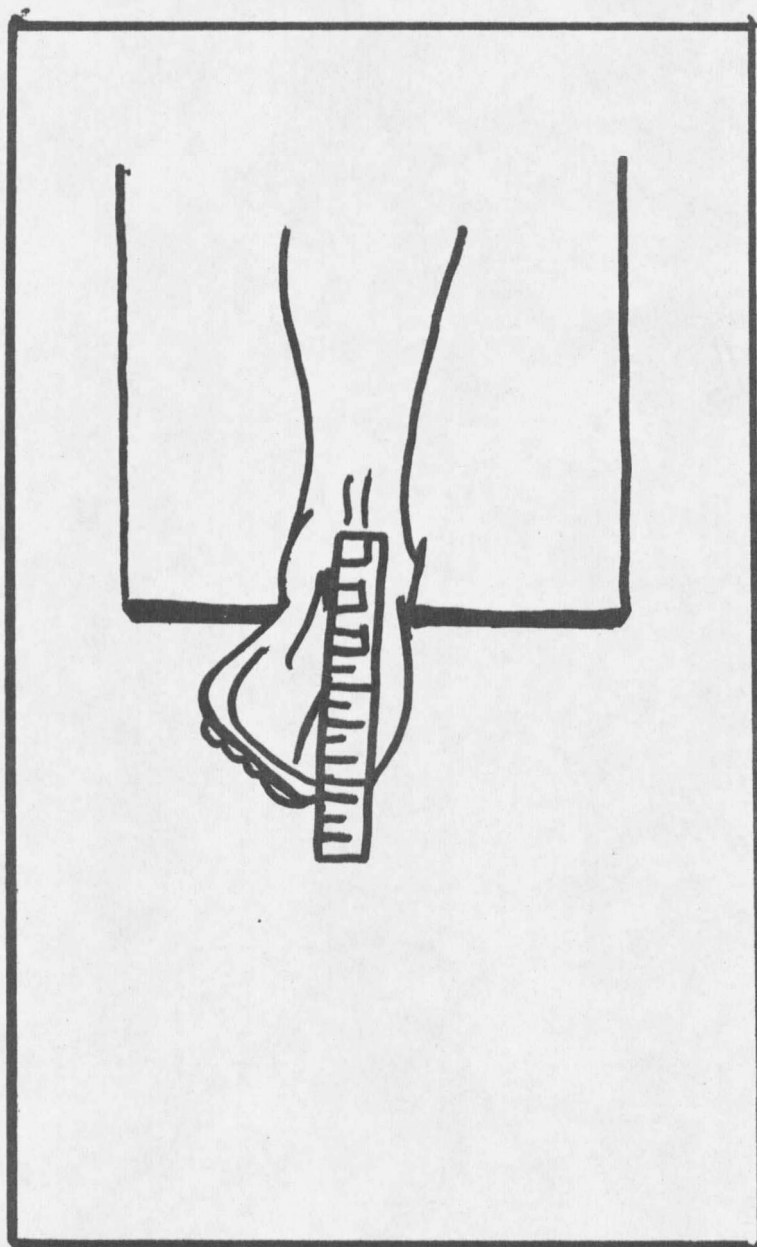


Figure 9. Determining axis of rotation for the subtalar joint (eversion) (18:28)

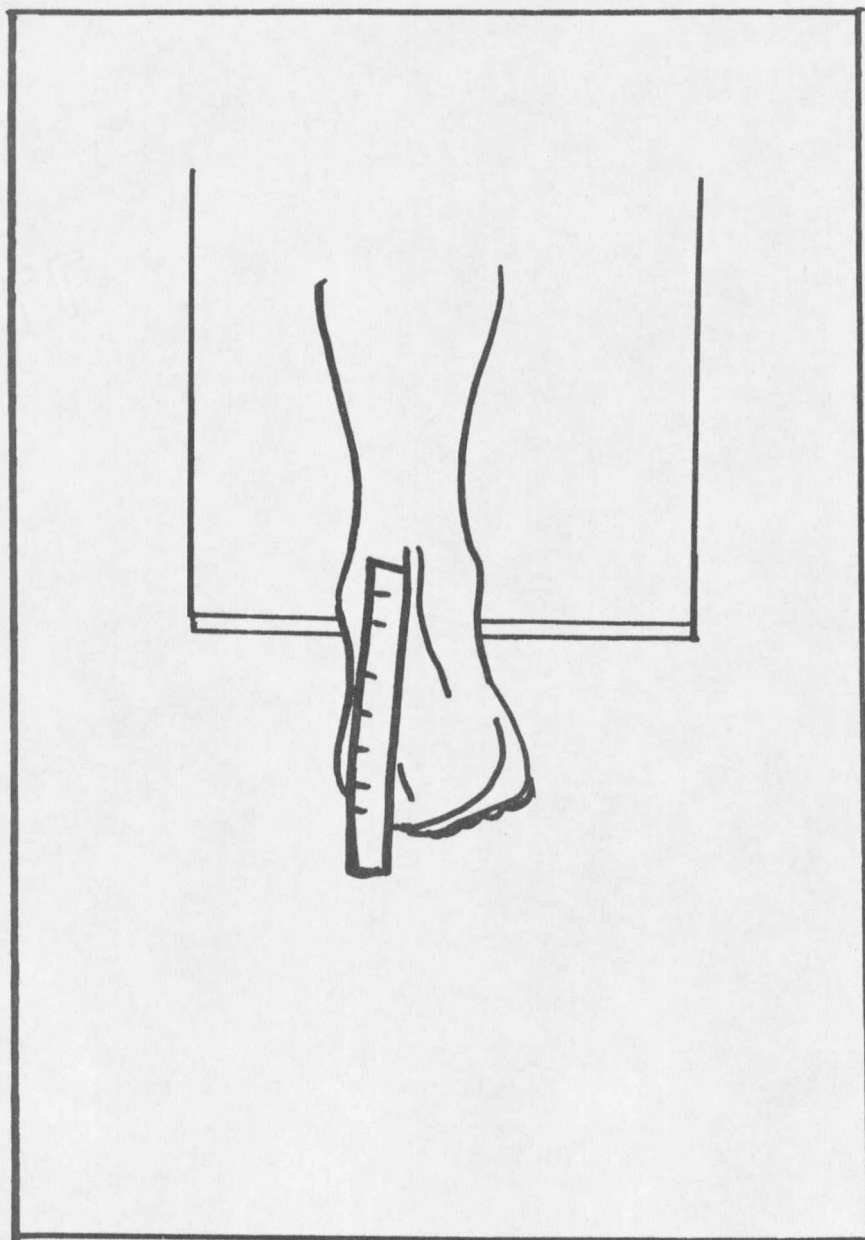


Figure 10. Determining axis of rotation for the sub-talar joint (inversion) (18:29)

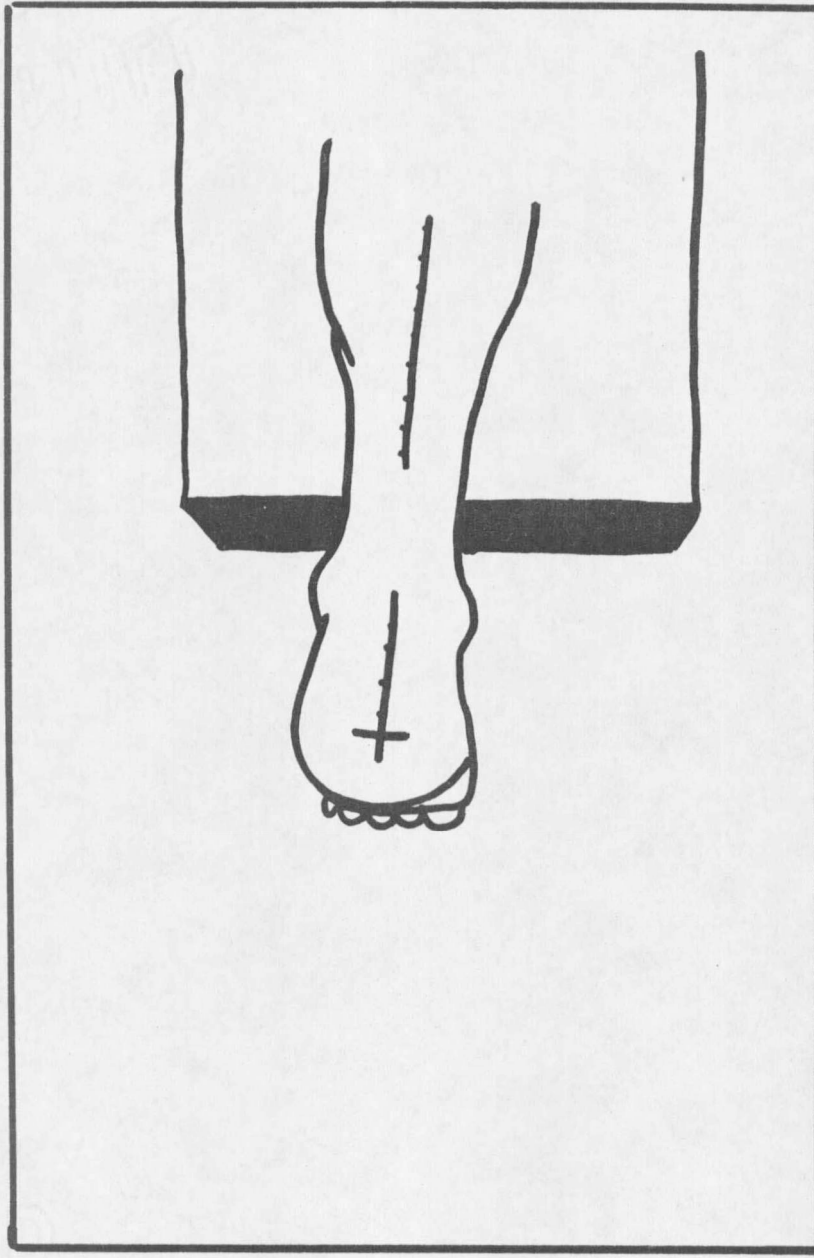


Figure 11. Lines bisecting the calcaneus, the lower leg, and denoting axis of rotation of the subtalar joint (18:30)

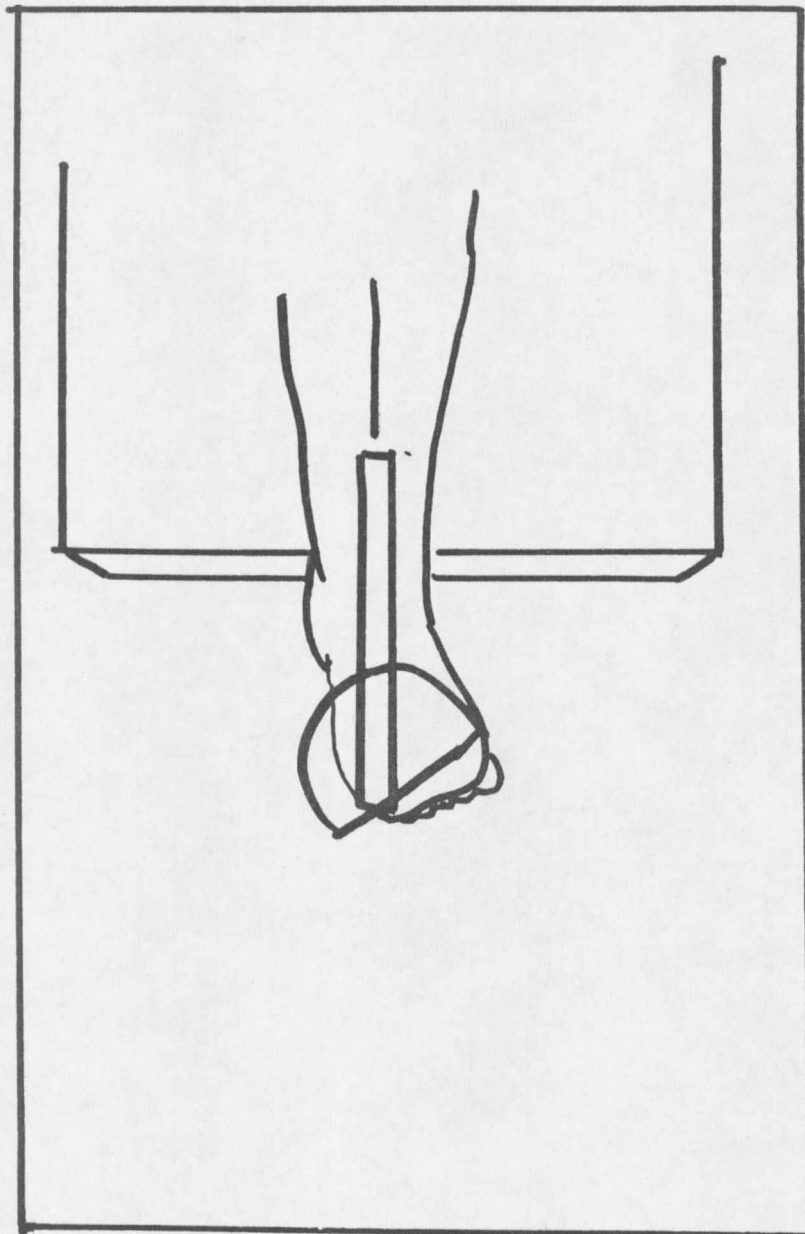


Figure 12. Determining inversion at the subtalar joint (18:31)

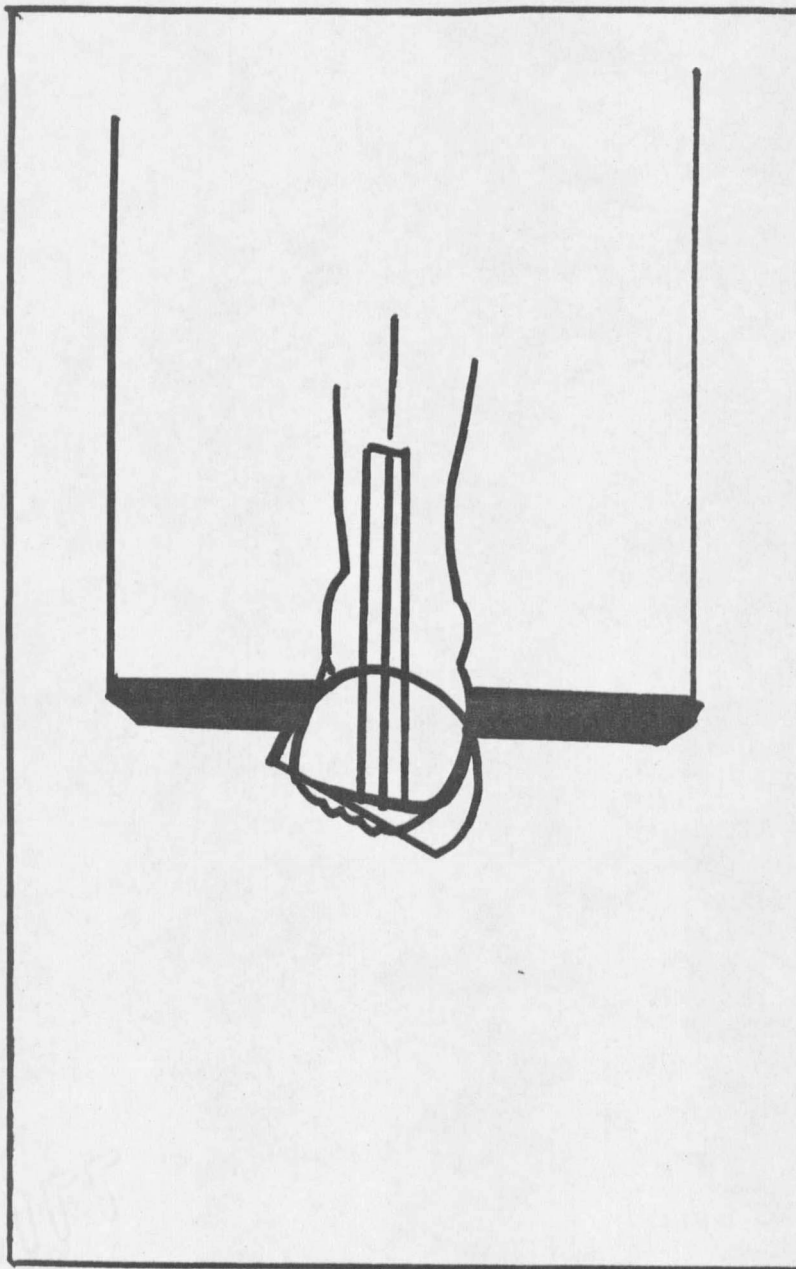


Figure 13. Determining eversion at the subtalar joint (18:32)

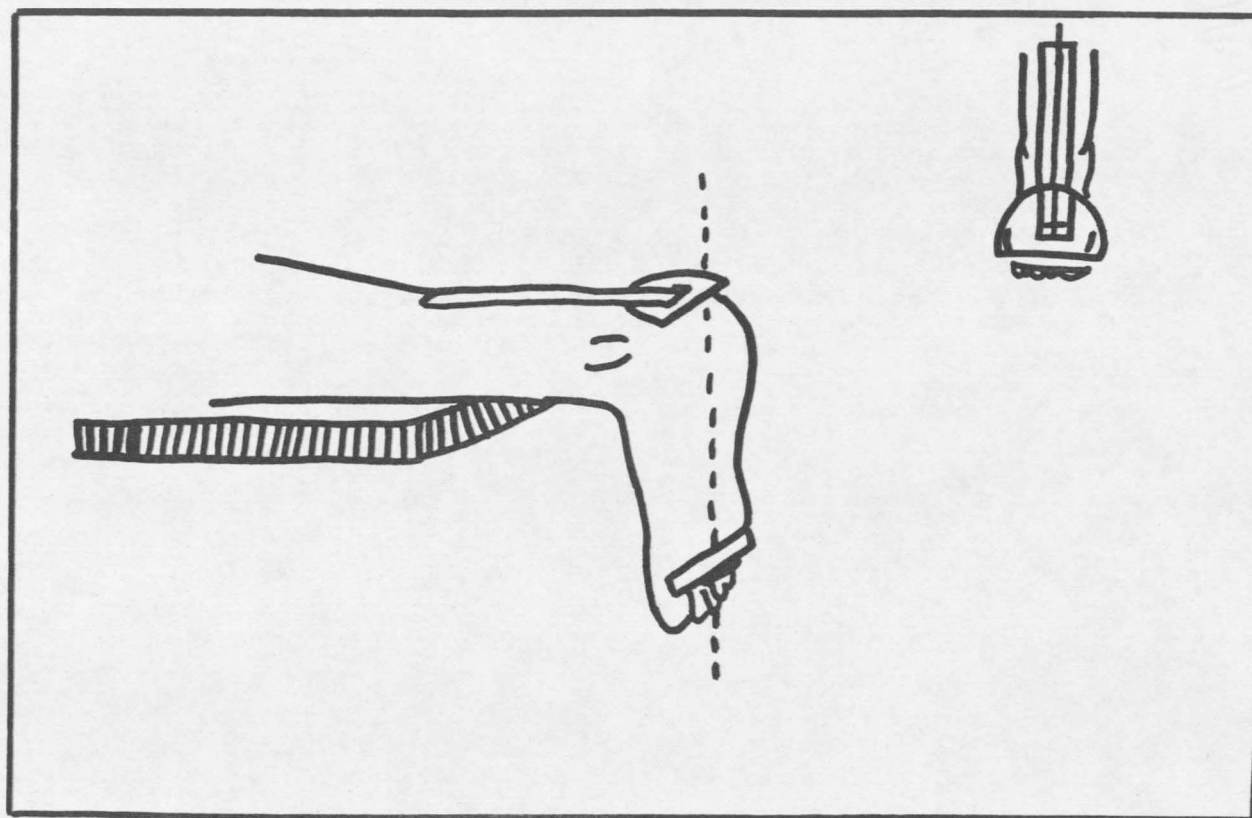


Figure 14. Determining the position of the forefoot in relationship to the rearfoot/subtalar joint neutral (18:33)

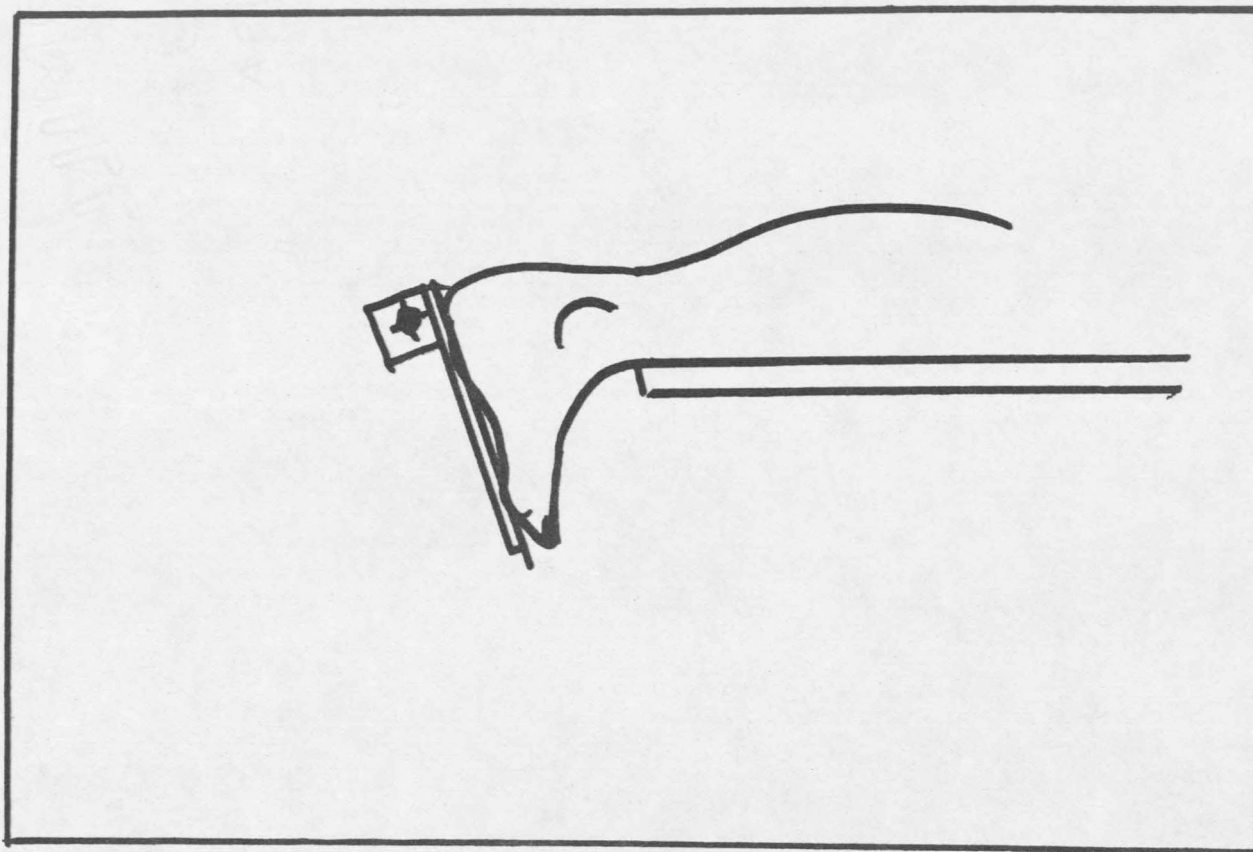
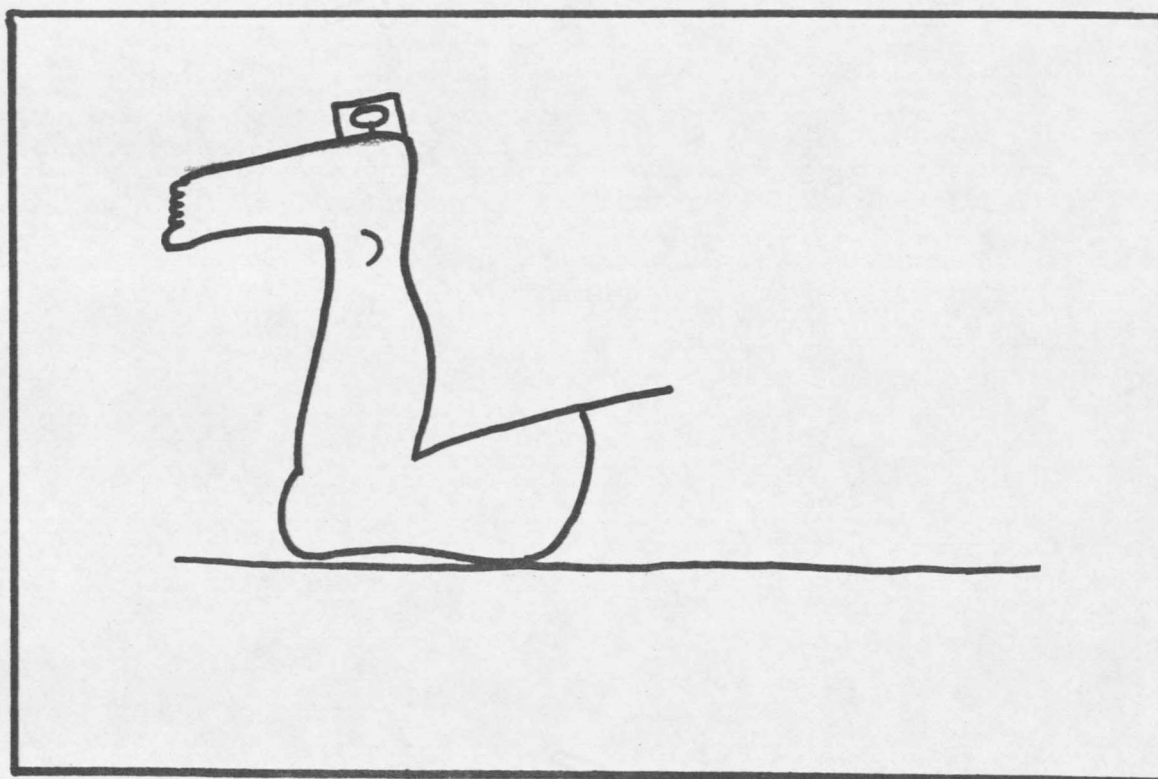


Figure 15. Determining dorsiflexion of the ankle with knee extended



Figures 16 and 17. Determining dorsiflexion of the ankle with knee flexed

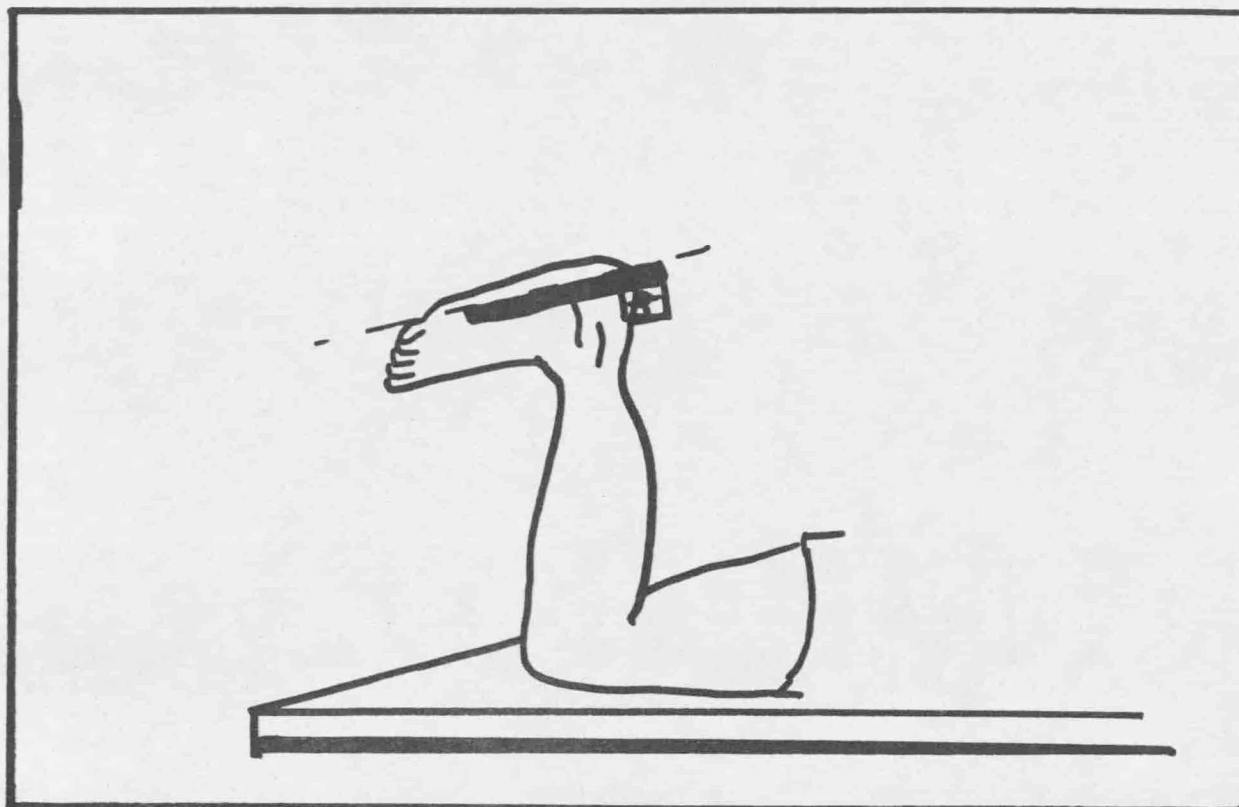


Figure 17.

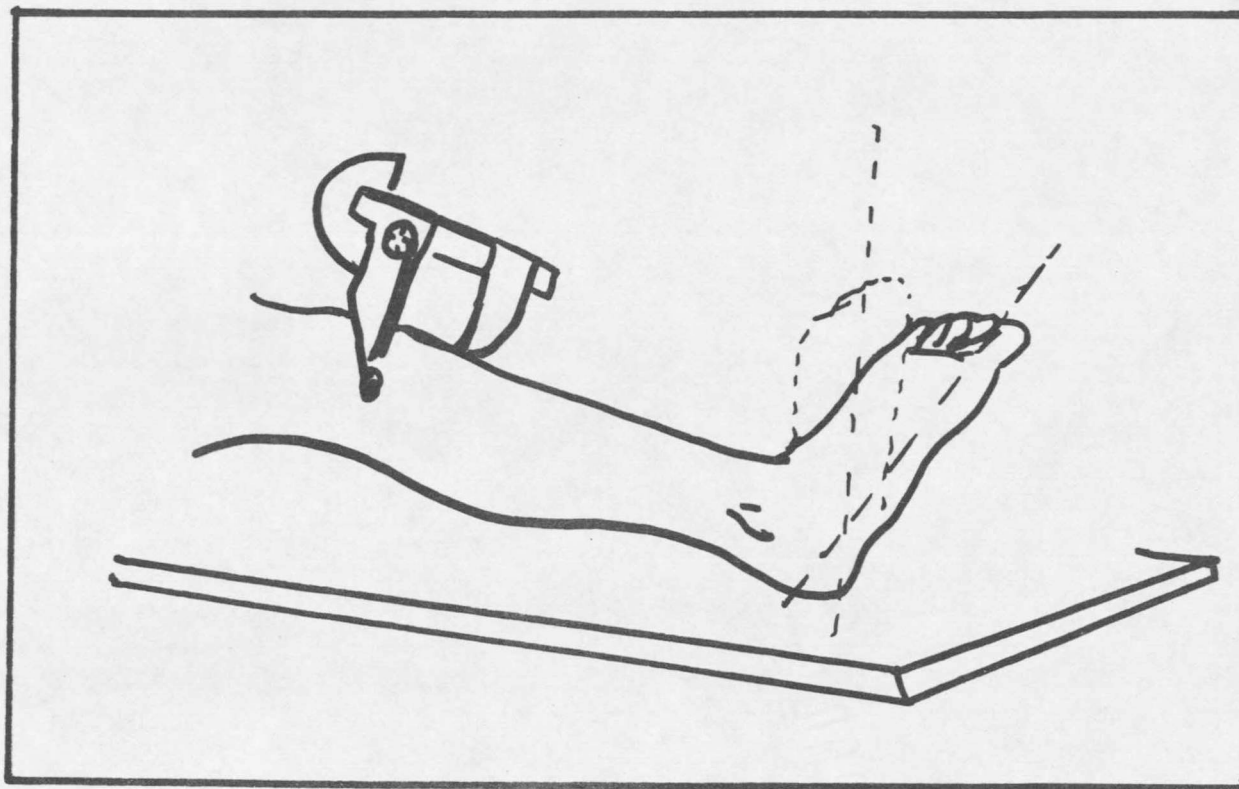


Figure 18. Determining internal rotation of the femur/hip extended (18:37)

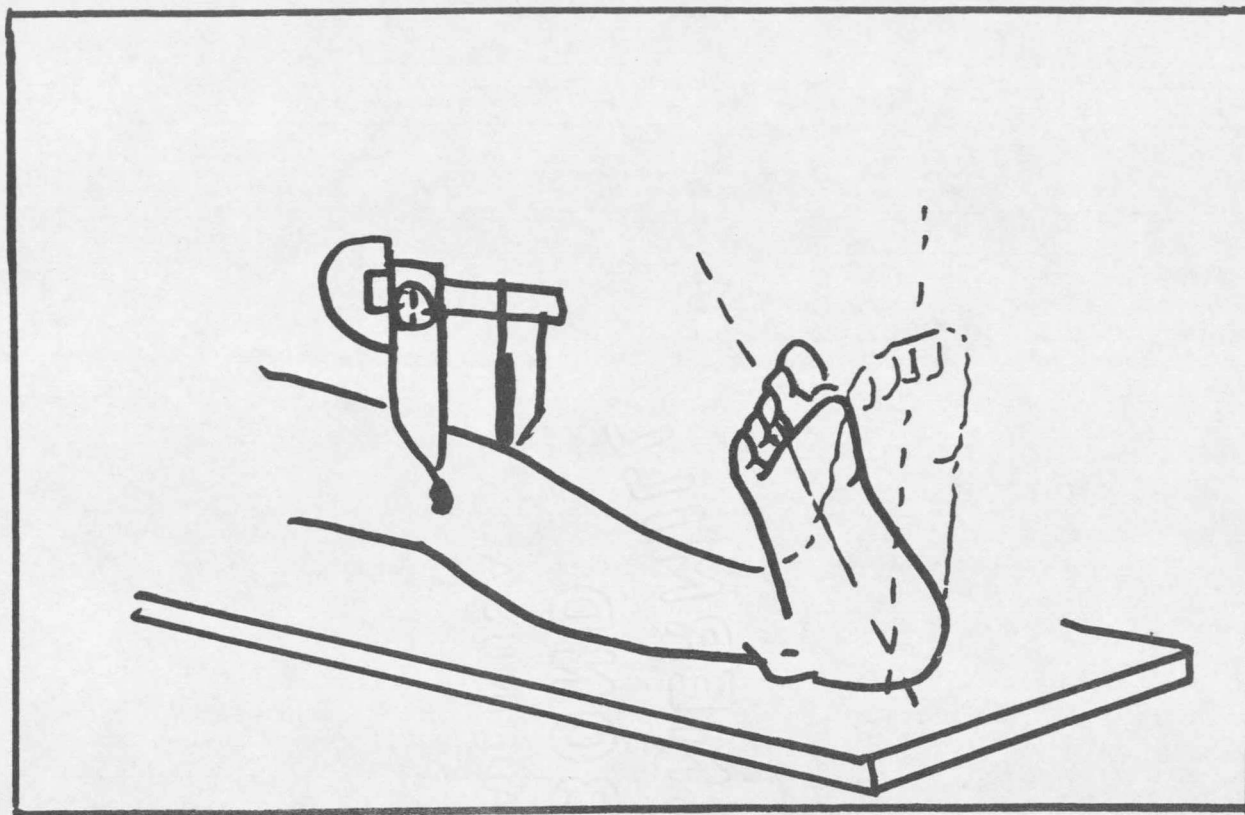


Figure 19. Determining external rotation of the femur/hip extended (18:36)

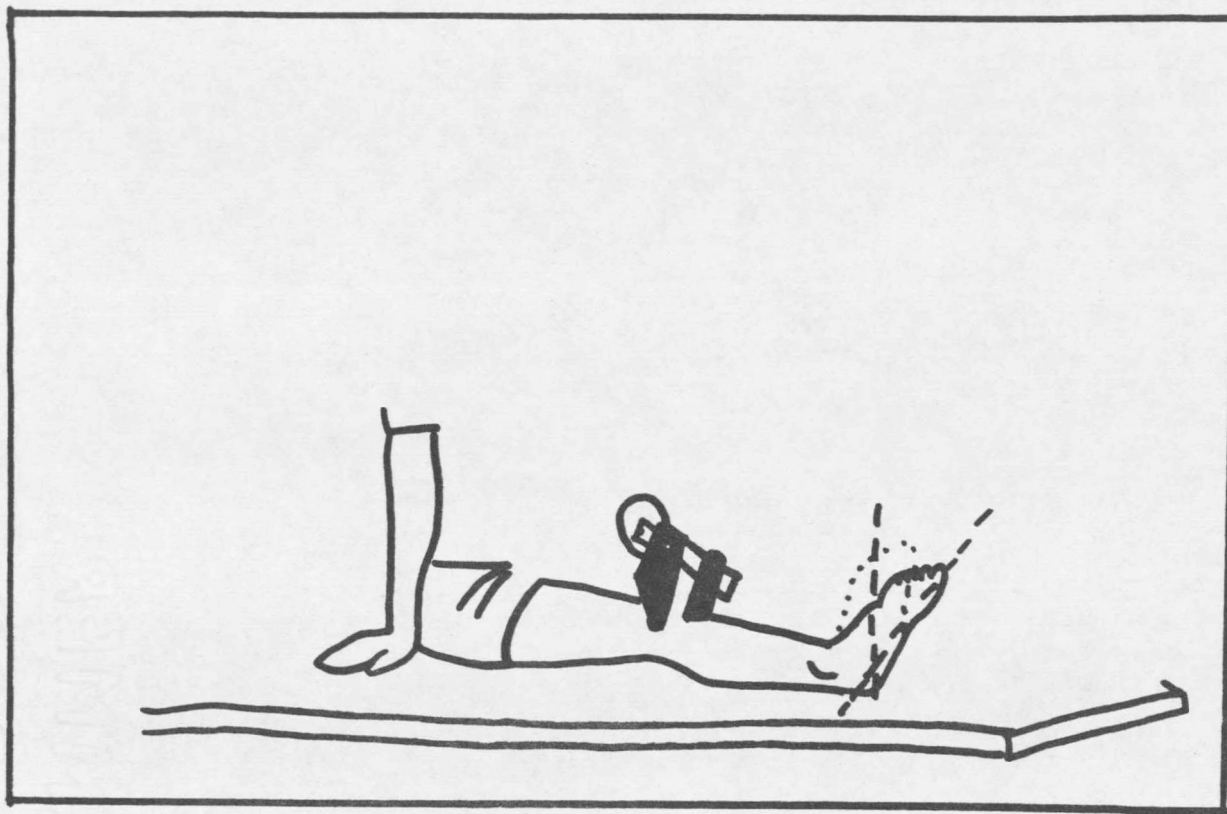
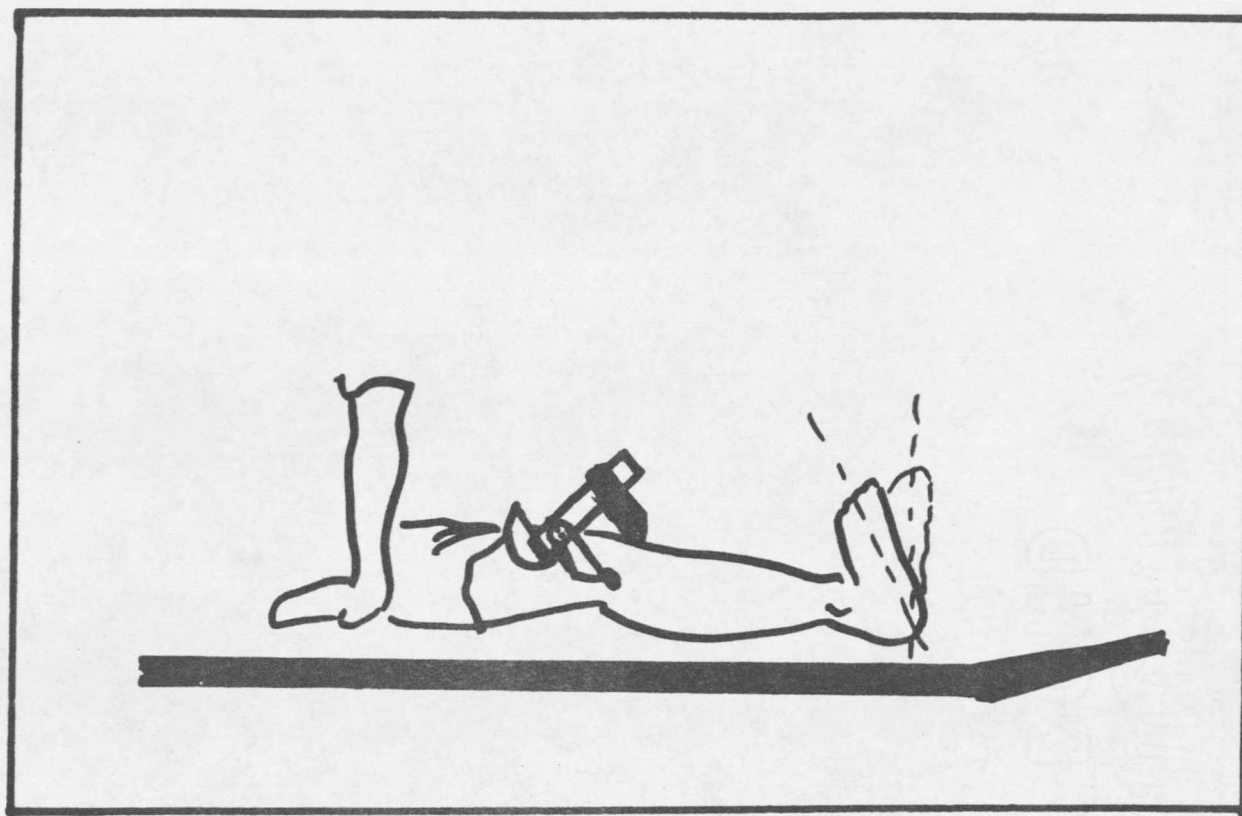


Figure 20. Determining internal rotation of the femur/hip flexed (18:39)



45

Figure 21. Determining external rotation of the femur/hip flexed (18:40)

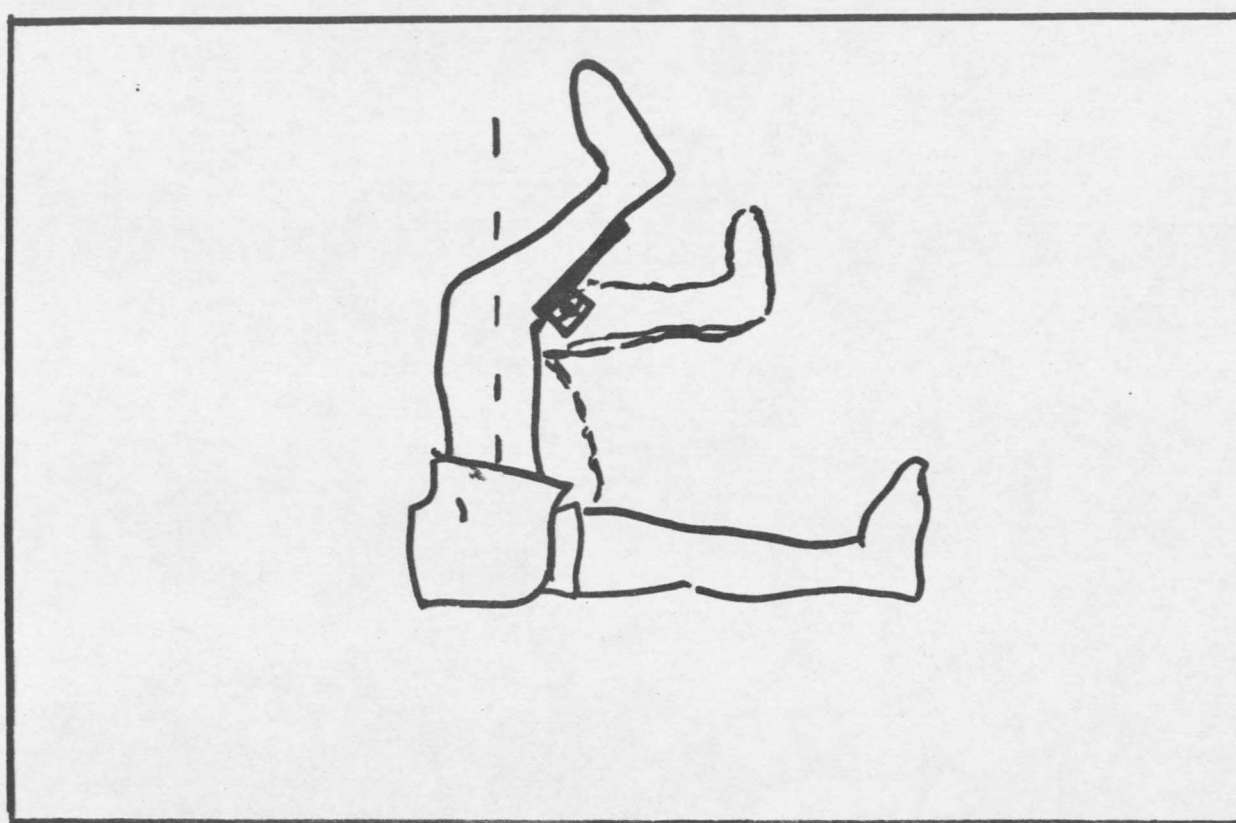


Figure 22. Determining flexibility of the hamstring muscle group.

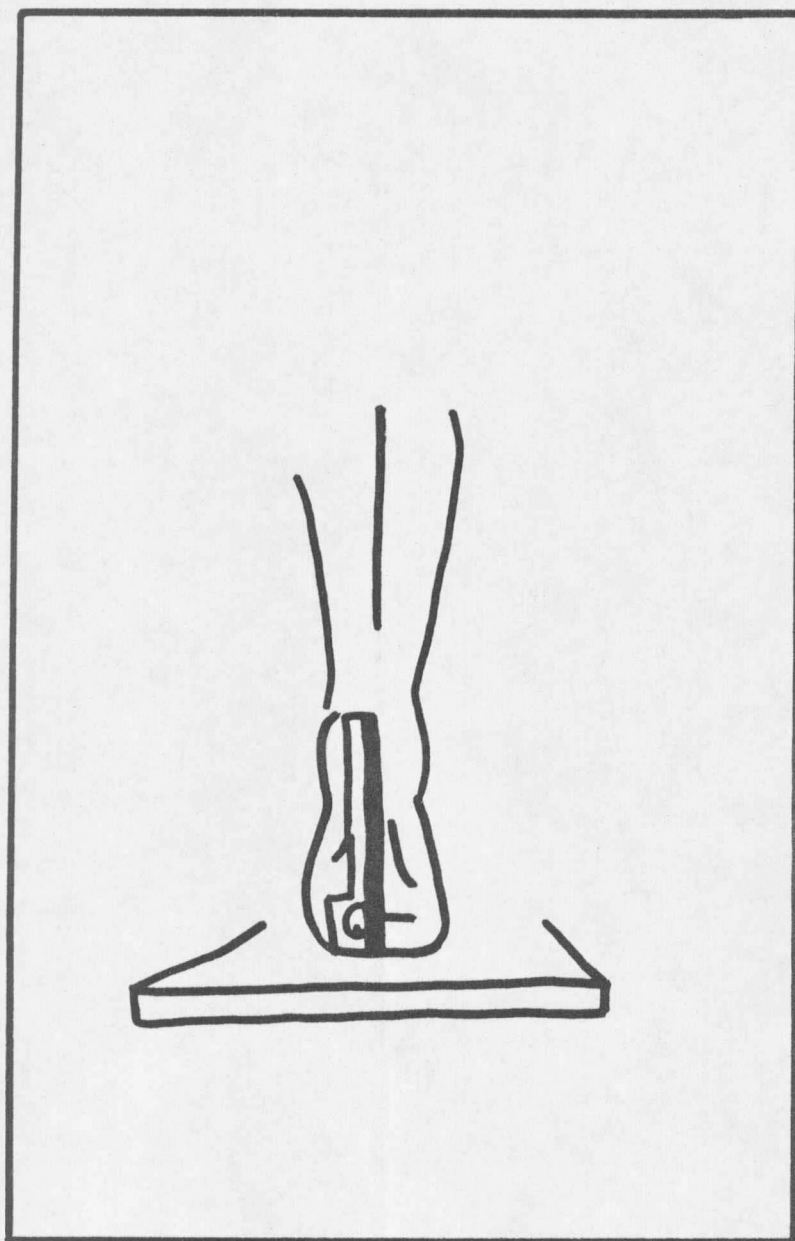


Figure 23. Determining the position of the calcaneus with the subtalar joint in either static or neutral position

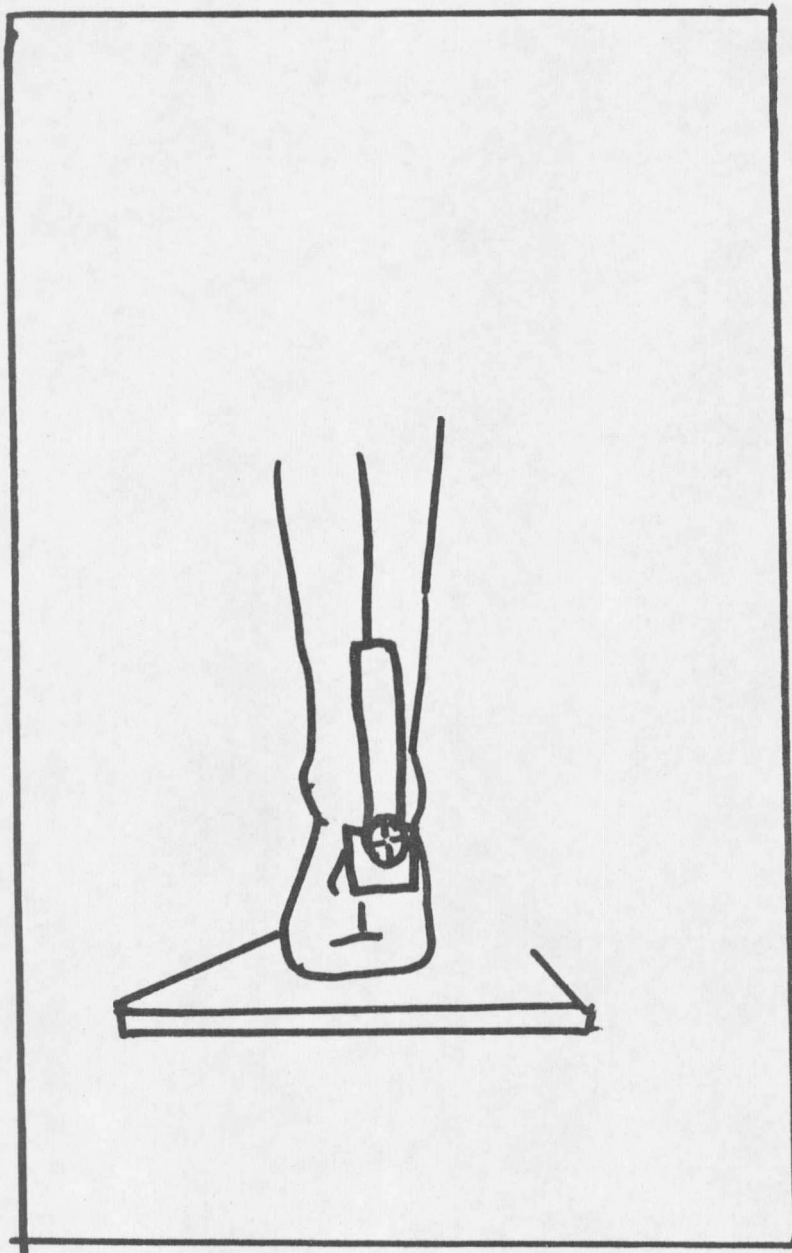


Figure 24. Determining the position of the lower leg with the subtalar joint in either static or neutral position

Researcher Reliability

A pilot study was performed to establish the author's reliability with the biometer.

Ten subjects from the Physical Education department at Montana State University, un-related to the study, were measured, as described in Figures 8 through 24, during two separate appointments. The data were collected for this pilot study from February 10, 1977 to March 1, 1977. The measurement techniques were identical to the previous description given (Figures 8 through 24). Both right and left legs of the subjects were used as separate measures, as the technique was the same for both legs. One subject's left leg was not measured as it could not be manipulated from nerve damage received in a car accident. The first 45 minute appointment served as a pre-test, and the second appointment, one week later, served as a post-test.

The data were transferred to a computer programming form by the investigator, and the Montana State University computer programming center key punched the data. Suvak (36) of the testing and counseling department at Montana State University designed the statistics that compared the pre- and post-test 14 alignment measurements. Because one subject's left leg was excluded from some measurements, the number of subjects varied from 18 to 20. Correlation values

obtained on the printout were compared to the critical values of (n = 18) at the .05 level of significance (.575), (n = 19) at the .05 level (.561) and (n = 20) at the .05 level (.549). The correlations for the pre- and post-test ranged from .730 to .987. The author was found reliable with the measurement techniques at the .05 level of significance.

Subject Selection

Subjects were chosen from a questionnaire (Appendix B) sent out to selected Bozeman, Montana residents who are known to exercise on a regular basis. A study description was also put in the "Wind Drinkers", the newsletter of a Bozeman, Montana running club, to ask for any interested participants and anyone who has experienced achilles tendonitis. Subjects who experienced achilles tendon problems were also referred by Montana State University Physical Education instructors and Montana State University trainer Chuck Karnop.

Subject Description

Twenty-nine Bozeman, Montana residents served as subjects for this study. No control was placed on age, sex, height or weight. The following chart lists the forms of exercise in which the subjects regularly participated. The number of participants per sport

is also listed.

JOGGING - 24	BIKE RIDING - 13
CALISTHENICS - 11	DOWNHILL SKIING - 9
WEIGHT LIFTING - 8	RACQUETBALL - 7
TENNIS - 6	HANDBALL - 6
CROSS-COUNTRY SKIING - 4	BASKETBALL - 3
DANCE - 2	KARATE - 1
VOLLEYBALL - 1	

Classification of Subjects

The subjects right and left leg served as separate measurements, thus a subject could have legs in two different categories.

Group 1 - No Achilles Tendonitis. Legs that have never experienced achilles tendonitis or any related problems. Any limb that had been casted within the last year for tendonitis or knee injuries, or any leg that had been broken within the last five years was excluded. Those limbs which were presently experiencing any form of trauma such as knee injury or sprained ankles were also excluded (N = 27).

Group 2 - Past Achilles Tendonitis. Legs in this group have had problems with their achilles tendon, anywhere from four years to six months before the examination. If the achilles tendon had been completely severed and surgically repaired, it was excluded from this group. The severity ranged from incomplete ruptures and microscopic tears to irritation and soreness (N = 12).

Group 3 - Present Achilles Tendonitis. Legs in group three

had achilles tendonitis within the last six months before testing took place. Those who had been casted within the last year for achilles tendonitis, who had completely severed the achilles and received surgical repair were excluded from the study. The activity in which the injury occurred was not held constant. The forms of exercise were: riding a bike, running stairs, handball, and distance running. Severity of achilles tendonitis ranged from irritation and soreness to incomplete ruptures and microscopic tears (N = 9).

Statistical Examination

Subjects for the study were examined between April 11, 1977 and May 13, 1977. Measures of each of the specific parameters to be considered were taken by the researcher with a biometer developed by Phillips (23). Data were recorded on Examination Charts (Appendix A) also provided by Phillips (12).

Statistical Treatment of Data

The data were transferred to computer programming forms and key-punched to yield means, standard deviations and variances for

14 alignment measurements. The measurement of forefoot to rearfoot had two variables when programmed, as the score could be either varus or valgus. Calcaneal stance analysis with the subtalar in neutral and static positions yielded four variables, as the score could either be inversion or eversion with the subtalar in neutral or static. The added variables yielded a total of 19 variables for the 14 alignment measurements.

The data were then examined to find the number of subjects in each variable. Several of the 14 alignment measurements were mutually exclusive. The measurements in which the number of cases was less than four were not statistically treated. The measurements where $N = 4$ were: forefoot valgus, tibial valgus with the subtalar in neutral, inversion with the subtalar in neutral, tibial valgus with the subtalar in static angle of gait, and calcaneal inversion in the static angle of gait.

The remaining 13 variables received statistical treatment of t-test and F-ratio to give correlation between the three groups and each of the 13 variables. The 13 variables treated were: inversion, eversion, forefoot varus, dorsiflexion with the leg straight and flexed, internal rotation with the hip straight and flexed, external rotation with the hip straight and flexed, tibial varus subtalar in static and neutral, calcaneal eversion with the subtalar in static angle of gait, and hamstring flexibility.

Chapter 4

RESULTS

The mean and variance of the 13 individual alignment variables were compared between: Group 1 - no achilles tendonitis and Group 3 - present achilles tendonitis; Group 1 - no achilles tendonitis and Group 2 - past achilles tendonitis; and Group 2 - past achilles tendonitis and Group 3 - present achilles tendonitis. Data were analyzed by the t-test of means and F-ratio of variance.

Group 1 - no achilles tendonitis and Group 3 - present achilles tendonitis

The t-test and F-ratio were used to examine the significant differences in means and variances between those legs which have never had achilles tendonitis and those subjects who have experienced tendonitis. Results showed a significant difference between the means of eversion and dorsiflexion with the legs straight, and a significant difference in variance in measure of external rotation with the hips flexed. Results are listed in Table 1.

Those legs who never had experienced achilles tendonitis had a mean of 13.88 degrees for eversion, which was a significantly greater number of degrees than the mean of 10.81 degrees for those legs which presently were experiencing achilles tendonitis. Thus, those experiencing achilles tendonitis had a smaller range of motion.

Table 1

T-test of Means and F-test of Variance Between
 Group 1 - no past History of A.T. and
 Group 3 - present History of A.T.

Item		n	$\bar{x}$ (degrees)	σ	σ^2	df	t	F
inversion	G ₁	27	25.18	6.31	39.84	34	1.37	1.64
	G ₃	9	22.00	4.92	24.25			
eversion	G ₁	27	13.88	3.95	15.64	34	2.16 *	3.58*
	G ₃	9	10.88	2.08	4.36			
forefoot varus	G ₁	20	4.60	2.21	4.88	25	.511	2.69
	G ₃	7	4.14	1.34	1.80			
dorsi-flexion legs flexed	G ₁	27	16.62	3.81	14.55	34	1.86	1.00
	G ₃	9	13.88	3.82	14.61			
dorsi-flexion legs straight	G ₁	27	18.29	3.86	14.90	34	2.12 *	1.70
	G ₃	9	14.88	5.03	25.36			
internal rotation hips straight	G ₁	27	50.33	9.64	93.07	34	.509	2.05
	G ₃	9	48.22	13.81	190.94			
internal rotation hips flex	G ₁	27	46.62	10.08	101.62	34	.238	1.36
	G ₃	9	45.66	11.75	138.25			

Table 1 Continued

Item		n	$\bar{x}$ (degrees)	σ	σ^2	df	t	F
external rotation	G ₁	27	59.96	13.07	170.88	34	.180	2.06
hips straight	G ₃	9	59.11	9.08	82.61			
external rotation	G ₁	27	53.18	12.88	166.00	34	.408	3.27*
hips flexed	G ₃	9	51.33	7.12	50.75			
tibial varus	G ₁	18	3.055	1.83	3.34	22	.134	1.54
neutral	G ₃	6	3.166	1.47	2.16			
tibial varus	G ₁	23	4.56	1.67	2.80	30	.637	1.64
static	G ₃	9	4.11	2.14	4.61			
calcaneal eversion	G ₁	23	5.69	2.03	4.13	28	.255	2.97
static	G ₃	7	5.42	3.50	12.28			
hamstring	G ₁	23	11.47	8.28	68.62	29	.115	1.09
flexibility	G ₃	8	11.87	8.65	74.98			

*Significant at .05 level.

on the measurement of eversion than those legs who never have had achilles tendonitis. Dorsiflexion with the leg straight for those legs with no past history of achilles tendonitis had a mean of 18.29 degrees. Those legs presently suffering from achilles tendonitis had a mean of 14.88 degrees which was significantly less than the previous group. This suggests those legs presently experiencing achilles tendonitis have a limited degree of dorsiflexion when compared to those legs with no past history of achilles tendonitis.

Using the F-ratio, those legs that have never had achilles tendonitis had a variance of 166.00 in the external rotation with the hips flexed. Group 3, present achilles tendonitis subjects, had a significantly smaller degree of variability in external rotation with the hips flexed, having a variance of 50.75.

Significant differences in the means and variances of an individual alignment measurements indicated that the alternative hypothesis, which stated that specific alignment measures could be used to describe those subjects likely to experience achilles tendonitis from those subjects who did not experience achilles tendonitis was accepted for the following measures:

1. eversion
2. dorsiflexion with the legs straight
3. external rotation with hips flexed

Group 1 - no achilles tendonitis and Group 2 - past achilles tendonitis

The t-test and F-ratio showed that there were several significant differences in the 13 variables mean's and variance's between Group 1 and Group 2. Table 2 gives the results of the t-test and F-ratio. Inversion and eversion were the variables in which significant differences were found in the means. Using the F-ratio, the significant differences in variances of those who have had achilles tendonitis was the measurement of forefoot varus.

Using the t-test of means, the inversion variable between Group 1 and Group 2 showed a significant difference in the mean measurement. Those who have had achilles tendonitis had a mean inversion of 29.75 degrees, and those legs who have never had achilles tendonitis had a lesser mean measurement of 25.18 degrees. This implies those subjects who have never had achilles tendonitis tend to invert less than those who have experienced achilles tendonitis. The variable of forefoot varus also showed a significant difference in means, with Group 1 having a mean of 1.85 degrees. Those legs which have never experiences achilles tendonitis have a higher degree of forefoot varus than those legs who have achilles tendonitis.

Examining the data by the F-ratio of variance, those who have never had achilles tendonitis had a variance of 1.14 in forefoot

Table 2

T-test of Means and F-test of Variance Between
 Group 1 - no History of A.T. and
 Group 2 - past History of A.T.

Item		n	$\bar{x}$ (degrees)	σ	σ^2	df	t	F
inversion	G ₁	27	25.18	6.31	39.84	37	2.28 *	2.35
	G ₂	12	29.75	4.11	16.93			
eversion	G ₁	27	13.88	3.95	15.64	37	.39	1.43
	G ₂	12	14.41	3.75	14.08			
forefoot varus	G ₁	20	4.60	2.21	4.88	25	3.12 *	4.25*
	G ₂	7	1.85	1.06	1.14			
dorsi-flexion leg flexed	G ₁	27	16.62	3.81	14.55	37	.97	1.86
	G ₂	12	18.08	5.21	27.17			
dorsi-flexion leg straight	G ₁	27	18.29	3.86	14.90	37	.03	1.31
	G ₂	12	18.25	4.43	19.65			
internal rotation hips straight	G ₁	27	50.33	9.64	93.07	37	.033	1.37
	G ₂	12	51.33	8.23	67.87			
internal rotation hips flexed	G ₁	27	46.62	10.08	101.62	37	.262	1.52
	G ₂	12	47.50	8.17	66.91			

Table 2 Continued

Item		n	$\bar{x}$ (degrees)	σ	σ^2	df	t	F
external rotation hips straight	G ₁	27	59.96	13.07	170.88	37	.272	1.29
	G ₂	12	61.25	14.81	220.93			
external rotation hips flexed	G ₁	27	53.18	12.88	166.00	37	.399	1.60
	G ₂	12	54.83	16.33	266.87			
tibial varus neutral	G ₁	18	3.05	1.83	3.24	26	.372	1.39
	G ₂	10	2.80	1.54	2.40			
tibial varus static	G ₁	23	4.56	1.67	2.80	33	.373	1.25
	G ₂	12	4.33	1.87	3.51			
calcaneal eversion static	G ₁	23	5.69	2.03	4.13	31	.843	1.50
	G ₂	10	5.00	2.49	6.22			
hamstring flexibility	G ₁	23	11.47	8.28	68.62	32	.390	1.09
	G ₂	11	10.27	8.68	75.41			

*Significant at .05 level.

varus; those who have never had achilles tendonitis had a larger degree of variability with a variance of 4.88.

Significant differences in the means and variances of an individual alignment measurements indicated that the alternative hypothesis, which stated that specific alignment measures could be used to describe those subjects likely to experience achilles tendonitis from those subjects who did not experience achilles tendonitis was accepted for the following measures:

1. inversion
2. forefoot varus

Group 2 - past achilles tendonitis and Group 3 - present achilles tendonitis

The results of the t-test of means and F-ratio of variance between those legs which presently are experiencing achilles tendonitis and those legs which have had achilles tendonitis are given in Table 3. The significant variables found by the use of the t-test of means included inversion, eversion and forefoot varus. The F-ratio of variance yielded a significant difference in the variable of external rotation with the hips flexed.

The mean degree of inversion for those who have had achilles tendonitis was 29.75 degrees. Those presently experiencing achilles tendonitis had a significant difference in means with a smaller measurement of 22.00 degrees. Those presently experiencing achilles

Table 3

T-test of Means and F-test of Variance Between
 Group 2 - Past History of A.T. and
 Group 3 - Present History of A.T.

Item		n	$\bar{x}$ (degrees)	σ	σ^2	df	t	F
inversion	G ₂	12	29.75	4.11	16.93	19	3.92 *	1.43
	G ₃	9	22.00	4.92	24.25			
eversion	G ₂	12	14.41	3.75	14.08	19	2.53 *	3.22
	G ₃	9	10.88	2.08	4.36			
forefoot varus	G ₂	7	1.857	1.06	1.14	12	3.51 *	1.58
	G ₃	7	4.142	1.34	1.80			
dorsi-flexion legs flexed	G ₂	12	18.08	5.21	27.17	19	2.03	1.85
	G ₃	9	13.88	3.82	14.61			
dorsi-flexion legs straight	G ₂	12	18.25	4.43	19.65	19	1.62	1.29
	G ₃	9	14.88	5.03	25.36			
internal rotation hips straight	G ₂	12	51.33	8.23	67.87	19	.644	2.81
	G ₃	9	48.22	13.81	190.94			
internal rotation hips flexed	G ₂	12	47.50	8.17	66.81	19	.422	2.06
	G ₃	9	45.66	11.75	138.25			

Table 3 Continued

Item		n	$\bar{x}$ (degrees)	σ	σ^2	df	t	F
external rotation	G ₂	12	61.25	14.86	220.93	19	.380	2.67
hips straight	G ₃	9	59.11	9.08	82.61			
external rotation	G ₂	12	54.83	16.33	266.87	19	.598	5.28*
hips flexed	G ₃	9	51.83	7.12	50.75			
tibial varus	G ₂	10	2.80	1.54	2.40	14	.466	1.107
neutral	G ₃	6	3.16	1.47	2.16			
tibial varus	G ₂	12	4.33	1.87	3.51	19	.252	1.311
static	G ₃	9	4.11	2.14	4.61			
calcaneal eversion	G ₂	10	5.00	2.49	6.22	15	.295	1.97
static	G ₃	7	5.42	3.50	12.28			
hamstring	G ₂	11	10.27	8.68	75.41	17	.397	1.00
flexibility	G ₃	8	11.87	8.65	74.98			

*Significant at .05 level.

tendonitis tend to have smaller range of motion in inversion at the subtalar joint than those who have experienced achilles tendonitis but are not presently experiencing achilles tendonitis. Eversion of those legs who have had achilles tendonitis had a mean of 14.41 degrees, which was significantly different from those legs presently suffering from achilles tendonitis with a mean of 10.88 degrees. Thus, the subjects presently experiencing achilles tendonitis have smaller range of motion at the subtalar joint in the measurement of eversion than the subjects who have had achilles tendonitis. This mean measurement of those who have had achilles tendonitis for forefoot varus was 1.85 degrees which was significantly less than those legs presently suffering from achilles tendonitis, which had a mean measurement of 4.14 degrees. The present achilles tendonitis subjects have a higher degree of forefoot varus than those who have had achilles tendonitis.

The F-ratio yielded a significant difference in the variance of external rotation between past and present achilles tendonitis subjects. The variance for the past subjects was 266.87 and was 50.75 for the present achilles tendonitis subjects. This shows a greater degree of variability among those legs that have had achilles tendonitis and less variability from the mean among subjects who presently have achilles tendonitis in the measure of external

rotation with the hips flexed.

Significant differences in the means and variances of an individual alignment measurements indicated that the alternative hypothesis, which stated that specific alignment measures could be used to describe those subjects likely to experience achilles tendonitis from those subjects who did not experience achilles tendonitis was accepted for the following measures:

1. eversion
2. inversion
3. forefoot varus
4. external rotation with hips flexed

Summary of Significant and Non-Significant Variables

Table 4 is a summary of the variables that are significantly different in the mean or variance, when comparing: Group 1 - no achilles tendonitis and Group 3 - present achilles tendonitis, Group 1 - no achilles tendonitis and Group 2 - past achilles tendonitis, and Group 2 - past achilles tendonitis and Group 3 - present achilles tendonitis.

There were several alignment measurements among the three groups where no significant difference was found. They were: position of calcaneus in relationship to the floor with the subtalar in neutral and static angle of gait; internal rotation with the hips straight

Table 4

Significant Variables Between: Group 1 and Group 3,
Group 1 and Group 2, and Group 2 and Group 3,
And t-test of Means and F-ratio of Variance

Groups	t-test	F-ratio
Group 1 - no tendonitis	eversion	eversion
Group 3 - present tendonitis	dorsiflexion with legs straight	external rotation with hips flexed
Group 1 - no tendonitis	inversion	forefoot varus
Group 2 - past tendonitis	forefoot varus	
Group 2 - past tendonitis	inversion	external rotation
	eversion	with hips flexed
Group 3 - present tendonitis	forefoot varus	

and flexed; dorsiflexion with the knee flexed; external rotation with the hips straight; tibial varus with the subtalar joint in neutral; and hamstring flexibility.

Chapter 5

DISCUSSION

Achilles tendonitis has been described as an overuse syndrome injury and leg alignment abnormalities have been listed as causative agents (36:37). Achilles tendonitis seems to affect some people and not others when the type of running surface, duration, and speed of running are held constant. This study accepted the alternative hypothesis which stated each group could be independently described by certain lower alignment measurements. By accepting the alternative hypothesis, the study supports the theory that certain alignment measures are contributing factors in the overuse injury of achilles tendonitis. Thus, a person with certain alignment measures of the lower extremity possibly would be more predisposed to experiencing achilles tendonitis than another subject, with factors such as running surface, distance, and speed held constant.

Examining Group 1 - no achilles tendonitis, and Group 3 - present achilles tendonitis by the t-test of means and F-ratio of variance, several alignment measurement variables were found to be significantly different between the two groups. When examining the function of the subtalar joint in gait analysis, pronation (the combination of abduction, dorsiflexion, and eversion) was found to be important in the heel strike phase. Pronation makes the subtalar joint into a mobile

adapter to absorb the shock on the heel strike phase (35:122). Thus, if eversion is limited, pronation has a limited range of motion. It has been found that limited adaptation of the foot is related to range of motion at the subtalar joint, i.e. the less the pronation, the more limited the mobility (7:826). With limited mobility, the subtalar is unable to absorb as much shock. It would appear that trauma would be more likely to occur to the achilles tendon, as the subtalar can not absorb as much of the impact on the heel strike. Thus, in this study, those presently experiencing achilles tendonitis everted less than those who have never had achilles tendonitis, would seem to be more prone to achilles tendonitis because the range of motion at the subtalar joint is limited in eversion and consequently the mobile adaption at this joint is limited so that the joint absorbs less shock.

The subtalar joint also is important in making adaptations to the ground and running surface. It's the universal joint beneath the ankle, as the ground doesn't allow the foot to internally or externally rotate, the subtalar joint does this by inverting or everting (35:41). Those presently experiencing achilles tendonitis everted less than those legs which have never had achilled tendonitis, which would imply that present achilles tendonitis subjects are limited in the amount of adaptation the foot can do in varying running surfaces. Changes in running surfaces, hill workouts, and

run-down shoes were cited as causative factors in achilles tendonitis (30). Because those with achilles tendonitis can adapt less, it would seem that changes in surfaces and hill running might present situations that would injure the achilles tendon as it couldn't compensate as well to irregularities.

Dorsiflexion was another variable found to be significantly different between those legs presently experiencing achilles tendonitis, Group 3, and those who have never had achilles tendonitis, Group 1. The legs presently experiencing achilles tendonitis had a significantly less degree of dorsiflexion with the leg straight than those legs who have never had achilles tendonitis. Sheehan (6) cites a shortened achilles tendon as a factor promoting achilles tendonitis. Short inflexible calf muscles which develop from prolonged participation in sports seems to enhance the possibilities of achilles tendonitis, as the tendon attempts to compensate for this limited range of motion (30). Subotnick (34) describes the achilles tendon as a rubber band that is always stretched to a point of breaking and when the slightest extra pull is put on it, something gives. The achilles tendon is a cord connecting the gastrocnemius and soleus to the calcaneus and at the narrowest point, just above the heel, it isn't any bigger around than a finger. An overstressed achilles tendon usually gives at this point, with Subotnick and Pagliano (34) citing inflexibility as a contributing factor. When the

gastrocnemius and soleus are tight, the leg bone can't easily move the required 10 degrees over the foot in the normal gait and an unusual strain is put on the achilles tendon and shin area. The study's findings would seem to support these beliefs that a shortened achilles tendon or inflexible calf muscle might contribute to achilles tendonitis. The study found that those legs presently experiencing achilles tendonitis had a significantly less amount of dorsiflexion, which indicates less flexibility in the achilles tendon and calf muscles, than those subjects who have never had achilles tendonitis. This limited dorsiflexion in present achilles tendonitis subjects would seem to support the idea of Sheehan (6), Subotnick and Pagliato (34), that an inflexible achilles tendon or calf muscles contribute to achilles tendonitis.

Group 3 - present achilles tendonitis, also had less variability around the mean in external rotation with the hip flexed than Group 1 - no achilles tendonitis. The mean for Group 3 - present achilles tendonitis, was 51 degrees and Group 1 - no achilles tendonitis, had a greater range of external rotation with the hip flexed with a mean of 53.80 degrees. The accepted norms for the range of motion at the hips state that there should never be more internal rotation than external rotation; and the zero point is the position where the internal and external rotation are the same number of degrees (15:131). The data were analyzed so that external rotation with the hips flexed

was examined alone, so no inter-dependence of the two variables was shown. Examining the data by hand tally, Group 3 - no achilles tendonitis were found to have eight out of nine legs externally rotating with the hips flexed farther than internally rotating. Group 1 - no achilles tendonitis, had eleven internally rotating farther or having the same number of degrees for internal and external rotation, and sixteen having a greater external rotation than internal rotation with the hips flexed. This would seem to indicate that Group 3 - present achilles tendonitis tended to externally rotate with the hips flexed more on the whole than Group 1. When examining the gait, internal rotation on a planted foot promotes pronation at the subtalar joint and mobile adaption at this joint to absorb shock upon the heel strike (35). If the limb has excessive external rotation, it would appear that the amount of pronation upon heel strike is reduced. Achilles tendonitis in Group 3 - present achilles tendonitis, therefore, could possibly result from a lessening of the internal rotation and pronation on heel strike, thus increasing the shock the limb receives upon heel strike.

When examining the results of data collected between Group 1 - no achilles tendonitis and Group 2 - past achilles tendonitis, it was found that a significant difference occurred in inversion, with Group 1 - no achilles tendonitis inverting less than Group 2 - past

achilles tendonitis. This might suggest that those with past achilles tendonitis have increased the range of motion at the subtalar joint, and thus become able to adapt the foot upon the heel strike to absorb more shock. Subotnick (35) states the greater the range of motion the subtalar joint, the greater amount of adaptations the foot can make.

The results of the study, when looking at Group 2 - past achilles tendonitis and Group 3 - present achilles tendonitis, showed Group 2 - past achilles tendonitis legs having a significantly greater inversion and eversion measurement than present achilles tendonitis subjects. This again suggests that a limited range of motion at the subtalar joint limits the adaptation of this joint, thus increasing the shock to the lower extremity and perhaps contributing to achilles tendonitis. Group 2 - past achilles tendonitis, were found to have less forefoot varus than Group 3 - present achilles tendonitis subjects. This suggests that the angle in which the foot contacts the ground is indeed important, as noted by Sheehan (29), Sgarlato (28) and Subotnick (35). Overstress, causing achilles tendonitis, can come from the foot structure itself or a deformity when the bend in the leg places the foot at an improper angle such that the forefoot isn't parallel to the rearfoot (35:37). Those who presently have achilles tendonitis have a greater degree of forefoot varus than the past achilles tendonitis subjects, which implies forefoot varus, an

improper forefoot to rearfoot angle, might increase the possibility of achilles tendonitis. The fact that no significant difference in any of the groups for the stance analysis of the calcaneus to the floor and tibia to calcaneus seems to support the theory advanced by Snook (33). He stated in a personal letter that the angle of pull of the achilles tendon is in a rather straight line and doesn't have to work around a corner such as the peroneal and posterior tibial tendon, who have to angle around the malleoli. Snook feels the cause is a result of a tear in the substance due to shortening such as the findings in limited dorsiflexion. Because no difference was found in stance analysis (see Figures 23 and 24) between any of the groups it would seem the angle of pull of the achilles tendon isn't greatly affected by deviations.

A conflict in findings showed up in the forefoot varus variable. When examining Group 1 - no achilles tendonitis and Group 2 - past achilles tendonitis, Group 1 had a significantly greater degree of forefoot varus than did Group 2, although Group 1 had also a significantly greater variance. When examining Group 2 - past achilles tendonitis and Group 3 - present achilles tendonitis, Group 3 was found to have significantly greater degree of forefoot varus. Thus, those with past achilles tendonitis tended to have less forefoot varus than those who have never had achilles tendonitis and those legs who presently have achilles tendonitis. The findings therefore show

those legs who have had achilles tendonitis, land on a foot that is more parallel with the running surface than either legs without achilles tendonitis and presently experiencing achilles tendonitis.

The data weren't analyzed to show the inter-dependence of variables, but the author did note a trend in those legs with achilles tendonitis. Several subjects had a change in degree of external rotation between a flexed and straight hip. Subjects seemed to also decrease in external rotation from extended hip to flexed hip while they increased in internal rotation from extended to flexed hips. Transverse plane abnormalities, such as external and internal rotation with hips both flexed and extended may cause abnormalities as it alters foot strike (18:65).

Applying these findings to coaches and trainer, knowledge of the alignment measures that were found to enhance the possibility of achilles tendonitis in an athlete would be useful to screen possible achilles tendonitis candidates. Specific conditioning programs and formulating preventative measures could then be employed by the trainer and coach. The alignment variables could be used to predict likely athletes, then preventative measures taken might eliminate injury.

Training programs designed with these alignment variables considered might want to include the following suggestions in order to decrease the possibility of the overuse syndrome of achilles

tendonitis.

1. An increase in the flexibility of the subtalar joint is desired. Increasing the range of motion of eversion of the calcaneus is most specifically desired, in order to increase the amount of pronation upon heel strike phase of the gait. This would decrease the amount of shock received by the lower limb upon heel strike and thus decrease the shock that might produce achilles tendonitis.
2. The plantarflexors of the foot should be stretched to increase the degree of flexion, thus preventing undue stretching of the achilles tendon when the limb is prevented from moving over 10 degrees over the foot.
3. Possibly excessive stretching of the external rotators of hip should be avoided. Increased external rotation limits pronation at the subtalar joint, on heel strike, as internal rotation is necessary for subtalar to pronate and become a mobile adapter. The degree of external rotation of the femur may be controlled and/or reduced by strengthening internal rotators and the hip consequently stretching the external rotators.
4. The more parallel the forefoot to rearfoot relationship is made, probably the less likely an athlete will experience achilles tendonitis. Orthotics, a molded plastic shoe

inlay molded around the neutral foot position, would seem like a possible solution to have the foot with a forefoot varus simulates the normal foot.

5. ' Since the study showed a limited range of motion at the subtalar joint, thus less mobile adaption by that joint, a relative type of shoes could possibly help in the prevention of achilles tendonitis. The less the eversion, the less amount of shock the foot can absorb or adapt, so therefore a pair of shoes that have a firm heel counter and especially a good amount of wedging on the sole to help absorb some of the impact upon heel strike.

Although the above considerations are indicated by the study, further investigation is required before firm and exacting conclusions can be drawn and suggestions made.

Chapter 6

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

Summary

A study was conducted to investigate the relationships between lower extremity alignments and the overuse syndrome of achilles tendonitis. Selected measures describing the alignment of the lower alignment of 29 Bozeman, Montana residents who were known to exercise on a regular basis. Data recorded were classified into three groups: Group 1 - no achilles tendonitis; Group 2 - past achilles tendonitis; Group 3 - present achilles tendonitis. Data were analyzed through the use of t-test of means and F-ratio of variance.

The t-test of mean showed a significant difference in the means of eversion and dorsiflexion with leg straight between Group 1 - no achilles tendonitis and Group 3 - present achilles tendonitis, and the F-ratio between these two groups showed a significant difference in variance in external rotation with the hip flexed. Group 1 - no achilles tendonitis and Group 2 - past achilles tendonitis indicated a significant difference in the means using the t-test in the measures of the forefoot varus and inversion. The F-ratio of variance between Group 1 and Group 2 produced a significant difference in variance of the forefoot varus. The t-test of means between Group 2 - past

achilles tendonitis and Group 3 - present achilles tendonitis showed a significant difference in the measure of inversion, eversion and forefoot varus, with the F-ratio between Group 2 and Group 3 indicating a significant difference in variance in external rotation with the hips flexed.

Conclusion

The study produced data that would appear to support the hypothesis promoted by podiatrist as to the treatment and prevention of achilles tendonitis, by correcting abnormalities in lower alignment by re-alignment of the lower leg. The study found certain alignment measures of the lower extremity that were significantly related to achilles tendonitis, hence it should be possible to predict occurrence of the overuse syndrome with the knowledge of these specific measures.

Recommendations

More in depth research and investigation is needed before the findings of the study and previous studies will convince those in athletics that leg alignment is important in prevention and treatment of injuries. Suggestions for further investigation include:

1. A study in which the number of subjects in each group is larger, especially those subjects with the present overuse injury. Statistical treatment of the data could then be

more detailed.

2. An investigation of the relationship between leg alignment while running and in the static position.
3. A study which leg alignment measurements are taken before and after a set exercise or activity session.
4. A study in which the type of activity where the achilles tendon injury occurred is the same for all subjects.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Allman, Fred J. and Allan J. Ryan. Sports Medicine. New York: Academic Press, 1974, pp. 240, 290-295.
2. Anthony, Catherine Parker and Norma Kalthoff. Textbook of Anatomy and Physiology. St. Louis: C. V. Mosby Co., 1971, pp. 119-120.
3. Arnheim, Daniel D. and Carl E. Klofs. Modern Principles of Athletic Training. St. Louis: C. V. Mosby Co., 1973, pp. 275-279.
4. Brand, Robert L. and William G. Clancy. "Achilles Tendonitis in Runners: A Report of Five Cases." American Journal of Sports Medicine. Vol. 4, No. 2, March/April, 1976, pp. 46-57.
5. Cockrell, James, John W. Mackie, Bruce Golden and Merle Foss. "Mechanical Properties of Rabbit Tendons after Repeated Anti-inflammatory Steroid Injections." Medicine and Science in Sports. Vol. 6, No. 3, 1974, pp. 198-202.
6. Complete Runner. Mt. View California: World Publications, 1974.
7. Degiovanni, Jane. DPM and Stephen Smith, DPM. "Normal Biomechanics of Adult Rearfoot, and Radiographic Analysis." Journal of American Podiatry Association. Vol. 66, No. 11, November, 1976, pp. 812-823.
8. Dixon, Dwayne. The Disonary of Athletic Training. Bloomington, Indiana; Dwayne Spike Dixon, 1965, pp. 28a, b, 72-76, 138.
9. Dolan, Joseph P. and Lloyd D. Holladay. Treatment and Prevention of Athletic Injuries. Danville, Illinois: Interstate Printers and Publishers, Inc., 1967, pp. 99-101, 118-119.
10. Forsyth, Harvey and Wayne Sinning. "Lower-Limb Actions While Running at Different Velocities." Medicine and Science in Sports. Vol. 2, No. 1, Spring 1970, pp. 28-34.
11. Gille, Gunnar, Olaf Renguts and Rebekka Berg. Sports Medicine: Pathology. New York: MSS Information Corporation, 1973, pp. 77-81.

12. Glick, James and Victor Katch. "Musculoskeletal Injuries in Jogging." Sports Medicine: Pathology. New York: MSS Information Corporation, 1973, pp. 81-87.
13. Henderson, Joe. "Adding Insert to Injury." Runner's World, Vol. 10, No. 7, July 1973, pp. 16-17.
14. Hlavac, Harry F., DPM. "Major Consideration in the Clinical Evaluation of the Lower Extremity." The Injured Athlete. 3rd Annual Sports Medicine Seminar, May 3-4, 1975, pp. 118-135.
15. Jesse, John P. "Muscular Imbalance and its Relationship to Lower Extremity Injuries: Prevention and Correction." The Athlete's Dilemma: "Overuse Syndrome of Foot and Leg". April 28 and 29, 1973, pp. 65-73.
16. Lindsey, Ruth, Billie J. Jones and Ada Whitley. Body Mechanics. Duguque, Iowa: W. C. Brown Co., 1968, pp. 65-66.
17. Leech, Robert. "Medicine and Skiing: Tendonitis and "In" Diagnosis". Skiing, December, 1976, pp. 21-22.
18. Lilletvedt, Janice Marie. Descriptive Analysis of Selected Alignment Factors of Lower Extremity in Relation to Lower Extremity Trauma in Athletic Training. Montana State University, Bozeman, Montana, August 1976.
19. Matthes, David O. and Richard A. Thompson. Athletic Injuries: A Trainer's Manual and Textbook. Dubuque, Iowa: W. C. Brown Company, 1963, p. 73.
20. McGregor, Robert Roy, DPM. Personal letter between McGregor and the author, April 1977.
21. Morehouse, Laurence and Philip Rasch. Sports Medicine for Trainers. Philadelphia: W. B. Saunders Company, 1963, pp. 159, 218-219.
22. O'Donoghue, Don. Treatment of Injuries to Athletes. Philadelphia: W. B. Saunders Company, 1970, pp. 76-78, 614, 620, 671.
23. Phillips, Robert L., DPM. Personal Interview between Phillips and author in Great Falls, Montana, October 1, 1976 - January 1977.

24. Root, Morton L., William P. Orien, John H. Weed, Robert J. Hughes. Biomechanical Examination of the Foot, Vol. 1. Los Angeles: Clinical Biomechanics Corporation, 1971.
25. Schumacker, Dr. Ralph H. "Traumatic Joint Effusion and the Synovium." Journal of Sports Medicine. Vol. 3., No. 3., May/June 1975, pp. 108-114.
26. Schuster, Richard O., DPM. "Overuse Syndrome - Arch Strains, Heel Pains, Shin Splints." The Athlete's Dilemma: "Overuse Syndrome of Foot and Leg", April 28 and 29, 1973, pp. 37-38.
27. Sgarlato, Thomas E., DPM. A Compendium of Podiatric Biomechanics. San Francisco: California College of Podiatric Medicine, 1971, pp. 1-8, 284-296.
28. Sgarlato, Thomas E., DPM. "Tendo-Achilles and Other Tendon Injuries," "Orthotics". The Athlete's Dilemma: "Overuse Syndrome of Foot and Leg". April 28 and 29, 1973, pp. 47-53.
29. Sheehan, Dr. George. "Medical Advice." Runner's World. Mt. View, California, February 1977, pp. 18-20.
30. Sheehan, Dr. George. "How to Live with your Achilles Tendon". Reprint courtesy of River View Hospital, Red Bank, New Jersey.
31. Snook, Dr. George A. "Achilles Tendon and Tenosynovitis in Long Distance Runners." Medicine and Science in Sports, Vol. 4, No. 3, 1972, pp. 155-158.
32. Snook, Dr. George A. "Chronic Injury-Marathon." Encyclopedia of Sport Sciences and Medicine. New York: Macmillan Co., 1971.
33. Snook, Dr. George A. Personal letter between Snook and author, April 27, 1977.
34. Subotnick, Steven, DPM. ed. Athlete's Feet. Mt. View, California: World Publication, 1974.
35. Subotnick, Steven, DPM. "Orthotic Foot Control for Athletes-The Importance of Pronation," "Soft Tissue Disorders of Foot and Leg," "The Field Treatment of Athletic Overuse Injuries (first aid)", and "Orthotic Foot Control and Overuse Syndrome." Injured Athlete, 3rd Annual Sports Medicine Seminar. May 3-4, 1975, pp. 1-10, 10-31, 31-48, 48-52.

APPENDIX

APPENDIX A

LEFT		RIGHT		SUBTALAR JOINT:	
☐	INVERSION	☐	SUPINATION	☐	
☐	EVESION	☐	PROMATION	☐	
☐		☐	TOTAL ROM	☐	
☐	VALGUS	☐	NEUTRAL POSITION	☐	

0 = NORMAL
 1 = GOOD
 2 = FAIR
 3 = POOR
 4 = TRACE
 5 = ZERO

LEFT		RIGHT		MIDTARSAL JOINT:	
☐	VALGUS	☐	VALGUS	☐	

EVALUATION
1st to 8th Ray

LEFT		RIGHT		ANKLE JOINT:	
☐	DORSIFLEXION	☐	RANGE OF DORSIFLEXION	☐	
☐	PLANTARFLEXION	☐	RANGE OF PLANTARFLEXION	☐	
☐	DORSIFLEXION	☐	RANGE OF DORSIFLEXION	☐	
☐	PLANTARFLEXION	☐	RANGE OF PLANTARFLEXION	☐	

ANKLE TO KNEE:

LEFT		RIGHT		ANKLE TO KNEE:	
☐	INTERNAL	☐	INTERNAL	☐	
☐	EXTERNAL	☐	EXTERNAL	☐	
☐	INTERNAL	☐	INTERNAL	☐	
☐	EXTERNAL	☐	EXTERNAL	☐	

HIP JOINT:

LEFT		RIGHT		HIP JOINT:	
☐	EXTENDED	☐	EXTENDED	☐	
☐	EXTENDED	☐	EXTENDED	☐	
☐	EXTENDED	☐	EXTENDED	☐	
☐	EXTENDED	☐	EXTENDED	☐	

GENU DEVIATION:

LEFT		RIGHT		GENU DEVIATION:	
☐	VALGUS	☐	VALGUS	☐	
☐	VALGUS	☐	VALGUS	☐	
☐	VALGUS	☐	VALGUS	☐	
☐	VALGUS	☐	VALGUS	☐	

STANCE CORRELATION:

LEFT		RIGHT		STANCE CORRELATION:	
☐	ADDUCTION	☐	ADDUCTION	☐	
☐	ADDUCTION	☐	ADDUCTION	☐	
☐	ADDUCTION	☐	ADDUCTION	☐	
☐	ADDUCTION	☐	ADDUCTION	☐	

LEFT		RIGHT		STANCE CORRELATION:	
☐	ADDUCTION	☐	ADDUCTION	☐	
☐	ADDUCTION	☐	ADDUCTION	☐	
☐	ADDUCTION	☐	ADDUCTION	☐	
☐	ADDUCTION	☐	ADDUCTION	☐	

Get Analysis

Name

Date

Age

Weight

Height

Hand

Examined

APPENDIX B

NAME _____ PHONE _____ SEX - M _____
 ADDRESS _____ AGE _____ F _____

1. What type of regular exercise do you participate in? Please check.

jogging _____	racquetball _____
tennis _____	handball _____
swimming _____	x-country skiing _____
bike riding _____	dancing _____
basketball _____	weight lifting _____
skiing _____	calisthenics _____
Other _____	

2. How long do you exercise per day:

10 - 20 min. _____	1 - 1½ hours _____
20 - 40 min. _____	1½ - 2 hours _____
40 - 60 min. _____	Other _____

3. Do you run?

yes _____ no _____
 if so, how far? _____

4. Are you a member of a Varsity Team?

yes _____ no _____
 if so, what team? _____

5. Have you ever had a problem with your Achilles tendon?

yes _____ no _____

6. Are you presently experiencing this problem?

yes _____ no _____

If yes to 5 or 6, please check appropriate blank:

Right Leg ---

slight soreness _____
 & irritation _____
 muscle tendon _____
 tears _____
 severence _____

Left Leg ---

slight soreness _____
 & irritation _____
 muscle tendon _____
 tears _____
 severence _____

7. Please check any of the following injuries you have received:

Right

Left

Lower Back

Pelvis

Leg Fracture

Foot Fracture

Sprained Ankle

Shin Splints

8. Have you ever had surgery on your leg?

yes

no

Please check appropriate leg:

right

left

Please describe:

9. What type of shoes do you wear for exercising?

Model number:

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