AN INVESTIGATION TO DETERMINE THE EFFECT OF SHORT TERM LOW –DYE TAPING ON VERTICAL GROUND REACTION FORCES IN ASYMPTOMATIC PES PLANUS, CAVUS AND NORMAL FEET.

A dissertation presented to the Faculty of Health Services, Durban Institute of Technology, in partial fulfillment of the requirements for the Master's Degree in Technology: Chiropractic

By

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I, John Wayne Elphinstone, do hereby declare that the following dissertation represents my own work, both in conception and execution.

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DEDICATION

This work is dedicated to my family whose love and belief in me will never fail. You're my inspiration to be a stronger and wiser man.

To Nicole whose fearless love and innate goodness always reminds me what it means to be alive.

I love you all.

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ABSTRACT

Low -Dye taping is a method commonly used in sport participation and normal daily activity (Harradine, Herrington and Wright, 2001). It has been indicated in support of injured structures, decreasing edema and protection against re-injury (Reid, 1992:232). Contrary to these beliefs, studies have shown that low -dye anti-pronatory control is lost after relatively short episodes of exercise (Ator et al., 1991 and Vicenzino et al., 1997). The variations in dynamic foot function with low -dye taping is not well understood, although taping of the foot in low-dye type method has been advocated by many authors (Brantingham et al., 1992, Ryan, 1995 and Chandler and Kibler, 1993).

It was the purpose of this study to investigate the maximum ground reaction force and percentage contact time within 10 demarcated regions of the foot in asymptomatic patient with pes planus, cavus and normal medial longitudinal arches at four time intervals over 24 hours. Having established its baseline function it may serve as point of reference for clinical trials that wish to determine the role of taping as part of the management of symptomatic feet.

This trial consisted of 60 participants with asymptomatic feet that were divided into three groups of 20. Participants were divided into three groups depending on their respective foot structures. To qualify for one of the three groups subjects had to either have flexible low, high or normal medial longitudinal arches.

Maximum ground reaction forces (GRF) and Percent contact time was obtained for each of the three groups and for each of four visits. GRF were obtained with the aid of a registered orthotist who has agreed to work with the researcher on this project using the RSscan International 1m footscan plate system (Appendix L). The data was interpreted and analyzed using the RSscan Clinical Version 7.08 software package.

All data was analyzed using the SPSS statistical software package. Univariate analysis of variance (one way ANOVA) was used to determine the interaction of variables within the set time periods. This method of analysis was also used to determine if any interaction existed between groups and variables in those groups. The Post- Hoc test was used to determine the location of significant values within each subset. The T-test was done to determine the effect of taping on different means at different time intervals.

There appears to be a definite trend towards a supinated foot position directly after taping. This is supported by the increased contact time and maximum force over metatarsals 4 and 5. The low-dye taping appears to be elevating metatarsals 2 and 3 and in the process restricting their motion. The taping technique appears to cause an initial foot contact that is less distinctive at the heel but is more widespread throughout the mid and frontfoot regions. Although these trends exist after one hour of taping there seems to be a gradual loss of these effects over time so that after 24 hours a definite regression can be observed. These findings may indicate a complete return to the pre- taped condition over a longer period of time.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction:

The foot is a highly specialized structure (Jahss 1991:31) designed to carry out three important functions: support, propulsion and shock absorption (Kleneman 1991:1). The main functions of the foot are to distribute ground reaction forces associated with heel strike and to allow the transfer of body weight for effective locomotion.

These tasks are achieved by the effects of soft tissue structures and complex articulations (Michaud, 1993:1). Thus according to Cailliet (1997) the normal foot should conform to the following criteria:

I. The foot must be pain free
II. The foot must exhibit normal muscle balance
III. The foot must have an absence of contractures
IV. The foot must have a central heel
V. The foot must have straight and mobile toes
VI. The foot must have three points of weight bearing

Further to this, the foot may be classified as being pes planus, pes cavus or normal, with respect to the medial longitudinal arch of the foot (Magee 1997).

In this respect pes planus, as defined by Dorland's Medical Dictionary (1997:638), is a condition in which one or more of the arches of the foot have flattened out. Michaud (1993:173) goes further to divide pes planus into four different categories based on the structural and functional causes for pes planus:

I. Convex pes valgus (congenital in nature)
II. Talipes calcaneovalgus (congenital in nature)
III. Peroneal spastic flat foot (congenital in nature)
IV. Hypermobile flat foot (Biomechanical in nature)

The hypermobile flat foot or flexible pes planus can be differentiated from the other forms of pes planus by extending the hallux or asking the patient to stand on his toes (Magee, 1997:458). This causes the plantar aponeurosis to tighten thereby re-establishing the arch of the foot (Brown, 1996). Flexible pes planus can be further categorized into first second and third degree based on the amount of navicular drop present (Magee, 1997:484).

Pes cavus consists of an excessively high medial longitudinal arch that causes the foot to be shorter and the metatarsal heads to make oblique contact with the ground. This type of foot structure often leads to metatarsalgia and callus formation under the metatarsal heads as well as claw toes (Cailliet, 1997).

Plantar fasciitis is often associated with biomechanical changes of the medial longitudinal arch. It has been found to be the fourth most common overuse injury of the lower limb (Leach, Seavey and Salter, 1986). It represents between 7% to 9% of all running injuries (Batt and Tanji, 1995) and 8.5 to10% of all presenting sports injuries (Pollard and So, 1999 and Batt and Tanji, 1995)

Much emphasis has been placed on the effect of pronation on the plantar fascia. However, any condition causing excessive tension on the plantar fascia may be responsible for the development of clinical signs and symptoms in the foot (Batt and Tanji, 1995, Barret O'Malley, 1999). Conditions such as pes planus, pes cavus and tight Achilles tendons are some of the factors that may contribute to the increase in tension of the plantar fascia (Brown, 1996).

Various clinicians use strapping as a method to support the plantar fascia (Ambrosius and Kondracki, 1992). A common technique called low-dye taping has been used since the 1940's and was developed by Dr. Dye (Saxelby, Betts and Bygrave, 1997). Anecdotal evidence suggests its function to be restricting pronation as well as supporting the medial longitudinal arch during mid-stance of the gait cycle. (Tanner and Harvey, 1988, Brantingham et al., 1992 and Ryan, 1995). Lynch et al. (1998) in their study of conservative treatment of plantar fasciitis concluded that mechanical control of the foot with taping and orthoses was more effective than either anti-inflammatory drugs or therapy with heel cups.

Although taping of the foot using the low-dye type method has been advocated for plantar fasciitis (Brantingham et al., 1992, Chandler and Kibler, 1993 and Ryan, 1995) it's relevance with respect to ground reaction forces remains uncertain. The role of low-dye taping has for the most part been extrapolated from its use in strapping of the ankle (Reid 1992:233), where:

I. It provides post injury support and controls edema,
II. It prevents re-injury between treatments,
III. It decreases the chances of re-injury on return to activity,
IV. It provides stability when chronic instability is present, and
V. It protects the structure against injury when applied prophylactically.

With the clinical efficacy of low-dye taping clearly still in question, it makes sense to determine and evaluate its effect on the ground reaction forces of the asymptomatic foot. Having established its baseline function it may serve as point of reference for clinical trials that wish to determine the role of taping as part of the management of symptomatic feet.

1.2 Objectives of the Study:

1.2.1 Objective one:

The first objective of the study is to determine the extent of peak ground reaction forces in the asymptomatic foot with pes cavus, planus and normal medial longitudinal arches prior to taping.

1.2.2 Objective two:

This study will determine the effect low- dye taping has on ground reaction forces by doing measurements immediately after taping, 1hour and 24 hours after taping in the asymptomatic foot with pes cavus, planus and normal medial longitudinal arches respectively.

1.2.3 Objective three:

The third objective of the study is to determine the extent of percentage contact time in the asymptomatic foot with pes cavus, planus and normal medial longitudinal arches respectively.

1.2.4 Objective four:

This study will determine the effect low- dye taping has on percentage contact time by doing measurements immediately after taping, 1hour and 24 hours after taping in the asymptomatic foot with pes cavus, planus and normal medial longitudinal arches respectively.

CHAPTER TWO

A REVIEW OF RELATED LITTERATURE:

2.1 INTRODUCTION:

In this chapter follows a detailed discussion with regards to foot structure, taping, ground reaction forces and their relationship to the foot.

The information will be presented as follows:

i. The role of taping
ii. Review of the Anatomy and Biomechanics,
iii. Normal gait cycle.
iv. Pes planus, pes cavus and their effect on the gait cycle
v. Low -dye taping and related literature

This chapter contains literature relating to the structure, function and biomechanics of the foot as well as low -dye taping.

2.2 THE ROLE OF TAPING

Taping is used by therapists for its mechanical support, proprioceptive feedback and control of swelling and pain in the treatment and prevention of many injuries (Callaghan, 1997)

The role of plantar fascial taping is still slightly obscure and has for the most part been extrapolated from its use in strapping of the ankle, where:

I. It provides post injury support and controls oedema,
II. It prevents re-injury between treatments,
III. It decreases the chances of re-injury on return to activity,
IV. It provides stability when chronic instability is present, and
V. It protects the structure against injury when applied prophylactically (Reid 1992:233).

The main mechanisms of action is considered to be the ability to limit mechanical joint stability, prevention of the extremes of ankle motion while at the same time increasing the reaction time and proprioception of surrounding structures (Cordova, Ingersoll & Leblanc, 2000, Karlsson, 1993).

The mechanical support provided by taping has long been the primary indication application of this intervention, Perrin (1995) stated that tape should limit abnormal or excessive motion while supporting the underlying compromised structures. Karlsson (1993) found in his research of ankle taping that although taping cannot completely eliminate movement it does prevent excessive end of range movement and therefore added that it does play a role in increasing the mechanical stability of the ankle. Laughmann (1980) stated that the tape acts as an external ligament that is dependent on the tensile strength of the tape and its adhesive quality only at the origin and insertion of the tape. However it has been reported that the stabilising effect of tape is drastically decreased after excessive movement (Alt et al., 1999, Callaghan, 1997)

Perhaps the greatest contributions of the tape are to the proprioceptive feedback by stimulation of mechanoreceptors in the ligaments and capsules of the underlying articulation (Karlsson, 1993). This in turn shortens the reaction time of the supporting muscles. Robbins et al. (1995) in a randomized, crossed over, controlled comparative trial showed how proprioception in the taped ankle improves after exercise compared to the untapped ankle. Absolute mean estimate error increased 7% in the taped ankle compared to an increase of 39% in the untapped ankle. Robbins et al. (1995) also tested proprioception with athletic footwear and found that although the taped ankle performed better proprioception was greatly limited compared to the barefoot readings and therefore showed that proprioception generally is less when shod.

2.3 ANATOMY AND BIOMECHANICAL REVIEW:

The foot and ankle articulations, although so often described individually, function dynamically to distribute forces at the end of the lower kinematic chain (Abboud, 2002). Although movement at each individual joint seems insignificant the combinations of these articular movements is what guarantees us functional mobility (Abboud, 2002). For ease of understanding we will discuss only the anatomy relevant to the medial longitudinal arch and the changes associated with those structures.

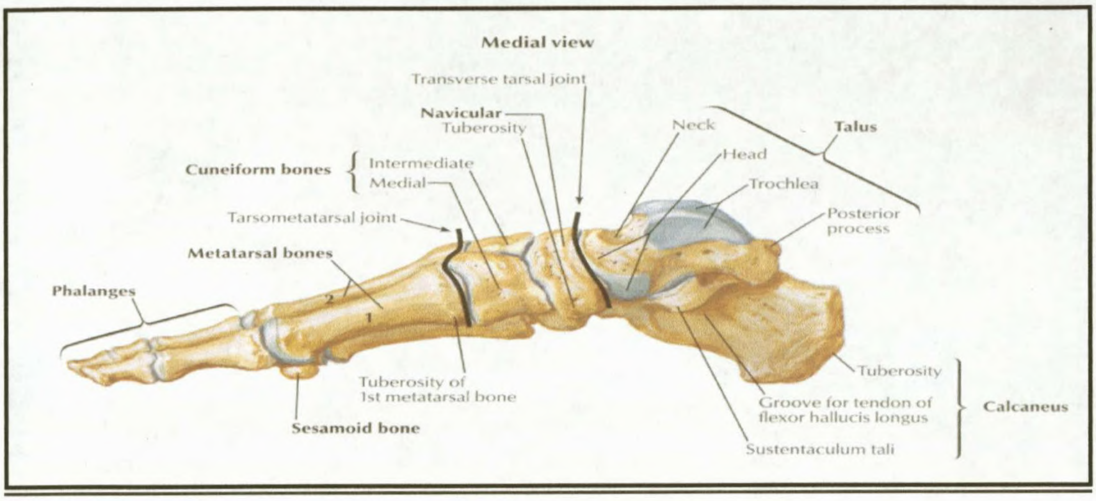


Figure 1: The right foot demonstrating the hind, mid and forefoot (Netter, 1999:489).

According to Magee (2001:446) the foot can be divided into three distinct regions (Refer to Figure 1):

I. Hindfoot, consisting of the tibia, fibula, talus and the calcaneus and functioning through the tibiofibular, talocrural and subtalar joints.

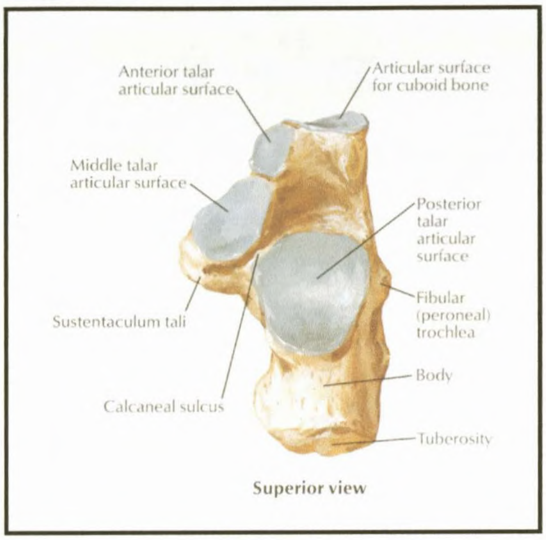
II. Midfoot, consisting of the calcaneus, navicular, cuboid and three cuneiform bones and the talocalcaneonavicular, cuneonavicular, cuboideonavicular, intercuneiform, cuneocuboid and calcaneocuboid articulations collectively known as the Chopart's joints.

III. Forefoot, consisting of the metatarsals, phalanges and some sesamoid bones. The main articulations are the intermetatarsal, tarsometatarsal, metatarsophalangeal and interphalangeal joints also collectively known as Lisfranc's joints.

The medial longitudinal arch stretches throughout these three regions (Norkin and Levangie, 1992:389). The osseous components of the medial longitudinal arch consist of the calcaneus, talus, navicular, as well as the three cuneiforms and metatarsals (Moore and Dalley, 1999:640)

Weight bearing supination is a combination of inversion, adduction and plantarflexion while pronation is defined as eversion, abduction and dorsiflexion (Cailliet 1997, Hunt et al., 2001, Abboud, 2002, McDonald and Tavener, 1999). Two of the main articulations involved with these motions are the subtalar and talocalcaneonavicular joints.

Figure 2: Superior view of the calcaneus and subtalar joint (Netter, 1999:490).



The subtalar joint is generally accepted to consist of three articulations between the talus and the calcaneus (Moore and Dalley, 1999:637, Michaud, 1993:9). The posterior facet formed by the talus and calcaneus is the largest of the three facets. The inferior surface of the talus is concave while the calcaneus has a convex superior surface (Refer to figure1 and figure 2). The two anterior facets are formed by two convex surfaces on the inferior surface of the neck of the talus that correspond to two anterior calcaneal concavities (Refer to figure 2) (Michaud 1993:9, Norkin and Levangie 1992:389). The tarsal canal runs obliquely between these two osseous structures and is formed by sulcus on the inferior surface of the talus and calcaneus (Refer to figure 2). Ligaments running in this tunnel divide the posterior from the middle and anterior facets, forming two distinct joint cavities. The anterior two articulations share one joint capsule with the talonavicular joint (Norkin and Levangie 1992:389).

The primary motions of the subtalar joints are inversion / eversion and abduction / adduction but these two motions do not occur independently of each other, rather the subtalar joint is said to have one degree of freedom namely pronation and supination (Abboud, 2002).

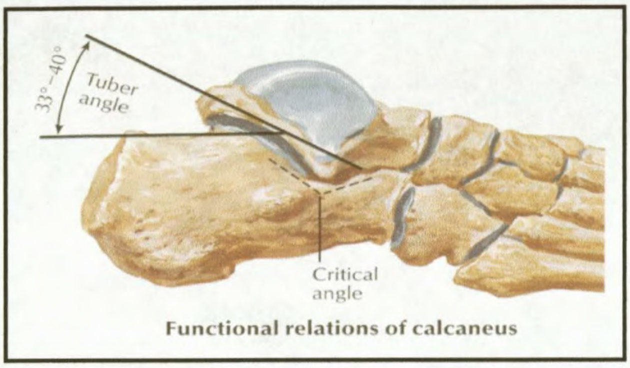


Figure 3: The subtalar and talocalcaneonavicular joints (Netter, 1999:490)

The talocalcaneonavicular (TCN) joint is a combination of the subtalar joints and talonavicular joint (Refer to figure 1 and figure 4). The talonavicular joint consists of the head of the talus articulating with the corresponding navicular articular facet. This surface is deepened and enlarged by the plantar calcaneonavicular ligament, deltoid ligament and the bifurcate ligaments. These ligaments connect the calcaneus to the navicular creating a joint with one degree of freedom, being supination and pronation (Norkin and Levangie 1992:390). This joint's function (TCN) is virtually identical to the subtalar joint, it is said to be the key to foot biomechanics from which the other articulations form an elastic unit. (Norkin and Levangie 1992:390)

Two other articulations, the talonavicular and calcaneocuboid joints combine as the transverse tarsal joint (Refer to figure 1 and figure 4). This joint forms the separation between the hindfoot and the midfoot. In contrast to the talonavicular joint described above, the calcaneocuboid joint allows very little motion due to complex concave and convex articulating surfaces (Norkin and Levangie 1992:391). Movement is therefore predominantly around a longitudinal axis of the foot which allow supination and pronation as their primary movements although inversion and eversion seem to predominate (Norkin and Levangie 1992:391). Due to its intimate relationship with the TCN joint, any motion at one joint would mean reciprocal movement in the others creating a dynamically moving complex of articulations (Norkin and Levangie 1992:391).

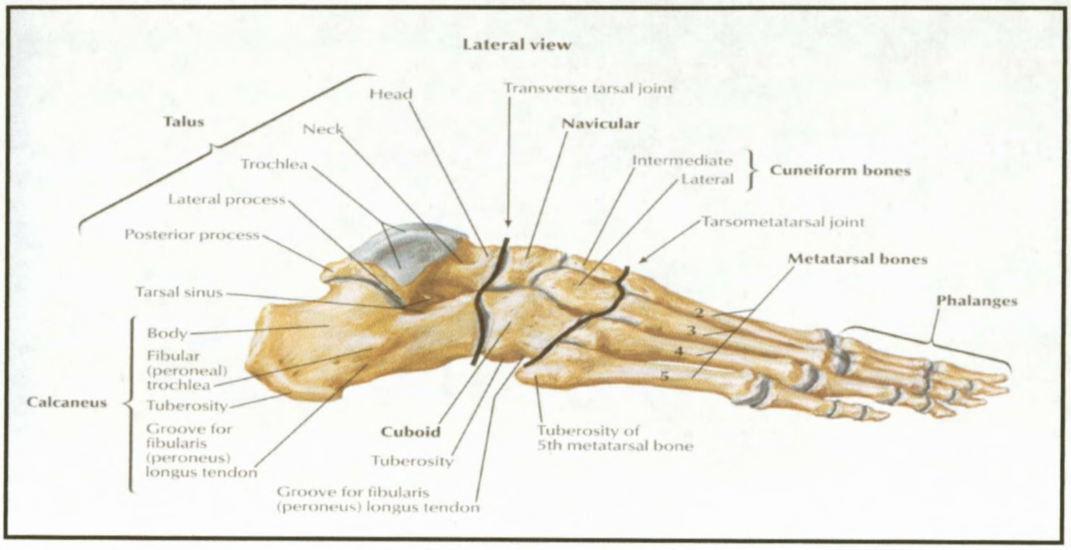


Figure 4: Lateral aspect of the foot showing the transverse tarsal joint (Netter, 1999:489).

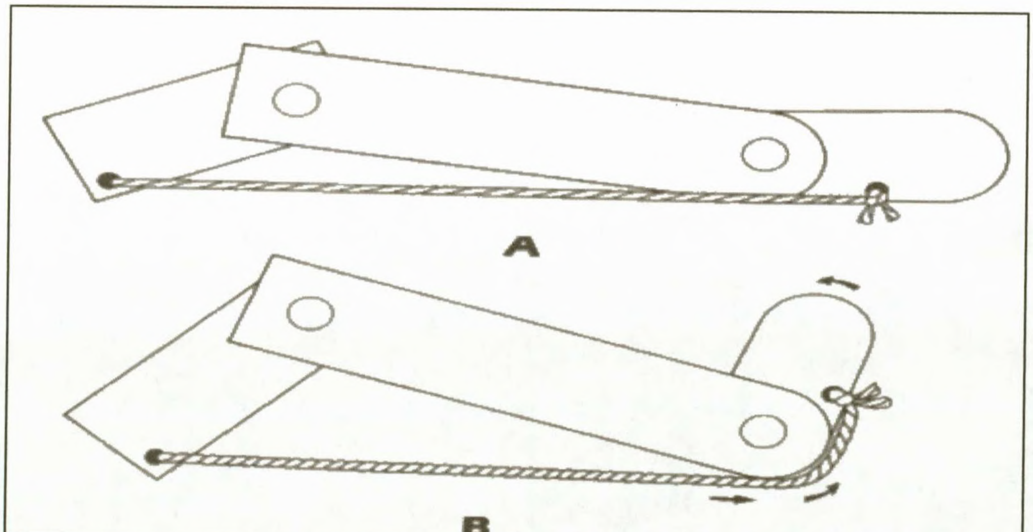


Figure 5: (A) The resting position of the plantar fascia. (B) Dorsiflexion of the first toe leads to tightening of the fascia and lifting of the arch. (www.orthoteers.co.uk/Nrujp~ij33lm/Orthfootmech.htm).

Passing over and maintaining these articulations are the soft tissue structures consisting of the ligaments and tendons of the foot. The plantar ligaments are of particular importance providing support whiles at the same time allowing slight mobility neccesary for shock absorbtion during the gait cycle (Norkin and Levangie 1992:391). The plantar ligaments consist of the the calcaneonavicular ligament, long plantar ligament, plantar fascia (aponeurosis) and short plantar ligaments (Moore and Dalley, 1999:586).

The plantar aponeurosis creates a bowstring effect in the foot (Refer to figure 5) (Reid, 1992:130, Brown, 1996). It enables the fibrous structure of the plantar aspect of the foot to enhance distribution of forces, support the articular components and enable a spring like action during the final aspects of gait also called the windlass mechanism (Soderberg 1996:313, Erdemir et al., 2004). This action can be readily seen by dorsiflexion of the great toe and is often used to differentiate between flexible and rigid pes planus (Magee, 1997:458)

The calcaneonavicular ligament, also called the spring ligament is a triangular structure passing from the sustentaculum tali to the posterioinferior surface of the navicular bone (Refer to figure 6). The long plantar ligament passes from the plantar surface of the calcaneus to the groove on the cuboid bone. Some of the fibres extend to the base of the middle three metatarsals thereby forming a tunnel for the peroneus longus muscle. The short plantar ligament, deep to the long plantar ligament, extends from the antero-inferior surface of the calcaneus to the inferior surface of the cuboid (Refer to figure 6) (Moore and Dalley, 1999:586).

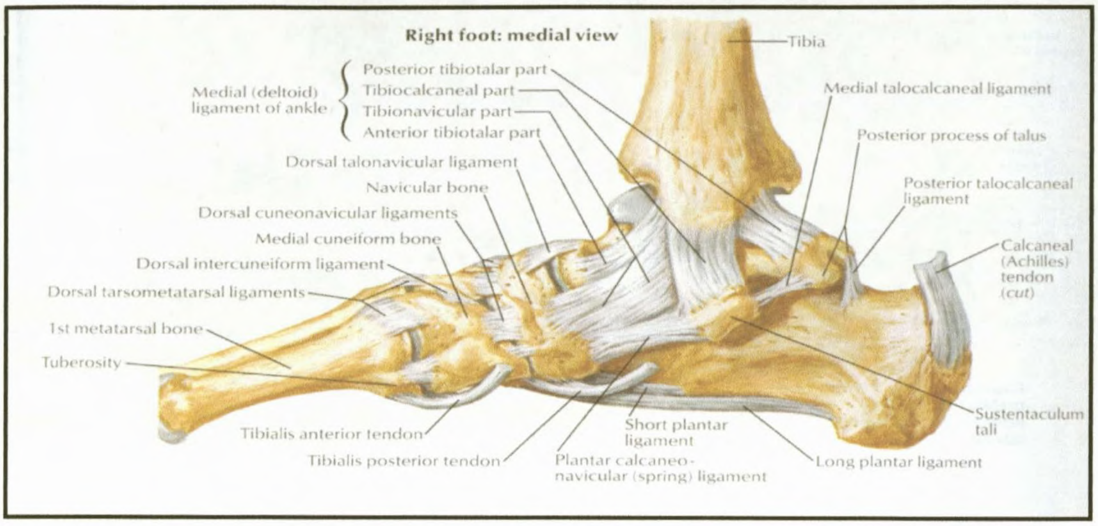


Figure 6: Ligaments supporting the articulations of the foot (Netter, 1999:491)

Although the gastrocnemius and soleus muscle (Figure 7), often referred to as the calf muscles or triceps surae, aren't directly related to the stability of the MLA. It acts via the achilles tendon attachment to the posterior surface of the calcaneus and ensures that hind-foot supination occurs during the gait cycle (Soderberg 1996:312, Moore and Dalley, 1999:586). This supination locks the talocalcaneonavicular (TCN) joint into a rigid lever, which will eventually lead to elevation of the heel and plantar arch if contraction continues (Soderberg 1996:325-326, Norkin and Levangie 1992 and Moore and Dalley, 1999:586).

Other muscles are more directly related the stability and function of the MLA. These include:

1. The tibialis posterior (Refer to figure 7) which pass behind the medial maleolus to anchor the navicular, calcaneus, cuneiforms, cuboids and base of the four metatarsals (Travell, and Simons, 1983:460). The main action of this muscle is primarily inversion and adduction while also giving a weak contribution to plantar flexion of the ankle (Travell, and Simons, 1983:460). Functionally it resists lateral valgus force of the ankle at early stance phase

and plays a significant role controlling functional pronation during gait and therefore also medial rotation of the leg (Norkin and Levangie, 1992, Travell, and Simons, 1983:460).

2. The Tibialis Anterior crosses the anterior surface of the tibia to attach to the medial plantar surface of the cuneiform and first metatarsal bones (Travell, and Simons, 1983:355). Dorsiflexion and supination is the main action of this muscle but has also been found to be vital in maintenance of balance during the stance phase of the gait cycle (Travell, and Simons, 1983:358-359).

3. The flexor digitorum longus (FDL) (Refer to figure 7) terminates in a tendon that passes over the flexor hallicus longus and joins the quadrates plantae muscle. It divides into four tendinous slips attaching each on its own to the distal phalynx of the terminal four toes (Travell, and Simons, 1983:490). FDL flexes the four lesser toes, which together with the flexor hallicus longus (FHL) causes clawing allowing the toes to grip the ground while walking (Travell, and Simons, 1983:491-492).

4. Flexor hallicus longus (Refer to figure 7) tendon passes deep to the flexor digitorum longus tendon and between the two heads of flexor hallicus brevis. It attaches to the terminal phalynx of the first toe (Travell, and Simons, 1983:490). The action produced by this muscle causes the hallux to be pressed against the ground to allow walking, together with FDL it supports the MLA during gait (Travell, and Simons, 1983:491-492)

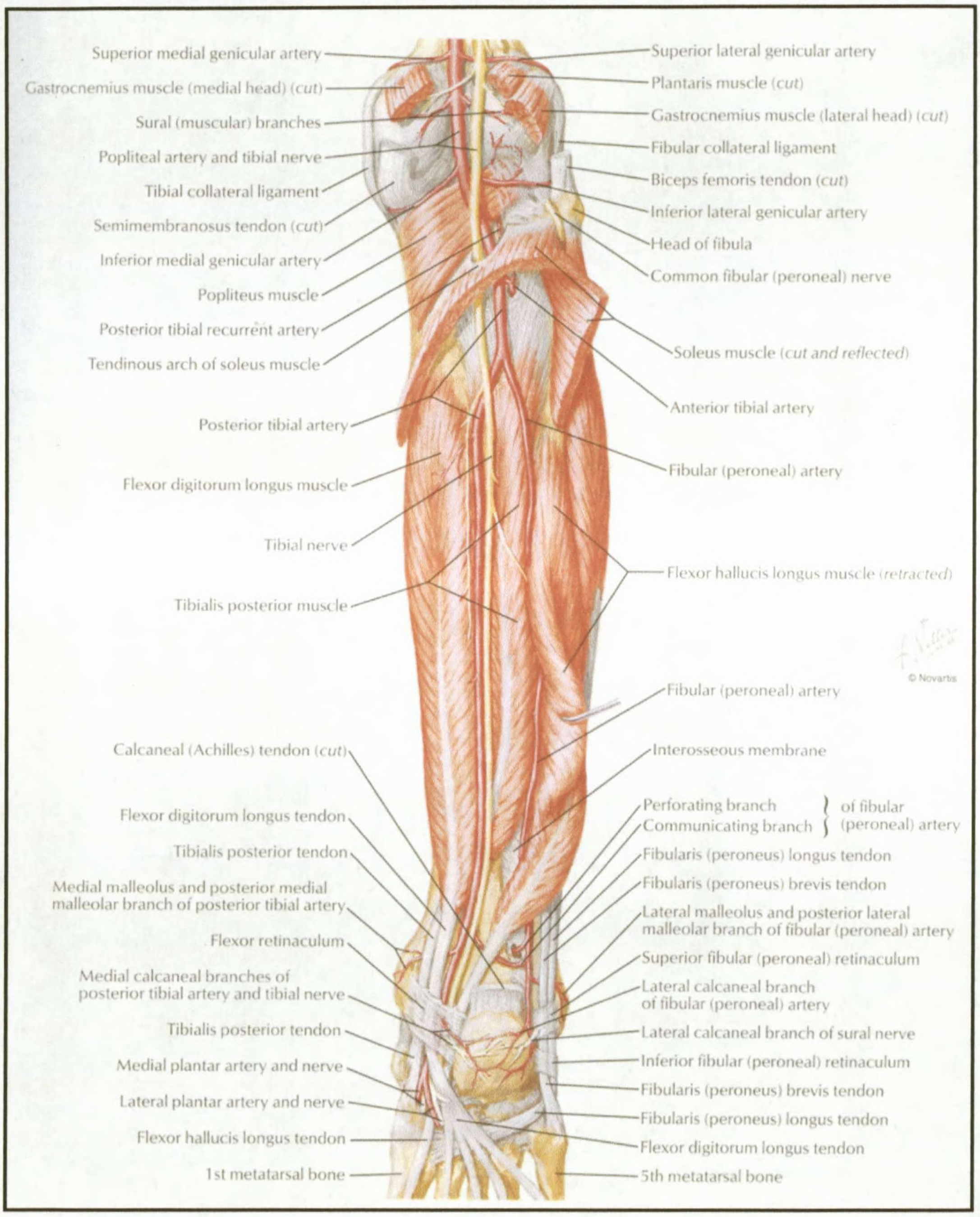
5. The Abductor hallicus (AH) covers the entrance to the plantar nerves and vessels (Travell, and Simons, 1983:504). Proximally it attaches to the medial calcaneal tuberosity, flexor retanaculum, plantar fascia and intermuscular septum of flexor digitorum brevis. Together with flexor hallicus brevis it attaches to the medial aspect of the base of the first toe (Travell, and Simons, 1983:504). The AH can flex and abduct the great toe. Although the AH and

flexor digitorum brevis (FDB) may contribute to static arch support in flatfooted individuals its activity is not required for normal foot arch maintenance rather their activity seems necessary where compensation is required in feet suffering with lax ligamentous and articular structures (Travell, and Simons, 1983:507-508)

6. The flexor digitorum brevis (FDB) covers the lateral plantar nerve and vessels. Proximaly it extends from the medial process of the anterior calcaneus, plantar fascia and adjacent intermuscular septa (Travell, and Simons, 1983:505). Distally it divides into four tendons that splits to allow passage for flexor digitorum longus after which it unites and then split again just before attaching to the middle phalynx. The FDB's role together with AH seems to be one of support in feet with biomechanical inadequacies; it does not seem to be active in normal feet. (Travell, and Simons, 1983:507-508)

When looking at the literature it can be reasoned that even a small deviation in anatomical structure will lead to significant alterations in the gait cycle. The gait cycle is unique in every individual but general trends can be distinguished to allow us to describe the normal gait cycle.

Figure 7: Muscles of the posterior leg (Netter, 1999:483)



2.4 THE NORMAL GAIT CYCLE

Due to the complexity of the gait cycle this discussion on gait patterns will be limited to the ankle and foot only due to its relevance in this study.

The human gait can be described as a translatory progression of the whole body due to coordinated rotatory movements of specific body segments (Norkin and Levangie, 1992:450). Although no two individuals share the exact same gait patterns the large majority of movements can be described in each individuals making disruption of this pattern easily identifiable (Norkin and Levangie, 1992:450).

The gait cycle represents the period between two identical events of the same limb, therefore from one event until the identical limb repeats the same action (Abboud, 2002). The gait cycle consist of two main phases, a swing phase consisting of 38 % of the gait cycle and a stance phase consisting of 62 % of the cycle (Jahss, 1982:400). A complete cycle is known as a stride while one step is considered the period between which the same event occurs in both limbs (Soderberg, 1997:412). Therefore the terms stride length and step distance is self-explanatory (Refer to figure 8) (Norkin and Levangie, 1992:388, Soderberg, 1997:412).

The stance and swing phase can further be broken down into sections. Multiple classifications exist but for the purposes of this study the more recent classifications of the Rancho Los Amigos (RLA) Medical Centre will be used, as they are more accurate in the breakdown of the phases (Figure 8) (Norkin and Levangie, 1992:450):

2.4.1 Stance Phase (Norkin and Levangie, 1992:388, Soderberg, 1997:413)

I. Initial contact: The point at which the extremity strikes the ground.

II. Loading response: From initial contact until contra lateral extremity is lifted

III. Midstance: Continues until body has moved over the supporting limb.

IV. Terminal stance: the period between midstance and initial contact of the contra lateral extremity or following heel off of the ipsilateral limb.

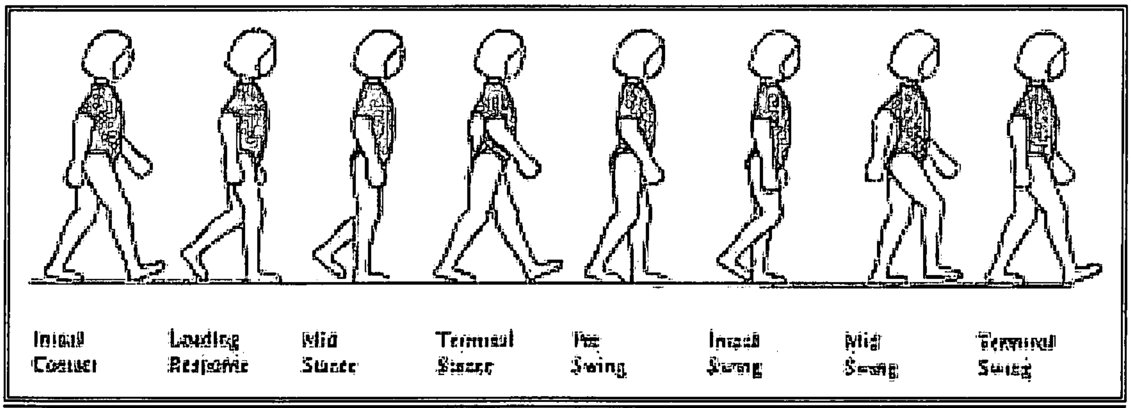
V. Preswing: period following heel off until the toe leaves the ground.

2.4.2 Swing Phase (Norkin and Levangie, 1992:388, Soderberg, 1997:413)

I. Initial swing: The end of preswing until the reference extremity has maximum knee flexion.

II. Midswing: The period between initial swing until the tibia is in a vertical position.

III. Terminal swing: The period between midswing and initial contact.



<u>**Figure 8:**</u> The Gait cycle also demonstrating stride length and step length. (http://www.childsdoc.org/images/99-1-motion2.jpg)

Table 1: Divisions of stance phase, ankle/foot motions and muscular actions (Norkin and Levangie, 1992:388, Soderberg, 1997:413).

Stance Phase	**Ankle/ Foot Motion**	**Muscular Action**
Initial contact to Midstance	◦ Plantarflexion: 0°-15° Calcaneal valgus movement ◦ Neutral → Maximum subtalar pronation. ◦ Transverse tarsal pronation	◦ Tib Ant, EDL, EHL → Eccentric contractions ◦ Tib Post→ Eccentric contraction
Midstance	◦ Plantarflexion (15°) to Dorsiflexion (5°-10°) ◦ Subtalar joint move to supination, neutral at midstance	◦ Triceps surae, plantar flexors→Eccentric contraction ◦ Tib Post→ Concentric contraction
Midstance to Terminal stance	◦ Plantarflexion: 5°-0° Dorsiflexion ◦ Toes 0°-30° extension ◦ Supination subtalar joint	◦ Triceps surae→ Concentric contraction. ◦ FHL, FHB, AH, Interoseii, Lumbricals→ Eccentric ◦ Plantar flexors→ Concentric contraction
Preswing	◦ Ankle: Plantarflexion 0°-20°. ◦ Toes: Extension 50°-60° ◦ Subtalar: Maximum supination	◦ Triceps surae, Peroneii, FHL→ Concentric ◦ AH, FDB, FHB, Interoseii Lumbricals→ Concentric ◦ Plantar flexors→ Concentric

The calcaneus strikes the ground at initial contact and immediately moves into a valgus position allowing the subtalar joint to pronate (Norkin and Levangie, 1992:388). This functional pronation is essential for weight absorption and adaptation to the supporting surface. Pronation continues until the start of midstance (25% of stance phase), during this period tibialis posterior controls the movement towards pronation while the tibialis anterior controls the plantar flexion of the foot. In response to the functional pronation of the foot the tibia is forced to rotate medially (Norkin and Levangie, 1992:388, Soderberg, 1997:414).

By midstance the talus retreats back into its mortise and the foot moves from plantar flexion (15°) to dorsiflexion (20°) as the weight is transferred onto the weight-bearing limb (Soderberg, 1997:328-329, Abboud, 2002). Supination is initiated at the subtalar joint as midstance continues until the subtalar joint assumes its neutral position, at the end of midstance (Abboud, 2002). The triceps surae muscles control dorsiflexion while subtalar supination is brought about by concentric contraction of the tibialis posterior (Norkin and Levangie, 1992:388, Soderberg, 1997:313).

During terminal stance the weight is distributed throughout the front foot. The toes in response start to extend. The foot plantarflexes and the subtalar joint continue supinating whilst pulling the tibia into external rotation along with it. All the toe flexor muscles control the movement of the toes while tibialis posterior continues to supinate the foot and the peroneii muscles control its movements eccentrically (Norkin and Levangie, 1992:388, Soderberg, 1997:328-329).

Weight is further transferred onto the toes causing hyperextension at the metetarsophalageal joint (30°-50°) during preswing. The great toe or first digit is the last to bear weight and together with the heel allows the spring like action of the windlass mechanism (Refer to figure 4) (Soderberg, 1997:313). Supination continues throughout preswing reach a maximum while the foot actively is plantar flexed to produce forward propulsion (Soderberg, 1997:414)

The swing phase sees very little ankle motion with the ankle dorsiflexing 20° to return to neutral during the initial swing and midswing and remaining in that position until initial contact. The subtalar joint assumes a slight supinated position throughout the swing phase (Abboud, 2002).

Swing Phase	**Foot/ Ankle motion**	**Muscular action**
Initial and Midswing	○ Ankle: Dorsiflexion to neutral (20°) ○ Subtalar: Supination	○ Tib Ant, EDL, EHL→ Concentric Contraction
Terminal swing	○ Neutral	○ Tib Ant, EDL, EHL→ Isometric contraction.

Table 2: The Ankle/foot motion and related muscular action during the swing phase of the gait cycle (Abboud, 2002).

2.5 FLEXIBLE PES PLANUS AND PES CAVUS

Pes planus in the adolescent and adult result from the collapse of the medial longitudinal arches (Moore and Dally, 1999:642; Calliet, 1998). Continual stresses on the plantar ligaments specifically the calcaneonavicular ligament causes the ligaments to become abnormally stretched. The talus and navicular as a result slide medially and inferiority, becoming more prominent (Calleit, 1998). As a result the medial longitudinal arch is abnormally decreased and the forefoot deviates slightly laterally (Moore and Dalley, 1999:642). Although some muscular compensation have been thought to occur in asymptomatic patients with pes planus the extent and duration of this compensations is thought to be limited (Hunt and Smith, 2004).

Pes planus and the resultant hyperpronated position of the subtalar and transverse tarsal joints have been associated with a wide variety of conditions some of which include plantar fasciitis, metetarsal stress fractures and achilles tendinitis (Hunt et al., 2004).

Kwong et al. (1988) have shown that pronation creates an increase in the tensile stress at the plantar fascial insertion. Kibler et al. (1991) in his article proposed that tight posterior musculature and decreased range of motion may lead to valgus heel strike and push off causing a decreased mid- and hind foot supination and therefore a reduced push of and propulsive phase. This leads to increased load and stress placed on the musculature and ligamentous attachments and therefore poorer stress absorption and distribution resulting in functional hind foot pronation (Kibler et al., 1991). During continual running this places more tensile stress on the plantar fascia, which is at a disadvantage compared to the Achilles tendon (Kibler et al., 1991). He suggests that when coupled with other factors this biomechanical alteration may become pathological.

Ambrosias and Kondracki (1992) in their review of literature discussed the effect of abnormal joint mechanics on the foot and in particular the effect of prolonged pronation causing abnormal loading patterns throughout the foot. Other problems that commonly occur are functional limb length inequality, dorsiflexed first ray and hallux valgus due to excessive first ray supination (Norkin and Levangie 1992:388).

Pes planus may also lead to excessive medial rotation of the tibia on the talus, which in turn may cause multiple problems around the knee joint (Williams III, McClay, Hamill, 2001).

Less commonly but more ominous is the flexible pes cavus foot. Flexible pes cavus is a foot in which normal movements are decreased due to either tight soft tissue structures or hypomobile articulations leading to a rigid and pronounced medial longitudinal arch (Williams III, McClay and Hamill, 2001).

Like pes planus movement, or lack of movement, have compounding effects higher up the biomechanical chain specifically at the ankle and knee joints (Williams III, McClay, Hamill, 2001). The lack of subtalar and TCN joint motion prevents normal medial rotation of the tibia and therefore excessive stress is placed on the lateral knee structures. Furthermore the poor shock absorption and distribution in the foot places higher demands on the ankle joint, in particular, the lateral collateral ligaments of the ankle (Williams III, McClay and Hamill, 2001). The plantar aponeurosis remains slack and may in time become abnormally shortened (Norkin and Levangie, 1992:388)

2.6 LOW –DYE TAPING AND RELATED LITERATURE

Low- Dye taping, named after Dr. Ralph Dye, has been used for stabilizing the medial longitudinal arch and preventing it from collapse (Reid, 1992:198). Although different variations are now used in practice, one technique has been used frequently and is documented in literature to have a beneficial effect particularly in patients suffering with plantar fasciitis (Reid, 1992:198-199)

Low -Dye taping is a method commonly used in sport participation and normal daily activity (Harradine, Herrington and Wright, 2001). It is thought to function by restricting pronation as well as supports the medial longitudinal arch during mid-stance of the gait cycle and in so doing protects the plantar fascia by decreasing the stress along the plantar fascial plate (Tanner and Harvey, 1988, Brantingham et al., 1992 and Ryan, 1995). Taping has been indicated in support of the injured structure, decreasing oedema and protection against re-injury (Reid, 1992:232).

Hunt et al. (2004) evaluated the effectiveness of arch taping in controlling pain during ambulation, taping appeared effective in controlling pain and improving ambulation. Saxelby et al. (1997) reported benefits in plantar fascial symptoms over two days using low -dye taping. A study done by McCloskey (1992) assessed the effect upon foot function using mediolateral force readings from a kistler force plate. It was concluded that low -dye taping significantly altered the mediolateral force.

Contrary to these beliefs, studies have shown that low -dye anti-pronatory control is lost after relatively short episodes of exercise (Ator et al., 1991 and Vicenzino et al., 1997). Both studies found an initial reduction in pronation which was lost following the exercise. Harradine, Herrington and Wright (2001) assessed the effect of low -dye taping upon static pronatory control and dynamic hindfoot motion before and after walking. They found that taping initially reduced static pronation but that effects were lost after 30 minutes walking.

The variations in dynamic foot function with low -dye taping is not well understood, although taping of the foot in low-dye type method has been advocated by many authors (Brantingham et al., 1992, Ryan, 1995 and Chandler and Kibler, 1993).It's relevance in respect to ground reaction forces remains questionable and the efficacy of low dye taping is currently still under debate.

Most overuse injuries caused by excess pronation manifest during weight bearing activities such as standing, walking and running. The effectiveness of any taping technique in the treatment of these injuries depends upon its ability to prevent abnormal pronation for this period of time (Harradine, Herrington and Wright, 2001).

It is the purpose of this study to investigate the maximum ground reaction force and percentage contact time within 10 demarcated regions of the foot in asymptomatic patient with pes planus, cavus and normal medial longitudinal arches. Having established its baseline function it may serve as point of reference for clinical trials that wish to determine the role of taping as part of the management of symptomatic feet.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction:

In this chapter follows:

i. A detailed description of the study design,
ii. Discussions with regards to the intervention used,
iii. Discussion of methods used during the data collection,
iv. Description of the statistical analysis and testing.

A discussion of each sample group and their inclusion and exclusion criteria will also be given in this chapter.

3.2 Sampling Procedure:

This trial was designed as a quasi-experimental comparative trial, utilizing asymptomatic participants limited to those residing in the Kwazulu-Natal province.

A non-probability sampling technique was used to attract participants. There was no bias to race, religion or socio-economic standing:

1 Advertisements (Appendix F) were placed at the Durban Institute of Technology Chiropractic Day Clinic, Durban Institute of Technology Campus, local sports clubs, gyms, old age homes and local newspapers.
2 Advertising by word of mouth was also one of the methods used to attract participants to this study.

Interested participants were screened for suitability for this study by applying certain set questions; these questions could be employed telephonically or by direct contact with the prospective participant. These questions were structured in a manner that would insure a strong possibility of qualification for this specific trial. Details of these questions are listed in appendix G.

This trial consisted of 60 participants with asymptomatic feet that were divided into three groups of 20. Participants were divided into three groups depending on their respective foot structures. To qualify for one of the three groups subjects had to either have flexible low, high or normal medial longitudinal arches.

Group one consisted of participants with pes cavus (high medial longitudinal arch), group two consisted of participants with pes planus (low medial longitudinal arches) and group three consisted of participants with normal medial longitudinal arches.

Table 3: Representation of the three sub -divisions of the sample population.

Arch height	Population
Normal	20
High arch	20
Low arch	20
Total	**60**

Participants were classified into their respective groups using a line drawn from the plantar aspect of the first metetarsophalageal joint to the apex of the medial maleolus (Feiss Line) (Magee, 1997). The position of the navicular in relation to this line was used to determine their particular classification (Magee, 1997):

- ***Normal:*** The weight bearing navicular tuberosity remains along this line not dropping more than one third to the floor.
- ***Pes planus:*** The weight bearing navicular drops more than on third of the distance to the floor.
- ***Pes cavus:*** The weight bearing navicular should exhibit a position above this line or a normal navicular with a weight bearing leg heel alignment greater than 8 degrees in the varus position.

Measuring the extent of navicular drop is a common and satisfactory manner of determining severity pronation and hence pes planus (Vincenzino, 1997).

3.2.1 Inclusion and Exclusion Criteria:

Suitability for this study required that certain parameters be met. Participants were selected in such a manner as to apply maximum homogenicity. Once the interview indicated an eligible and willing participant for this study the participant was scheduled for a initial consultation with the researcher during which the researcher screened the individual for suitability for the study by applying a thorough history, physical and foot regional examination. No intervention or measurements were taken during the initial consultation. During this time the participant was also screened for relevant inclusion and exclusion criteria.

2.2.1.1 Exclusion criteria:

1. Participants suffering from systemic or local pathology for example gout or osteoarthritis were excluded from the study. Exclusions were based on findings obtained by taking a complete history as well as performing physical and regional examinations.

2. Any participant who was on any oral non-steroidal anti-inflammatory drug was required to participate in a 48 hour wash out period prior to entering the study (Poul et.al, 1993)

3. Participants were asked not to change their lifestyle, daily activities, and regular medication or exercise programs in any way to avoid being excluded from the study.

3.2.1.2 Inclusion criteria.

1. Participants were between the ages of 18-45 years. Participants under the age of 18 were not included in this study as they required parental consent, and would not have attained skeletal maturity. Selecting participants less than 45 eliminated those patients with degenerative joint diseases that could compromise the ability of the patient to adequately weight bear or render the foot as painful.

2. Participants that spent at least 3 but no more than 8 hours a day seated behind office desks. This prevented variations from occurring due to different participant occupations.

3. All participants received a letter (Appendix E) informing them about the study. They then had to complete and sign an informed consent form in agreement that they understood the implication of the research (Appendix D).

4. All participants presented with a normal foot according to the following edited guidelines of Michaud (1997):
    1 The foot must be pain free,
    2 The foot must exhibit normal muscle balance,
    3 The foot must have an absence of contractures,
    4 The foot must have straight and mobile toes,
    5 The foot must have three points of weight bearing

3.3 Intervention:

The research project and the procedures were clearly explained to the participant (Appendix E), participants were also asked to complete an informed consent form to indicate their willingness to take part in this study.

Participants were informed with regards to which group they belonged to and all three the group received the same intervention in the form of modified low -dye taping. This taping technique is widely accepted and well documented in literature and was done as described by Reid (1992).

3.3.1 Modified Low- Dye strapping of the foot:

This taping procedure, as can be seen on the picture of appendix K, consists of a forefoot anchor over the metetarsophalageal joint. Three strips of tape are then taken in a teardrop manner around the calcaneus. All three strips of plaster have their origin at the base of the first metatarsal. Each one is passed around the calcaneus from its medial aspect to its termination at the base of the fifth metatarsal (Appendix K) (Reid 1992:199, Ryan 1995 and Batt and Tanji, 1995).

All taping was done using 38mm Rigid Leuko Sports tape Premium; this tape has been widely endorsed by various sports teams and widely used for its supportive functions during activity (www.sharksmart.co.za).

3.4 Measurements:

3.4.1 Location of the data:

This study included primary and secondary data

3.4.2 The primary data:

3.4.2.1 Objective data:

Dynamic ground reaction forces of the foot prior to and after taping.
Percentage time spent per region of the foot prior to and after taping.

3.4.2.2 Subjective data:

None was recorded in this study as the participants where asymptomatic

3.4.3 The secondary data:

Secondary data was collected using Journal articles, Textbooks and the Internet.

3.4.4 Measurement methods:

Maximum ground reaction forces (GRF) and Percent contact time was obtained for each of the three groups and for each of their four visits. GRF were obtained with the aid of a registered orthotist who has agreed to work with the researcher on this project using the RSscan International 1m footscan plate system (Appendix L). The data was interpreted and analysed using the RSscan Clinical Version 7.08 software package.

All three groups underwent the same procedure. Participants were required to walk unassisted and with their natural stride across a one-meter force platform (RSscan International footscan) whilst data was collected for each of the regions of the left foot. An average of three readings was calculated for each time interval.

This procedure took place four times:

1. Once prior to taping
2. Once immediately after taping
3. One hour after taping
4. 24 hours after taping

The taping was required to stay on the participant's feet for 24 hours and participants were instructed on how to deal with the tape. These instructions included:

1. To maintain their daily routine and activities.
2. Not to perform any unusual or compensatory activities that does not form part of their daily routine.
3. Participants were encouraged to keep the foot dry during bathing and were instructed to dry the tape with a blow dryer in the event of it getting wet.
4. Participants were instructed not to tamper with the tape.

Maximum ground reaction forces and percentage time spent per region for each of the 10 areas were calculated.

The 10 areas of calculation included:

1. Medial Heel
2. Lateral heel
3. Mid- foot
4. First metetarsal
5. Second metetarsal
6. Third metetarsal
7. Fourth metetarsal
8. Fifith metetarsal
9. Hallux
10. Toes 2-5

3.5 Statistical Analysis

All data was analyzed using the SPSS statistical software package(SPSS Inc., Marketing Department, 444 North Michigan Avenue, Chicago, Illinois, 606611).

Univariate analysis of variance (one way ANOVA) was used to determine the interaction of variables within the set time periods. This method of analysis was also used to determine if any interaction existed between groups and variables in those groups. The Post- Hoc test was used to determine the location of significant values within each subset. The T-test was done to determine the effect of taping on different means at different time intervals..
Frequency distribution was calculated for all the data and the Chi-Squared test was used in the comparison of data together with the Kriskal Walis test that was used in the comparison of the demographic data.
Repeated measures of variance were also tested within each group against time although they showed no statistical significance. Correlation statistics were run using a significance level of $p <= 0.05$.

CHAPTER FOUR

RESULTS AND DISCUSSION:

4.1 Introduction:

This chapter contains detailed information related to the statistical methods used in the analysis of data and the relevant significant findings of that analysis.
The information will be presented as follows:

i. Discussion of statistical method,
ii. Description of demographic data,
iii. Analysis of percentage contact time and
iv. Analysis of maximum force

The discussion of the results will be carried out throughout this chapter for the comfort of the reader.

4.2 Discussion of statistical method:

All data was analyzed using the SPSS statistical software package (SPSS Inc., Marketing Department, 444 North Michigan Avenue, Chicago, Illinois, 606611).

Univariate analysis of variance (one way ANOVA) was used to determine the interaction of variables within the set time periods. This method of analysis was also used to determine if any interaction existed between groups and variables in those groups. The Post- Hoc test was used to determine the location of significant values within each subset. The T-test was done to determine the effect of taping on different means at different time intervals.
Frequency distribution was calculated for all the data and the Chi-Squared test was used in the comparison of data together with the Kruskal Wallis which was used in the comparison of some of the demographic data.

Repeated measures of variance were also tested within each group against time although they showed no statistical significance. Correlation statistics were run using a significance level of $p <= 0.05$.

Multiple comparisons were conducted of which none showed a significantly altered pattern between the three groups (neutral, pes planus and pes cavus). The results shown below only consist of the significant information gathered during the statistical process. For your convenience the remainders of the statistical test results are shown in appendix m.

4.2.1 Data layout and notation

Foot measurements (percentage contact time and maximum force) were obtained from each of 60 people:

- 20 with normal foot arches (n),
- 20 with low foot arches (l) and
- 20 with high foot arches (h)

These measurements were taken at each of 10 regions on the foot:

- The big toe (t1),
- The four smaller toes (t2),
- Metatarsal 1 to metatarsal 5 (m1 to m5),
- mid foot (mf), medial heel (mh) and
- Lateral heel (lh).

In order to determine the effectiveness of taping on a person's foot, these measurements were taken at 4 different times:

- Initially without taping (time 0),
- Immediately after taping (time 1),
- One hour after taping (time 2) and
- 24 hours after taping (time 3).

Contact time measurements at these 4 times will be denoted by:

- ct0 - Contact time prior to taping
- ct1 - Contact time immediately after taping
- ct2 - Contact time after 1 hour of taping
- ct3 - Contact time after 24 hours of taping

Maximum force measurements are denoted by:

- mf0 - Maximum force prior to taping
- mf1 - Maximum force immediately after taping
- mf2 - Maximum force one hour after taping
- mf3 - Maximum force after 24 hours of taping

The analysis also involves a summary of some basic demographic information.

4.3 Demographic Data:

Age:

Figure 9: Age frequency distributions for arch groups

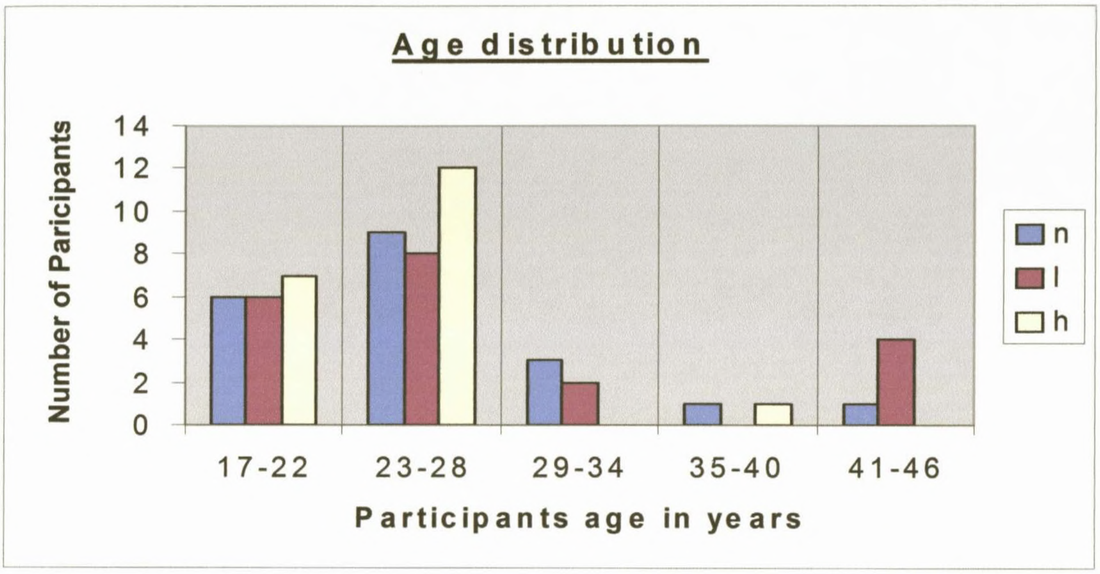
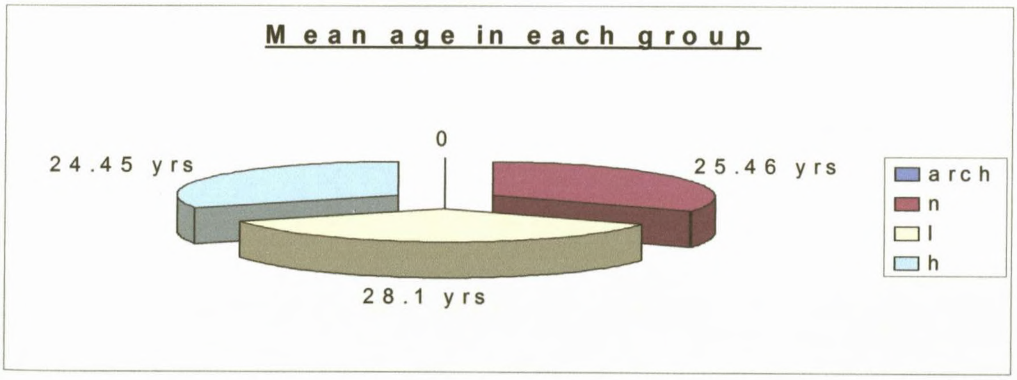


Figure 10: Means of ages for arch groups



The age of participants varied from 18 to 46 years of age as can be seen from Figure 9. Although a greater proportion of the participants seemed to occur in the subset of ages 23- 28 years, the mean age for all the groups were not significantly different (The Kruskal-Wallis test shows chi-square = 1.696 with a p-value of 0.428.). The three arch types seem to occur evenly throughout all age groups.

4.3.1 Heights:

Figure 11: Height frequency distributions for arch groups

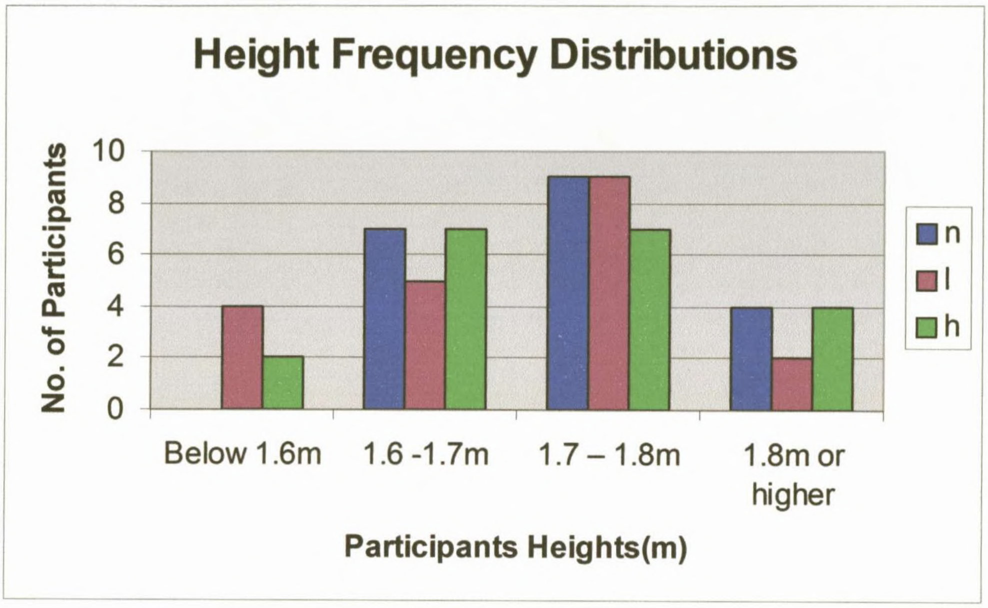


Table 4: Height frequency distributions for arch groups

Arch	Below 1.6m	1.6 - 1.7m	1.7 - 1.8m	1.8m or higher
	Height grouping			
N	0	7	9	4
L	4	5	9	2
H	2	7	7	4

Participants heights for the three arch groups were analyzed using the F -test that showed F = 0.571 with a p-value of 0.568. This meant that no group had a significant advantage in terms of height. The largest percentage of participants seemed to be between the height of 1,7-1,8m. The means of heights for each group is shown in table 5.

Table 5: Means and standard deviations of heights for arch groups

Arch	Mean	Standard deviation
N	1.7195m	0.0807
L	1.6885m	0.1091
H	1.712m	0.0951

4.3.2 Weight

Figure 12: Weight frequency distributions for arch groups

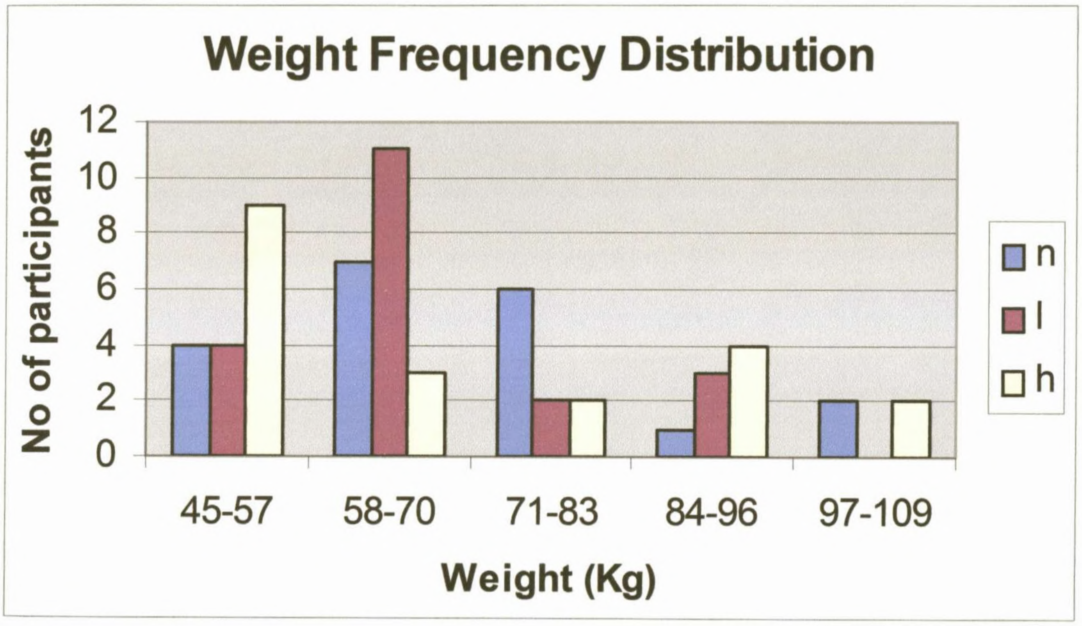


Table 6: Weight frequency distributions for arch groups

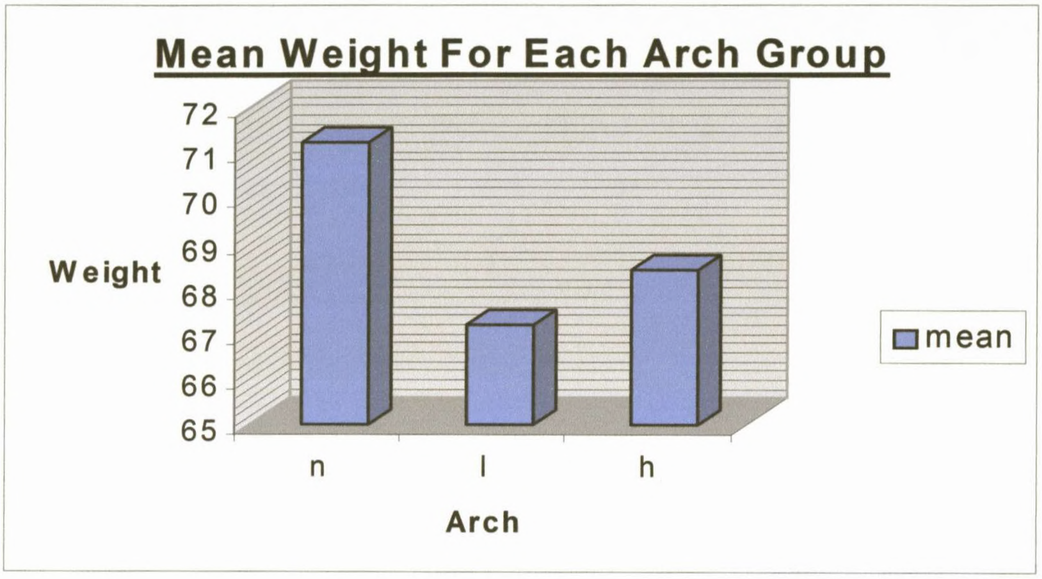
Weight group

Arch	45-57kg	58-70kg	71-83kg	84-96kg	97-109kg
N	4	7	6	1	2
L	4	11	2	3	0
H	9	3	2	4	2

Table 7: Means of weights for arch groups

Arch	Mean
N	71.2kg
L	67.175kg
H	68.4kg

Figure 12: Means of weight or arch groups



Frequency distributions for weight indicated that the neutral arches more frequently occurred between the weights of 58-70kg, the pes planus arches occurred more frequently between the weights of 58-70kg and that high arches were more common among individuals of weight 45-57kg. The weight means for the three arch groups were not significantly different and the Kruskal-Wallis test shows chi-square = 0.833 with a p-value of 0.659. (Refer to table 7 and figure 12)

4.3.3 Occupation:

Figure 13: Cross classification according to arch group and occupation

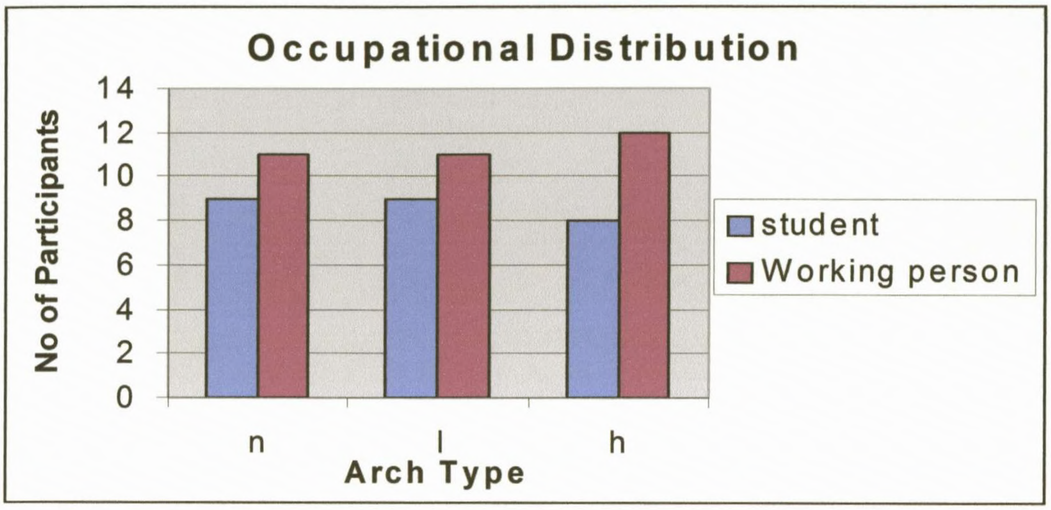


Table 8: Cross classification according to arch group and occupation

Arch	Student	Working person
N	9	11
L	9	11
H	8	12

A cross classification of occupations of participants showed an even spread throughout the three groups. The occupation patterns are the same for the 3 groups (chi-square = 0.136 with p-value = 0.934). This indicated that variances between readings due to occupational habits were limited during the course of the study (Refer to figure 13).

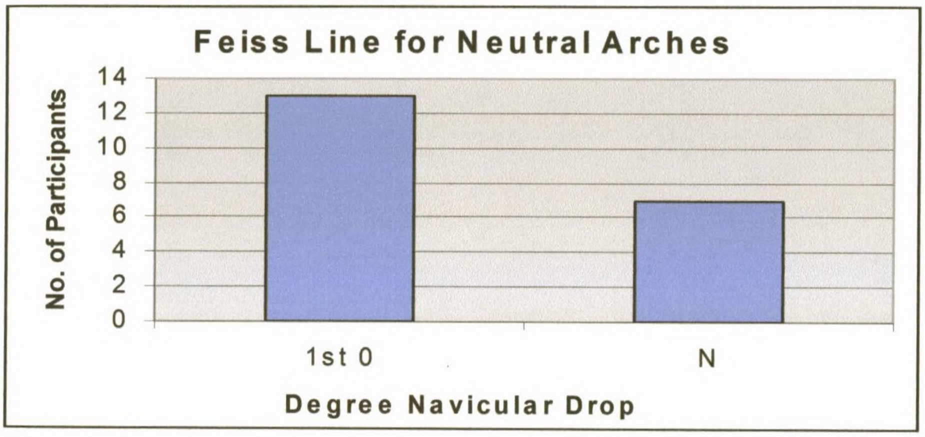
4.3.4 Feiss line:

4.3.4.1 Normal Arches

Table 9: Feiss line classification for normal arches

Feiss line	Number
1st ^{0}	13
N	7

Figure 14: Feiss line classification for normal arches



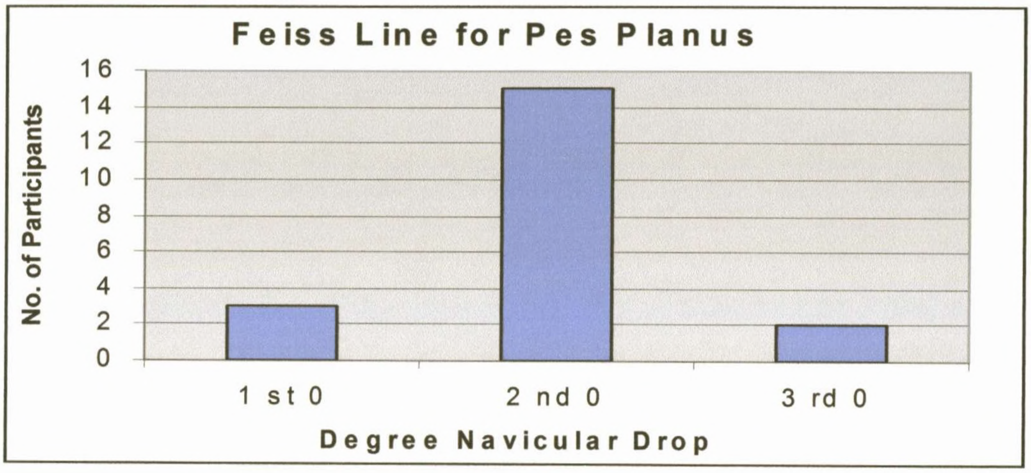
Feiss line readings in participants with normal arches showed that 13 (65%) participants presented with 1st degree navicular drop and 7 (35%) presented without any deviation of the navicular during weight bearing. The majority of pes planus participants presented with 2nd degree navicular drop with only 2 participants presenting with complete collapse of the navicular to the ground (Refer to table 10).

4.3.4.2 Low Arches

Table 10: Feiss line classification for low arches

Feiss line	Number
1 st ^{0}	3
2 nd ^{0}	15
3 rd ^{0}	2

Figure 15: Feiss line classification for low arches



4.3.4.2 High Arches

For high arches the Feiss line classification is N in all the cases.

4.3.5 Heel leg:

Table 11: Heel leg alignment degrees valgus

valgus ⁰	2	4	5	6	8	9	10	12	13
number n	2	1	4	5	3	0	0	0	0
number l	0	2	2	1	1	2	8	2	2

Figure 16: Participants demonstrating a valgus heel leg alignment.

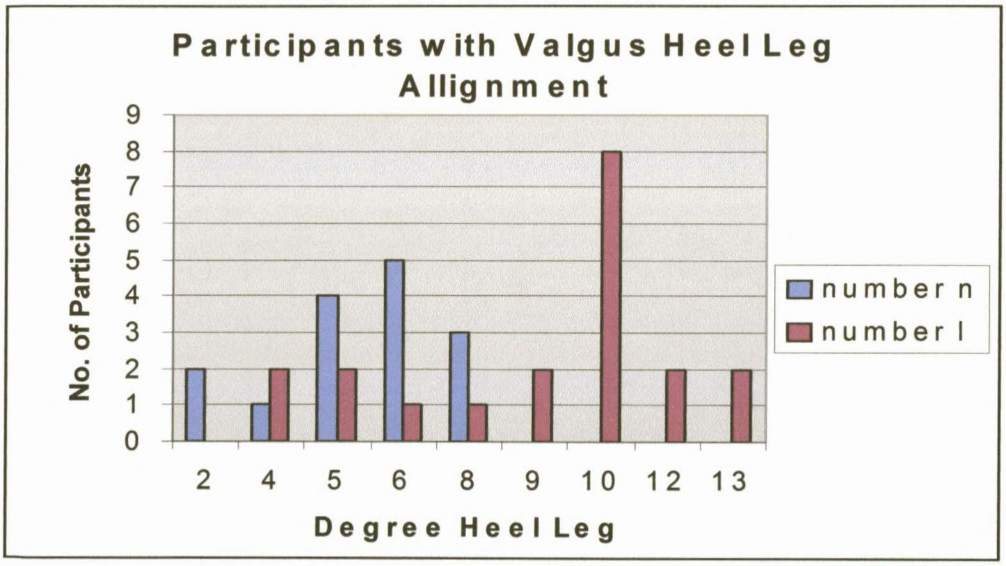
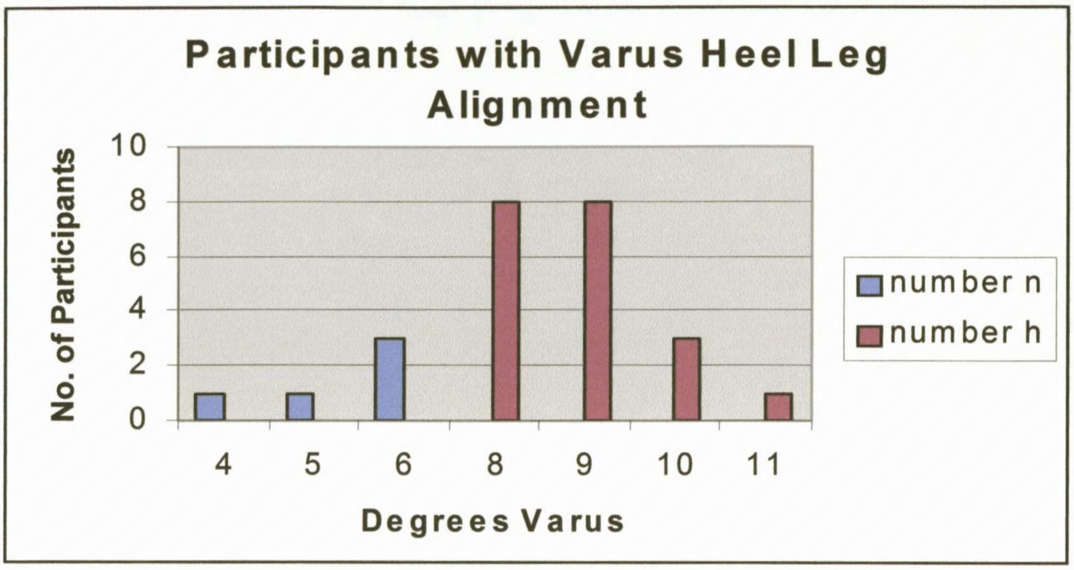


Table 12: Heel leg alignment degree varus

varus ⁰	4	5	6	8	9	10	11
number n	1	1	3	0	0	0	0
number h	0	0	0	8	8	3	1

Figure 17: Participants demonstrating a varus heel leg alignment.



Subjects with normal arches have heel legs ranging from 8 degree valgus to 6 degree varus. Those with low arches had heel legs ranging from 4 to 13 degrees valgus and those with high arches from 8 to 11 degrees varus. The majority of participants with neutral arches (25%) presented with 6 degrees heel leg valgus while the majority pes planus participants (50%) presented with 10 degrees heel leg valgus. The majority of pes cavus participants (40%) evenly presented between 8 and 9 degrees varus (Refer to figure 16 and 17).

4.4 Analysis of Percentage Contact Time

4.4.1 Values of means across time

Percentage contact time denotes that percentage of stance phase for which a specific region (of the 10 regions) is in contact with the ground.

The percentage contact time means for the different types of arches and different regions as well as their ranks are shown in the tables below.

Table 13: Percentage contact time means for arches at different times

	Time			
Arch	0	1	2	3
H	60.3983 (1)	60.0900 (1)	62.2183 (1)	59.3650 (1)
L	58.2817 (2)	59.8950 (2)	59.9517 (2)	57.9850 (2)
N	55.5967 (3)	56.3700 (3)	55.3333 (3)	56.8550 (3)

The figure shown in brackets is the rank. Rank 1 indicates the largest mean, rank 2 the second largest mean and so on.

4.4.2 Patterns for different arches

The mean for high arches is consistently the highest (over the 4 time periods), for low arches consistently second highest and for normal arches consistently the lowest. When comparing means for the individual time periods, the following differences were found to be significant.

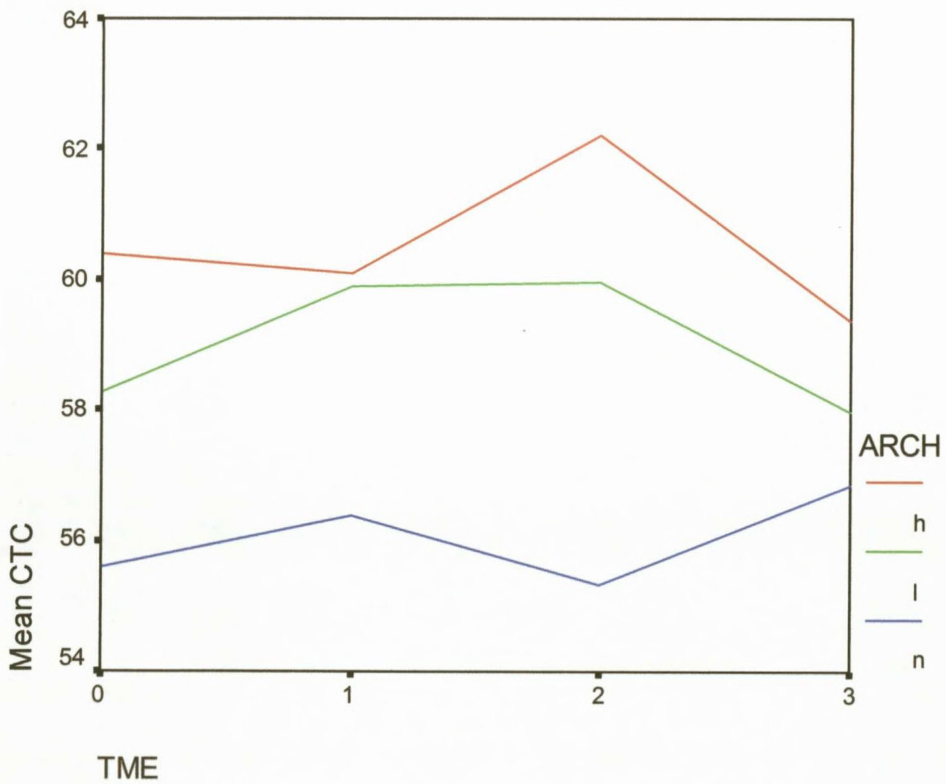
From the Figure 18 it can be seen that the difference between the contact time means for high and low arches is much smaller for time 1 (just after taping) than for the other 3 times (a difference of 0.195 for time 1 versus differences of 2.1166, 2.2666 and 1.38 for times 0, 2 and 3 respectively).

Table 14: Significant differences between means for individual time periods

Time	Significant differences
0	n < h
1	n < l , n < h
2	N < l , n < h
3	None

A plot of the means (mean ct) versus time (time) for the 3 arches is shown in figure 1 on the next page.

Figure 18: Plots of contact time means for arches at different times



TME refers to time.

Table 13 and figure 15 display certain definite trends.

When looking at Group h (pes cavus) we notice a high contact time as compared to the other two groups (60.3983%). It's possible that the high contact time is due to this type of foot structure being more rigid in nature than low arched foot structures (Norkin and Levangie, 1992:415). Due to this the ability of the foot to accommodate to the surface is decreased (Norkin and Levangie, 1992:415). It is possible that a larger amount of time is spent on the 10 regions because of a decrease in gradual weight transfer. At time period one we see very little change to this percent contact (60.0900%) but at time period 2 we observe a significant increase in contact time (62.2183%). It is possible that the taping technique lends itself to further rigidity at time period 2. A possible reason for this delay is that the natural rigidity of the foot resists the effect of the taping on the respective regions at time period 1 (Norkin and Levangie, 1992:415). At time period 3 (24hours) we note a decrease in contact time (59.3650%), this may be due to the inability of the tape to alter foot structure for long periods of time as documented by Vicenzino et al. (1997)and Harradine, Herrington and Wright, (2001.).

Looking at group l (pes planus) we observe a lower percent contact time within the ten regions (58.2817%).The reason for the contact time being greater than those exhibited by group n (Normal arches) is the effect the lowered arch of the midfoot will have on the contact surface. Due to the increased contact surface we have a larger percent contact time as compared to the normal aches. At time period 2 we have a similar effect as observed with group h. This could be due to either the mechanical rigidity of the tape limiting the normal gait and therefore increasing the relative contact times or due to the nature of the taping technique as the tape might come into contact with the ground. This effect is maintained through period 2. At period 3 we observe the highest percent contact time (57.9850%), this may be due to an alternate compensatory gait employed to deal with the weakening tape.

Group n (neutral arches) has the lowest percent contact time of all the time periods (55.5967) indicating a natural roll of the foot during the gait cycle. At time period 1 a similar increase in percent contact time occurs as with group I (56.3700%) this may be due to the mechanical effect of the tape on the arch of the foot. At time period 2 however this contact time is significantly decreased (55.3333%), this might indicate adaptation of a compensatory gait due to the tape. At time period 3 the contact time is once more increased (56.8550%), this might indicate a desire of the foot to return to its normal function due to failure of the tape (Vicenzino et al., 1997, Harradine, Herrington and Wright, 2001) but not completely achieving that aim and in the process adopting an altered gait pattern.

4.4.3 Patterns for different regions

Table 15: Percentage contact time means for regions at different times

	Time			
Region	0	1	2	3
m3	68.5000 (1)	65.3944 (3)	67.3000 (3)	68.2222 (2)
m4	68.3000 (2)	72.4556 (1)	73.4556 (1)	71.9889 (1)
m2	66.1333 (3)	61.2222 (4)	62.8444 (4)	63.1944 (4)
m5	61.3278 (4)	68.9000 (2)	69.6556 (2)	64.8944 (3)
m1	55.8444 (5)	59.0944 (5)	61.1500 (5)	59.4833 (5)
Mf	55.5444 (6)	56.5556 (7)	57.9111 (6)	57.5944 (6)
Hm	54.6556 (7)	57.5611 (6)	54.4611 (7)	53.3611 (7)
Hl	53.2111 (8)	56.4778 (8)	53.0500 (8)	51.5444 (8)
t2	48.7889 (9)	37.3333 (10)	43.3389(10)	42.8889(10)
t1	48.6167(10)	52.8556 (9)	48.5111 (9)	47.5111 (9)

The figure shown in brackets is the rank.

The following are clear from tables 15 and 16. The means for the 5 front foot regions (m1 to m5) are consistently the highest over the 4 time periods. The next highest is the mean for mid foot (mf) which is higher than that for both the heel regions (hl and hm) for times 0, 2 and 3. Only for time 1 is this mean slightly smaller than the mean for the medial heel (hm) region. The means for the two toe regions (t1 and t2) are consistently the lowest over the 4 time periods.

Table 16: Differences between percentage contact time means for successive time periods for each of the regions

	Difference			
Region	Ct1-ct0	ct2-ct1	ct3-ct2	Ct3-ct0
hl	3.2667	-3.4278	-1.5056	-1.6667
Hm	2.9055	-3.1	-1.1	-1.2945
m1	3.2500	2.0556	-1.6667	3.6389
m2	-4.9111	1.6222	0.35	-2.9389
m3	-3.1056	1.9056	0.9222	-0.2778
m4	4.1556	1	-1.4667	3.6889
m5	7.5722	0.7556	-4.7612	3.5666
Mf	1.0112	1.3555	-0.3167	2.05
t1	4.2389	-4.3445	-1	-1.1056
t2	-11.4556	6.0056	-0.45	-5.9

Shifts in contact percentage means over time:

Between times 0 (before taping) and 1 (just after taping) there is a shift in contact from the center of the front foot region towards the two sides. From table 15 it can be seen that the means for regions m2 and m3 (center of foot) decrease and those for regions m1, m4 and m5 (sides of foot) increase. This increase is larger on the outside of the foot (regions m4 and m5) than on the inside (region m1). There are indications that this trend is reversed as more and more time after taping elapses (means for m2 and m3 increase after time 1 and those for m1, m4 and m5 eventually decrease).

The two heel regions (hl and hm) show significant increases in the mean from time 0 to time 1 (for hl t = 4.193 with a p-value of 0.00004681, for hm t = 3.51 with a p-value of 0.000432597), but revert back to the pre-taping means after that i.e. they show decreases after time period 1.

Except for time period 0 (where the t1 and t2 means are approximately the same), the means for time period 1 (the big toe) are consistently higher than the corresponding ones for time period 2 (the 4 smaller toes). The big toe (region t1) shows a significant increase in contact from time period 0 to time period 1, while the 4 smaller toes (region t2) show a huge decrease over this period. The reason for this seems to be the shift in contact (after taping) towards the sides. The increase in contact for the big toe (which is on the inside of the foot) together with the increase in contact for region m1 (also on the inside of the foot) balances out with the increase in contact for m5 on the outside of foot) i.e. increase in m1+increase in t1 = 3.25 + 4.2389 = 7.4889 balances with increase in m5 = 7.5722. The increase in regions m4 and m5 from time period 0 to time period 1 results in a corresponding decrease in region t2. After time period 1 the mean for t1 returns to its value at time period 0 (before taping). During this period the mean for t2 also starts returning to its value at time period 0 but at a slower pace.

We can therefore extrapolate that the following relationships may exist with respect to percentage contact time in certain regions:

Metatarsal 2 and 3 appear to function as a unit. A high percent contact time exist before taping. At time period 1 there seems to be a drastic decrease in contact time that continues through to period 2. At time period 3 the percentage contact time appears to be approaching the initial reading. This trend may be due to the taping technique elevating metatarsal 2 and 3. This trend is supported by Saxelby, Betts and Bygrave (1997) who suggests that the elevated metatarsals could either be due to induced supination of the foot by the taping technique or due to the horizontal anchoring straps preventing the usual metatarsal spread on the floor during weight bearing. The increase in contact time at time period 3 may indicate eventual failure of the tape to maintain them in an elevated position.

Metatarsal 1, 4 and 5 also appear to follow a similar pattern. A rapid increase in contact time that is maintained through to time interval 2 is observed. This indicates a peripheral shift in contact of the foot with the ground. At time period 4 this effect is depleting and appears to be returning to a pre –taped condition. This may be explained in two ways:

a. The taping technique causes an alteration in the gait pattern of the foot by plantar flexing metatarsal 1 and fixing metatarsal 4 and 5 which are inherently more mobile. This causes greater contact with the peripheral aspects of the foot specifically the lateral aspects suggesting a shift towards a supinated foot position after taping (Saxelby, Betts and Bygrave, 1997). This effect of the tape can be seen to decrease at time interval 3 possibly due to failure of the tape (Vicenzino et al., 1997, Harradine, Herrington and Wright, 2001).

b. Due to the taping technique being primarily over these two regions it may be possible that the tape thickness itself had an influence in the contact time of the foot. This explanation however fails to clarify the clear trend towards the pre -taped condition seen at time interval 3.

The midfoot appears to be increasing the percent contact time throughout the 4 time periods. This could be due to the tape causing a less distinctive heel strike with a shift towards the lateral front and mid foot regions. This is supported by the findings at the medial and lateral heel regions which indicate an initial rise in contact followed by a gradual decrease which may indicate a shift of contact towards the mid and frontfoot. This effect seems to increase with time as the heel contact decrease.

The participants seem to have a rigid foot in response to the initial tape, after which we start to seeing a clear shift away from a large heel strike and a shift towards the peripheral aspects of the foot seen under metatarsals 1, 4 and 5.

4.4.4 Interaction:

There is no interaction between arches (n, l and h) and their regions for time periods 0, 1 and 3. The pattern appeared the same for all arch types. For time 2 there appears to be some interaction between these variables. The nature of this interaction can be seen from the means in the table below.

Table 17: Contact percentage means for different regions and arches at time 2

	Arch			
Region	Normal	Low	High	Overall
m4	69.9500 (1)	72.8667 (1)	77.5500 (1)	73.4556 (1)
m5	69.3167 (2)	67.9333 (2)	71.7167 (4)	69.6556 (2)
m3	62.8333 (3)	66.2000 (3)	72.8667 (2)	67.3000 (3)
m2	58.3500 (4)	63.1500 (5)	67.0333 (5)	62.8444 (4)
m1	55.4000 (5)	63.9500 (4)	64.1000 (6)	61.1500 (5)
Hm	52.8833 (6)	57.1670 (6)	52.7833 (7)	54.4611 (7)
Hl	51.9333 (7)	56.0667 (7)	51.1500 (8)	53.0500 (8)
Mf	47.4167 (8)	54.0333 (8)	72.2833 (3)	57.9111 (6)
t1	44.2500 (9)	50.4000 (9)	50.8833 (9)	48.5111 (9)
t2	41.0000(10)	47.2000 (10)	41.8167 (10)	43.3389 (10)

The figure shown in brackets is the rank.

From table 17 it can be seen that:

I. With the exception of region m5 (where the means are approximately equal) the region means for normal arches are all less than the corresponding ones for low arches (as is the case overall).

II. The ranks for normal and low arches follow the same pattern as the overall ranks except for mf where the rank is lower than overall (mean smaller) and hm and hl where the rank is higher than overall (means greater).

III. Region mf has a below average mean for normal and low arches, but an exceptionally large mean (14.3722 above overall mean) for high arches. This may indicate a substantial increase in mid foot contact as the participant alters his heel strike (refer to figure 13) and gait pattern to accommodate to the tape.

The findings above suggest that after 1 hour of taping the mid foot region has a higher than average percentage contact in participants with high arches and the heel regions have a higher than average contact for participants with normal and low arches.

4.5 Analysis of Maximum Force

4.5.1 Values of means across time

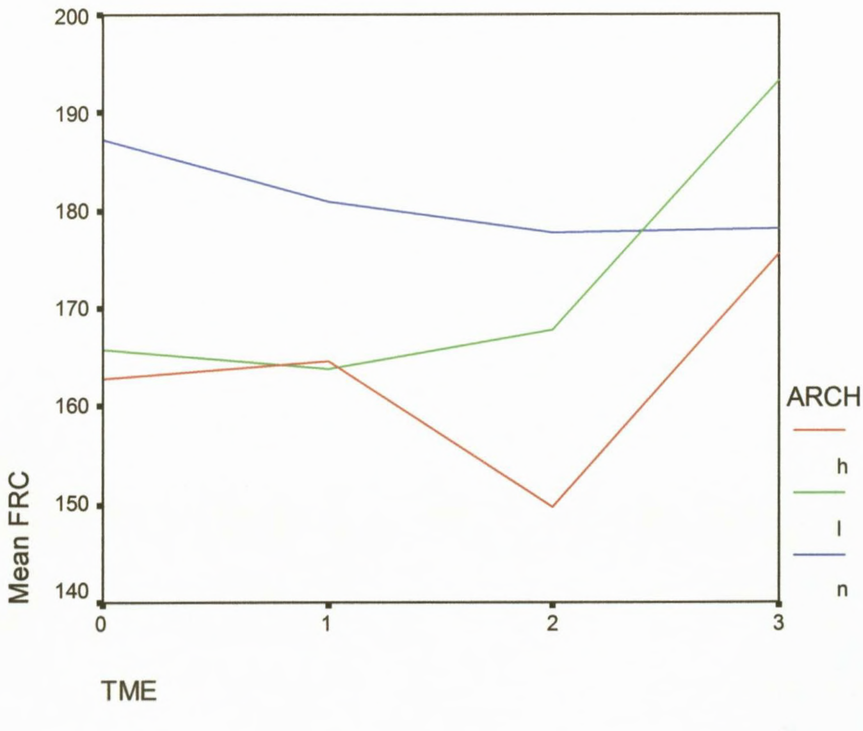
The maximum force means for the different types of arches and different regions as well as their ranks are shown in the tables below

Table 18: Maximum force means for arches at different times

	Time			
Arch	0	1	2	3
N	187.3087 (1)	180.9127 (1)	177.7825 (1)	178.1688 (3)
L	165.8480 (2)	163.8600 (3)	167.7305 (2)	193.2077 (1)
H	162.8572 (3)	164.5632 (2)	149.6850 (3)	175.6123 (2)

The figure shown in brackets is the rank.

Figure 19: Plots of maximum force means for arches at different time



4.5.2 Patterns for different arches

From the above plot the following can be seen:

I. The maximum force mean for normal arches shows a slight downward trend over time.

II. The maximum force mean for low and high arches show an upward trend over the 24 hour period. The rate of increase in maximum force appears to be slightly greater for low arches than for high arches.

III. Initially (before taping, just after taping and 1 hour after taping) the maximum force mean for normal arches is higher than those for high and low arches. As time goes by the means for low and high arches catch up with that for normal arches. At time 3 (24 hours after taping) the mean for low arches is higher than that for normal arches and the mean for high arch just about the same as that for normal arches.

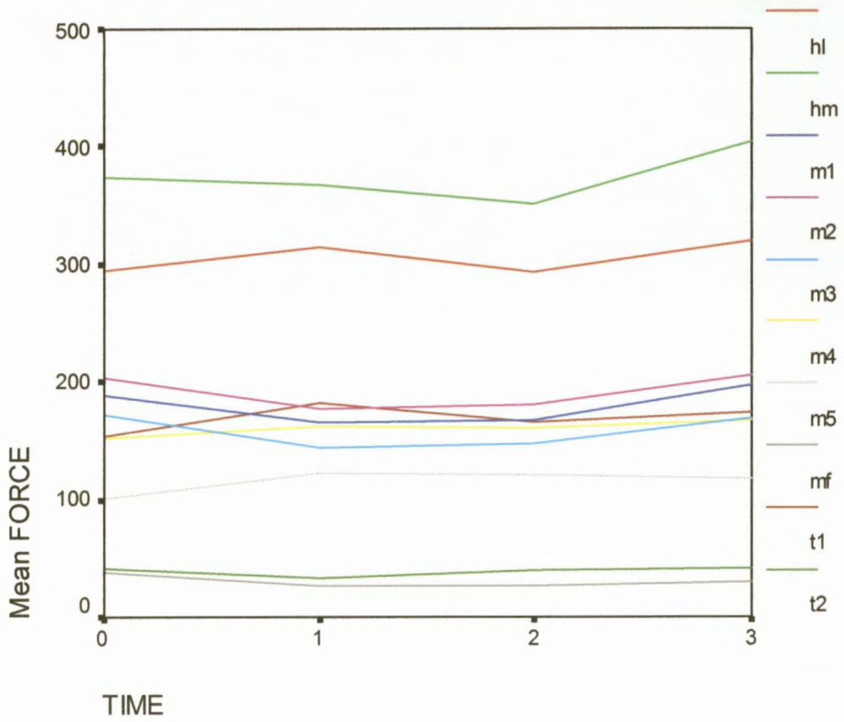
4.5.3 Patterns for different regions

Table 19: Maximum force means for regions at different times

Region	0	1	2	3
hm	374.1250 (1)	368.3156 (1)	350.6544 (1)	403.6644 (1)
Hl	294.1306 (2)	315.3944 (2)	292.3017 (2)	318.7900 (2)
m2	204.3561 (3)	177.3244 (4)	179.7622 (3)	204.6156 (3)
m1	188.6594 (4)	164.9811 (5)	166.7106 (4)	197.6883 (4)
m3	172.2472 (5)	144.7467 (7)	146.8817 (7)	169.0789 (6)
t1	154.1472 (6)	181.8706 (3)	165.0039 (5)	173.9161 (5)
m4	152.3017 (7)	162.8378 (6)	160.4006 (6)	166.6294 (7)
m5	100.3089 (8)	123.2389 (8)	121.4817 (8)	118.1089 (8)
t2	40.9061 (9)	32.4167 (9)	40.3211 (9)	41.3678 (9)
Mf	38.8639 (10)	26.6600 (10)	27.1422 (10)	29.4367 (10)

The figure shown in brackets is the rank.

Figure 20: Plots of maximum force means for regions at different times



Throughout the 4 time periods the largest maximum force is in the heel region (hm and hl) and the smallest are the mid foot, small toes and outside front foot regions (mf, t2 and m5).

Both heel regions and the outside foot region (m5) show a slightly upward trend over time. The mean maximum force for the small toes region stays the same over time, while that for the mid foot region decreases over time.

Of the remaining 5 regions that occupy ranks 3 to 7 regions t1 and m4 show slight increases over time, while regions m1, m2 and m3 stay the same over time.

4.5.3.1 Differences:

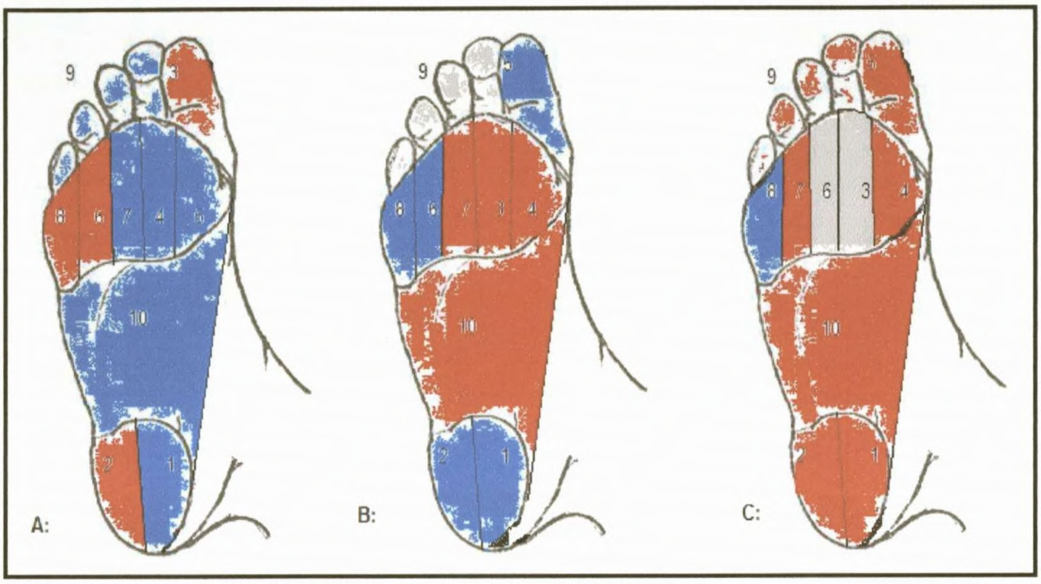
Table 20: Differences between maximum force means for successive time periods for each of the regions

Region	Ct1-ct0	Ct2-ct1	ct3-ct2	ct3-ct0
Hl	21.2638	-23.0932	26.4883	24.6589
Hm	-5.8094	-17.6612	53.01	29.5394
m1	-23.6783	1.7295	30.9777	9.0289
m2	-27.0317	2.4378	24.8534	0.2595
m3	-27.5005	2.135	22.1972	-3.1683
m4	10.5361	-2.4372	6.2288	14.3277
m5	22.93	-1.7572	-3.3728	17.8
Mf	-12.2039	0.4822	2.2945	-9.4272
t1	27.7254	-16.8667	8.9122	19.7709
t2	-8.4894	7.9044	1.0467	0.4617

Prior to taping the maximum ground reaction forces appear to be over the two heel regions and metatarsals 1 and 2. The toe 1 region has a high maximum force (154.3017) compared to toe 2-5 (40,9061). These values suggest a distribution of force throughout the foot to be similar as those documented in the literature (Norkin and Levangie, 1992:466).

Period 1 shows a drastic change in force along the lateral aspect of the foot. The lateral heel, metatarsal 4, 5 and toe one all increase their maximum force immediately after taping. This is counterbalanced by decreased values throughout the front foot and midfoot regions. The areas of metatarsal 2 and 3 are especially decreased in the front foot indicating that the taping technique may cause an elevation in the transverse arch of the foot which is n agreement with the findings of percent contact time. Toe one has a high increase in maximum force indicating that the tape might force a larger degree of toe off in the final stages of the gait cycle. These findings are in agreement Hunt, et al. (2004) who states that low dye method may increase the windlass mechanism at toe off

Figure 21: A: Indicates changes between period 0 and 1. B: indicates changes beween period 1 and 2. B: indicates changes between period 2 and 3.
Blue → Decrease in maximum force. Red→ increase in maximum force.
Gray→ Minimal change. Number indicates their rankings in maximum force.



Period 2 (1hour) shows a slightly different pattern. Maximum force at the lateral and medial heel areas decrease drastically. This may indicate a shift of force toward the front foot and midfoot areas as compared to previous trend. This is substantiated by a increase of maximum midfoot force (0.4822) and a increase in force of metatarsal 1, 2 and 3. The decrease in maximum force of metatarsal 4 and 5 may either be due to toe 2-5 bearing a greater amount of force or due to metatarsal 1-3 increasing their weight bearing capacity but this is not greatly significant.

Period 3 (24hours) shows an incomplete attempt to return to the normal force transfer across the foot. There is a substantial return of maximum force at heel strike indicating a return of emphasis to hindfoot contact. Midfoot maximum force is further increased together with maximum forces across metatarsals 1, 2, 3 and

4. Metatarsal 1 and 2 bear the greatest maximum force of all the metatarsal and have an increase of 30.997 and 24.8534 respectively indicating a shift towards the pre -taped foot measurements and the medial aspect of the front foot. This can further be seen be the gain in maximum force of the first toe at toe off.

Failure of the tape to maintain the foot in its original position is a plausible explanation for the regression of maximum forces towards the pre –taped foot measurements and is substantiated by the literature (Vicenzino et al., 1997, Harradine, Herrington and Wright, 2001). Ator et al. (1991) suggests that this failure of the maintain the foot for long periods of time could be due to a loss of tensile strength of the tape or due to decreased adhesion to the skin.

4.6 Relationship Between Percentage Contact Time and Maximum Force

There appears to be a moderate linear relationship between the difference between the time 1and time 0 values for percentage contact time and maximum force for some of the regions. The correlations between the differences for the 2 variables for the different regions are given in the table below.

Table 13: Correlations between percentage contact time and maximum force differences for the different regions

Region	m1	m2	m3	m4	m5	hl	hm	t1	t2	mf
Correlation	0.481	0.601	0.611	0.522	0.332	0.136	0.149	0.603	0.17	-0.02

The moderately high positive correlations are in the front foot regions m1 to m4 and big toe region. The correlations imply that in these regions the differences move together i.e. as the one difference increases (decreases), so does the other one.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions:

1. This research has shown that with the exception of period 2, where pes cavus presented with a significantly higher contact time in the midfoot, there is no clear distinction between maximum force and percent contact time within the three groups namely pes cavus, pes planus and normal arches.

2. The distribution of maximum force in the three groups were similar throughout al the time periods(immediately after taping, one hour after taping and 24 hours after taping):

   I. Prior to taping the maximum ground reaction forces appear to be over the two heel regions and metatarsals 1 and 2. The toe 1 region has a high maximum force compared to toe 2-5. These values suggest a distribution of force throughout the foot to be similar as those documented in the literature (Norkin and Levangie, 1992:466).

   II. Immediately after taping there seemed to be a shift of maximum force away from the hindfoot and towards the lateral aspect of the frontfoot (metatarsal 4 and 5) with a decrease of maximum force over metatarsal 2 and 3 and a decrease of maximum force at metatarsal 1. This could be due to the transverse anchoring and securing straps elevating the metatarsals. This is supported by Saxelby, Betts and Bygrave, (1997) who suggests that these findings could be an indication of decreased pronation of the foot.

   III. A the trend towards front foot maximum force is seen again at 1 hour after taping with a decrease in heel maximum force, a greater maximum force at the midfoot and at the metatarsals 1, 2 and 3. This may indicate a loss of tensile strength or adhesive properties of the tape (Vicenzino et al, 1997; and Harradine, Herrington and Wright, 2001).

IV. The changes seen at the 24 hours reading suggests an incomplete return to the maximum forces seen prior to the initial taping (as evident at the increase in force of the heel strike as well as the mid foot increasing in maximum force but still remaining far from its high force value and the maximum force at metatarsal 3 remaining unchanged). This indicates some restriction from the taping in this region. Metatarsal 1 and 4 compensates for this deficiency by having increased maximum force values.

3. The distribution of percent contact time in the three groups were similar throughout al the time periods(immediately after taping, one hour after taping and 24 hours after taping):

I. Percent contact time increase in metatarsal 4, 5, and metatarsal one indicating a shift of contact from the center of the foot to the peripheral structures. The increased contact of the heel regions support Hunt et al (2004) in their theory of calcaneal sagital restriction by the swing like strap around the heel. An increased contact time at toe 1 and deceased contact at toe 2-5 indicate a larger degree of toe off.

II. The readings at time period two indicates a slight increase of contact at metatarsal 2 and 3. The remainder of the metatarsals and the midfoot increase in contact time while both the heel regions undergo a drastic decrease in contact. This may indicate a further shift to the front and midfoot regions.

III. Twenty four hours after the employment of the tape there seems to be a trend to returning to the pre –taped contact time readings. Metatarsal 2 and 3 increase their contact while metatarsal 4 and 5 decrease their contact with the ground. The midfoot region seems to decrease contact time slightly together with metatarsal 1 and the first toe. These findings seem to support the theory of limited use of adhesive taping as stated by Vicenzino et al. (1997) and Harradine, Herrington and Wright, (2001).

In summation there appears to be a definite trend towards a supinated foot position directly after taping. This is supported by the increased contact time and maximum force over metatarsals 4 and 5. The low-dye taping appears to be elevating metatarsals 2 and 3 and in the process restricting their motion. The taping technique appears to cause an initial foot contact that is less distinctive at the heel but is more widespread throughout the mid and frontfoot regions. Although these trends exist after one hour of taping there seems to be a gradual loss of these effects over time so that after 24 hours a definite regression can be observed. These findings may indicate a complete return to the pre- taped condition over a longer period of time.

5.2 Recommendations:

I. Since our findings indicate that a similar pattern of percent contact time and maximum force exist between the three groups a more accurate result may have been achieved by focusing on one type of arch only.

II. Greater accuracy could have been attained in the classification of the arch by types. It's the author's suggestion to use either x -ray findings or the arch ratio (Williams III. Et al, 2004) in studies where distinction between arched feet will be made.

III. A more homogeneous sample group could have been attained by only accepting individuals within a certain weight category and limiting the participants to one specific type of activity or group e.g. hockey, rugby or cricket players.

IV. Greater measurement accuracy can be attained through fixing the speed with which the participant walks across the platform and by increasing the plate length from 1m to 2m in order to measure the effect on both feet.

V. If this study is to be repeated a greater number of measurements with a shorter time interval (e.g. measurement every half an hour) should be done. This will document the changes of the tape over time more accurately.

VI. In future studies a method should be devised to ensure a standardization of taping tension when it is applied. Although care was taken to repeat the taping procedure in the most identical manner it is not known whether taping tension varied significantly between participants and whether that might have had an effect on the outcome of the study.

VII. A similar study investigating the effect of taping on patients with foot disorders would be useful to further increase our knowledge of the effect of low –dye taping.

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DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC APPENDIX A:
CASE HISTORY

Patient: .... Date: ....

File # : .... Age : ....

Sex : .... Occupation: ....

Intern : ....Signature: ....

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature :

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

Case Status:

PTT:	Signature:	Date:

CONDITIONAL: Reason for Conditional:	
Signature:	Date:

Conditions met in Visit No:	Signed into PTT:	Date:

Signed off:	Date:

6. **Current health status and life-style:**

- Allergies
- Immunizations
- Screening Tests incl. xrays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. **Immediate Family Medical History:**

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

8. **Psychosocial history:**

- Home Situation and daily life
- Important experiences
- Religious Beliefs

APPENDIX B:

PHYSICAL EXAMINATION
SENIOR & RESEARCH

Patient:________________________ **File#:**____________ **Date:**_______

Student: **Signature:**

VITALS

Pulse rate			Respiratory rate	
Blood pressure	R	L	Medication if hypertensive:	
Temperature			Height	
Weight:	Any recent change Y/N	If Yes : how much gain/loss		Over what period

GENERAL EXAMINATION

General Impression	
Skin	
Jaundice	
Pallor	
Clubbing	
Cyanosis (Central/Peripheral)	
Oedema	
Lymph nodes - Head and neck	
- Axillary	
- Epitrochlear	
- Inguinal	
Pulses	
Urinalysis	

SYSTEM SPECIFIC EXAMINATION

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

COMMENTS

NEUROLOGICAL EXAMINATION: See regionals

Clinician: **Signature:**

APPENDIX C DURBAN INSTITUTE of TECHNOLOGY

Foot and ankle regional examination

Patient:______________________________ File no:__________ Date:________
Intern / Resident______________________ Signature:______________________
Clinician:____________________________ Signature:______________________

Observation
Gait analysis (antalgic limp,toe off, arch, foot alignment, tibial alignment).
____
____
Swelling____
Heloma dura / molle____
Skin____
Nails____
Shoes____
Contours (achilles tendon, bony prominences)______________________

Active movements

weight bearing:	R	L	***Non weight bearing:***	R	L
Plantar flexion			50°		
Dorsiflexion			20°		
Supination					
Pronation					
Toe dorsiflexion			40° (mtp)		
Toe plantar flexion			40° (mtp)		
			Big toe dorsiflexion (mtp) ($65-70^\circ$)		
			Big toe plantar flexion (mtp) 45°		
			Toe abduction + adduction		
			5° first ray dorsiflexion		
			5° first ray plantar flexion		

Passive movement motion palpation (Passive ROM quality, ROM overpressure, joint play)

	R	L		R	L
Ankle joint: *Plantarflexion*			Subtalar joint: *Varus*		
Dorsiflexion			*Valgus*		
Talocrural: *Long axis distraction*			Midtarsal: *A-P glide*		
First ray: *Dorsiflexion*			*P-A glide*		
Plantarflexion			*rotation*		
Circumduction of forefoot on fixed rearfoot			Intermetatarsal glide		
			Tarso metatarsal joints: *A-P*		
Interphalangeal joints: *L→A dist*			Metatarsophalangeal dorsiflexion (with associated plantar flexion of each toe		
A-P glide					
lat and med glide					
rotation					

APPENDIX D:

DURBAN INSTITUTE *of* TECHNOLOGY

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date :

Title of research project :

Name of supervisor :
Tel ☎ :

Name of research student :
Tel ☎ :

<u>**Please circle the appropriate answer**</u> **YES /NO**

1.	Have you read the research information sheet?	Yes	No
2.	Have you had an opportunity to ask questions regarding this study?	Yes	No
3.	Have you received satisfactory answers to your questions?	Yes	No
4.	Have you had an opportunity to discuss this study?	Yes	No
5.	Have you received enough information about this study?	Yes	No
6.	Do you understand the implications of your involvement in this study?	Yes	No
7.	Do you understand that you are free to withdraw from this study? at any time without having to give any a reason for withdrawing, and without affecting your future health care.	Yes	No
8.	Do you agree to voluntarily participate in this study	Yes	No
9.	Who have you spoken to? ______________________________		

Please ensure that the researcher completes each section with you
If you have answered NO to any of the above, please obtain the necessary information before signing

<u>**Please Print in block letters:**</u>

Patient /Subject Name:______________________ Signature: ________________

Parent/ Guardian:______________________ Signature:________________

Witness Name:______________________ Signature:________________

Research Student Name:______________________ Signature:________________

DURBAN INSTITUTE *of* TECHNOLOGY

APPENDIX E:

Letter of information

Dear Participant

Welcome to my research.

Title of research:

An investigation to determine the effect of short term low –dye taping on vertical ground reaction forces in asymptomatic pes planus, cavus and normal feet.

NAME OF RESEARCH STUDENT
Wayne Elphinstone Contact number: (031) 2042205
NAME OF RESEARCH SUPERVISOR
Dr C. Korporaal Contact number: (0312042611)
NAME OF RESEARCH CO-SUPERVISOR
Dr. H. Kretzmann Contact number: (0312055520)

INTRODUCTION:

Dear participant, welcome to my research project. You have been selected to take part in a trial to determine the efficacy of taping. In order for you to take part in this study you have to either have high arched, low arched or normal arched feet that is pain free.

Purpose of the study:

The aim of this study will be to determine how effective strapping is when using it to treat the foot. I will therefore determine how pressures across your foot change when strapping is employed and will require you to walk barefoot across a foot plate. This will give me an indication of how effective it is as a treatment approach.

Procedures:

Sixty people will be required to take part in this study. These sixty people will be divided into three groups of twenty. Twenty of the people must have normal arches, twenty must have flat arches and twenty must have high arches. At the first visit you will be screened for suitability for the study by taking a history and doing a full physical and foot regional examination.

The second visit will take place at Durban Orthopaedic Services at Kings Park Medical Centre, both groups will have their vertical ground reaction forces measured by walking across a force plate. Then strapping will be taped to your foot after which you will have the measurement taken again, one hour after the strapping you will once again have the measurement taken. The strapping must remain on your feet for 24 hours. On the third visit, the next day, you will have the measurement taken for the last time after which we will remove the taping.

Risks:

The treatments are safe and are unlikely to cause any discomfort or side effects. Having mentioned the above temporary side effects of taping has been previously noted and include itching, burning, skin rash, peeling and loosening of the skin.

New Information:

The results of the study will be published as a research Dissertation at the Durban Institute of Technology Library and you may request a copy of the results, which will be provided.

Cost:

The treatments for the duration of the study will be free of charge. You will also receive two free treatments for any other condition commonly treated by chiropractors.

Withdrawals:

You may withdraw from the study at any time. You may be withdrawn without your consent if you are taking any medication or undergoing any other treatments for foot pain during the duration of the study. If the taping is removed before the subsequent follow-up you may also be excluded from the study. No data will be used if you do not complete the full four measurements.

Confidentiality:

All your information will be kept confidential and your relevant file numbers will be used in order for no names to be displayed on the data sheets. Information may be viewed by the researcher as well as the research supervisors for the period of the study and will be kept for 5 years in your respective files, before the data is shredded.

Please feel free to ask any questions regarding any aspect of this study. If you experience any problems or want to ask any more questions please don't hesitate to contact me or my supervisors at the contact numbers above. Your full co-operation will assist the Chiropractic profession in expanding its knowledge of this condition.

Sincerely yours

John Wayne Elphinstone. **B. Tech(Chiropractic)(Researcher)**

Dr. C. Korporaal. **M.Tech: Chiropractic (SA), CCFC (SA), CCSP (ICCSD)(USA)**
(Supervisor)

Dr. H Kretzmann. **M.Tech:Chiropractic(SA), CCFC(SA)**
(Co-supervisor)

APPENDIX F:

Are you between the ages

18 to 45years

and consider yourself to have

HIGH ARCH FEET?

LOW ARCH FEET?

NORMAL ARCH FEET?

Research is currently being carried out on

FOOT STRAPPING

at

The Durban Institute of Technology
Chiropractic Day Clinic.

FREE TREATMENT

Is available to those who qualify to take part in this study

For more information contact

Wayne Elphinstone

on

(031) 204 2205/2512

Appendix G: Questions to be asked at initial or telephonic interview.

1. Are you between the ages of 18 and 45?
2. Do you think you have high arch, low arch or normal feet?
3. Are you a full time student?
4. Do you have pain free feet?
5. Are you on any medication for foot pain?

Appendix K:

Classic Low – Dye taping of the foot(Reid,1992)

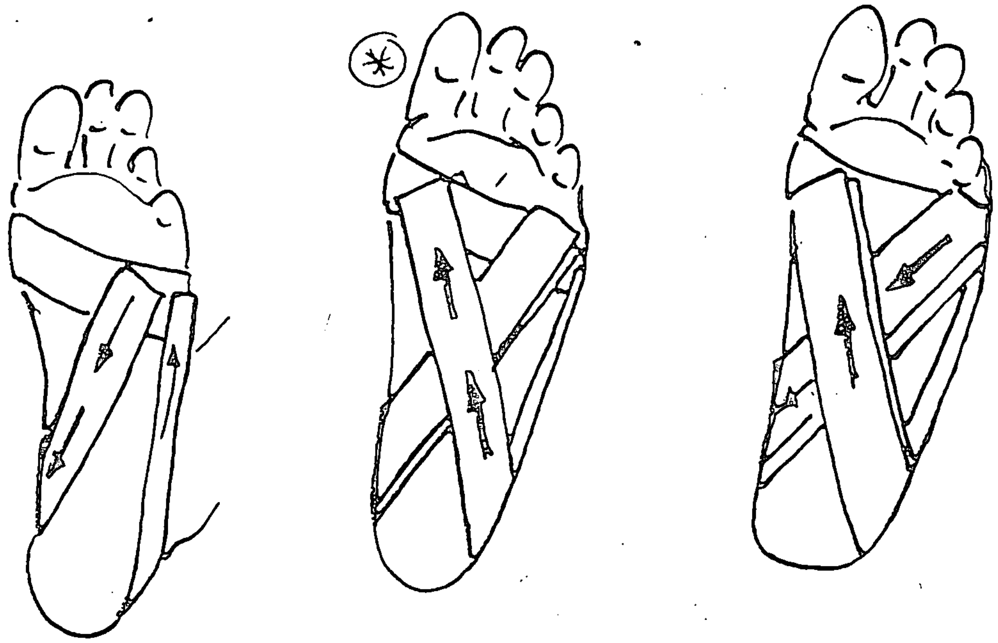


Fig. 8-11. Low dye taping for support of plantar fascia. It may be completed with a final forefoot anchor placed while the foot is bearing weight.

APPENDIX L:

DURBAN O&P SERVICES

DARRYL GROBBELAAR T/A
DURBAN O&P SERVICES
Medical Orthotists and Prosthetists
PRACTICE NO. 087-000-0071145

Collegians Club, Walter Gilbert Road, Durban 4001 Tel: (031) 303-3874/5 Fax: (031) 303-3894
P.O.Box 2224 Mount Edgecombe Country Club 4301 eMail: darrylop@mweb.co.za

Appendix L: Letter of participation of outside contractor

I Darryl Grobbelaar hereby acknowledge that Mr. J.W. Elphinstone has approached me to take part in his study on **An investigation to determine the effect of short term low-dye taping on asymptomatic pes planus, cavus and normal feet.**

I have agreed to take part in this study by allowing him to make use of my facilities and equipment in particular the RS scanner for the duration of the study. He will use this instrument to determine the relative ground reaction forces of the foot. I will assist Mr. Elphinstone where necessary. He will in turn provide me with remunerations for service and time provided by the due amount discussed between us in accordance with what he can afford.

My practice, Durban O & P Services, is located at Kings Park Sports Medicine Centre.

Thank you

Mr. D. Grobbelaar

Phone 2021122
Cell 0833038509

APPENDIX M:

STATISTICAL ANALYSIS

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: CT0

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	35303.908[a]	29	1217.376	4.893	.000
Intercept	2024823.770	1	2024823.770	8138.519	.000
FOOT	2316.367	2	1158.184	4.655	.010
REGN	30669.997	9	3407.777	13.697	.000
FOOT * REGN	2317.544	18	128.752	.518	.951
Error	141813.211	570	248.795		
Total	2201940.889	600			
Corrected Total	177117.119	599			

a. R Squared = .199 (Adjusted R Squared = .159)

Post Hoc Tests

FOOT

Homogeneous Subsets

CT0

Duncan[a,b]

FOOT	N	Subset 1	Subset 2
n	200	55.5967	
l	200	58.2817	58.2817
h	200		60.3983
Sig.		.089	.180

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 248.795.

a. Uses Harmonic Mean Sample Size = 200.000.

b. Alpha = .05.

Homogeneous Subsets

CT0

Duncan[a,b]

REGN	N	Subset 1	2	3	4	5
t1	60	48.6167				
t2	60	48.7889				
hl	60	53.2111	53.2111			
hm	60	54.6556	54.6556			
mf	60		55.5444	55.5444		
m1	60		55.8444	55.8444		
m5	60			61.3278	61.3278	
m2	60				66.1333	66.1333
m4	60					68.3000
m3	60					68.5000
Sig.		.055	.412	.057	.096	.443

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 248.795.

a. Uses Harmonic Mean Sample Size = 60.000.

b. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: CT1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	55158.393[a]	29	1902.014	8.743	.000
Intercept	2073405.735	1	2073405.735	9530.433	.000
FOOT	1753.470	2	876.735	4.030	.018
REGN	50762.508	9	5640.279	25.926	.000
FOOT * REGN	2642.415	18	146.801	.675	.837
Error	124007.094	570	217.556		
Total	2252571.222	600			
Corrected Total	179165.487	599			

a. R Squared = .308 (Adjusted R Squared = .273)

Post Hoc Tests

FOOT

Homogeneous Subsets

CT1

Duncan[a,b]

FOOT	N	Subset 1	Subset 2
n	200	56.3700	
l	200		59.8950
h	200		60.0900
Sig.		1.000	.895

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 217.556.

a. Uses Harmonic Mean Sample Size = 200.000.

b. Alpha = .05.

Homogeneous Subsets

CT1

Duncan[a,b]

REGN	N	Subset					
		1	2	3	4	5	6
t2	60	37.3333					
t1	60		52.8556				
hl	60		56.4778	56.4778			
mf	60		56.5556	56.5556			
hm	60		57.5611	57.5611			
m1	60			59.0944			
m2	60			61.2222	61.2222		
m3	60				65.3944	65.3944	
m5	60					68.9000	68.9000
m4	60						72.4556
Sig.		1.000	.112	.119	.122	.194	.187

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 217.556.

a. Uses Harmonic Mean Sample Size = 60.000.

b. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: CT2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	61138.755[a]	29	2108.233	9.025	.000
Intercept	2100495.556	1	2100495.556	8992.109	.000
FOOT	4924.667	2	2462.334	10.541	.000
REGN	49379.496	9	5486.611	23.488	.000
FOOT * REGN	6834.592	18	379.700	1.625	.049
Error	133148.133	570	233.593		
Total	2294782.444	600			
Corrected Total	194286.888	599			

a. R Squared = .315 (Adjusted R Squared = .280)

Means

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
CT2 * REGN * FOOT	600	100.0%	0	.0%	600	100.0%

Report

CT2

REGN	FOOT	Mean	N	Std. Deviation
hl	h	51.1500	20	10.25435
	l	56.0667	20	8.58504
	n	51.9333	20	11.89112
	Total	53.0500	60	10.38575
hm	h	52.7833	20	10.27076
	l	57.7167	20	7.94445
	n	52.8833	20	12.09285
	Total	54.4611	60	10.33344
m1	h	64.1000	20	11.43765
	l	63.9500	20	8.32053
	n	55.4000	20	15.97278
	Total	61.1500	60	12.78276
m2	h	67.0333	20	11.54392
	l	63.1500	20	10.31009
	n	58.3500	20	16.52235
	Total	62.8444	60	13.33735
m3	h	72.8667	20	12.41693
	l	66.2000	20	9.90564
	n	62.8333	20	14.81839
	Total	67.3000	60	13.02463
m4	h	77.5500	20	10.66188
	l	72.8667	20	9.95922
	n	69.9500	20	14.75067
	Total	73.4556	60	12.18949
m5	h	71.7167	20	12.23277
	l	67.9333	20	14.94497
	n	69.3167	20	14.84756
	Total	69.6556	60	13.91377
mf	h	72.2833	20	26.74512
	l	54.0333	20	21.98854
	n	47.4167	20	23.60292
	Total	57.9111	60	26.03669
t1	h	50.8833	20	13.62715
	l	50.4000	20	11.33106
	n	44.2500	20	17.61441
	Total	48.5111	60	14.50300
t2	h	41.8167	20	19.21789
	l	47.2000	20	22.00037
	n	41.0000	20	25.99235
	Total	43.3389	60	22.36215
Total	h	62.2183	200	18.42369
	l	59.9517	200	15.34259
	n	55.3333	200	19.40983
	Total	59.1678	600	18.00978

foot= N

Univariate Analysis of Variance

Between-Subjects Factors

		N
REGN	hl	20
	hm	20
	m1	20
	m2	20
	m3	20
	m4	20
	m5	20
	mf	20
	t1	20
	t2	20

Tests of Between-Subjects Effects

Dependent Variable: CT2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17661.122[a]	9	1962.347	6.506	.000
Intercept	612355.556	1	612355.556	2030.129	.000
REGN	17661.122	9	1962.347	6.506	.000
Error	57310.433	190	301.634		
Total	687327.111	200			
Corrected Total	74971.556	199			

a. R Squared = .236 (Adjusted R Squared = .199)

Post Hoc Tests

REGN

Homogeneous Subsets

CT2

Duncan[a,b]

REGN	N	Subset				
		1	2	3	4	5
t2	20	41.0000				
t1	20	44.2500	44.2500			
mf	20	47.4167	47.4167	47.4167		
hl	20	51.9333	51.9333	51.9333	51.9333	
hm	20	52.8833	52.8833	52.8833	52.8833	
m1	20		55.4000	55.4000	55.4000	
m2	20			58.3500	58.3500	58.3500
m3	20				62.8333	62.8333
m5	20					69.3167
m4	20					69.9500
Sig.		.054	.071	.077	.078	.054

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 301.634.

a. Uses Harmonic Mean Sample Size = 20.000.

b. Alpha = .05.

foot = 1

Univariate Analysis of Variance

Between-Subjects Factors

		N
REGN	hl	20
	hm	20
	m1	20
	m2	20
	m3	20
	m4	20
	m5	20
	mf	20
	t1	20
	t2	20

Tests of Between-Subjects Effects

Dependent Variable: CT2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12094.327[a]	9	1343.814	7.348	.000
Intercept	718840.467	1	718840.467	3930.428	.000
REGN	12094.327	9	1343.814	7.348	.000
Error	34749.317	190	182.891		
Total	765684.111	200			
Corrected Total	46843.644	199			

a. R Squared = .258 (Adjusted R Squared = .223)

Post Hoc Tests

REGN

Homogeneous Subsets

CT2

Duncan[a,b]

REGN	N	Subset 1	2	3	4	5	6	7
t2	20	47.2000						
t1	20	50.4000	50.4000					
mf	20	54.0333	54.0333	54.0333				
hl	20	56.0667	56.0667	56.0667	56.0667			
hm	20		57.7167	57.7167	57.7167	57.7167		
m2	20			63.1500	63.1500	63.1500	63.1500	
m1	20				63.9500	63.9500	63.9500	63.9500
m3	20					66.2000	66.2000	66.2000
m5	20						67.9333	67.9333
m4	20							72.8667
Sig.		.059	.121	.052	.094	.071	.315	.057

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 182.891.

a. Uses Harmonic Mean Sample Size = 20.000.

b. Alpha = .05.

foot= h

Univariate Analysis of Variance

Between-Subjects Factors

		N
REGN	hl	20
	hm	20
	m1	20
	m2	20
	m3	20
	m4	20
	m5	20
	mf	20
	t1	20
	t2	20

Tests of Between-Subjects Effects

Dependent Variable: CT2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26458.638[a]	9	2939.849	13.594	.000
Intercept	774224.201	1	774224.201	3580.151	.000
REGN	26458.638	9	2939.849	13.594	.000
Error	41088.383	190	216.255		
Total	841771.222	200			
Corrected Total	67547.022	199			

a. R Squared = .392 (Adjusted R Squared = .363)

Post Hoc Tests

REGN

Homogeneous Subsets

CT2

Duncan[a,b]

REGN	N	Subset 1	2	3	4
t2	20	41.8167			
t1	20	50.8833	50.8833		
hl	20	51.1500	51.1500		
hm	20		52.7833		
m1	20			64.1000	
m2	20			67.0333	
m5	20			71.7167	71.7167
mf	20			72.2833	72.2833
m3	20			72.8667	72.8667
m4	20				77.5500
Sig.		.058	.704	.095	.259

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 216.255.

a. Uses Harmonic Mean Sample Size = 20.000.

b. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: CT3

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50775.659[a]	29	1750.885	7.537	.000
Intercept	2023158.802	1	2023158.802	8708.740	.000
FOOT	632.093	2	316.047	1.360	.257
REGN	46714.348	9	5190.483	22.343	.000
FOOT * REGN	3429.218	18	190.512	.820	.677
Error	132418.761	570	232.314		
Total	2206353.222	600			
Corrected Total	183194.421	599			

a. R Squared = .277 (Adjusted R Squared = .240)

Post Hoc Tests

FOOT

Homogeneous Subsets

CT3

Duncan[a,b]

FOOT	N	Subset
		1
n	200	56.8550
l	200	57.9850
h	200	59.3650
Sig.		.121

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 232.314.

a. Uses Harmonic Mean Sample Size = 200.000.

b. Alpha = .05.

Homogeneous Subsets

CT3

Duncan[a,b]

REGN	N	Subset 1	2	3	4	5	6
t2	60	42.8889					
t1	60	47.5111	47.5111				
hl	60		51.5444	51.5444			
hm	60			53.3611	53.3611		
mf	60				57.5944	57.5944	
m1	60					59.4833	59.4833
m2	60					63.1944	63.1944
m5	60						64.8944
m3	60						
m4	60						
Sig.		.097	.148	.514	.129	.057	.066

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 232.314.

CT3

Duncan[a,b]

REGN	Subset 7	8
t2		
t1		
hl		
hm		
mf		
m1		
m2	63.1944	
m5	64.8944	
m3	68.2222	68.2222
m4		71.9889
Sig.	.088	.176

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 232.314.

a. Uses Harmonic Mean Sample Size = 60.000.

b. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: MF0

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6057175.585[a]	29	208868.124	28.813	.000
Intercept	17751351.746	1	17751351.746	2448.748	.000
FOOT	71158.743	2	35579.372	4.908	.008
REGN	5871125.841	9	652347.316	89.989	.000
FOOT * REGN	114891.001	18	6382.833	.880	.603
Error	4132017.225	570	7249.153		
Total	27940544.557	600			
Corrected Total	10189192.811	599			

a. R Squared = .594 (Adjusted R Squared = .574)

Post Hoc Tests

FOOT

Homogeneous Subsets

MF0

Duncan[a,b]

FOOT	N	Subset 1	Subset 2
h	200	162.8572	
l	200	165.8480	
n	200		187.3087
Sig.		.726	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 7249.153.

a. Uses Harmonic Mean Sample Size = 200.000.

b. Alpha = .05.

Homogeneous Subsets

MF0

Duncan[a,b]

REGN	N	Subset 1	2	3	4	5	6
mf	60	38.8639					
t2	60	40.9061					
m5	60		100.3089				
m4	60			152.3017			
t1	60			154.1472			
m3	60			172.2472	172.2472		
m1	60				188.6594		
m2	60				204.3561		
hl	60					294.1306	
hm	60						374.1250
Sig.		.896	1.000	.229	.050	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 7249.153.

a. Uses Harmonic Mean Sample Size = 60.000.

b. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: MF1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6299912.515[a]	29	217238.363	28.556	.000
Intercept	17294866.075	1	17294866.075	2273.415	.000
FOOT	37239.602	2	18619.801	2.448	.087
REGN	6182341.184	9	686926.798	90.297	.000
FOOT * REGN	80331.728	18	4462.874	.587	.910
Error	4336241.170	570	7607.441		
Total	27931019.759	600			
Corrected Total	10636153.684	599			

a. R Squared = .592 (Adjusted R Squared = .572)

Post Hoc Tests

FOOT

Homogeneous Subsets

MF1

Duncan[a,b]

FOOT	N	Subset 1
l	200	163.8600
h	200	164.5632
n	200	180.9127
Sig.		.064

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 7607.441.

a. Uses Harmonic Mean Sample Size = 200.000.

b. Alpha = .05.

Homogeneous Subsets

MF1

Duncan[a,b]

REGN	N	Subset 1	2	3	4	5	6
mf	60	26.6600					
t2	60	32.4167					
m5	60		123.2389				
m3	60		144.7467	144.7467			
m4	60			162.8378	162.8378		
m1	60			164.9811	164.9811		
m2	60			177.3244	177.3244		
t1	60				181.8706		
hl	60					315.3944	
hm	60						368.3156
Sig.		.718	.177	.061	.282	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 7607.441.

a. Uses Harmonic Mean Sample Size = 60.000.

b. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: MF2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5450393.643[a]	29	187944.608	29.157	.000
Intercept	16348070.614	1	16348070.614	2536.157	.000
FOOT	81076.819	2	40538.409	6.289	.002
REGN	5261217.552	9	584579.728	90.689	.000
FOOT * REGN	108099.273	18	6005.515	.932	.540
Error	3674220.648	570	6446.001		
Total	25472684.905	600			
Corrected Total	9124614.291	599			

a. R Squared = .597 (Adjusted R Squared = .577)

Post Hoc Tests

FOOT

Homogeneous Subsets

MF2

Duncan[a,b]

FOOT	N	Subset 1	Subset 2
h	200	149.6850	
l	200		167.7305
n	200		177.7825
Sig.		1.000	.211

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 6446.001.

a. Uses Harmonic Mean Sample Size = 200.000.

b. Alpha = .05.

Homogeneous Subsets

MF2

Duncan[a,b]

REGN	N	Subset 1	2	3	4	5	6
mf	60	27.1422					
t2	60	40.3211					
m5	60		121.4817				
m3	60		146.8817	146.8817			
m4	60			160.4006	160.4006		
t1	60			165.0039	165.0039		
m1	60			166.7106	166.7106		
m2	60				179.7622		
hl	60					292.3017	
hm	60						350.6544
Sig.		.369	.084	.222	.234	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 6446.001.

a. Uses Harmonic Mean Sample Size = 60.000.

b. Alpha = .05.

Univariate Analysis of Variance

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Tests of Between-Subjects Effects

Dependent Variable: MF3

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7132545.014[a]	29	245949.828	35.034	.000
Intercept	19946452.253	1	19946452.253	2841.253	.000
FOOT	36153.197	2	18076.599	2.575	.077
REGN	6972405.347	9	774711.705	110.353	.000
FOOT * REGN	123986.470	18	6888.137	.981	.480
Error	4001571.437	570	7020.301		
Total	31080568.703	600			
Corrected Total	11134116.451	599			

a. R Squared = .641 (Adjusted R Squared = .622)

Post Hoc Tests

FOOT

Homogeneous Subsets

MF3

Duncan[a,b]

FOOT	N	Subset 1	Subset 2
h	200	175.6123	
n	200	178.1688	178.1688
l	200		193.2077
Sig.		.760	.073

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 7020.301.

a. Uses Harmonic Mean Sample Size = 200.000.

b. Alpha = .05.

Homogeneous Subsets

MF3

Duncan[a,b]

REGN	N	Subset 1	2	3	4	5	6
mf	60	29.4367					
t2	60	41.3678					
m5	60		118.1089				
m4	60			166.6294			
m3	60			169.0789			
t1	60			173.9161	173.9161		
m1	60			197.6883	197.6883		
m2	60				204.6156		
hl	60					318.7900	
hm	60						403.6644
Sig.		.436	1.000	.063	.057	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 7020.301.

a. Uses Harmonic Mean Sample Size = 60.000.

b. Alpha = .05.

General Linear Model

Within-Subjects Factors

Measure: CONTACT

TIME	Dependent Variable
1	CT0
2	CT1
3	CT2
4	CT3

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
TIME	Pillai's Trace	.008	1.614[a]	3.000	568.000	.185
	Wilks' Lambda	.992	1.614[a]	3.000	568.000	.185
	Hotelling's Trace	.009	1.614[a]	3.000	568.000	.185
	Roy's Largest Root	.009	1.614[a]	3.000	568.000	.185
TIME * FOOT	Pillai's Trace	.022	2.153	6.000	1138.000	.045
	Wilks' Lambda	.978	2.154[a]	6.000	1136.000	.045
	Hotelling's Trace	.023	2.156	6.000	1134.000	.045
	Roy's Largest Root	.019	3.587[b]	3.000	569.000	.014
TIME * REGN	Pillai's Trace	.172	3.841	27.000	1710.000	.000
	Wilks' Lambda	.835	3.925	27.000	1659.495	.000
	Hotelling's Trace	.191	4.006	27.000	1700.000	.000
	Roy's Largest Root	.141	8.911[b]	9.000	570.000	.000
TIME * FOOT * REGN	Pillai's Trace	.100	1.094	54.000	1710.000	.300
	Wilks' Lambda	.903	1.097	54.000	1693.232	.295
	Hotelling's Trace	.105	1.100	54.000	1700.000	.290
	Roy's Largest Root	.061	1.926[b]	18.000	570.000	.012

a. Exact statistic

b. The statistic is an upper bound on F that yields a lower bound on the significance level.

c.
Design: Intercept+FOOT+REGN+FOOT * REGN
Within Subjects Design: TIME

Mauchly's Test of Sphericity[b]

Measure: CONTACT

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
TIME	.965	20.074	5	.001

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: CONTACT

Within Subjects Effect	Epsilon[a]		
	Greenhouse -Geisser	Huynh-Feldt	Lower-bound
TIME	.977	1.000	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+FOOT+REGN+FOOT * REGN
Within Subjects Design: TIME

Tests of Within-Subjects Effects

Measure: CONTACT

Source		Type III Sum of Squares	df	Mean Square
TIME	Sphericity Assumed	525.936	3	175.312
	Greenhouse-Geisser	525.936	2.932	179.397
	Huynh-Feldt	525.936	3.000	175.312
	Lower-bound	525.936	1.000	525.936
TIME * FOOT	Sphericity Assumed	1301.424	6	216.904
	Greenhouse-Geisser	1301.424	5.863	221.959
	Huynh-Feldt	1301.424	6.000	216.904
	Lower-bound	1301.424	2.000	650.712
TIME * REGN	Sphericity Assumed	11583.353	27	429.013
	Greenhouse-Geisser	11583.353	26.385	439.011
	Huynh-Feldt	11583.353	27.000	429.013
	Lower-bound	11583.353	9.000	1287.039
TIME * FOOT * REGN	Sphericity Assumed	6384.965	54	118.240
	Greenhouse-Geisser	6384.965	52.770	120.995
	Huynh-Feldt	6384.965	54.000	118.240
	Lower-bound	6384.965	18.000	354.720
Error(TIME)	Sphericity Assumed	178083.544	1710	104.142
	Greenhouse-Geisser	178083.544	1671.059	106.569
	Huynh-Feldt	178083.544	1710.000	104.142
	Lower-bound	178083.544	570.000	312.427

Tests of Within-Subjects Effects

Measure: CONTACT

Source		F	Sig.
TIME	Sphericity Assumed	1.683	.169
	Greenhouse-Geisser	1.683	.170
	Huynh-Feldt	1.683	.169
	Lower-bound	1.683	.195
TIME * FOOT	Sphericity Assumed	2.083	.052
	Greenhouse-Geisser	2.083	.054
	Huynh-Feldt	2.083	.052
	Lower-bound	2.083	.126
TIME * REGN	Sphericity Assumed	4.119	.000
	Greenhouse-Geisser	4.119	.000
	Huynh-Feldt	4.119	.000
	Lower-bound	4.119	.000
TIME * FOOT * REGN	Sphericity Assumed	1.135	.235
	Greenhouse-Geisser	1.135	.237
	Huynh-Feldt	1.135	.235
	Lower-bound	1.135	.313
Error(TIME)	Sphericity Assumed		
	Greenhouse-Geisser		
	Huynh-Feldt		
	Lower-bound		

Tests of Within-Subjects Contrasts

Measure: CONTACT

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	2.904	1	2.904	.026	.872
	Quadratic	481.809	1	481.809	4.443	.035
	Cubic	41.223	1	41.223	.445	.505
TIME * FOOT	Linear	88.467	2	44.233	.398	.672
	Quadratic	510.862	2	255.431	2.355	.096
	Cubic	702.095	2	351.047	3.786	.023
TIME * REGN	Linear	2605.905	9	289.545	2.603	.006
	Quadratic	6132.384	9	681.376	6.283	.000
	Cubic	2845.065	9	316.118	3.409	.000
TIME * FOOT * REGN	Linear	2369.676	18	131.649	1.183	.269
	Quadratic	3083.567	18	171.309	1.580	.060
	Cubic	931.722	18	51.762	.558	.929
Error(TIME)	Linear	63412.493	570	111.250		
	Quadratic	61816.711	570	108.450		
	Cubic	52854.340	570	92.727		

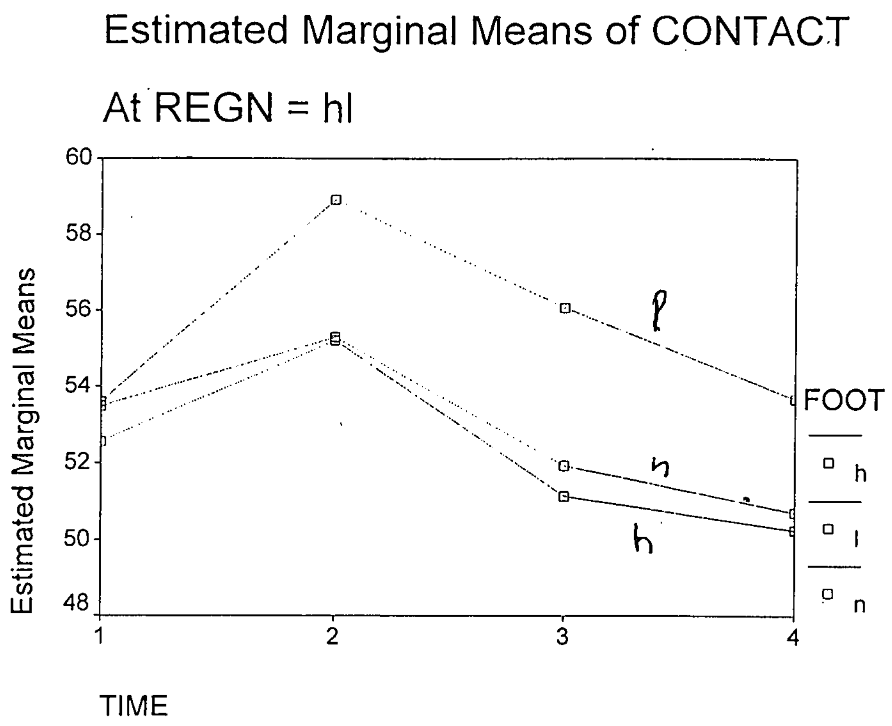
Tests of Between-Subjects Effects

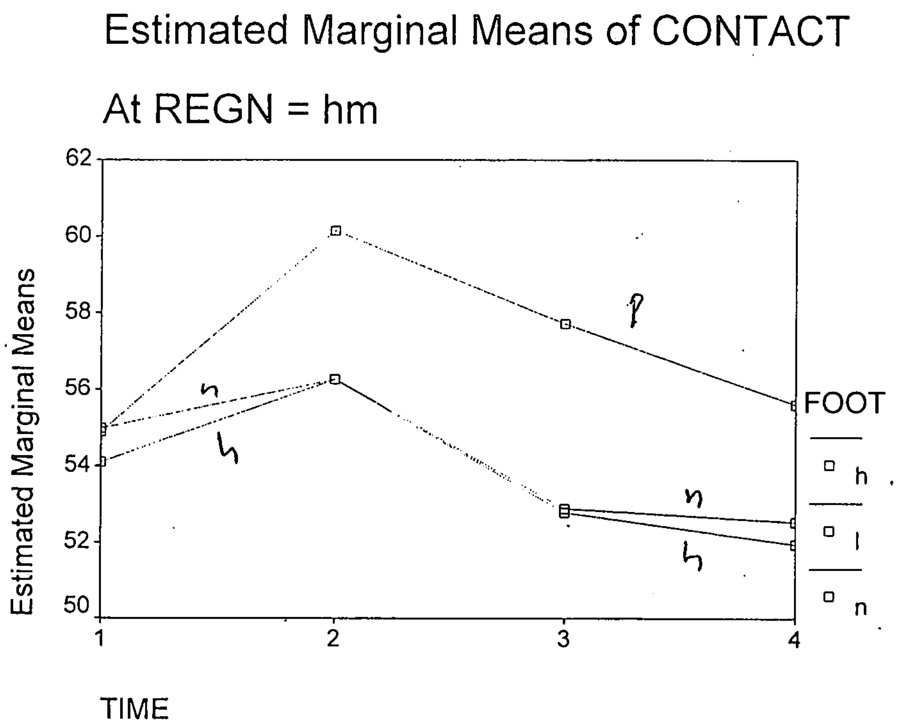
Measure: CONTACT
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	8221357.927	1	8221357.927	13263.871	.000
FOOT	8325.174	2	4162.587	6.716	.001
REGN	165942.996	9	18438.111	29.747	.000
FOOT * REGN	8838.804	18	491.045	.792	.711
Error	353303.656	570	619.831		

Profile Plots

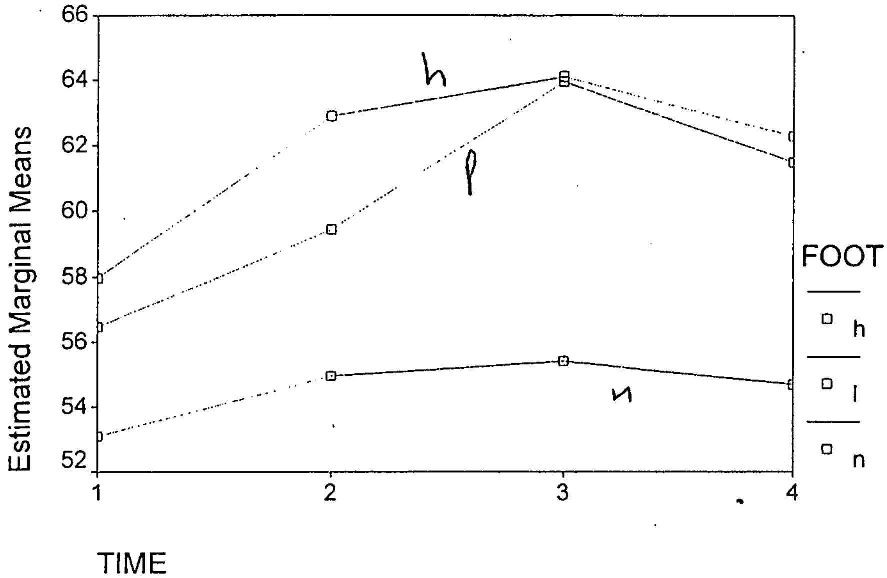
TIME * FOOT * REGN





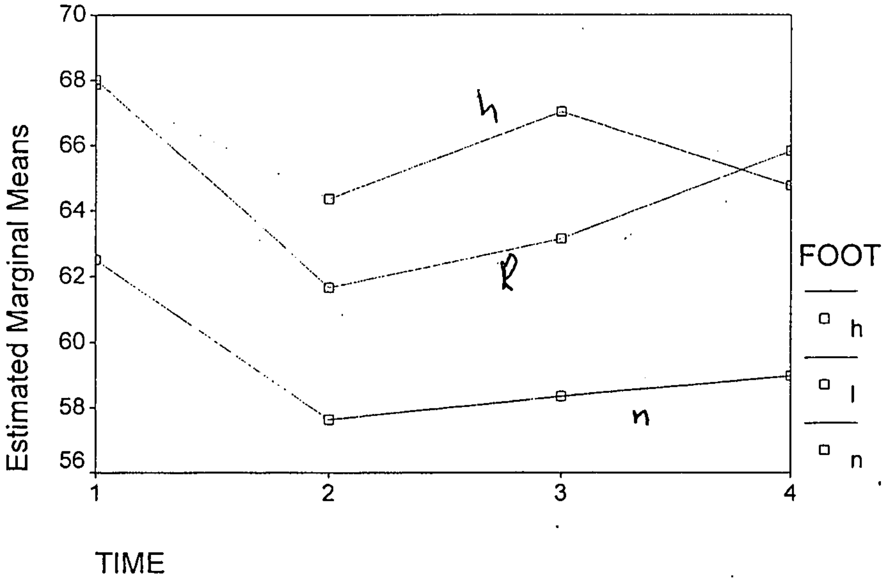
Estimated Marginal Means of CONTACT

At REGN = m1



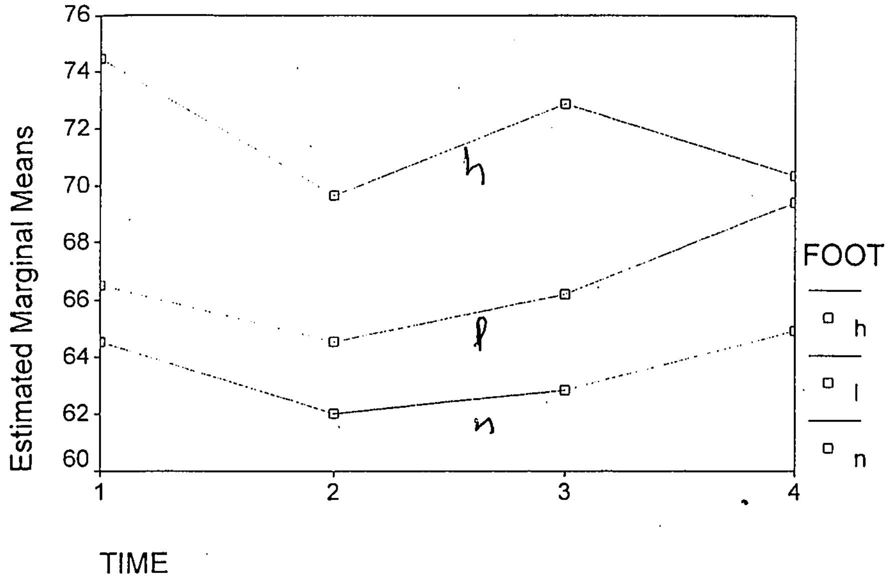
Estimated Marginal Means of CONTACT

At REGN = m2



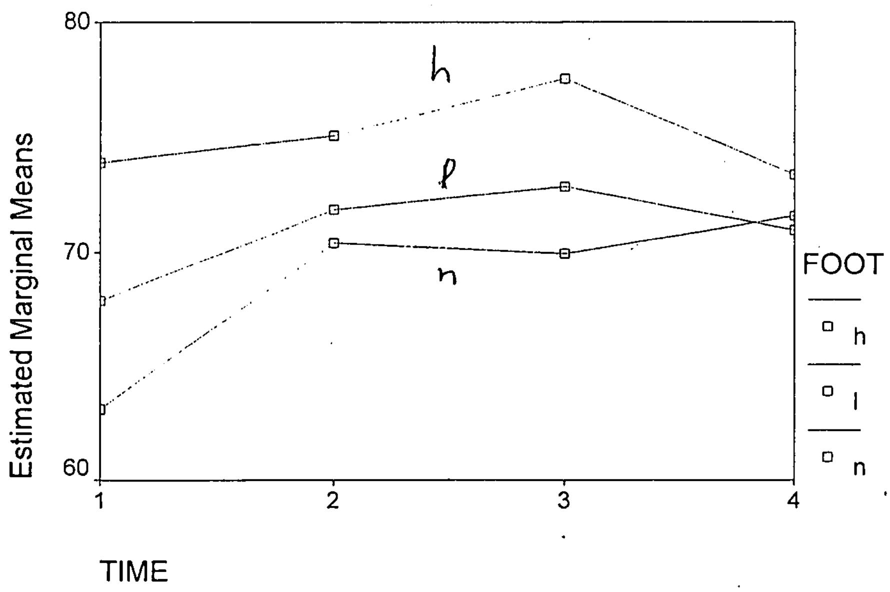
Estimated Marginal Means of CONTACT

At REGN = m3



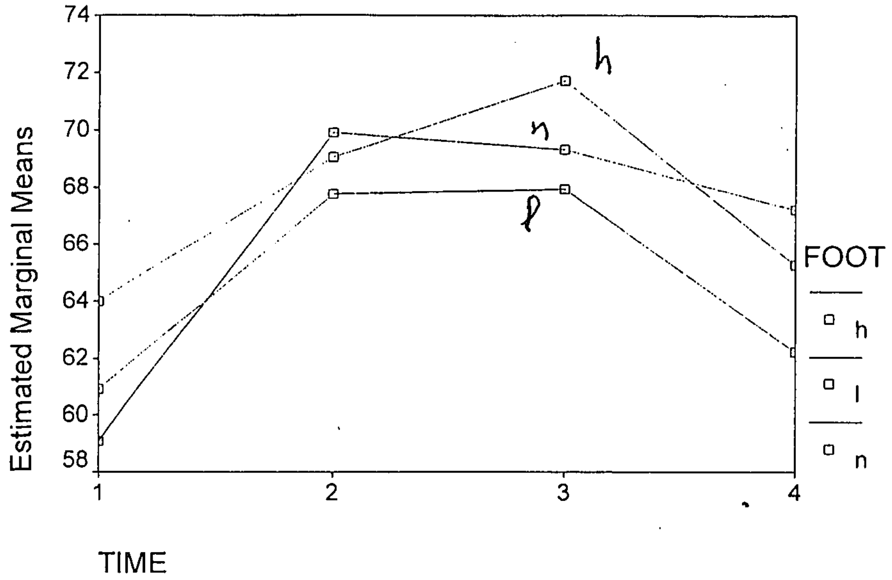
Estimated Marginal Means of CONTACT

At REGN = m4



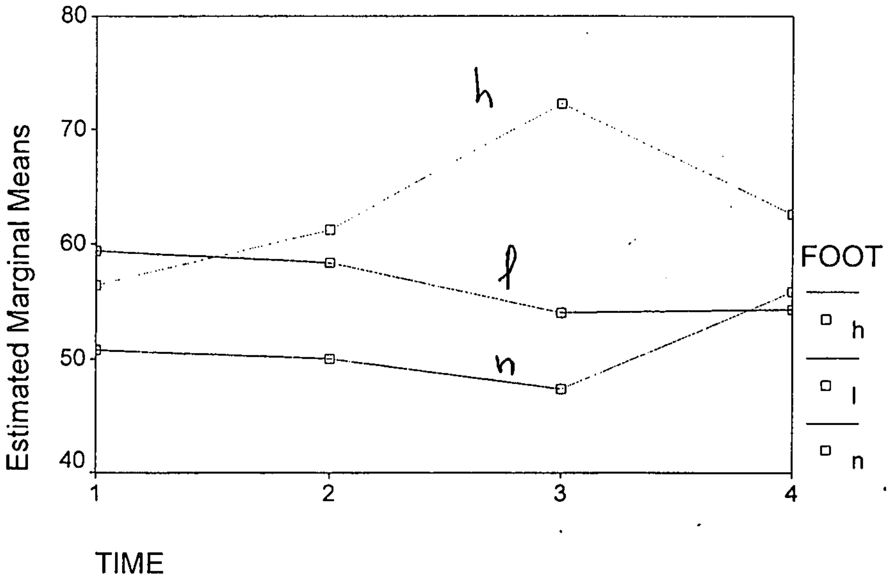
Estimated Marginal Means of CONTACT

At REGN = m5



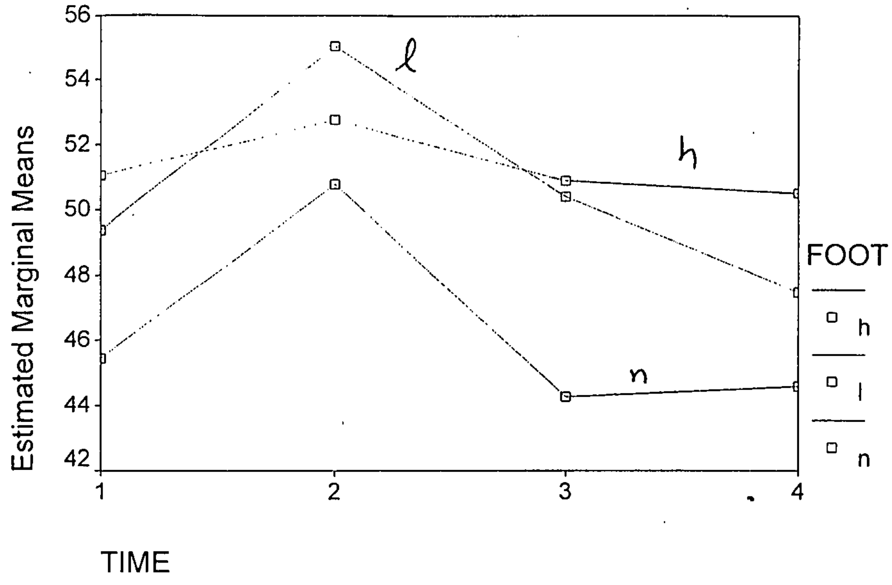
Estimated Marginal Means of CONTACT

At REGN = mf



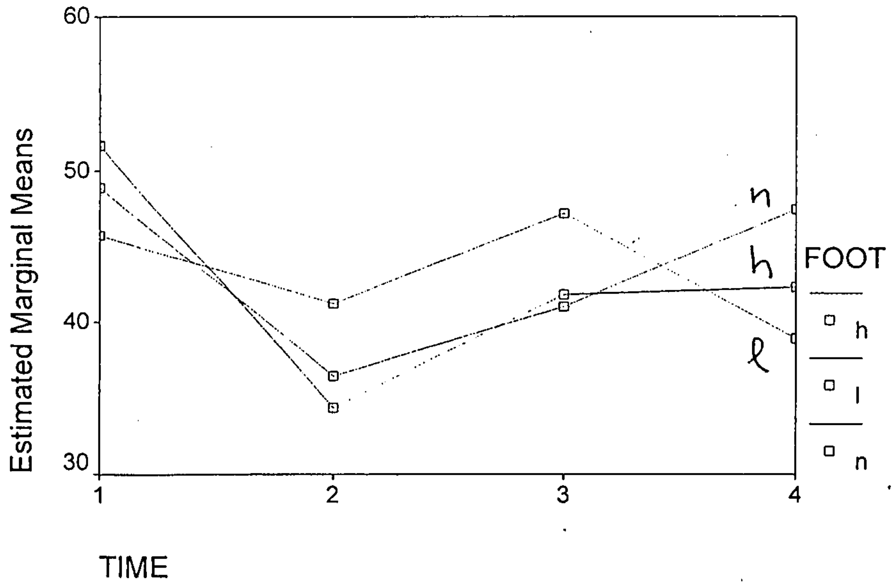
Estimated Marginal Means of CONTACT

At REGN = t1



Estimated Marginal Means of CONTACT

At REGN = t2



General Linear Model

Within-Subjects Factors

Measure: CONTACT

TIME	Dependent Variable
1	MF0
2	MF1
3	MF2
4	MF3

Between-Subjects Factors

		N
FOOT	h	200
	l	200
	n	200
REGN	hl	60
	hm	60
	m1	60
	m2	60
	m3	60
	m4	60
	m5	60
	mf	60
	t1	60
	t2	60

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
TIME	Pillai's Trace	.062	12.557[a]	3.000	568.000	.000
	Wilks' Lambda	.938	12.557[a]	3.000	568.000	.000
	Hotelling's Trace	.066	12.557[a]	3.000	568.000	.000
	Roy's Largest Root	.066	12.557[a]	3.000	568.000	.000
TIME * FOOT	Pillai's Trace	.062	6.077	6.000	1138.000	.000
	Wilks' Lambda	.939	6.091[a]	6.000	1136.000	.000
	Hotelling's Trace	.065	6.106	6.000	1134.000	.000
	Roy's Largest Root	.049	9.266[b]	3.000	569.000	.000
TIME * REGN	Pillai's Trace	.154	3.438	27.000	1710.000	.000
	Wilks' Lambda	.851	3.491	27.000	1659.495	.000
	Hotelling's Trace	.169	3.540	27.000	1700.000	.000
	Roy's Largest Root	.116	7.318[b]	9.000	570.000	.000
TIME * FOOT * REGN	Pillai's Trace	.089	.974	54.000	1710.000	.530
	Wilks' Lambda	.913	.973	54.000	1693.232	.530
	Hotelling's Trace	.093	.973	54.000	1700.000	.531
	Roy's Largest Root	.049	1.560[b]	18.000	570.000	.065

a. Exact statistic

b. The statistic is an upper bound on F that yields a lower bound on the significance level.

c. Design: Intercept+FOOT+REGN+FOOT * REGN
Within Subjects Design: TIME

Mauchly's Test of Sphericity[b]

Measure: CONTACT

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
TIME	.951	28.795	5	.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: CONTACT

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TIME	.967	1.000	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+FOOT+REGN+FOOT * REGN
Within Subjects Design: TIME

Tests of Within-Subjects Effects

Measure: CONTACT

Source		Type III Sum of Squares	df	Mean Square
TIME	Sphericity Assumed	95621.040	3	31873.680
	Greenhouse-Geisser	95621.040	2.902	32944.442
	Huynh-Feldt	95621.040	3.000	31873.680
	Lower-bound	95621.040	1.000	95621.040
TIME * FOOT	Sphericity Assumed	97821.456	6	16303.576
	Greenhouse-Geisser	97821.456	5.805	16851.277
	Huynh-Feldt	97821.456	6.000	16303.576
	Lower-bound	97821.456	2.000	48910.728
TIME * REGN	Sphericity Assumed	213079.908	27	7891.848
	Greenhouse-Geisser	213079.908	26.122	8156.967
	Huynh-Feldt	213079.908	27.000	7891.848
	Lower-bound	213079.908	9.000	23675.545
TIME * FOOT * REGN	Sphericity Assumed	131213.192	54	2429.874
	Greenhouse-Geisser	131213.192	52.245	2511.503
	Huynh-Feldt	131213.192	54.000	2429.874
	Lower-bound	131213.192	18.000	7289.622
Error(TIME)	Sphericity Assumed	4014313.215	1710	2347.552
	Greenhouse-Geisser	4014313.215	1654.421	2426.415
	Huynh-Feldt	4014313.215	1710.000	2347.552
	Lower-bound	4014313.215	570.000	7042.655

Tests of Within-Subjects Effects

Measure: CONTACT

Source		F	Sig.
TIME	Sphericity Assumed	13.577	.000
	Greenhouse-Geisser	13.577	.000
	Huynh-Feldt	13.577	.000
	Lower-bound	13.577	.000
TIME * FOOT	Sphericity Assumed	6.945	.000
	Greenhouse-Geisser	6.945	.000
	Huynh-Feldt	6.945	.000
	Lower-bound	6.945	.001
TIME * REGN	Sphericity Assumed	3.362	.000
	Greenhouse-Geisser	3.362	.000
	Huynh-Feldt	3.362	.000
	Lower-bound	3.362	.001
TIME * FOOT * REGN	Sphericity Assumed	1.035	.406
	Greenhouse-Geisser	1.035	.407
	Huynh-Feldt	1.035	.406
	Lower-bound	1.035	.418
Error(TIME)	Sphericity Assumed		
	Greenhouse-Geisser		
	Huynh-Feldt		
	Lower-bound		

Tests of Within-Subjects Contrasts

Measure: CONTACT

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	20691.392	1	20691.392	7.270	.007
	Quadratic	56976.741	1	56976.741	24.636	.000
	Cubic	17952.906	1	17952.906	9.530	.002
TIME * FOOT	Linear	67984.268	2	33992.134	11.944	.000
	Quadratic	12373.680	2	6186.840	2.675	.070
	Cubic	17463.508	2	8731.754	4.635	.010
TIME * REGN	Linear	25780.155	9	2864.462	1.006	.433
	Quadratic	138047.558	9	15338.618	6.632	.000
	Cubic	49252.194	9	5472.466	2.905	.002
TIME * FOOT * REGN	Linear	75239.896	18	4179.994	1.469	.095
	Quadratic	29734.543	18	1651.919	.714	.798
	Cubic	26238.753	18	1457.708	.774	.732
Error(TIME)	Linear	1622236.502	570	2846.029		
	Quadratic	1318278.610	570	2312.769		
	Cubic	1073798.103	570	1883.856		

Tests of Between-Subjects Effects

Measure: CONTACT
Transformed Variable: Average

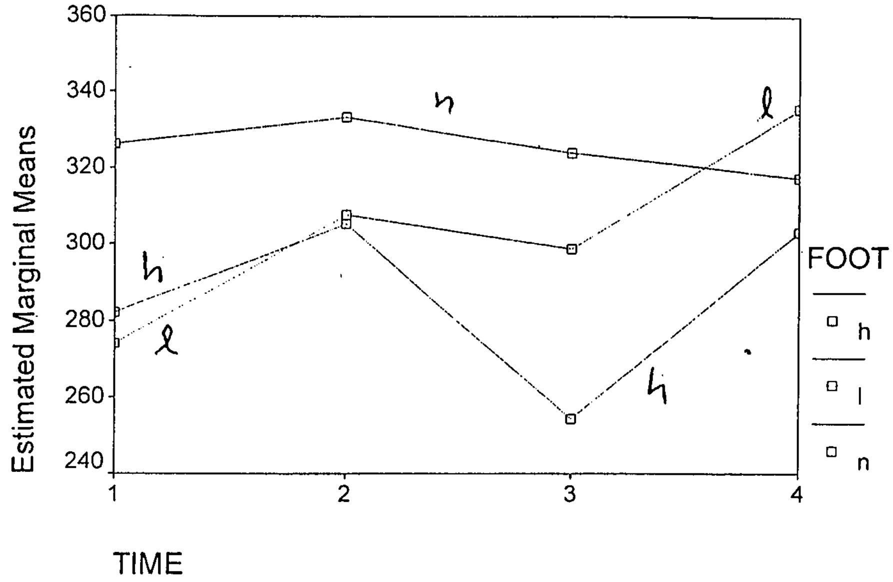
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	71245119.648	1	71245119.648	3347.947	.000
FOOT	127806.906	2	63903.453	3.003	.050
REGN	24074010.017	9	2674890.002	125.698	.000
FOOT * REGN	296095.279	18	16449.738	.773	.733
Error	12129737.265	570	21280.241		

Profile Plots

TIME * FOOT * REGN

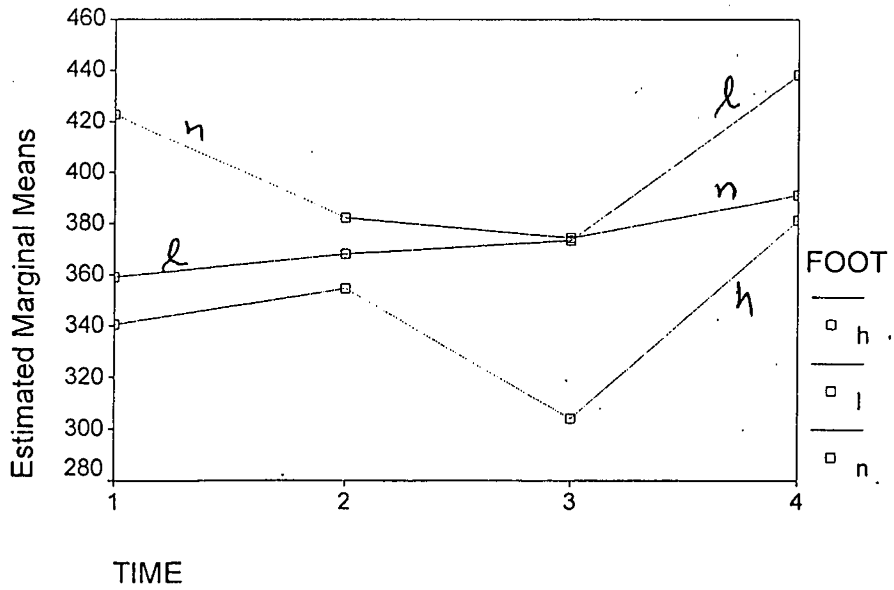
Estimated Marginal Means of CONTACT

At REGN = hl



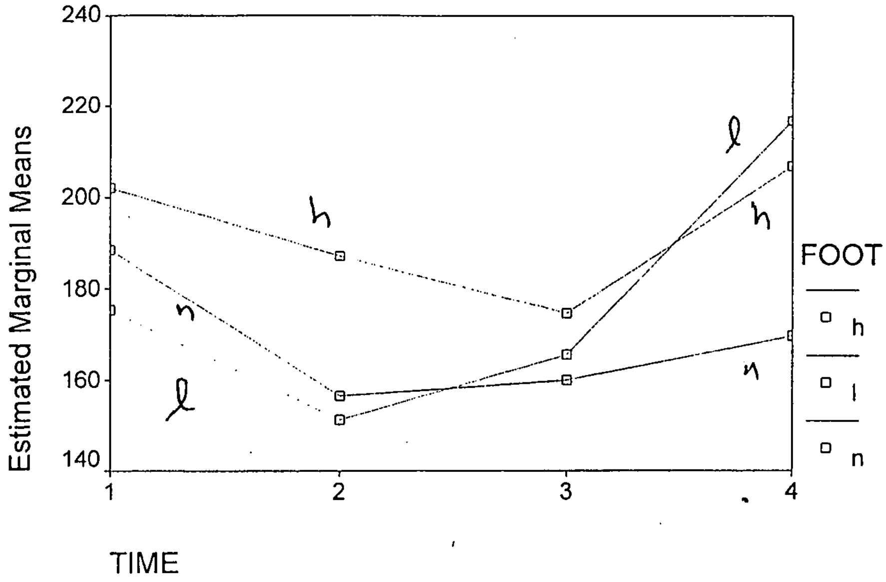
Estimated Marginal Means of CONTACT

At REGN = hm



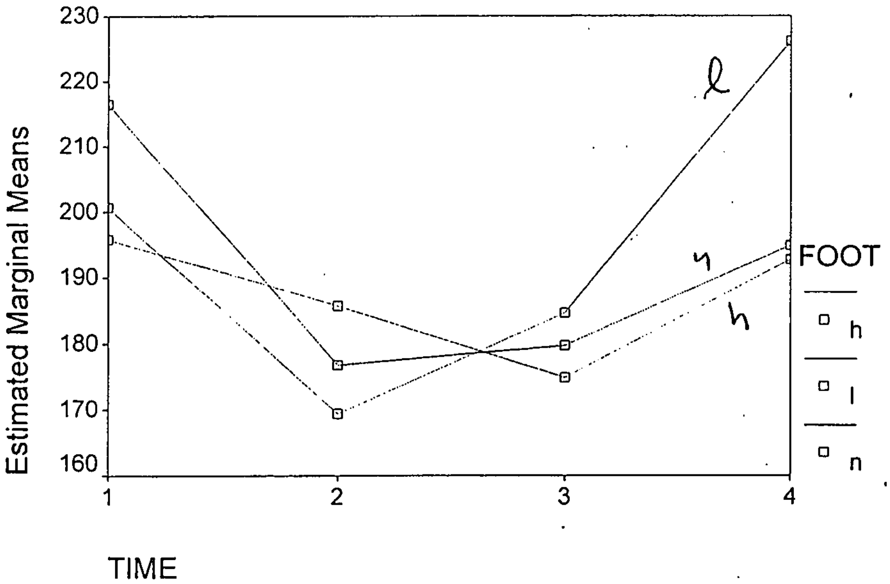
Estimated Marginal Means of CONTACT

At REGN = m1



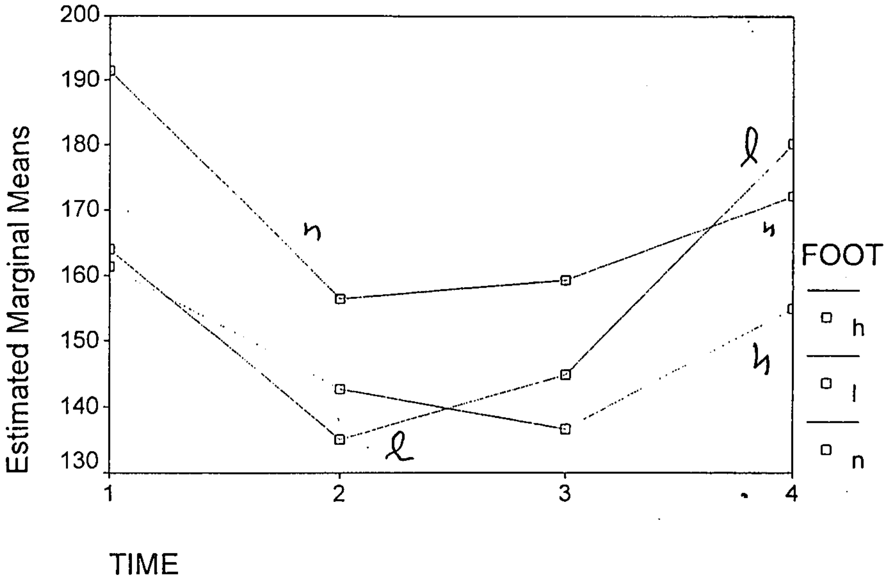
Estimated Marginal Means of CONTACT

At REGN = m2



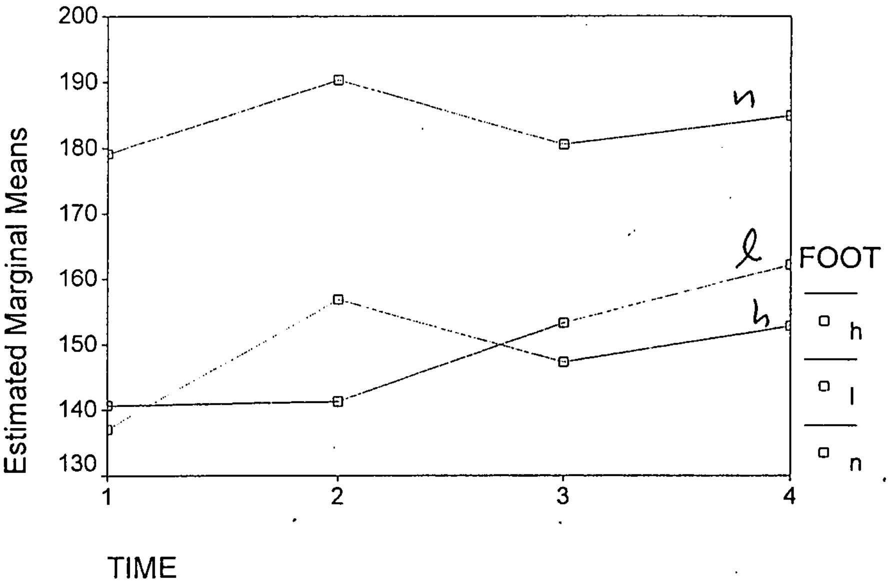
Estimated Marginal Means of CONTACT

At REGN = m3



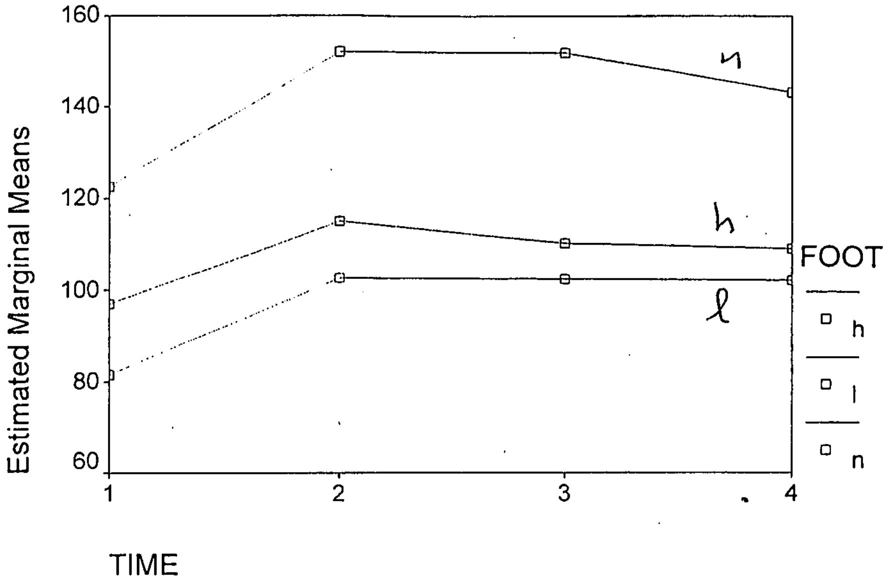
Estimated Marginal Means of CONTACT

At REGN = m4



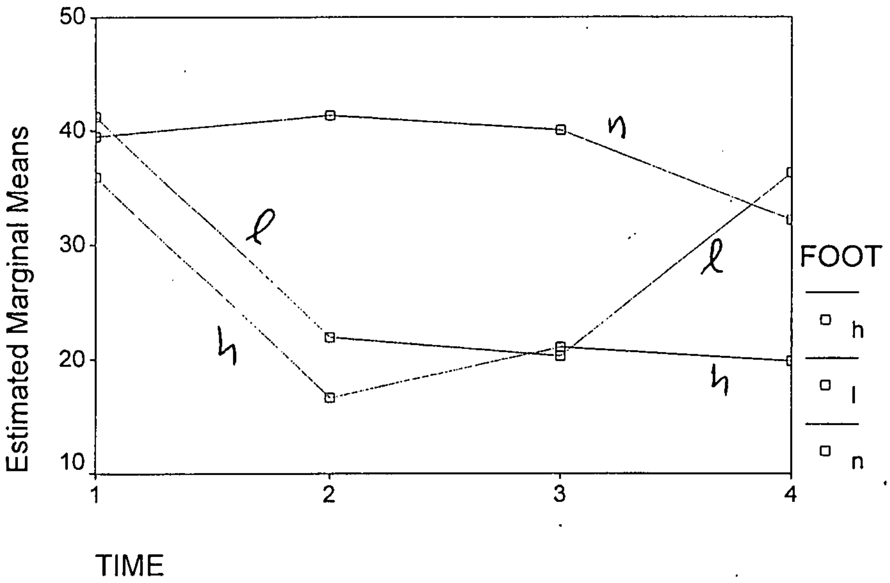
Estimated Marginal Means of CONTACT

At REGN = m5



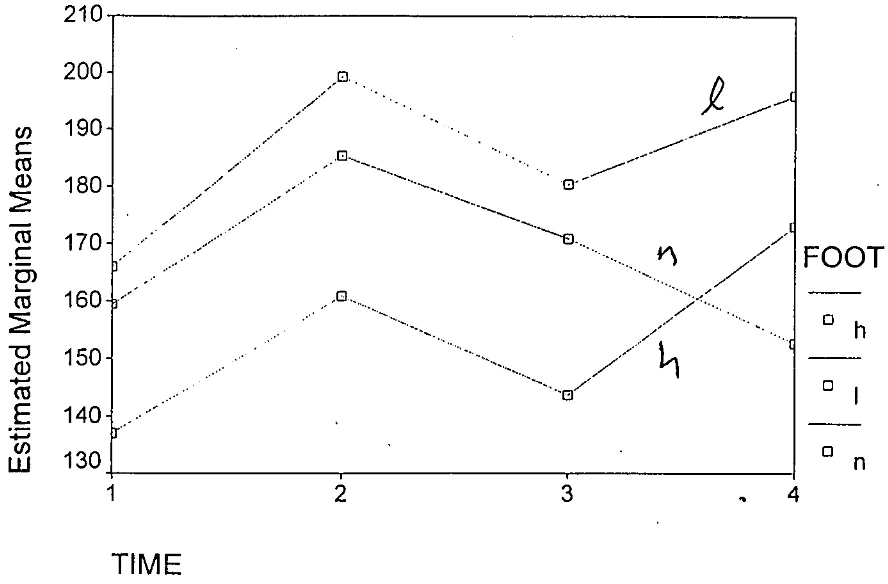
Estimated Marginal Means of CONTACT

At REGN = mf



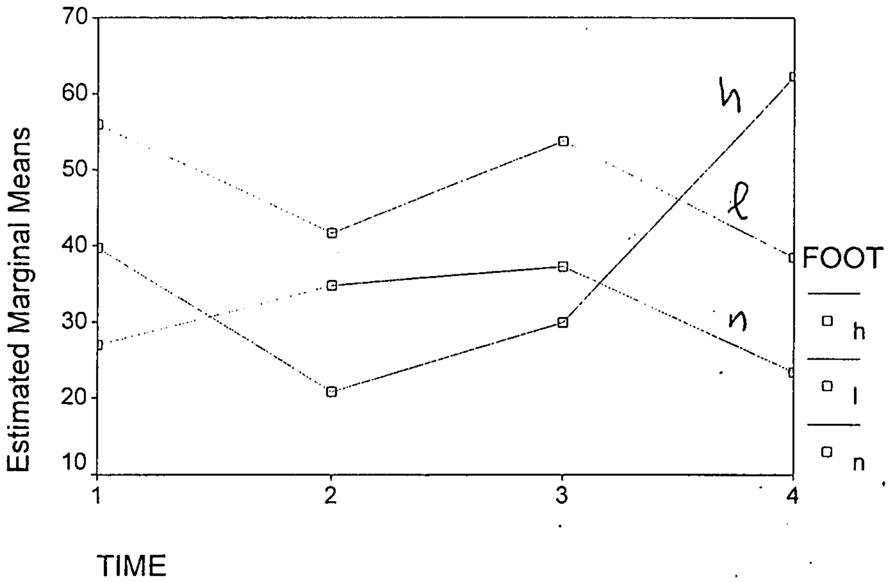
Estimated Marginal Means of CONTACT

At REGN = t1



Estimated Marginal Means of CONTACT

At REGN = t2



Means

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
CT0 * FOOT	600	100.0%	0	.0%	600	100.0%
CT1 * FOOT	600	100.0%	0	.0%	600	100.0%
CT2 * FOOT	600	100.0%	0	.0%	600	100.0%
CT3 * FOOT	600	100.0%	0	.0%	600	100.0%
CT0 * REGN	600	100.0%	0	.0%	600	100.0%
CT1 * REGN	600	100.0%	0	.0%	600	100.0%
CT2 * REGN	600	100.0%	0	.0%	600	100.0%
CT3 * REGN	600	100.0%	0	.0%	600	100.0%

CT0 CT1 CT2 CT3 * FOOT

FOOT		CT0	CT1	CT2	CT3
h	Mean	60.3983	60.0900	62.2183	59.3650
	N	200	200	200	200
	Std. Deviation	17.38096	19.03160	18.42369	18.00622
l	Mean	58.2817	59.8950	59.9517	57.9850
	N	200	200	200	200
	Std. Deviation	15.47391	14.90478	15.34259	15.90906
n	Mean	55.5967	56.3700	55.3333	56.8550
	N	200	200	200	200
	Std. Deviation	18.35364	17.52608	19.40983	18.44117
Total	Mean	58.0922	58.7850	59.1678	58.0683
	N	600	600	600	600
	Std. Deviation	17.19558	17.29473	18.00978	17.48810

t = 4.193 (0.000) 0.00004681

CT0 CT1 CT2 CT3 * REGN

REGN		CT0	CT1	CT2	CT3
hl	Mean	53.2111	56.4778	53.0500	51.5444
	N	60	60	60	60
	Std. Deviation	9.35429	9.76973	10.38575	10.24814
hm	Mean	54.6556	57.5611	54.4611	53.3611
	N	60	t=3.5 60	(0.001) 60	60
	Std. Deviation	9.47153	9.75259	10.33344	10.35751
m1	Mean	55.8444	59.0944	61.1500	59.4833
	N	60	60	60	60
	Std. Deviation	13.41367	13.82907	12.78276	13.45165
m2	Mean	66.1333	61.2222	62.8444	63.1944
	N	60	60	60	60
	Std. Deviation	13.86459	13.12703	13.33735	11.97475
m3	Mean	68.5000	65.3944	67.3000	68.2222
	N	60	60	60	60
	Std. Deviation	14.39535	13.59454	13.02463	11.95466
m4	Mean	68.3000	72.4556	73.4556	71.9889
	N	60	60	60	60
	Std. Deviation	13.91347	13.35520	12.18949	11.93421
m5	Mean	61.3278	68.9000	69.6556	64.8944
	N	60	60	60	60
	Std. Deviation	15.02459	13.78395	13.91377	13.71975
mf	Mean	55.5444	56.5556	57.9111	57.5944
	N	60	60	60	60
	Std. Deviation	24.50812	22.11200	26.03669	24.49606
t1	Mean	48.6167	52.8556	48.5111	47.5111
	N	60	60	60	60
	Std. Deviation	14.18705	15.38120	14.50300	14.10059
t2	Mean	48.7889	37.3333	43.3389	42.8889
	N	60	60	60	60
	Std. Deviation	22.45707	18.53393	22.36215	22.45268
Total	Mean	58.0922	58.7850	59.1678	58.0683
	N	600	600	600	600
	Std. Deviation	17.19558	17.29473	18.00978	17.48810

0.000432597

CT01 $(t_1, t_2) < (mf, m_1)$

$(hl, hm) < m5$

	d_1
hl	3.2667
hm	2.9055
m1	3.25
m2	−4.9111
m3	−3.1056
m4	4.1556
m5	7.5722
mf	1.0112
t_1	4.2389
t_2	−11.4556

Means

Case Processing Summary

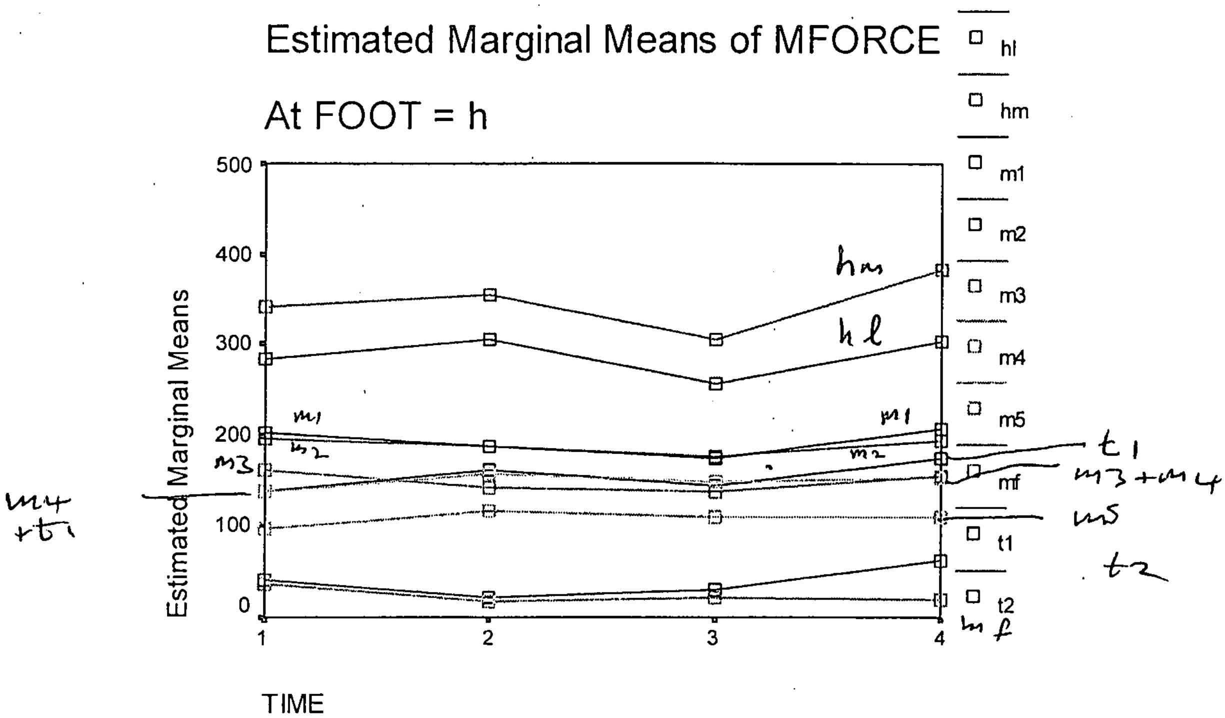
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
MF0 * FOOT	600	100.0%	0	.0%	600	100.0%
MF1 * FOOT	600	100.0%	0	.0%	600	100.0%
MF2 * FOOT	600	100.0%	0	.0%	600	100.0%
MF3 * FOOT	600	100.0%	0	.0%	600	100.0%
MF0 * REGN	600	100.0%	0	.0%	600	100.0%
MF1 * REGN	600	100.0%	0	.0%	600	100.0%
MF2 * REGN	600	100.0%	0	.0%	600	100.0%
MF3 * REGN	600	100.0%	0	.0%	600	100.0%

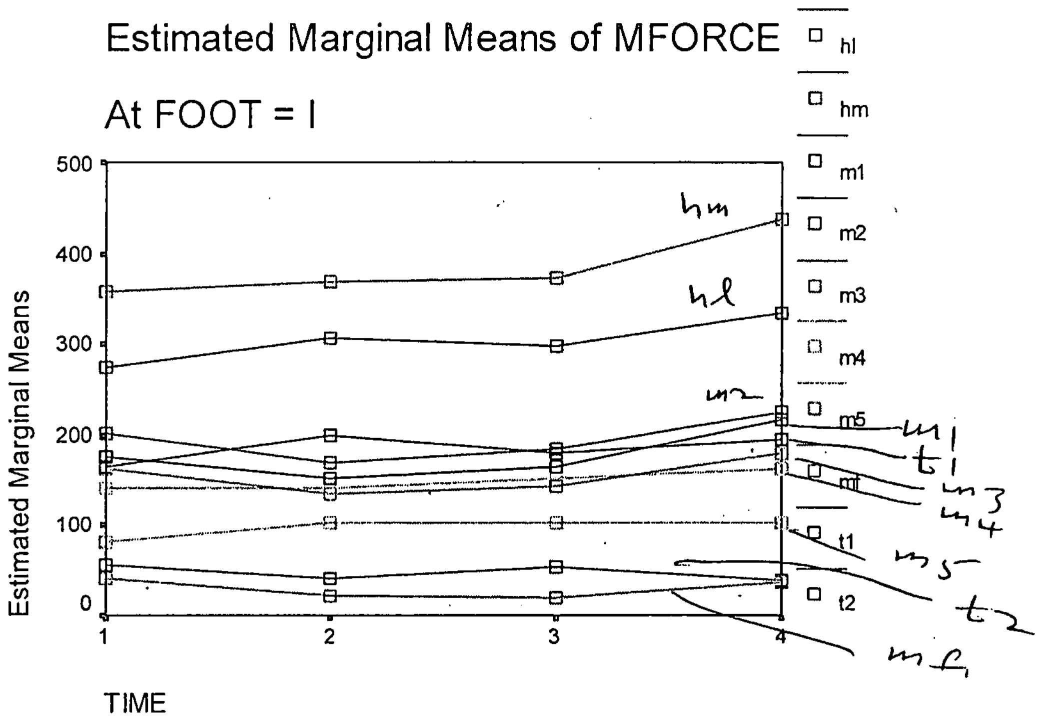
MF0 MF1 MF2 MF3 * FOOT

FOOT		MF0	MF1	MF2	MF3
h	Mean	162.8572	164.5632	149.6850	175.6123
	N	200	200	200	200
	Std. Deviation	122.45989	135.03039	110.16966	140.16007
l	Mean	165.8480	163.8600	167.7305	193.2077
	N	200	200	200	200
	Std. Deviation	127.69394	137.38906	130.08005	141.79443
n	Mean	187.3087	180.9127	177.7825	178.1688
	N	200	200	200	200
	Std. Deviation	139.79351	127.09018	128.01070	126.56284
Total	Mean	172.0046	169.7786	165.0660	182.3296
	N	600	600	600	600
	Std. Deviation	130.42369	133.25358	123.42236	136.33723

MF0 MF1 MF2 MF3 * REGN

REGN		MF0	MF1	MF2	MF3
hl	Mean	294.1306	315.3944	292.3017	318.7900
	N	60	60	60	60
	Std. Deviation	103.00420	124.08783	115.47424	118.72032
hm	Mean	374.1250	368.3156	350.6544	403.6644
	N	60	60	60	60
	Std. Deviation	119.65200	130.33719	124.35458	134.03487
m1	Mean	188.6594	164.9811	166.7106	197.6883
	N	60	60	60	60
	Std. Deviation	102.13251	95.62542	86.41111	88.23495
m2	Mean	204.3561	177.3244	179.7622	204.6156
	N	60	60	60	60
	Std. Deviation	82.23521	76.74285	74.33864	72.96220
m3	Mean	172.2472	144.7467	146.8817	169.0789
	N	60	60	60	60
	Std. Deviation	79.67429	62.47127	53.14029	60.31340
m4	Mean	152.3017	162.8378	160.4006	166.6294
	N	60	60	60	60
	Std. Deviation	84.56200	79.10636	70.84118	71.20694
m5	Mean	100.3089	123.2389	121.4817	118.1089
	N	60	60	60	60
	Std. Deviation	69.47138	70.08526	69.36927	68.87722
mf	Mean	38.8639	26.6600	27.1422	29.4367
	N	60	60	60	60
	Std. Deviation	56.12086	45.29304	40.82942	36.62666
t1	Mean	154.1472	181.8706	165.0039	173.9161
	N	60	60	60	60
	Std. Deviation	76.16721	97.41866	83.32334	87.64004
t2	Mean	40.9061	32.4167	40.3211	41.3678
	N	60	60	60	60
	Std. Deviation	61.57465	38.14200	49.24983	53.79806
Total	Mean	172.0046	169.7786	165.0660	182.3296
	N	600	600	600	600
	Std. Deviation	130.42369	133.25358	123.42236	136.33723


Estimated Marginal Means of MFORCE
At FOOT = h
Estimated Marginal Means
500
400
300
200
100
0
1
2
3
4
TIME
hl
hm
m1
m2
m3
m4
m5
mf
t1
t2


Estimated Marginal Means of MFORCE
At FOOT = l
Estimated Marginal Means
500
400
300
200
100
0
1
2
3
4
TIME
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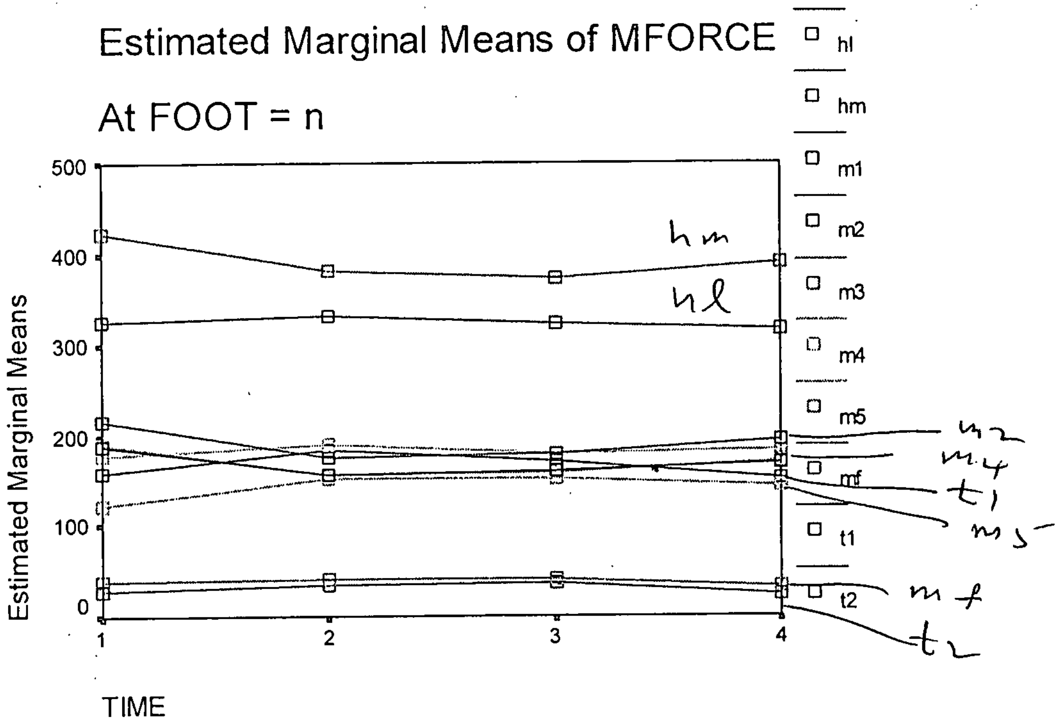
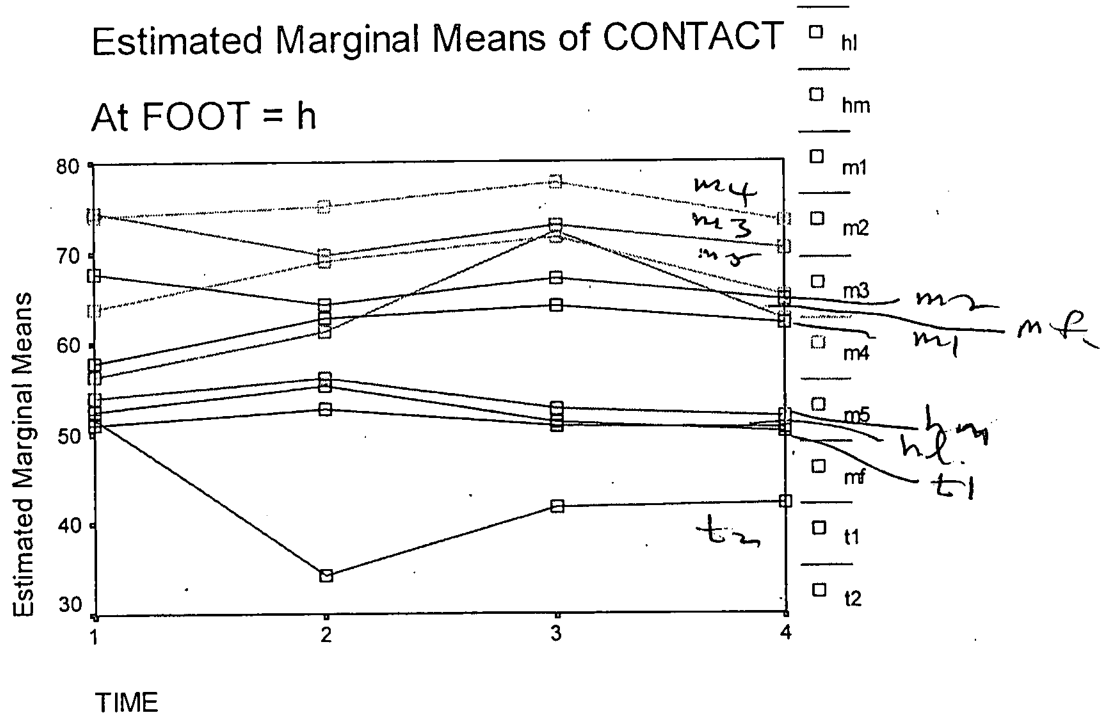
m3
m4
m5
mf
t1
t2


Estimated Marginal Means of MFORCE
At FOOT = n
Estimated Marginal Means
500
400
300
200
100
0
1
2
3
4
TIME
hl
hm
m1
m2
m3
m4
m5
mf
t1
t2


Estimated Marginal Means of CONTACT
At FOOT = h
Estimated Marginal Means
80
70
60
50
40
30
1
2
3
4
TIME
hl
hm
m1
m2
m3
m4
m5
mf
t1
t2

For submission to The Foot.

An investigation to determine the effect of short term low –dye taping on vertical ground reaction forces in asymptomatic pes planus, cavus and normal feet.

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Abstract:

The effect of low –dye taping on maximum ground reaction force and percentage contact time was assessed in 60 participants with asymptomatic feet. Three groups of 20 participants were separated according to their respective foot structures namely pes planus, cavus and normal medial longitudinal arches. Readings were obtained for each of the three groups and for four visits over a 24 hour period. There appears to be a definite trend towards a supinated foot position directly after taping. The taping technique appears to cause an initial foot contact that is less distinctive at the heel but is more widespread throughout the mid and frontfoot regions. Although these trends exist after one hour of taping there seems to be a gradual loss of these effects over a 24 hour period.

1. Introduction:

Low -Dye taping is a method commonly used in sport participation and normal daily activity (Harradine, Herrington and Wright, 2001). It is thought to function by restricting pronation as well as supports the medial longitudinal arch during mid-stance of the gait cycle and in so doing protects the plantar fascia by decreasing the stress along the plantar fascial plate (Tanner and Harvey, 1988, Brantingham et al., 1992 and Ryan, 1995). Taping has been indicated in support of the injured structure, decreasing oedema and protection against re-injury (Reid, 1992:232).

Hunt et al. (2004) evaluated the effectiveness of arch taping in controlling pain during ambulation, taping appeared effective in controlling pain and improving ambulation. Saxelby et al. (1997) reported benefits in plantar fascial symptoms over two days using low -dye taping. A study done by McCloskey (1992) assessed the effect upon foot function using mediolateral force readings from a kistler force plate. It was concluded that low -dye taping significantly altered the mediolateral force.

Contrary to these beliefs, studies have shown that low -dye anti-pronatory control is lost after relatively short episodes of exercise (Ator et al., 1991 and Vicenzino et al., 1997). Both studies found an initial reduction in pronation which was lost following the exercise. Harradine, Herrington and Wright (2001) assessed the effect of low -dye taping upon static pronatory control and dynamic hindfoot motion before and after walking. They found that taping initially reduced static pronation but that effects were lost after 30 minutes walking.

The variations in dynamic foot function with low -dye taping is not well understood, although taping of the foot in low-dye type method has been advocated by many authors (Brantingham et al., 1992, Ryan, 1995 and Chandler and Kibler, 1993).It's relevance in respect to ground reaction forces remains questionable and the efficacy of low dye taping is currently still under debate.

Most overuse injuries caused by excess pronation manifest during weight bearing activities such as standing, walking and running. The effectiveness of any taping technique in the treatment of these injuries depends upon its ability to prevent abnormal pronation for this period of time (Harradine, Herrington and Wright, 2001).

It is the purpose of this study to investigate the maximum ground reaction force and percentage contact time within 10 demarcated regions of the foot in asymptomatic patient with pes planus, cavus and normal medial longitudinal arches. Having established its baseline function it may serve as point of reference for clinical trials that wish to determine the role of taping as part of the management of symptomatic feet.

2. Methods:

2.1 Subjects:

This trial consisted of 60 participants with asymptomatic feet that were divided into three groups of 20. Participants were divided into three groups depending on their respective foot structures. To qualify for one of the three groups subjects had to either have flexible low, high or normal medial longitudinal arches.

Group one consisted of participants with pes cavus (high medial longitudinal arch), group two consisted of participants with pes planus (low medial longitudinal arches) and group three consisted of participants with normal medial longitudinal arches.

2.2 Design:

Maximum ground reaction forces (GRF) and Percent contact time was obtained for each of the three groups and for each of their four visits. GRF were obtained with the aid of a registered orthotist who has agreed to work with the researcher on this project using the RSscan International 1m footscan plate system (Appendix L). The data was interpreted and analysed using the RSscan Clinical Version 7.08 software package.

All three groups underwent the same procedure. Participants were required to walk unassisted and with their natural stride across a one-meter force platform (RSscan International footscan) whilst data was collected for each of the regions of the left foot. An average of three readings was calculated for each time interval.

This procedure took place four times:

1. Once prior to taping
2. Once immediately after taping
3. One hour after taping
4. 24 hours after taping

Maximum ground reaction forces and percentage time spent per region for each of the 10 areas were calculated. The 10 areas of calculation included the, medial heel, lateral heel, mid- foot, first metatarsal, second metatarsal, third metatarsal, fourth metatarsal, fifth metatarsal, hallux and toes 2-5

2.3 Modified Low- Dye taping of the foot:

This taping procedure, as can be seen on the picture of appendix K, consists of a forefoot anchor over the metetarsophalageal joint. Three strips of tape are then taken in a teardrop manner around the calcaneus. All three strips of plaster have their origin at the base of the first metatarsal. Each one is passed around the calcaneus from its medial aspect to its termination at the base of the fifth metatarsal (Appendix K) (Reid 1992:199, Ryan 1995 and Batt and Tanji, 1995).

All taping was done using 38mm Rigid Leuko Sports tape Premium; this tape has been widely endorsed by various sports teams and widely used for its supportive functions during activity (www.sharksmart.co.za).

2.4 Statistical Analysis:

All data was analyzed using the SPSS statistical software package(SPSS Inc., Marketing Department, 444 North Michigan Avenue, Chicago, Illinois, 606611).

Univariate analysis of variance (one way ANOVA) was used to determine the interaction of variables within the set time periods. This method of analysis was also used to determine if any interaction existed between groups and variables in those groups. The Post- Hoc test was used to determine the location of significant values within each subset. The T-test was done to determine the effect of taping on different means at different time intervals.
Repeated measures of variance were also tested within each group against time although they showed no statistical significance. Correlation statistics were run using a significance level of $p <= 0.05$.

3. Results:

3.1 Percent contact time:

Percentage contact time denotes that percentage of stance phase for which a specific region (of the 10 regions) is in contact with the ground.

The percentage contact time means for the different types of arches and different regions as well as their ranks are shown in the tables below.

Table 13: Percentage contact time means for arches at different times

Time

Arch	0	1	2	3
H	60.3983 (1)	60.0900 (1)	62.2183 (1)	59.3650 (1)
L	58.2817 (2)	59.8950 (2)	59.9517 (2)	57.9850 (2)
N	55.5967 (3)	56.3700 (3)	55.3333 (3)	56.8550 (3)

The figure shown in brackets is the rank. Rank 1 indicates the largest mean, rank 2 the second largest mean and so on.

From the Figure 18 it can be seen that the difference between the contact time means for high and low arches is much smaller for time 1 (just after taping) than for the other 3 times (a difference of 0.195 for time 1 versus differences of 2.1166, 2.2666 and 1.38 for times 0, 2 and 3 respectively).

Table 14: Significant differences between means for individual time periods

Time	Significant differences
0	n < h
1	n < l , n < h
2	N < l , n < h
3	None

Table 15: Percentage contact time means for regions at different times

Time

Region	0	1	2	3
m3	68.5000 (1)	65.3944 (3)	67.3000 (3)	68.2222 (2)
m4	68.3000 (2)	72.4556 (1)	73.4556 (1)	71.9889 (1)
m2	66.1333 (3)	61.2222 (4)	62.8444 (4)	63.1944 (4)
m5	61.3278 (4)	68.9000 (2)	69.6556 (2)	64.8944 (3)
m1	55.8444 (5)	59.0944 (5)	61.1500 (5)	59.4833 (5)
Mf	55.5444 (6)	56.5556 (7)	57.9111 (6)	57.5944 (6)
Hm	54.6556 (7)	57.5611 (6)	54.4611 (7)	53.3611 (7)
Hl	53.2111 (8)	56.4778 (8)	53.0500 (8)	51.5444 (8)
t2	48.7889 (9)	37.3333 (10)	43.3389(10)	42.8889(10)
t1	48.6167(10)	52.8556 (9)	48.5111 (9)	47.5111 (9)

The figure shown in brackets is the rank.

Table 16: Differences between percentage contact time means for successive time periods for each of the regions

Difference

Region	Ct1-ct0	ct2-ct1	ct3-ct2	Ct3-ct0
hl	3.2667	-3.4278	-1.5056	-1.6667
Hm	2.9055	-3.1	-1.1	-1.2945
m1	3.2500	2.0556	-1.6667	3.6389
m2	-4.9111	1.6222	0.35	-2.9389
m3	-3.1056	1.9056	0.9222	-0.2778
m4	4.1556	1	-1.4667	3.6889
m5	7.5722	0.7556	-4.7612	3.5666
Mf	1.0112	1.3555	-0.3167	2.05
t1	4.2389	-4.3445	-1	-1.1056
t2	-11.4556	6.0056	-0.45	-5.9

3.2 Maximum force:

Maximum force denotes the highest amount of force within each of the ten devisions of the foot.

The maximum force means for the different types of arches and different regions as well as their ranks are shown in the tables below.

Table 19: Maximum force means for regions at different times

Region	0	1	2	3
hm	374.1250 (1)	368.3156 (1)	350.6544 (1)	403.6644 (1)
Hl	294.1306 (2)	315.3944 (2)	292.3017 (2)	318.7900 (2)
m2	204.3561 (3)	177.3244 (4)	179.7622 (3)	204.6156 (3)
m1	188.6594 (4)	164.9811 (5)	166.7106 (4)	197.6883 (4)
m3	172.2472 (5)	144.7467 (7)	146.8817 (7)	169.0789 (6)
t1	154.1472 (6)	181.8706 (3)	165.0039 (5)	173.9161 (5)
m4	152.3017 (7)	162.8378 (6)	160.4006 (6)	166.6294 (7)
m5	100.3089 (8)	123.2389 (8)	121.4817 (8)	118.1089 (8)
t2	40.9061 (9)	32.4167 (9)	40.3211 (9)	41.3678 (9)
Mf	38.8639 (10)	26.6600 (10)	27.1422 (10)	29.4367 (10)

The figure shown in brackets is the rank.

Throughout the 4 time periods the largest maximum force is in the heel region (hm and hl) and the smallest are the mid foot, small toes and outside front foot regions (mf, t2 and m5).

Both heel regions and the outside foot region (m5) show a slightly upward trend over time. The mean maximum force for the small toes region stays the same over time, while that for the mid foot region decreases over time.

Of the remaining 5 regions that occupy ranks 3 to 7 regions t1 and m4 show slight increases over time, while regions m1, m2 and m3 stay the same over time.

Figure 20: Plots of maximum force means for regions at different times

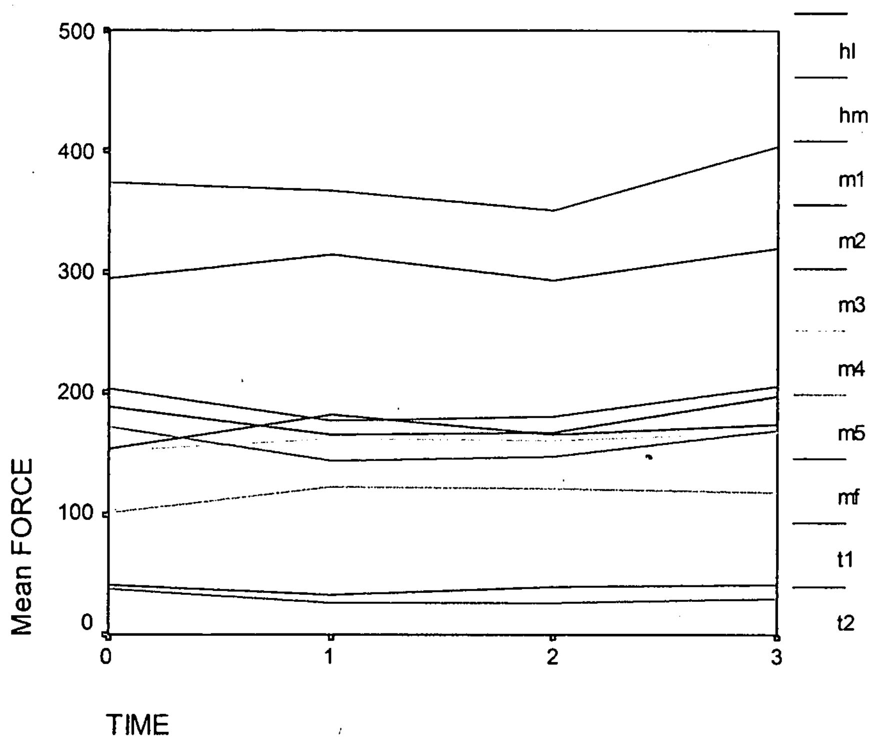

Table 20: Differences between maximum force means for successive time periods for each of the regions

Region	Ct1-ct0	Ct2-ct1	ct3-ct2	ct3-ct0
Hl	21.2638	-23.0932	26.4883	24.6589
Hm	-5.8094	-17.6612	53.01	29.5394
m1	-23.6783	1.7295	30.9777	9.0289
m2	-27.0317	2.4378	24.8534	0.2595
m3	-27.5005	2.135	22.1972	-3.1683
m4	10.5361	-2.4372	6.2288	14.3277
m5	22.93	-1.7572	-3.3728	17.8
Mf	-12.2039	0.4822	2.2945	-9.4272
t1	27.7254	-16.8667	8.9122	19.7709
t2	-8.4894	7.9044	1.0467	0.4617

4. Discussion:

1. The distribution of maximum force in the three groups were similar throughout al the time periods(immediately after taping, one hour after taping and 24 hours after taping):

    I. Immediately after taping there seemed to be a shift of maximum force away from the hindfoot and towards the lateral aspect of the frontfoot (metatarsal 4 and 5) with a decrease of maximum force over metatarsal 2 and 3 and a decrease of maximum force at metatarsal 1. This could be due to the transverse anchoring and securing straps elevating the metatarsals. This is supported by Saxelby, Betts and Bygrave, (1997) who suggests that these findings could be an indication of decreased pronation of the foot.

    II. A the trend towards front foot maximum force is seen again at 1 hour after taping with a decrease in heel maximum force, a greater maximum force at the midfoot and at the metatarsals 1, 2 and 3. This may indicate a loss of tensile strength or adhesive properties of the tape (Vicenzino et al, 1997; and Harradine, Herrington and Wright, 2001).

    III. The changes seen at the 24 hours reading suggests an incomplete return to the maximum forces seen prior to the initial taping (as evident at the increase in force of the heel strike as well as the mid foot increasing in maximum force but still remaining far from its high force value and the maximum force at metatarsal 3 remaining unchanged). This indicates some restriction from the taping in this region. Metatarsal 1 and 4 compensates for this deficiency by having increased maximum force values.

2. The distribution of percent contact time in the three groups were similar throughout al the time periods(immediately after taping, one hour after taping and 24 hours after taping):

    I. Percent contact time increase in metatarsal 4, 5, and metatarsal one indicating a shift of contact from the centre of the foot to the peripheral structures. The increased contact of the heel regions support Hunt et al (2004) in their theory of calcaneal sagital restriction by the swing like strap around the heel. An increased contact time at toe 1 and deceased contact at toe 2-5 indicate a larger degree of toe off.

II. The readings at time period two indicates a slight increase of contact at metatarsal 2 and 3. The remainder of the metatarsals and the midfoot increase in contact time while both the heel regions undergo a drastic decrease in contact. This may indicate a further shift to the front and midfoot regions.

III. Twenty four hours after the employment of the tape there seems to be a trend to returning to the pre –taped contact time readings. Metatarsal 2 and 3 increase their contact while metatarsal 4 and 5 decrease their contact with the ground. The midfoot region seems to decrease contact time slightly together with metatarsal 1 and the first toe. These findings seem to support the theory of limited use of adhesive taping as stated by Vicenzino et al, (1997) and Harradine, Herrington and Wright, (2001).

5. Conclusion:

In summary there appears to be a definite trend towards a supinated foot position directly after taping. This is supported by the increased contact time and maximum force over metatarsals 4 and 5. The low-dye taping appears to be elevating metatarsals 2 and 3 and in the process restricting their motion. The taping technique appears to cause an initial foot contact that is less distinctive at the heel but is more widespread throughout the mid and frontfoot regions. Although these trends exist after one hour of taping there seems to be a gradual loss of these effects over time so that after 24 hours a definite regression can be observed. These findings may indicate a complete return to the pre- taped condition over a longer period of time.

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