The Effect of Foot Type on Lower Extremity Muscle Activity and Center of Pressure

By
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ABSTRACT
SEAN M. KUPIEC: The Effect of Foot Type on Lower Extremity Muscle Activity and Center of Pressure
(Under the direction of Dr. Kevin M.Guskiewicz)

The purpose of this study was to examine how foot type and a foot orthotic device (FOD) affect electromyography (EMG) and kinetic data (COP). Thirty-nine individuals (20 with normal and 19 with pronated feet) were tested in overground walking in a pretest-posttest design. Results of statistical analyses show no significant differences with regards to onset and duration of the tibialis anterior, peroneus longus, vastus medialis (VMO), and gluteus medius muscles. These results suggest there is no difference in onset and duration, between normal and pronated feet. There was a trend specifically with VMO duration, suggesting a possible shorter duration time with FOD intervention. The COP examination indicated that the normal group had significantly greater COP excursion during the first 50% of stance phase. Also, a similar trend in greater normal foot COP excursion existed between the groups for the entire stance phase.

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LIST OF ABBREVIATIONS

Avg	Average
COP	Center of Pressure
EMG	Electromyography
ESJP	Excessive Subtalar Joint Pronation
FOD	Foot Orthotic Device
GMO	Gluteus Medius Onset
GMD	Gluteus Medius Duration
L_M	Center of Pressure Excursion Loading to Midstance
L_P	Center of Pressure Excursion Loading to Propulsion
ND	Navicular Drop
PLO	Peroneus Longus Onset
PLD	Peroneus Longus Duration
PoN	Post Test No Foot Orthotic Device
PoF	Post Test with Foot Orthotic Device
Pre	Pre Test
TAO	Tibialis Anterior Onset
TAD	Tibialis Anterior Onset
VMOO	Vastus Medialis Obliqus Onset
VMOD	Vastus Medialis Obliqus Duration

Chapter 1: Introduction

Lower extremity injuries, especially in the athletic population, are often a multifactoral problem. They may stem from a variety of anatomical locations, and begin at a location other than where symptoms are being experienced. In some conditions, it is difficult to specifically isolate and treat the source of the problem. Research has shown that the one factor contributing to lower extremity dysfunction more than any other is excessive/compensatory subtalar joint pronation (ESJP) (Tomaro and Burdett, 1993). Pronation is a dynamic measurement due to it's triplanar movement. Normal pronation is crucial to normal biomechanical function of the ankle foot, but can lead to injury if it occurs excessively or in a compensatory manner (Tomaro and Burdett 1993; Rockar 1995).

ESJP occurs when the threshold of normal limits of pronation, approximately six degrees, is exceeded (Subotnick, 1975). This resultant ESJP has been found to facilitate several deleterious conditions both distally and proximally along the kinetic chain. The treatment of choice for ESJP has often been to create a foot orthotic device (FOD). The use of FODs has been shown to decrease symptom severity and even eliminate symptoms completely in individuals as high up the kinetic chain as the knee (Nawoczenski, Cook et al. 1995; Ball and Afheldt 2002; Gross and Foxworth 2003). Research has also shown that the majority of individuals receiving FODs experienced relief of symptoms such as pain, and chose to continue use of the device following the cessation of their symptoms (Donatelli, Hurlbert, Conaway, and Pierre, 1988).

The immediate direct effect of FODs occurs at the foot/ankle complex. The goal of the FOD at the ankle joint is to restore optimal biomechanical function, eliminate harmful excessive movement, and prevent possible injury and abnormal forces throughout the kinetic chain-by placing the foot in a more neutral position (Donatelli 1987; Donatelli 1988; Razeghi and Batt 2000; Stacoff, Reinschmidt et al. 2000; Stackhouse, Davis et al. 2004). For individuals who exhibit ESJP, typically the course of action is to post the medial foot under the longitudinal arch by "bringing the floor to the foot"(Hunter 1996). Also, directly at the foot/ankle, the FOD serves to attenuate forces produced during bouts of physical activity that may lead to overuse injuries (Nigg 1999).

The indirect effects of FODs help to prevent possible medially displacement of the knee (valgus), as well as adduction and internal rotation at the hip (Nester 2000; Gross and Foxworth 2003). Thus, the effects of ESJP can be seen throughout the entire kinetic chain.

Commonly, lower extremity pathology is a result of three manifestations of ESJP, magnitude, velocity, and timing (Tiberio 1988). Magnitude refers to excessive motion allowed by ESJP. In the event this excessive motion continues to press the available limits, stabilizing structures and noncontractile tissues such as the joint capsule or ligaments may then sustain injury. (Tiberio 1988). Velocity refers to the speed of the ESJP. The resultant increases in velocity of a lower extremity with ESJP forces the eccentric decelerating structures to carry the load often leading to stress at the muscle-tendon unit. (Tiberio 1988). Finally, timing refers to occurrence of motion at an improper moment of the gait cycle. ESJP can disturb the natural sequence of motion of pronation/supination during gait possibly allowing them to occur at the wrong time. If allowed to continue, this disruption can alter motion through the entire lower extremity, and may then lead to injuries of load bearers such

as the forefoot or possible more proximal structures at the knee and hip. (Tiberio 1988). Specific resultant pathologies include hallux valgus deformity and decreased weight bearing of the great toe leading to compensatory weight bearing on the second metatarsal (Tiberio 1988).

Another factor to consider when examining ESJP is the potential indirect effect on muscle activity. The possible resultant positions as described above (internal tibial rotation, knee valgus, internal femoral rotation, and adduction and internal rotation of the hip) may actually inhibit muscular function, which is critical to stability in the ankle/foot, knee, and hip. Disruption of the length-tension relationships governing normal biomechanics will cause muscles to be lengthened or shortened based on the position they are forced into. This change in length will no longer allow the muscles to function appropriately due to fatigue/inhibition and may facilitate the cascade into pathology of vital arthrokinematic structures. The cuboid pulley is essential for the peroneus longus to provide stability to the foot/ankle complex (Root ML 1977). In the knee the vastus medialis obliqus (VMO) is critical to maintaining proper tracking of the patella (Neptune, Wright et al. 2000). Finally, the gluteus medius functions to eccentrically control internal rotation of the hip (Clark 2001).

Studies examining the impact of FODs on lower extremity muscle activity (EMG) have shown both an increase and decrease in the activity of specific muscles (Tomaro and Burdett 1993; Nawoczenski and Ludewig 1999; Hertel, Sloss et al. 2005). A possible explanation for these results may be the restoration of proper length-tension relationships and neuromuscular activation (Hertel, Sloss et al. 2005). These results are promising, yet all limit their focus to amplitude solely, without addressing onset and duration. Therefore it is important to

determine what possible ramifications a FOD has on all facets of EMG and COP if efforts are to be made to maximize performance through their use.

Statement of the problem:

The purpose of this study was to examine the differences in lower extremity EMG onsets and durations of musculature surrounding the foot/ankle, knee, and hip, between a neutral and pronated foot-type. Additionally, the effect of FOD intervention on these foot-types was studied with regard to EMG (onsets and durations) and kinetic (COP) data.

Research Questions:

1. Is there a significant difference in lower extremity EMG timing characteristics of the tibialis anterior (TA), peroneus longus (PL), vastus medialis oblique (VMO), and gluteus medius (GM) between a pronated and normal foot type during a walking task.
2. Is there a significant interaction effect between FOD conditions and baseline across the normal and pronated foot type groups in EMG as measured by onset, and duration on the TA, PL, VMO, and GM.
3. Is there a significant difference in COP from loading to midstance, and from loading to propulsion between a pronated and normal foot type?
4. Is there a significant interaction effect between FOD conditions and baseline across the normal and pronated foot type groups in COP, from loading to midstance, and from loading to propulsion?

Research Hypotheses:

1. TA, PL, VMO, and GM onset time will be significantly earlier for the normal foot-type as compared to the pronated foot-type.
2. TA, PL, VMO and GM duration time will be significantly greater for the normal foot-type as compared to the pronated foot-type.
3. There will be a significant interaction effect between FOD conditions and baseline across the normal and pronated foot type groups in EMG as measured by onset, and duration on the TA, PL, VMO, and GM.
4. The normal foot type will have significantly less excursion in COP path values from loading to midstance and loading to propulsion than the pronated foot type.
5. There will be a significant interaction effect between FOD conditions and baseline across the normal and pronated foot type groups in COP path values from loading to midstance and loading to propulsion.

Null Hypotheses:

1. There will be no difference in TA, PL, VMO, and GM onset time between groups.
2. There will be no difference in TA, PL, VMO, and GM duration time between groups.
3. There will be no significant interaction effect between FOD conditions and baseline across the normal and pronated foot type groups in EMG as measured by onset, and duration on the TA, PL, VMO, and GM.
4. There will be no difference in COP path between the pronated and normal foot type.
5. There will be no significant interaction effect between FOD conditions and baseline across the normal and pronated foot type groups in GRF as measured by COP path.

Definition of Terms:

Center of Pressure (COP)**:** Point at which all forces exerted by a person can be centralized.

Electromyography (EMG): Measure of the electrical activity within a muscle. Utilized to determine activation patterns such as onset and duration, and can also measure amplitude.

Gait: The normal ambulation of an individual about their feet.

Ground Reaction Force: Forces exerted by a person as they contact the ground.

Kinetic Chain: The interdependent network of articulations in the human body.

Pronation: Measurable degree to which the foot and calcaneus everts, navicular drops, and metatarsals splay out.

Operational Definitions:

COP Excursion: Amount of displacement (mm) COP path varies in weight bearing stance.

Forefoot Varus: Osseous deformity in which medial metatarsal heads are inverted in relation to the plane of the calcaneus.

Foot-Type: Postural presentation of foot and its exhibition of a pronated, normal, or supinated position as measured by navicular drop in both weight and non-weight bearing.

Navicular Drop: Assessment of the navicular tuberosity and the difference of its height compared between subtalar neutral in a non weight-bearing position and a relaxed weight-bearing stance. An excessive navicular drop measurement is greater than 10mm whereas a normal measurement is less than 7mm.

Orthotic/Foot Orthotic Device (FOD): Device that is molded to an individual's foot and utilized to help correct biomechanical faults and to help alleviate undesirable symptoms associated with foot pathology. AMFIT custom orthoses will be used in this study.

Pronated: Position in weight bearing resulting in excessive navicular drop and flattening of the medial longitudinal arch, causing the medial aspect of the talar head to be more palpable.

Rearfoot Varus: Deformity which, in non-weight bearing subtalar neutral position, the calcaneus is inverted in relation to the lower leg.

Subtalar Neutral: Position in which the talus is equally prominent on the medial and lateral aspects of the ankle anteriorly while in non-weight-bearing.

Supinated: Position while the foot is in weight bearing resulting in calcaneal inversion and causing the lateral aspect of the talar head to be more palpable.

Stance Phase of Gait: portion of gait and in which the foot is in contact with the force plate.

Assumptions:

1. Participants will walk normally during walking trials.
2. FODs were fabricated correctly and successfully fit to individual's feet.
3. There will be differences in the amount of necessary FOD intervention among the population.
4. EMG procedure will be reliable and valid in measuring muscle onset and activity of TA, PL, VMO, and GM from baseline to post-testing sessions.

Limitations:

1. Participants may have altered normal walking biomechanics during analysis because they knew they were under assessment.
2. Surface EMG procedures do not assess muscle activity as reliably or validly as compared to indwelling EMG electrodes, due to variables like cross talk.

Delimitations:

1. Individuals exhibiting pes cavus or supinated foot stature during foot assessment were excluded from this study.
2. Participants other than adult recreational athletes were excluded from this study.
3. Only participants assessed to have normal or pronated foot types were included.
4. A podiatrist skilled in FOD interventions performed FOD fabrication.
5. Participants were measured in one session and fitted for FODs, reported for a second session to receive FODs, and attended a third session for final data collection.

Significance of the Study

Research has shown differences in EMG of foot/ankle musculature between FOD control and experimental groups during activities such walking and running. Specifically, the TA, during walking and running has previously been shown to have a longer duration and greater amplitude respectively during the stance phase of gait during a FOD condition than without a FOD (Tomaro and Burdett 1993; Nawoczenski and Ludewig 1999). Research utilizing FODs and EMG should not be limited to foot/ankle however, as several other pathologies throughout the kinetic chain have been implicated with regards to ESJP, and have great implications for gross motor movement in sport and physical activity. Such dysfunctions include but are certainly not limited to patellofemoral pain syndrome (PFPS) (Eng and Pierrynowski 1993), and low back pain (Bird, Bendrups et al. 2003), and each have cited successful results with the use of FODs. In a recent study examining the effect of FODs more proximally at the knee and hip, VMO and GM activity was shown to increase in both a single leg squat with FOD and lateral step down with FOD (Hertel, Sloss et al. 2005). These

instances of increase in TA, VMO, and GM activity coincide with the goals of both rehabilitation and injury prevention to facilitate muscle activity in efforts to either re-establish or enhance neuromuscular control (Blackburn 2003).

Kinetic data analysis may also play a role in examining lower extremity biomechanics typically with postural/neuromuscular control. Hertel et al. (2002) found that individuals with a more pes cavus foot type exhibited greater COP excursion area than those with a pes planus foot. The authors sought to explain this by one of two methods. The first being that there was no medial block stopping the collapse into pronation. The second was due to the lack of ground contact; the cavus foot type lacked the afferent sensory input available to that of the planus foot. The implications of this finding may be useful as a measure of neuromuscular control and the stability of the foot/ankle complex during ambulation.

The literature is very limited regarding studies of the effect of foot type and FOD on lower extremity muscles at the knee and more proximally during gait. The number of studies that utilize both EMG and kinetic data is even fewer. By examining both EMG and kinetics during gait, a more global view and understanding of the effect of foot type and ultimately a FOD on the entire lower extremity and kinetic chain can be achieved.

Chapter 2: Literature Review

Introduction

This review of literature serves to provide information regarding FOD intervention, EMG, and kinetic data on individuals with excessive compensatory pronation. An anatomical overview and biomechanical analysis will provide background on involved structures and their proper functions, and common abnormalities. FODs will be discussed as well as the concepts of EMG and kinetics in an attempt to determine the effect of excessive pronation on muscle activity up the kinetic chain.

Anatomical Overview of the Lower Extremity

Bone

Foot/Ankle

The ankle joint is formed proximally by the tibia medially and the fibula laterally and distally by the hindfoot, consisting of the talus and calcaneus (Anderson, 1997). The talus sits superiorly upon the calcaneus forming the subtalar joint. The talus has a head, neck, and body and is wider anteriorly than posteriorly creating a bony wedge that fits into what is often called the ankle mortise (Moore 1999). The calcaneus, often referred to as the heel bone, is the foots strongest and largest bone and transmits body weight forces from the talus to the ground.

The remaining bones of the foot are the navicular, cuboid, three (3) cuneiforms, five (5) metatarsals, and fourteen (14) phalanges. The navicular is bordered by the talus posteriorly and the cuneiforms anteriorly (Moore 1999).This bone is commonly used as a reference point when assessing foot type, specifically when examining amount of pronation (Kelly 2003).

The cuboid is positioned laterally to the navicular and cuneiforms and is bordered posteriorly by the calcaneus and anteriorly by the fourth and fifth metatarsals. The cuboid is critical to normal biomechanical functioning of the foot and essentially the entire lower extremity. This is due to a tuberosity on the inferiolateral aspect, forming a groove for the peroneus longus, called the "cuboid pulley." The cuboid pulley allows for the stabilization of the first ray by the peroneus longus as the foot moves through toe-off. (Donatelli 1985; Donatelli 1987).

The cuneiforms are numbered one through three from medial to lateral with the first located on the medial aspect of the foot. All three are bordered posteriorly by the navicular and anteriorly by metatarsals one, two, and three. Together, the talus, calcaneus, cuboid, navicular, and (3) cuneiforms form the tarsus. (Moore 1999). The metatarsals comprise the metatarsus and are bordered by the cuneiforms and cuboid posteriorly, and the phalanges anteriorly. The phalanges are commonly referred to as the toes. Each toe has three phalanxes except for the first toe, which has two. These separate bones are classified as either proximal, middle, or distal (Rockar 1995; Moore 1999) . The metatarsals and phalanges comprise what is called the forefoot and the talus and calcaneus form the hind or rearfoot (Anderson 1997).

Bone: Knee Joint

The knee joint is formed primarily by the articulation of the medial and lateral femoral condyles proximally upon the medial and lateral tibial condyles distally. This contact occurs

on the flat superior surface of the tibia called the tibial plateau. In the center of the plateau is an eminence, which fits with the intercondylar notch of the femur. The tibia is a primary weight bearing bone located in the anteromedial aspect of the lower leg. Proximally the tibia is triangularly shaped and as it continues distally, the tibia becomes broad where is articulates with the ankle joint forming the medial malleolus (Moore 1999).

Proximally, but not forming a true component of the knee joint, the fibula articulates posteriorly with the inferior aspect of the lateral condyle of the tibia. An interosseous membrane connects the fibula and tibia between their proximal and distal articulations. The fibula runs somewhat parallel to the tibia with a twisted shaped forming the location of several muscle attachments, thus establishing its importance to lower extremity function. Distally the fibula articulates with the ankle by forming the lateral malleolus. (Moore 1999).

Moving superiorly but still at the knee an articulation also exists between the patella and femur anteriorly. The patella is located on the anterior aspect of the knee with its anterior surface attached to the quadriceps tendon. The posterior surface of the patella articulates within the trochlear groove of the femur moving superiorly and inferiorly during knee flexion and extension. The patella serves to provide a mechanical advantage to knee motion during gait (Moore 1999).

Bone: Hip Joint

The hip joint is the most proximal articulation of the lower extremity, and connects the lower extremities to the axial skeleton. The hip is responsible for facilitating locomotion and supporting the weight of the upper body. This joint is formed by the articulation of three hip bones proximally and the femur distally via the acetabulum. The complete hip bone, commonly referred to as an innominate, is created by the ossification of the ilium, ischium, and pubis bones. Each of these three bones serves as attachments for muscles of the lower extremity. The ilium is the largest and superiorly positioned bone and upon its lateral aspect are landmarks termed the posterior, anterior, and inferior gluteal lines which serve as attachments for the gluteal muscles. The ischium is the most inferior of the bones and comprises the majority of the acetabulum both inferiorly and posteriorly. The pubis is found anteromedially and forms the anterior portion of the acetabulum. The acetabulum is cup shaped and forms the socket portion of the joint. The border of this structure is incomplete inferiorly to allow congruency with the head of the femur. (Moore 1999).

The femur is the longest bone in the human body, and is responsible for the transmission of force/body weight from the hip to the tibia during weight bearing activities. Proximally it articulates superiomedially and slightly anteriorly with the hip via the head of the femur. The insertion of the femoral head into the acetabulum forms the ball portion of the hip joint. The body of the femur is predominantly smooth except for the vertically running ridge on the posterior aspect called the linea aspera. This line continues inferiorly where it splits to form condylar lines at the distal end of the femur. These condylar lines lead to the medial and lateral femoral condyles. Anteriorly, these condyles border the trochlear groove, site of

articulation with the patella, and posteriorly, they create the intercondylar notch. All four landmarks define the articulating surface of the femur at the knee joint (Moore 1999).

Musculature

Muscle: Leg, Anterior Compartment

Four muscles comprise the anterior compartment of the lower leg, the tibialis anterior, extensor digitorum longus, extensor hallucis longus, and peroneus tertius (Moore 1999). The primary function of these muscles to dorsiflex the ankle. Tibialis anterior has proximal attachments on the tibia and distal attachments on the first cuneiform and first metatarsal. In conjunction with dorsiflexion, it also inverts the foot/ankle, and serves to eccentrically decelerate the action of plantar flexion during locomotion. The extensor digitorum longus proximally attaches to the tibia and upper ¾ of the fibula, and distally to the middle and distal phalanges of the lateral four digits. This muscle functions to extend the lateral four digits. The extensor hallucis longus attaches proximally to the anterior fibula and distally to the base of the distal phalanx of the great toe on the dorsal side. This muscle functions to extend the great toe. Finally, the peroneus tertius attaches proximally on the distal 1/3 of the anterior fibula and distally at the base of the fifth metatarsal. The peroneus tertius assists the muscles of the lateral compartment in eversion of the foot (Moore 1999).

Muscle: Leg, Lateral Compartment

The peroneus longus and peroneus brevis are the two muscles included in the lateral compartment of the lower leg. Both function to evert the foot as well as assist in ankle plantarflexion (Moore 1999). The peroneus longus proximally attaches to the superiolateral 2/3 of the fibula and runs along the plantar surface of the foot to attach distally on the base of

the first metatarsal and first cuneiform. The peroneus brevis attaches proximally at the inferiolateral 2/3 of the fibula and distally at the base of the fifth metatarsal (Moore 1999).

Muscle: Leg, Superficial Posterior Compartment

The muscles in this compartment function primarily to plantarflex the foot/ankle and include the gastrocnemius, soleus, and plantaris. Each of these muscles shares a common distal attachment through the achilles tendon insertion to the calcaneus. The combination of the gastrocnemius and soleus is commonly referred to as the triceps surae (Moore 1999). The gastrocnemius has two heads-medial and lateral. Medially the proximal attachment is upon the posterior femur proximal to the medial condyle. Laterally the proximal attachment is the lateral condyle of the femur. Specifically, the gastrocnemius plantarflexes the foot/ankle while in knee extension, and assists in knee flexion. The soleus' proximal attachment spans both the fibula and tibia beginning at the posterior head of the fibula along the soleal line and also from the medial border of the tibia. The soleus functions independent of the knee to plantarflex the foot/ankle. The plantaris proximally attaches to the lateral supracondylar line proximal to the lateral femoral condyle. The plantaris assists the motions of the gastrocnemius (Moore 1999).

Muscle: Leg, Deep Posterior Compartment

Four muscles are located within the deep posterior compartment; they include the popliteus, flexor hallucis longus, flexor digitorum longus, and tibialis posterior, the latter three muscles perform or assist in foot/ankle plantarflexion. The popliteus proximally attaches to the lateral femoral condyle and attaches distally upon the posterior tibia above the soleal line. This muscle has the distinction of "unlocking" the knee, assists in flexion of the knee (Moore 1999). The flexor hallicus longus attaches proximally on the inferior 2/3 of the

posterior fibula and distally at the base of the distal phalanx of the great toe, and functions to flex the great toe. The flexor digitorum longus attaches proximally on the posteriomedial tibia inferior to soleal line and also to the fibula. Distally the tendons attach at the bases of the distal phalanxes of the four lateral toes functioning to flex the lateral four digits, and to plantarflex the ankle. The tibialis posterior attaches proximally on the posterior tibia and fibula inferior to the soleal line, and distally to the navicular, first cuneiform, cuboid, and bases of metatarsals two, three, and four. The tibialis posterior functions to plantarflex and invert the foot/ankle (Moore 1999).

Muscle: Quadriceps

The quadriceps muscle group consists of four muscles, the rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis-which can be further divided into the vastus medialis obliqus (VMO), all of which function to extend the knee (Moore 1999). Specifically, the VMO is important in the maintenance of proper kinematic function of the knee. Weakness of the VMO has shown to produce conditions such as increased valgus moments (instances of medial shifting) during movement and lateral tracking of the patella in the trochlear groove, leading to patellofemoral pain (Houglum 2001; Gross and Foxworth 2003).

Muscle: Hip

The gluteus muscle group is located at the hip and contains three different muscles. The gluteus maximus is found on the posterior ilium running to the gluteal tuberosity of the femur, with some fibers terminating in the iliotibial band. This muscle functions primarily in hip extension while serving as an synergist in lateral rotation (Moore 1999). The gluteus medius runs from the external ilium via the anterior and posterior gluteal lines and the gluteus minimus runs from the anterior and inferior lines. Both muscles attach to the greater

trochanter of the femur, with the gluteus medius attaching on the lateral aspect, and the gluteus minimus on the anterior aspect. These muscles abduct and medially rotate the thigh (Moore 1999).

Biomechanics of the Lower Extremity

Normal

Motion of the foot depends primarily upon two articulations: the subtalar joint, and the midtarsal joint. The subtalar joint consists of the talus and calcaneus. The subtalar joint facilitates the motions of both pronation and supination (Donatelli 1985). Due to the dynamic functions of the foot/ankle during ambulation, the subtalar joint moves the foot from a position of pronation to supination during the stance phase (Subotnick 1975). The subtalar joint must allow for approximately 18^{o} of motion, with supination constituting two thirds of that motion. Thus 12^{o} of supination and 6^{o} of pronation must occur in order to appropriately and safely attenuate forces. The 6^{o} of pronation come from a reference starting position of the joint in 2^{o} supination at heel strike, immediately followed by a rapid pronation into 4^{o}, equaling the 6^{o} (Subotnick 1975). Proper functioning of the subtalar joint is imperative to the healthy maintenance of the entire lower extremity kinetic chain due to its responsibility of force absorption. It is because of this pronation/supination mechanism that the subtalar joint has been described as a torque converter as rotational force from the tibia is attenuated (Root ML 1977). The movement medially of the talus as the calcaneus everts laterally, allows for the normal internal and external rotation of the tibia upon the ankle complex.

The midtarsal joint itself is composed of two articulations: the talonavicular and calcanealcuboid joints. These two components of the midtarsal joint create and function via two separate, yet interdependent, axes of motion, the longitudinal and transverse (Subotnick 1975). The main axis that facilitates movement is the longitudinal. In a neutral foot position the axes are positioned in a more stable, oblique fashion when compared to each other. As the foot moves into pronation the axes become more parallel, unlocking the midtarsal joint and allowing the foot to become the "loose bag of bones" necessary for adaptation. Conversely, supination allows the axes to become more oblique restoring rigidity as the joint locks to provide an effective push off (Subotnick 1975).

Normal gait should have the following affect on the foot/ankle: At heel strike the subtalar joint should be in a slightly supinated position and the midtarsal joint axes positioned obliquely to each other. As the foot moves into the stance phase, the subtalar joint pronates unlocking the midtarsal joint causing its axes to become more parallel. This process should be completed in the first 25% of the stance phase so that the foot can effectively transition into the midstance phase. Approximately at the middle of midstance the foot should be in a neutral position with the subtalar joint in neutral and the midtarsal joint locked with oblique axes creating stability. Following neutral midstance the heel raises, and the calcaneus should invert approximately 2^{o} as the first ray plantarflexes and everts. This resulting supination allows the midtarsal joint to provide a rigid lever to push off during toe off as force passes out the first ray. (Subotnick 1975).

There are a multitude of forces acting upon the lower extremity including four discussed by Donatelli, (1985): compression, rotation, anterior shear, and medial shear. Compression forces are dissipated between the metatarsals and the calcaneus. Rotation and medial shear

forces of the tibia and femur- at the subtalar joint. Finally, anterior shear forces are dissipated by the gastrocnemius and soleus (Root ML 1977). Pronation is the mechanism the foot/ankle utilizes to cope with these forces and the subtalar and midtarsal articulations are the facilitators. Together through pronation, the subtalar and midtarsal joints unlock and allow the foot to become more flexible and capable of force attenuation upon any given surface(Subotnick 1975).

Abnormal

Certain conditions may predispose the foot/ankle and ultimately the entire lower extremity to injury. Failure to produce necessary pronation and supination will lead to deleterious compensatory force attenuation. Pronation increases attenuation whereas supination decreases it (Subotnick 1975; Donatelli 1987). Abnormal pronation or supination does not always mean that an excess of motion is the culprit; there can also be a lack of these fundamental motions. The hypo or hypermobile movements result in compensation by other structures for which the load is unnatural and harmful (Donatelli 1987). This compensation can lead to reduced attenuation, inhibited torque conversion, decreased adaptation to surface, and prevention of a rigid lever to push off (Donatelli 1987). Force attenuation is affected by the amount of pronation, in excess the ability for absorption is decreased with too little pronation the foot becomes rigid with the same result (Donatelli 1987). Torque conversion by the talus will be affected by excessive motion allowed by the subtalar and midtarsal joints (Donatelli 1987). The foot must become flexible to adapt to the surface it is on and if the foot is too rigid in supination this transition cannot be accomplished (Donatelli 1987). Finally, if the foot remains in a state of excessive pronation, the return to supination is not appropriately

achieved therefore decreasing the ability of the midtarsal joints to lock and create a rigid lever for push off (Donatelli 1987).

Excessive pronation is one such abnormal biomechanical pattern and is considered a primary component in the causation of lower extremity pathology. This motion can be characterized by an increase in pronation through greater than 25% of the stance phase, possibly inhibiting the rigid lever (Root ML 1977). The excessive pronation reduces the ability for optimal shock absorption and when perpetuated, has been implicated in several overuse pathologies. Such pathologies include posterior tibialis tendonitis, achilles tendonitis, plantar fascitis, medial tibial stress syndrome, stress reactions/fractures, hallux valgus deformity, and patellofemoral pain syndrome located up the kinetic chain in the knee (Root ML 1977; Tiberio 1988; Gross 1992).

Forefoot Varus

Postural deformities may predispose individuals to have excessive pronation. Forefoot varus is one such postural deformity and has various definitions in the literature. Some define it as a frontal plane deformity occurring when the plane of the metatarsals are inverted in relation to the plane of the calcaneus when the subtalar joint is in a neutral position (Root ML 1977). Others have described it as a sagittal plane deformity centered around a hypermobile first ray (McCrea 1985). The hypermobile first ray eliminates the mechanical advantage of the cuboid pulley, resulting in a "loose bag of bones" and inability to achieve full supination for rigid push off (Donatelli 1985). Forefoot varus however, has been predominantly portrayed by a lack in ground contact of the medial forefoot while the subtalar joint is in a neutral position. This causes a compensatory subtalar joint pronation at both the midstance and toe off portions of the gait cycle (Tiberio 1988).

This deformity also causes the midtarsal joint to remain unlocked resulting in a less rigid foot for push-off. First ray hypermobility has also been related to a compensatory subtalar joint pronation (ESJP) due to forefoot varus (Tiberio 1988). The slack created in the peroneus longus tendon causes the first ray to splay out transposing much of the body weight to the second metatarsal, often leading to injury (Tiberio 1988). The effects of ESJP are not only seen in the above-mentioned foot/ankle biomechanics, but also are correlated with increased internal rotation of the tibia, lateral compression forces of the knee joint, and femur medial/internal rotation (Tiberio 1988). Forefoot varus can be a substantially damaging deformity globally throughout the kinetic chain not just by its existence, but rather through compensatory actions at the ankle, knee, and hip (Tiberio 1988).

Rearfoot Varus

Rearfoot varus is another deformity, demonstrated by a lack of ground contact by the medial aspect of the calcaneus, and usually creates the need for a compensatory subtalar joint pronation and calcaneal eversion to restore full contact (Tiberio 1988). This pronation will also tend to occur at an abnormally rapid rate, thus placing exceedingly high loads of stress upon the tibialis posterior which functions to eccentrically decelerate the foot during midstance (Tiberio 1988). Rearfoot varus postural deformity is not commonly associated with the overuse pathology of abnormally excessive pronation when present alone. Injuries tend to be more proximal in nature as forces are attenuated in the knee, hip, or even sacroiliac joint to compensate for the increased medial rotation of the lower leg caused by excessive pronation (Tiberio 1988).

Navicular Drop

Several tests exist to aid examiners in the assessment of lower extremity dysfunction and abnormalities. One such reliable and valid test is the navicular drop test (NDT) (Mueller, Host et al. 1993). Although there are several variations of this NDT, they all are designed to assess vertical displacement of the navicular bone in the foot. Navicular Drop has been defined as the change in distance between the height of the navicular in a subtalar joint neutral position, and in a weight bearing position. A navicular drop measurement of greater than 10mm is abnormal/excessive and should be considered a predisposing factor of lower extremity pathology (Mueller, Host et al. 1993).

Foot Orthotic Devices (FODs)

One tool available for the treatment of a multitude of lower extremity pathologies and deformities is the foot orthotic device, or FOD. These devices can be soft, semi-rigid, or rigid depending on the need of the intervention required (Nawoczenski 1997). Soft/flexible FODs can provide cushioning, increase shock absorption, and decrease shear forces. These types of FODs are not used in individuals requiring stability and motion control (Nawoczenski 1997). Semirigid FODs allow for flexibility and shock absorption but can play a more active role in foot control and balance. These FODs are typically used when control of an excessive motion is desired but function will also create a need for shock absorption (Nawoczenski 1997). Rigid FODs are primarily concerned with motion control and are made typically out of hard plastics (Nawoczenski 1997).

Predominantly, the purpose of the FOD is to return the foot/ankle to a subtalar neutral position, correctly aligning a postural deformity or compensatory condition in order to restore healthy normal function (Donatelli 1987). The implementation of FODs can accomplish this goal by altering forces for protection, altering available motion for deformity correction, and to help with compensation of a deformity or some form of weakness (Redford 1995).

FODs have been utilized effectively to treat a variety of lower extremity injuries, as well as prevention of repeated injury (Ball and Afheldt 2002). Positive effects of FODs have been speculated to be due to a mechanical and or proprioceptive mechanism (Stacoff, Reinschmidt et al. 2000). In a study by Donatelli et al (1988), it was reported that 96% of subjects experienced ankle, shin, foot, and knee pain relief, 91% from FODs alone. This level of pain relief was also validated by (Nawoczenski, Cook et al. 1995).

Electromyography (EMG)

Electromyography is a measure of the electrical activity in a muscle, and has been utilized as a non-invasive technique (surface EMG) to assess neuromuscular function (Rainoldi, Melchiorri et al. 2004). Nigg et al (1999) found that during locomotion, shoes and FODs can affect EMG particularly. It is possible to graphically view muscle activity through the use of electrodes (EMG), either surface or indwelling, to collect information for use in programs such as biofeedback for muscle re-education and training (Basmajian 1985). These electrodes are typically positioned following palpation during manual muscle testing to determine the location of the muscle belly (Rainoldi, Melchiorri et al. 2004).Through analysis, several factors can be examined such as, amplitude (amount), onset (when excitation begins), and

duration (how long the excitation lasts). Therefore, utilization of this tool can be used for clinically beneficial information regarding effect of footwear (Basmajian 1985), and even FOD intervention on selected muscle activity.

Several studies have been done investigating EMG in lower extremity musculature, not necessarily with FODs. Blackburn et al (2003) found that the use of exercises sandals during selected activities significantly increased activity of the TA and PL. Type of activity has also been compared utilizing EMG. In a comparison of healthy volunteers during open versus closed chain exercises, the VMO was shown to have a significantly later onset during open chain knee extension (Stensdotter 2003). Other studies examining EMG onsets have found changes between a symptomatic and non symptomatic population in VMO and GM activity while ascending and descending stairs, and found that both the VMO and GM had delayed onset compared to the control group (Cowan 2001; Brindle, Mattacola et al. 2003).

In efforts to enhance/promote neuromuscular function EMG can be utilized to monitor the impact of activity or even FODs. EMG has been an informative tool in research and will continue to be so. Through the analysis of EMG signals better decisions regarding treatment options such as exercises and interventions (FODs) can be made with specific goals in mind.

Kinetics

Although the forces acting on the lower extremity cannot be seen, we still know they exist and can observe and explain their impact on kinematics (Bowker 1993; Neumann 2002). Understanding of these forces can predict muscle and joint forces, as well as be used to address concerns during FOD fabrication(Bowker 1993). Newton's Third Law: every action has an equal and opposite reaction, serves as the model and explanation of these kinetic forces.

Ground Reaction Forces (GRF)

As explained by Newton's Third Law, with every step taken upon ground during locomotion there are forces acting reciprocally upon the foot and lower extremity. These forces transmitted from the ground in direct response from a weight bearing extremity are called ground reaction forces (GRF) and are typically measured on a forceplate (Bowker 1993). When discussing GRF the descriptions follow three axes or directions: vertical-typically F_z, anterior-posterior-F_x (A/P), and medial-lateral-F_y (M/L) depending on the direction of travel (Griffiths 2006). These GRFs have different peak values, with the vertical being the greatest, reaching up to 120% of body weight (BW), A/P up to 20% of BW, and M/L up to 5% BW (Neumann 2002; Griffiths 2006).

Vertical GRF can best be described as occurring perpendicularly to the contacted surface and thus having the greatest magnitude. During the gait cycle there will be two peak Vertical GRF as the heel strikes and the toes push-off. These peaks serve the purposes of both deceleration at heel strike and propulsion at toe-off (Neumann 2002).

A/P GRFs are shear forces occurring parallel to the contacted surface. As the heel strikes during stance the resultant force will be a posterior GRF and as the foot toes off the force will be anterior and propulsive (Neumann 2002). A/P GRFs are highly dependent upon the speed of ambulation and rely upon friction to allow adequate movement. A balance of these GRF are maintained during normal gait as each force is equal and opposite including the explanation of increase force required for braking as well as acceleration (Neumann 2002).

M/L GRFs are also shear forces and have the smallest magnitude of the GRFs as well as the greatest variability among individuals (Neumann 2002). Typically during stance the M/L GRF will follow a short lateral at heel strike, to mostly medial during stance, back to lateral

at toe-off pathway (Neumann 2002). Medial GRF has been shown to be significantly lower in a symptomatic patellofemoral pain syndrome group (Levinger 2006). The authors cited Messier et al. (1991) explaining that compensation was the possible reason for this alteration.

Center of Pressure (COP)

Center of Pressure (COP) is a representation showing the individual points over time where the center of force of an individual can be focused on a forceplate (Griffiths 2006). Typically, the pathway has a slightly lateral displacement from the center of the heel at heel strike moving through the lateral midfoot during mid stance and medial forefoot as it the foot prepares again for toe-off (Neumann 2002). The COP path has graphically been shown to be affected in a medial deviation, by excessive SJP (Bowker 1993). COP excursion can be assessed as well objectively. This measurement is not directional but provides the total displacement (mm) of the COP through stance.

Foot Orthotic Devices and Electromyography

Pathological Population

Several studies have been done to examine the effect of FODs on lower extremity EMG, and some have varied on particular findings. In particular to the musculature in this study, several investigators have tested the TA, PL, VMO, and GM. However, few have focused both proximal and distal to the knee, and none have included all four during gait. The following investigations have included subjects other than normal healthy volunteers. Specifically, when examining the TA during treadmill walking, Tomaro and Burdett (1993) found there to be a statistically significant increase in TA duration with a FOD than without.

In concurrence with these results, another study examining the TA while running found FOD significantly increased TA EMG (Mundermann 2006).

During the studies mentioned above the PL was also tested. First reported was an average increase in PL activity, but not enough to be statistically significant (Tomaro and Burdett 1993). Later, Mundermann et al. (2006) did find statistically significant increases in the PL activity with the use of FODs.

Recently, focus has moved proximal to the knee and several investigators have tested the VMO. The activity of the VMO has been found to be individually specific when examining activation with use of a FOD in relation to the vastus lateralis in patellofemoral joint loading while running (Neptune, Wright et al. 2000). In contrast to those findings, Mundermann et al. (2006) demonstrated significantly greater VMO activity during running with FODs. The following two studies did not assess EMG during walking but can be generalized as functional activities. During a single leg lower extremity perturbation assessment, the VMO was found to have no difference between a FOD and non FOD condition (Rose, Shultz et al. 2002). Hertel et al. (2005) found that during a single leg squat and lateral step down the activity of the VMO was significantly higher in the FOD condition.

The only study utilizing a pathological sample while examining FODs and the GM was by Hertel et al. (2005). They found a significant increase in GM activity under a FOD intervention during a single leg squat and lateral step down.

Normal Healthy Population

The studies in this section utilized normal healthy volunteers. Nawoczenski and Ludewig (1999) found there to be a 37.5% increase in TA activity with a FOD condition as compared

to without a FOD during treadmill running. Also simultaneous examination of the VMO found a non-statistically significant decrease in activity by 2.2%. Only one study was found to contain EMG analysis of the GM during gait with a FOD and contained a non-pathological sample. The GM was shown to be non significantly affected by only a heel lift and by no form of medial wedging (Bird, Bendrups et al. 2003).

Foot Orthotic Devices and Kinetics

Few studies were found linking FODs with kinetic data collection. One study, examining medial/lateral ground reaction forces (GRF) was conducted by Nester et al. (2002), and found that medial wedging with a FOD significantly increased lateral GRF. Another study testing FOD and kinetics examined center of pressure (COP). COP was found to be extremely variable under four (4) FOD conditions (half medial and lateral, and full medial and lateral) and therefore unable to be generalized (Nigg 2003). Both of these studies were performed using normal healthy volunteers with no mention of excessive pronation as inclusion criteria.

Foot Orthotic Devices, Electromyography, and Kinetics

One study was found to examine all three of these components in conjunction with each other. The aim of the study was to determine how comfort of a FOD was related to kinematic, kinetic, and EMG data. The effect of FOD on the previously mentioned variables was found to have systematic significance. However, this study did not examine onset, duration, or COP variables specifically. EMG data regarding activity and kinetic variables of

vertical GRF as well as moments at the ankle and knee joints were specifically targeted (Mundermann, Nigg et al. 2003).

Summary

The previous topics encompass anatomical and biomechanical information about the lower extremity and provide an introduction into the areas of FOD intervention, EMG, and kinetics. These topics are critical to the comprehension of the lower extremity and its role in the kinetic chain. Various studies have collected data on how FODs affect EMG and lower extremity kinematics and kinetics separately. Few studies have examined EMG activity of the gluteus medius or VMO in an FOD condition, especially during walking. To this author's knowledge no study has examined EMG of the gluteus medius, VMO, PL, and TA, as well as kinetic COP data in a population exhibiting excessive pronation in effort to determine the effect of FODs at each of the lower extremity joints.

Chapter 3: Methodology

Subjects

An *a priori* power calculation concluded a total number of 20 subjects per group were required to provide a power of at least 0.80. Forty-one physically active volunteers from the student, faculty, and staff population at the University of North Carolina at Chapel Hill participated in this study. Physically active was defined as exercising at least three times per week for at least thirty minutes. The first group consisted of 20 subjects (age= 22.26 ± 2.26yrs, height= 172.65 ± 11.16cm, mass= 73.89 ± 14.64kg) and was named the experimental or pronated foot type group. The defining characteristic of this group was that the subjects exhibited a navicular drop of at least 10mm (Kelly 2003). The second group was composed of 21 normal foot type individuals (age= 23.20 ± 6.57yrs, height= 167.89 ± 11.42cm, mass= 63.07 ±12.85kg) and served as the control group. This group exhibited navicular drop measurements of less than 7mm. Inclusion criteria included: 1) healthy volunteer of at least 18 years of age, 2) presentation of navicular drop of at least 10mm (for pronated group), that was in no way debilitating in ADLs, or less than 7mm (for normal group) 3) physically active three times per week for 30 minutes. Exclusion criteria included: 1) previous history of lower extremity injury in past six months, 2) previous history of FOD use on regular basis, 3) participation in a lower extremity rehabilitation or training program during study. The University of North Carolina at Chapel Hill Institutional Review Board

approved an informed consent form that each participant in this study completed prior to participation.

Measurement and Instrumentation

FOD Fabrication

For FOD fabrication, an AMFIT Footfax-SL ® Contact Digitizer and CAD/CAM Mill Carving Station (AMFIT; Vancouver, WA) was used and operated by a podiatrist. The system digitized the participants' feet and transferred the collected data to the carving station for the creation of precise custom FODs.

Muscle Activity (EMG)

To measure muscle activity, an 8 channel Delsys Electromyography system (Delsys Bagnoli-8, Boston, MA**)** was used to gather EMG data via surface electrodes placed upon the involved muscles: tibialis anterior (TA), peroneus longus (PL), vastus medialis oblique (VMO), and the gluteus medius (GM). Electrodes were placed over the muscle bellies parallel to the fibers of each muscle tested and was verified via palpation and manual muscle testing (Basamaijan, 1985, Kendall and McCreary, 1983).

Kinetic Data

Kinetic data (center of pressure-COP) was collected by a forceplate (Bertec Corporation, Columbus, OH). Data was recorded during walking trials performed on level ground. All EMG and kinetic data was collected simultaneously stored and analyzed using Datapac 2K2 Software **(**Run Technologies, Mission Viejo, CA**).**

Procedures

Qualification

The principal investigator evaluated and determined which individuals exhibited pronation using a navicular drop test. Intrarater reliability was shown to be high with an ICC of .98 with an SEM of .79mm. Pronation for this study was defined as having an inferior displacement of at least a 10 mm during a weight-bearing stance as compared to subtalar neutral in a non weight-bearing stance.

Volunteers reported to Fetzer Athletic Training Room for the navicular drop assessment, and were measured utilizing a navicular drop test. Subjects sat on a table with their knees bent to a 90-degree angle over the edge with their feet resting on a box making sure to have their knee over the ankle joint. The medial and lateral borders of their talus were palpated anteriorly and subjects were asked to invert/evert until equal prominence was felt bilaterally. Once this position was achieved the subject was asked to hold the position until a mark was made on an index card at the same level as the marked navicular. Subjects then stood on the box and marched in place five times and assumed a standing weight bearing stance, facing straight ahead. A second mark was then made on the same card. This process was performed a total of three times per subject. Another certified athletic trainer measured all displacements on the cards, to ensure no biasing, and took either the average of the three trials or the mode measurement if one existed. This number served as the amount of navicular drop in mm.

Individuals exhibiting either less than 7mm or greater than 10mm of navicular drop were allowed to participate in the study. Qualifiers were separated into two groups based upon this measurement and the inclusion criteria above: normal foot type (control), and pronated foot type (experimental). Those who fell within the 7-10mm range were excluded from the study.

FOD Scanning and Distribution

All individuals meeting the inclusion criteria reported to the Sports Medicine Research Laboratory for a foot scanning session with the podiatrist for the fabrication of a pair of custom FODs. Subjects were fitted for a FOD by a podiatrist utilizing an AMFIT Footfax-SL ® Contact Digitizer and CAD/CAM Mill Carving Station (Vancouver, WA). Subjects sat in a chair with their knees and hips flexed to approximately 90 degrees. The foot of each subject was positioned by the podiatrist and the podiatrist asked each subject to remain still while the digitizer's hydraulic pegs rose from the base to create the impression of the foot. This process was repeated for each foot. Data was then sent via phone line to AMFIT where FODs were fabricated to the podiatrist's specifications.

Following approximately one week, the FODs arrived by mail and each subject reported for distribution and wear guideline instructions. FOD wear utilized the following progression: up to 2 hrs of wear the first day and increasing by up to 2 hours each successive day until a full day of wear was reached. The participants were given a log sheet when they received their FODs, to record the hours per day that they wore the FODs. It was asked of the participants that regardless of immediate effects of FOD wear, that their normal levels of activity were not altered (i.e. a feeling of improvement experienced by subject may have led them increase amount and intensity of physical activity). Also, subjects were asked to wait until up to a full days wear to use FODs for any vigorous activity.

Baseline/Pre Test

Subjects reported to the Sports Medicine Research Laboratory for two testing sessions. The purpose of the first session was for completion of informed consent/general health questionnaire, demographic information recording, providing of instructions, and baseline collection. Subjects were asked to report with shorts and the sneakers they planned to wear the FODs in.

For EMG collection, the location for electrode placement occurred as outlined previously following marking of the site with a marker. Subjects then had their skin prepared by shaving with a disposable razor, and abraded and cleaned with isopropyl alcohol. For recording, an 8 channel Delsys Electromyography system was used to record onset and duration during the stance phase of gate. A single bar adhesive Ag/AgCl surface EMG electrode (Delsys Inc., Boston, MA) with contact distance of 10mm was placed over the muscle bellies of the TA, PL, VMO, and GM. The electrodes used disposable adhesive interfaces to attach to the skin and were secured with underwrap and athletic tape following application. Placement was recorded to ensure consistency between baseline and posttest. Electrodes were connected to a transmitter attached to a comfortable fitting belt worn around the participant's waist and collected the muscle activity data throughout all trials.

Both the neutral and pronated foot type groups performed walking trials for baseline collection of EMG and kinetic data during this session. Walking was performed to the beat of a metronome set at 92 beats per minute. During each of the trials, EMG data was collected on selected lower extremity muscles (TA, PL, VMO, GM) of the subject's dominant leg during the stance phase of gait, as they walked over the force plate. Kinetic data was also collected simultaneously during stance. Stance phase was defined as total time in contact with the

forceplate, from heel strike through toe-off. Dominance was defined as the leg they would use to kick a soccer ball for maximum distance.

Post Test

The second and final session at the Sports Medicine Research Laboratory was for posttest data collection. This session occurred following a two-week accommodation period to the FODs. Subjects were asked to report with the following items: shorts, the sneakers they wore the FODs in, their original insoles to those sneakers, the FODs, and the FOD log sheet. During this session participants performed two counterbalanced walking trials. One of the walking trials occurred with the FODs, while the other occurred without the FODs. Procedures for this session were the exact same as the baseline/pretest session.

Data Reduction

Onset/Duration

All EMG data was reduced utilizing the following processing filters: Passive demeaning 0.0ms begin/ 50.0ms end, Band pass butterworth 10.0Hz-350.0Hz rolloff 5 (zero lag), RMS smoothing time constant 10.0ms. EMG onset and duration data was analyzed by setting a reference interval at 200.0ms, values above this threshold were considered "on" and values below were considered "off". The use of a max duration filter (0.0-1500.0ms) was used and excluded any activity lasting longer than the set time. Eight individual 2 X 3 Repeated Measures Mixed Model ANOVAs were run, one for each variable of onset/duration and muscle.

COP Excursion

All COP excursion data was processed utilizing Linear Smoothing at 10.0msec. Data files were exported as ASCII files and run through LabView (National Instruments; Austin, TX) to achieve mean data by running one of two calculations. The first was COP during loading minus COP at midstance (0-50% of stance), and the second was COP during loading minus COP at propulsion (0-100% of stance). This data was then run through SPSS 13.0. Two separated 2 X 3 Repeated Measures Mixed Model ANOVAs were utilized to analyze the data, dividing trials into 0-50% stance phase at each condition, and then at 0-100%.

Statistical Analysis

All data was analyzed using SPSS 13.0 statistical software (SPSS, Inc., Chicago, IL), using an *a priori* alpha-level of 0.05. An *a priori* power analysis provided a power level of 0.80 for 40 subjects. Power level was determined through investigation of literature involving EMG and FODs as well as pilot test data. Independent variables included two groups, the pronated and normal foot type, as well as three conditions, baseline, post with FOD, and post without FOD. Dependent variables examined included onset and duration of muscle activity, of the four muscles, TA, PL, VMO, and GM relative to stance phase of walking task, COP area both from 0-50%, and 0-100%.

Chapter 4: Results

Following statistical analyses, no significant differences were found in the timing characteristics (onset and duration) of selected lower extremity musculature (PL, TA, VMO, and GM) between the normal and pronated foot type groups over pre test (Pre), posttest without a FOD (PostNo), and post with a FOD (PostFOD) conditions. Additionally, no significant differences were found in the timing characteristics of the lower extremity musculature in the pronated group both before and after two weeks of FOD accommodation. Means and standard deviations (SD) as well as F and p values of the onsets and durations of the involved musculature are presented in Table 3 and Figures 1-8 (Appendix A) as well as listed below. Analysis of COP excursion data revealed that a main effect for group existed (Appendix A: Table 4), whereby the normal group's COP excursion was greater compared to the pronated group (Appendix A: Table 4, Figures 9 & 10). Means (±SD) of the COP excursion the first 50% and entire stance phase are reported in Table 4 (Appendix A).

Matching Subjects

We tested 41 subjects (39 completed all the requirements of the study). Two subjects decided to discontinue participation in the study. Subject demographical characteristics are presented in Table 1 and Figures 9-11 (Appendix A). These subjects were divided into two groups (19 excessive pronators and 20 normal foot individuals) based on a navicular drop test described in the Methods section. The pronated foot type group varied significantly in their

amount of pronation as compared to the normal foot group (mean difference =10.07mm) [t (37) =-12.224, p<.001)] (Appendix A: Table 2), as well as in weight (kg) [t (37) =-2.455, p<.05)] (Appendix A: Table 1).

Muscle timing characteristics

Onset

Means and standard deviations for the onsets of the TA, PL, VMO, and GM are shown in Table 3 (Appendix A). For the TA onset (TAO) there was no main effect for group [F (2,37) = .689, p=.505] or test [F (1,37) = .326, p=.571] as well as no test by group interaction [F(2,37) =.068, p=.935]. The PL onset (PLO) revealed no main effect for group [F(1,37) =.211, p=.649], test [F(2,37) =.608, p=.547], or a test by group interaction [F(2,37) =.568, p=.569]. For VMO onset (VMOO) no main effect for group [F(1,37) =.860, p=.360], test [F(2,37) =1.480, p=.234], or test by group interaction existed [F(2,37) =1.611, p=.207]. The GM onset (GMO) had no main effect for group [F(1,37) =.133, p=.717], test [F(2,37) =1.446, p=.242], or test by group interaction [F(2,37) =1.147, p=.323] (Appendix A: Table 5).

Duration

Means and standard deviations for the durations of the TA, PL, VMO, and GM are shown in Table 4 (Appendix A). For the TA duration (TAD) there was no main effect for group [F(1,37) =2.214, p=.145] or test [F(2,37) =.175, p=.840] as well as no test by group interaction [F(2,37) =.972, p=.383]. The PL duration (PLD) had no main effect for group [F(1,37) =.156, p=.696], test [F(2,37) =1.571, p=.215], or a test by group interaction [F(2,37) =.750, p=.476]. For VMO duration (VMOD) the assumption of sphericity was violated (p=.024), therefore the Greenhouse-Geisser correction was utilized for this analysis. No main effect for group [F(1,37) =.032, p=.859], test [F(1.685,37) =.3.001, p=.065], or test by group interaction existed [F(1.685,37) =.137, p=.838]. The GM duration (GMD) had no main effect

for group [F(1,37) =.413, p=.524], test [F(2,37) =1.365, p=.262], or test by group interaction [F(2,37) =1.835, p=.167] (Appendix A: Table 5).

Kinetic Data-COP

Loading to Midstance

We performed a 2 X 3 mixed model ANOVA to determine the effect of foot type and FOD on COP from loading (heel strike) to midstance. Means and SD are reported in Table 6 (Appendix A). No main effect was found for test (pre, post without a FOD, and post with a FOD) [F(1.434,28) =.997, p=.375], and no test by group interaction was found [F(1.434,28) =.321, p=.655]. There was however a main effect for group [F(1,28) =8.430, p=.000] revealing that a significant difference in COP excursion from loading to midstance existed between our groups. The normal foot type group had a greater COP excursion than did the pronated foot type group (Appendix A: Table 7). The assumption of sphericity was violated (p=.001), therefore the Greenhouse-Geisser correction was employed for these analyses.

Loading to Propulsion

We performed a 2 X 3 mixed model ANOVA to determine the effect of foot type and FOD on COP from loading propulsion (toe off). Means and SD are reported in Table 6 (Appendix A). There was no main effect for test [F(1.581,28) =.813, p=.424], or group [F(1,28) =3.189, p=.085]. Also, no test by group interaction effect existed [F(1.434,28) =.114, p=.846] (Appendix A: Table 7). The assumption of sphericity was violated (p=.016), therefore the Greenhouse-Geisser correction was employed for these analyses.

Chapter 5: Discussion

Introduction

The most important finding in our study is that the normal group's COP excursion during the first 50% of stance phase was greater than the pronated group's COP excursion. A similar trend was also observed towards an increase in COP excursion over the entire stance phase in the normal group. This result shows that the normal foot had more total movement/displacement of the COP path during the first 50% of stance phase as compared to the pronated foot. The greater value of COP excursion does not signify direction (medial/lateral), only an accumulated amount of movement represented in mm.

Typically, a medially displaced COP path is thought to be caused by excessive compensatory subtalar joint pronation (ESJP). ESJP has been implicated in creating numerous abnormal biomechanical processes throughout the kinetic chain. The use of FODs is one of the most common and effective treatments for the resultant malalignments and symptoms, such as pain (Nawoczenski, Cook et al. 1995; Ball and Afheldt 2002; Gross and Foxworth 2003). It has been shown that FODs significantly increase EMG amplitude (Nawoczenski and Ludewig 1999; Hertel, Sloss et al. 2005) however; varying results exist regarding the effect of foot type and the use of FOD intervention on EMG timing characteristics such as onset and duration (Tomaro and Burdett 1993; Rose, Shultz et al. 2002; Bird, Bendrups et al. 2003). COP measures are commonly utilized to examine abnormalities of the lower extremity as well. Specifically, ESJP has been show to have an

affect upon COP, causing an altered path that moves medially earlier in the stance phase (Bowker 1993).

Due to the previous duration specific findings of Tomaro and Burdett (1993), we hypothesized that onset would occur earlier and duration would last longer in the normal foot as compared to a pronated foot. Also, that the use of a FOD would provide results showing earlier onset and longer duration versus a non FOD group. The results of our study however fail to show any significant difference in the variables of onset and duration in lower extremity musculature regardless of FOD intervention. Although the results proved to be non significant, the EMG onset and duration values are important because they show no change in muscle timing characteristics exist between the normal and pronated group across FOD conditions.

In terms of kinetics, due to the possible resultant trend described in COP path due to ESJP, we hypothesized that the normal foot type group would have significantly less excursion in COP path values than the pronated foot type as well as that a FOD condition would also exhibit less COP excursion in comparison to a pronated foot type under no intervention. Analysis of our data showed the opposite, with significantly more COP excursion by the normal group as compared to the pronated foot type during the first half of stance phase.

EMG

Muscle activity has been shown in several studies to be affected by FODs. Typically this reported effect is with regards to amplitude, not the onset or duration. Few studies have specifically examined the role FODs play on onset and duration of muscle activity during gait. We chose to assess individuals in a dynamic manner by having them walk over ground

to the beat of a metronome. A forceplate was used to determine the stance phase of gait from heel strike through toe off.

Typically during gait the TA will have onset before toe off and reach peak activity just afterwards. Then the action of plantarflexion is eccentrically decelerated as stance phase begins, allowing the forefoot to lower smoothly to the ground. The TA will then usually become inactive as midstance is reached (Michaud 1993). The PL becomes active during midstance causing pronation at the subtalar joint (secondary to the peroneus tertius) in order to stabilize and decelerate resupination during late stance. It also functions to lock the midtarsal joints as propulsion begins (Michaud 1993). The quadriceps as a whole activate during the late swing phase, achieving peak activity just after heel strike as they decelerate knee flexion, and contract until midstance (Michaud 1993). The GM is active from late swing through midstance as it attempts to stabilize the pelvis through stance (Michaud 1993). After comparing the figures of Michaud (1993) and the information on datapac, muscular firing patterns appeared to have similar general appearance characteristics.

We found no statistically significant differences in onset or duration in any of the four tested muscles (Appendix A: Table 5). Our findings conflict with those of Tomaro and Burdett (1993), who found a significant increase in TA duration with a FOD intervention. However, they assessed walking on a treadmill instead of over ground, which may explain the differences between our results. In the current study we observed a trend in VMO duration that appears to demonstrate an earlier cessation of activity. The duration of the VMO appeared to decrease following the pre test as compared to each post test session and can be seen graphically in Figure 7 (Appendix A). If this assumption is accurate, our findings are consistent with those of Rose et al (2002) in which the VMO was found to have a shorter

duration with the use of FODs. However, neither this nor that study achieved statistical significance in this finding. Our methods also varied from theirs as they utilized a single leg perturbation assessment, not over ground walking. The trend suggesting a shorter VMO duration with FODs, can perhaps be explained by the FOD placing the VMO in a more optimal position. This position may actually prevent fatigue that results from prolonged knee valgus due to increased tibial and femoral internal rotation associated with excessive compensatory subtalar joint pronation.

Kinetic Data-COP

COP can be collected with the use of a forceplate and can provide valuable kinematic data to us as clinicians and researchers. Typically, the path of COP during stance begins at the lateral heel during heel strike progressing along the lateral foot to midstance where it then crosses over the forefoot in preparation for toe off, typically under the first or second metatarsal heads (Neumann, D., 2002). COP data was recorded as subjects walked across the forceplate and was divided into two measurable quantities for analysis, the difference in COP during weight acceptance and during propulsion.

Data from only 30 of our subjects could be analyzed kinetically due to file formatting error, leaving two equal groups of 15. For the first 50% of stance phase there was a significant increase in COP excursion in the normal group compared to the pronated group. Despite the sample size decrease we maintained a power of .80 as we found a significant difference between the groups in COP excursion during weight acceptance (Appendix A: Table 7). A possible cause of these results have been suggested that the normal foot lacks an anatomical medial block in weight bearing thus allowing the foot to collapse medially and

not just continuing to bear weight on the lateral border of the foot (Hertel et al, 2002). Care should be taken in comparing our results, as the results from Hertel and colleagues (2002) were from a single leg balance position. These results do confirm what is already known about foot biomechanics in that the normal foot will begin stance in supination, making a gradual transition into pronation, and then resupinate for push off, thereby giving us a greater COP excursion. The pronated foot will move into pronation rapidly after heel strike and remain there for the duration of stance, thus having a more medial COP path, but less COP excursion due to lack of resupination. The groups in this study varied significantly in their levels of navicular drop (Appendix A: Table 2) suggesting a predisposition for the foot to collapse medially thereby altering the COP path before toe off. Our results suggest that this reduced COP excursion in the pronated foot type group shows the excessive motion allowed by the foot only until full weight acceptance.

Speculation can be made as to what results may have been seen with a larger population than fifteen subjects in the trend towards significance was observed for group when comparing the entire duration of stance phase (Appendix A: Table 7). This result could be suggestive of the extent of alteration different foot types have on COP excursion. If a larger sample size had been used, the trend towards significance may have gained true statistical significance. Very few studies exist that examine the specific impact of foot type and FOD on COP path during walking (especially with EMG), making speculation and generalizations difficult.

Clinical Significance

The results of this study yield some suggestions for possible treatment of lower extremity pathologies. With regards to muscle activity, the shorter VMO duration may signify a possible benefit of the FODs to correct abnormal biomechanics and restore proper muscle function. Also, the findings of this study reinforce the knowledge that a pronated will exhibit excessive motion but little movement will take place after full weight acceptance. Our results speculate further on the importance of FOD intervention to not only restore proper length tension relationships, but to also possibly help assist the pronated foot achieve a greater ability to resupinate and not to stay a state of pronation throughout the entire stance phase. Hypothetically, if this mechanism proved successful, factors such as shock absorption and malaignment would be improved ultimately leading to a possible reduction in injury. Even though research has shown extreme variability in EMG with FOD intervention, greater sample sizes and systematic, yet individualized FOD fabrication may help to alter both onset/duration of muscle activity and COP path in a clinically significant way.

Limitations

We feel there are some contributing factors in the lack of significant findings. First, examination showed considerable variability in our EMG data (Appendix A: Tables 3 and 4). The use of the FOD had no specific intervention criteria, meaning that there was not a set amount of intervention (support) placed upon the subjects. This might possibly lead to varying degrees of change and ultimately more variability. The accommodation period of two weeks was chosen to fit the time frame of the desired study completion and to enhance subject compliance. This time frame may have been inappropriate, possibly yielding more

acute FOD intervention results than those that may occur over time. For example, perhaps the trend observed in shorter VMO duration would achieve significance as well as other duration measurements, thus suggesting that FODs help to decrease muscle duration time by reestablishing length-tension relationships and decreasing possible fatigue. Forefoot varus was not objectively quantified during the study. Perhaps examining this deformity more closely would have led to more specific FOD fabrication specifications. A person with a flexible flat foot may not have had appropriate contact area coverage from the FOD due to their allowed motion, whereas a rigid foot may have been given more appropriate support. These FODs could have also possibly corrected a host of abnormalities indiscriminant to the fact that navicular drop was the only qualifying measure. Another objective measurement that may have been added to the data collection was range of motion (ROM) assessment. Particularly examining whether or not individuals exhibited gastrocnemius/soleus complex tightness that may lead to increased toeing out or pronation to achieve ROM. Specifically during data collection, having the subjects hold the EMG cable during walking trials, and utilizing a quartz metronome set to a rate of 92 beats per minute to help standardize walking trials may have in some ways altered, possibly by restricting arm swing, or forcing a lunge or stutter step to contact forceplate, the normal gait of the subjects, thereby influencing results.

Fava et al. (2003) proposed a possible difficulty in the analysis of onset and duration could be that during dynamic activity, the muscle is already in an excited state making the distinction between “on” and “off” much more difficult than between a resting measure and some active movement. We were confident that our assessment of onset and duration was accurate despite the dynamic nature of our study. Historically, surface EMG has been criticized for validity with regards to issues like cross talk, adipose filtering, and skin

movement (Merletti 2004). Even though the muscles were palpated and manually tested to ensure proper placement, and the electrodes were secured with under wrap, the possibility cannot be ruled out that these confounding variables may have influenced our results. Furthermore, there is very little literature examining the use of FODs, EMG, and kinetic data analysis during over ground walking, making the results of our study difficult to fully generalize and compare with existing literature.

Future Research

Further EMG examination could focus locally at a joint under the intervention of FODs. The study could be aimed at discovering whether any change may be more of an injury prevention response due to possibly restored length-tension relationships or just related to fatigue. Available research is variable with regards to types of FODs, the degree of intervention they provide, how long of an accommodation period was used) and the circumstances they are tested under. More collective organization may help explain existing cause and effect relationships. It is also the author's opinion that sport specific or situational EMG assessment is paramount before generalization. In agreement with Tomaro and Burdett (1993), it is recommended that if possible, EMG testing of the tibialis posterior (TP) specifically, due to its function of a plantar flexor and inverter, and due to its attachment on the navicular itself, be conducted. We could not assess this activity due to the difficulty surface EMG has with the TP. Testing for runners may possibly require altering inclines and speeds rather than just a level walk/run. With athletes in the sports of basketball or volleyball, perhaps dynamic jumping could be the primary focus. A systematic approach to analyzing the effect of a wide variety of FODs on COP could be very informative.

Conclusions

The results of this study indicate there is no difference between a normal and pronated foot with regards to the timing characteristics of muscle onset and duration. There was a trend towards a shorter VMO duration that may be explored further as possibly should all the durations. The COP excursion investigation supports the concept of excessive motion allowed by a pronated foot until full weight acceptance. Similarly, the trend for increased normal foot COP excursion during the entire stance phase further supports this statement because inclusion of this phase takes into account the resupination by the normal foot through toe-off. Our data is suggestive that the decreased COP excursion by the pronated foot shows a lack of resupination late in stance as it remains in a state of pronation. Efforts to improve the motion of a pronated foot by preventing excessive pronation and correcting supination should continue due to possible implications on injury.

APPENDIX A

Abstract, Manuscript, Tables, Figures

The Effect of Foot Type on Lower Extremity Muscle Activity and Center of Pressure

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Context: Excessive compensatory subtalar joint pronation is the primary factor in overuse related injury in the lower extremity. Often the treatment of choice has been to create a foot orthotic device (FOD) due to their success with symptom resolution. By researching the effect of FODs on the tibialis anterior (TA), peroneus longus (PL), vastus medialis (VM), and gluteus medius (GM) musculature as well as center of pressure (COP) we may better address and understand the global implications of this excessive motion that leads to injury, rather than treating the symptoms alone.

Objective: The purpose of this study was to explore the differences in lower extremity muscular activity (EMG) and COP excursion in individuals with a normal and pronated foot type, as well as to examine if any interaction effects existed between the groups across three conditions-Pretest, Posttest with no FOD, and Posttest with a FOD.

Design: A pretest, posttest design was used. Subjects reported for a total of three sessions, two for EMG and kinetic data collection with a FOD distribution session in between. Separate 2X3 Mixed Model ANOVAs were used for each dependent variable.

Setting: Sports Medicine Research Laboratory at the University of North Carolina, Chapel Hill

Patients/Participants: Thirty-nine healthy active adult volunteers participated in this study

Intervention(s): Subjects were fitted for a custom made FOD and performed walking trials over a forceplate while their lower extremity muscle activity was recorded.

Results: The results of this study indicate there is no difference between a normal and pronated foot with regards to the timing characteristics of onset and duration. There was a trend towards a decreased VMO duration. The normal foot type group exhibited significantly greater COP excursion compared to the pronated foot type group for the first 50% of stance phase. A similar trend existed for the entire stance phase.

Conclusion: No differences exist between a normal and pronated foot with regards to EMG onset and duration; however the author feels that duration should be reexamined. The results of COP excursion data support clinical knowledge regarding biomechanics and support further research into methods to correct for excessive pronation during stance.

Key Words: foot orthotic device (FOD), electromyography (EMG), center of pressure (COP), stance phase, gait

Introduction:

Lower extremity injuries, especially in the athletic population, are often a multifactoral problem. They may stem from a variety of anatomical locations, and begin at a location other than where symptoms are being experienced. In some conditions, it is difficult to specifically isolate and treat the source of the problem. Research has shown that the one factor contributing to lower extremity dysfunction more than any other is excessive/compensatory subtalar joint pronation (ESJP) (Tomaro and Burdett, 1993). Pronation is a dynamic measurement due to it's triplanar movement. Normal pronation is crucial to normal biomechanical function of the ankle foot, but can lead to injury if it occurs excessively or in a compensatory manner (Tomaro and Burdett 1993; Rockar 1995).

ESJP occurs when the threshold of normal limits of pronation, approximately six degrees, is exceeded (Subotnick, 1975). This resultant ESJP has been found to facilitate several deleterious conditions both distally and proximally along the kinetic chain. The treatment of choice for ESJP has often been to create a foot orthotic device (FOD). The use of FODs has been shown to decrease symptom severity and even eliminate symptoms completely in individuals as high up the kinetic chain as the knee (Nawoczenski, Cook et al. 1995; Ball and Afheldt 2002; Gross and Foxworth 2003). Research has also shown that the majority of individuals receiving FODs experienced relief of symptoms such as pain, and chose to continue use of the device following the cessation of their symptoms (Donatelli, Hurlbert, Conaway, and Pierre, 1988).

Another factor to consider when examining ESJP is the potential indirect effect on muscle activity. The possible resultant positions as described above (internal tibial rotation, knee valgus, internal femoral rotation, and adduction and internal rotation of the hip) may actually

inhibit muscular function, which is critical to stability in the ankle/foot, knee, and hip. Disruption of the length-tension relationships governing normal biomechanics will cause muscles to be lengthened or shortened based on the position they are forced into. This change in length will no longer allow the muscles to function appropriately due to fatigue/inhibition and may facilitate the cascade into pathology of vital arthrokinematic structures. The cuboid pulley is essential for the peroneus longus to provide stability to the foot/ankle complex (Root ML 1977). In the knee the vastus medialis obliqus (VMO) is critical to maintaining proper tracking of the patella (Neptune, Wright et al. 2000). Finally, the gluteus medius functions to eccentrically control internal rotation of the hip (Clark 2001).

Studies examining the impact of FODs on lower extremity muscle activity (EMG) have shown both an increase and decrease in the activity of specific muscles (Tomaro and Burdett 1993; Nawoczenski and Ludewig 1999; Hertel, Sloss et al. 2005). A possible explanation for these results may be the restoration of proper length-tension relationships and neuromuscular activation (Hertel, Sloss et al. 2005). These results are promising, yet all limit their focus to amplitude solely, without addressing onset and duration. Therefore it is important to determine what possible ramifications a FOD has on all facets of EMG and COP if efforts are to be made to maximize performance through their use.

Statement of the problem:

The purpose of this study was to examine the differences in lower extremity EMG onsets and durations of musculature surrounding the foot/ankle, knee, and hip, between a neutral and pronated foot-type. Additionally, the effect of FOD intervention on these foot-types was studied with regard to EMG (onsets and durations) and kinetic (COP) data.

Methods:

Subjects

An *a priori* power calculation concluded a total number of 20 subjects per group were required to provide a power of at least 0.80. Forty-one physically active volunteers from the student, faculty, and staff population at the University of North Carolina at Chapel Hill participated in this study. Physically active was defined as exercising at least three times per week for at least thirty minutes. The first group consisted of 20 subjects (age= 22.26 ± 2.26yrs, height= 172.65 ± 11.16cm, mass= 73.89 ± 14.64kg) and was named the experimental or pronated foot type group. The defining characteristic of this group was that the subjects exhibited a navicular drop of at least 10mm (Kelly 2003). The second group was composed of 21 normal foot type individuals (age= 23.20 ± 6.57yrs, height= 167.89 ± 11.42cm, mass= 63.07 ±12.85kg) and served as the control group. This group exhibited navicular drop measurements of less than 7mm. Inclusion criteria included: 1) healthy volunteer of at least 18 years of age, 2) presentation of navicular drop of at least 10mm (for pronated group), that was in no way debilitating in ADLs, or less than 7mm (for normal group) 3) physically active three times per week for 30 minutes. Exclusion criteria included: 1) previous history of lower extremity injury in past six months, 2) previous history of FOD use on regular basis, 3) participation in a lower extremity rehabilitation or training program during study. The University of North Carolina at Chapel Hill Institutional Review Board approved an informed consent form that each participant in this study completed prior to participation.

Measurement and Instrumentation

FOD Fabrication

For FOD fabrication, an AMFIT Footfax-SL ® Contact Digitizer and CAD/CAM Mill Carving Station (AMFIT; Vancouver, WA) was used and operated by a podiatrist. The system digitized the participants' feet and transferred the collected data to the carving station for the creation of precise custom FODs.

Muscle Activity (EMG)

To measure muscle activity, an 8 channel Delsys Electromyography system (Delsys Bagnoli-8, Boston, MA**)** was used to gather EMG data via surface electrodes placed upon the involved muscles: tibialis anterior (TA), peroneus longus (PL), vastus medialis oblique (VMO), and the gluteus medius (GM). Electrodes were placed over the muscle bellies parallel to the fibers of each muscle tested and was verified via palpation and manual muscle testing (Basamaijan, 1985, Kendall and McCreary, 1983).

Kinetic Data

Kinetic data (center of pressure-COP) was collected by a forceplate (Bertec Corporation, Columbus, OH). Data was recorded during walking trials performed on level ground. All EMG and kinetic data was collected simultaneously stored and analyzed using Datapac 2K2 Software **(**Run Technologies, Mission Viejo, CA**).**

Procedures

Qualification

The principal investigator evaluated and determined which individuals exhibited pronation using a navicular drop test. Intrarater reliability was shown to be high with an ICC of .98 with an SEM of .79mm. Pronation for this study was defined as having an inferior displacement of at least a 10 mm during a weight-bearing stance as compared to subtalar neutral in a non weight-bearing stance.

Volunteers reported to Fetzer Athletic Training Room for the navicular drop assessment, and were measured utilizing a navicular drop test. Subjects sat on a table with their knees bent to a 90-degree angle over the edge with their feet resting on a box making sure to have their knee over the ankle joint. The medial and lateral borders of their talus were palpated anteriorly and subjects were asked to invert/evert until equal prominence was felt bilaterally. Once this position was achieved the subject was asked to hold the position until a mark was made on an index card at the same level as the marked navicular. Subjects then stood on the box and marched in place five times and assumed a standing weight bearing stance, facing straight ahead. A second mark was then made on the same card. This process was performed a total of three times per subject. Another certified athletic trainer measured all displacements on the cards, to ensure no biasing, and took either the average of the three trials or the mode measurement if one existed. This number served as the amount of navicular drop in mm.

Individuals exhibiting either less than 7mm or greater than 10mm of navicular drop were allowed to participate in the study. Qualifiers were separated into two groups based upon this measurement and the inclusion criteria above: normal foot type (control), and pronated foot type (experimental). Those who fell within the 7-10mm range were excluded from the study.

FOD Scanning and Distribution

All individuals meeting the inclusion criteria reported to the Sports Medicine Research Laboratory for a foot scanning session with the podiatrist for the fabrication of a pair of custom FODs. Subjects were fitted for a FOD by a podiatrist utilizing an AMFIT Footfax-SL ® Contact Digitizer and CAD/CAM Mill Carving Station (Vancouver, WA). Subjects sat in a chair with their knees and hips flexed to approximately 90 degrees. The foot of each subject was positioned by the podiatrist and the podiatrist asked each subject to remain still while the digitizer's hydraulic pegs rose from the base to create the impression of the foot. This process was repeated for each foot. Data was then sent via phone line to AMFIT where FODs were fabricated to the podiatrist's specifications.

Following approximately one week, the FODs arrived by mail and each subject reported for distribution and wear guideline instructions. FOD wear utilized the following progression: up to 2 hrs of wear the first day and increasing by up to 2 hours each successive day until a full day of wear was reached. The participants were given a log sheet when they received their FODs, to record the hours per day that they wore the FODs. It was asked of the participants that regardless of immediate effects of FOD wear, that their normal levels of activity were not altered (i.e. a feeling of improvement experienced by subject may have led them increase amount and intensity of physical activity). Also, subjects were asked to wait until up to a full days wear to use FODs for any vigorous activity.

Baseline/Pre Test

Subjects reported to the Sports Medicine Research Laboratory for two testing sessions. The purpose of the first session was for completion of informed consent/general health questionnaire, demographic information recording, providing of instructions, and baseline collection. Subjects were asked to report with shorts and the sneakers they planned to wear the FODs in.

For EMG collection, the location for electrode placement occurred as outlined previously following marking of the site with a marker. Subjects then had their skin prepared by shaving with a disposable razor, and abraded and cleaned with isopropyl alcohol. For recording, an 8 channel Delsys Electromyography system was used to record onset and duration during the stance phase of gate. A single bar adhesive Ag/AgCl surface EMG electrode (Delsys Inc., Boston, MA) with contact distance of 10mm was placed over the muscle bellies of the TA, PL, VMO, and GM. The electrodes used disposable adhesive interfaces to attach to the skin and were secured with underwrap and athletic tape following application. Placement was recorded to ensure consistency between baseline and posttest. Electrodes were connected to a transmitter attached to a comfortable fitting belt worn around the participant's waist and collected the muscle activity data throughout all trials.

Both the neutral and pronated foot type groups performed walking trials for baseline collection of EMG and kinetic data during this session. Walking was performed to the beat of a metronome set at 92 beats per minute. During each of the trials, EMG data was collected on selected lower extremity muscles (TA, PL, VMO, GM) of the subject's dominant leg during the stance phase of gait, as they walked over the force plate. Kinetic data was also collected simultaneously during stance. Stance phase was defined as total time in contact with the

forceplate, from heel strike through toe-off. Dominance was defined as the leg they would use to kick a soccer ball for maximum distance.

Post Test

The second and final session at the Sports Medicine Research Laboratory was for post test data collection. This session occurred following a two-week accommodation period to the FODs. Subjects were asked to report with the following items: shorts, the sneakers they wore the FODs in, their original insoles to those sneakers, the FODs, and the FOD log sheet. During this session participants performed two counterbalanced walking trials. One of the walking trials occurred with the FODs, while the other occurred without the FODs. Procedures for this session were the exact same as the baseline/pretest session.

Data Reduction

Onset/Duration

All EMG data was reduced utilizing the following processing filters: Passive demeaning 0.0ms begin/ 50.0ms end, Band pass butterworth 10.0Hz-350.0Hz rolloff 5 (zero lag), RMS smoothing time constant 10.0ms. EMG onset and duration data was analyzed by setting a reference interval at 200.0ms, values above this threshold were considered "on" and values below were considered "off". The use of a max duration filter (0.0-1500.0ms) was used and excluded any activity lasting longer than the set time. Eight individual 2 X 3 Repeated Measures Mixed Model ANOVAs were run, one for each variable of onset/duration and muscle.

COP

All COP data was processed utilizing Linear Smoothing at 10.0msec. Data files were exported as ASCII files and run through LabView (National Instruments; Austin, TX) to achieve mean data by running one of two calculations. The first was COP during loading minus COP at midstance (0-50% of stance), and the second was COP during loading minus COP at propulsion (0-100% of stance). This data was then run through SPSS 13.0. Two separated 2 X 3 Repeated Measures Mixed Model ANOVAs were utilized to analyze the data, dividing trials into 0-50% stance phase at each condition, and then at 0-100%.

Statistical Analysis

All data was analyzed using SPSS 13.0 statistical software (SPSS, Inc., Chicago, IL), using an *a priori* alpha-level of 0.05. An *a priori* power analysis provided a power level of 0.80 for 40 subjects. Power level was determined through investigation of literature involving EMG and FODs as well as pilot test data. Independent variables included two groups, the pronated and normal foot type, as well as three conditions, baseline, post with FOD, and post without FOD. Dependent variables examined included onset and duration of muscle activity, of the four muscles, TA, PL, VMO, and GM relative to stance phase of walking task, COP area both from 0-50%, and 0-100%.

Results:

Following statistical analyses, no significant differences were found in the timing characteristics (onset and duration) of selected lower extremity musculature (PL, TA, VMO, and GM) between the normal and pronated foot type groups over pre test (Pre), posttest without a FOD (PostNo), and post with a FOD (PostFOD) conditions. Additionally, no significant differences were found in the timing characteristics of the lower extremity musculature in the pronated group both before and after two weeks of FOD accommodation. Means and standard deviations (SD) as well as F and p values of the onsets and durations of the involved musculature are presented in Table 3 and Figures 1-8 (Appendix A) as well as listed below. Analysis of COP excursion data revealed that a main effect for group existed (Appendix A: Table 4), whereby the normal group's COP excursion was greater compared to the pronated group (Appendix A: Table 4, Figures 9 & 10). Means (±SD) of the COP excursion the first 50% and entire stance phase are reported in Table 4 (Appendix A).

Matching Subjects

We tested 41 subjects (39 completed all the requirements of the study). Two subjects decided to discontinue participation in the study. Subject demographical characteristics are presented in Table 1 and Figures 9-11 (Appendix A). These subjects were divided into two groups (19 excessive pronators and 20 normal foot individuals) based on a navicular drop test described in the Methods section. The pronated foot type group varied significantly in their amount of pronation as compared to the normal foot group (mean difference =10.07mm) [t (37) =-12.224, p<.001)] (Appendix A: Table 2), as well as in weight (kg) [t (37) =-2.455, p<.05)] (Appendix A: Table 1).

Muscle timing characteristics

Onset

Means and standard deviations for the onsets of the TA, PL, VMO, and GM are shown in Table 3 (Appendix A). For the TA onset (TAO) there was no main effect for group [F (2,37) = .689, p=.505] or test [F (1,37) = .326, p=.571] as well as no test by group interaction [F(2,37) =.068, p=.935]. The PL onset (PLO) revealed no main effect for group [F(1,37) =.211, p=.649], test [F(2,37) =.608, p=.547], or a test by group interaction [F(2,37) =.568, p=.569]. For VMO onset (VMOO) no main effect for group [F(1,37) =.860, p=.360], test [F(2,37) =1.480, p=.234], or test by group interaction existed [F(2,37) =1.611, p=.207]. The GM onset (GMO) had no main effect for group [F(1,37) =.133, p=.717], test [F(2,37) =1.446, p=.242], or test by group interaction [F(2,37) =1.147, p=.323] (Appendix A: Table 5).

Duration

Means and standard deviations for the durations of the TA, PL, VMO, and GM are shown in Table 4 (Appendix A). For the TA duration (TAD) there was no main effect for group [F(1,37) =2.214, p=.145] or test [F(2,37) =.175, p=.840] as well as no test by group interaction [F(2,37) =.972, p=.383]. The PL duration (PLD) had no main effect for group [F(1,37) =.156, p=.696], test [F(2,37) =1.571, p=.215], or a test by group interaction [F(2,37) =.750, p=.476]. For VMO duration (VMOD) the assumption of sphericity was violated (p=.024), therefore the Greenhouse-Geisser correction was utilized for this analysis. No main effect for group [F(1,37) =.032, p=.859], test [F(1.685,37) =.3.001, p=.065], or test by group interaction existed [F(1.685,37) =.137, p=.838]. The GM duration (GMD) had no main effect for group [F(1,37) =.413, p=.524], test [F(2,37) =1.365, p=.262], or test by group interaction [F(2,37) =1.835, p=.167] (Appendix A: Table 5).

Kinetic Data-COP

Loading to Midstance

We performed a 2 X 3 mixed model ANOVA to determine the effect of foot type and FOD on COP from loading (heel strike) to midstance. Means and SD are reported in Table 6 (Appendix A). No main effect was found for test (pre, post without a FOD, and post with a FOD) [F(1.434,28) =.997, p=.375], and no test by group interaction was found [F(1.434,28) =.321, p=.655]. There was however a main effect for group [F(1,28) =8.430, p=.000] revealing that a significant difference in COP excursion from loading to midstance existed between our groups. The normal foot type group had a greater COP excursion than did the pronated foot type group (Appendix A: Table 7). The assumption of sphericity was violated (p=.001), therefore the Greenhouse-Geisser correction was employed for these analyses.

Loading to Propulsion

We performed a 2 X 3 mixed model ANOVA to determine the effect of foot type and FOD on COP from loading propulsion (toe off). Means and SD are reported in Table 6 (Appendix A). There was no main effect for test [F(1.581,28) =.813, p=.424], or group [F(1,28) =3.189, p=.085]. Also, no test by group interaction effect existed [F(1.434,28) =.114, p=.846] (Appendix A: Table 7). The assumption of sphericity was violated (p=.016), therefore the Greenhouse-Geisser correction was employed for these analyses.

Discussion:

The most important finding in our study is that the normal group's COP excursion during the first 50% of stance phase was greater than the pronated group's. A similar trend was also observed towards a significant difference in COP excursion over the entire stance phase. This result shows that the normal foot had more total movement/displacement during the first 50% of stance phase as compared to the pronated foot. The greater value of COP excursion does not signify direction (medial/lateral), only amount (mm).

Typically, a medially displaced COP path is thought to be caused by excessive compensatory subtalar joint pronation (ESJP). ESJP has been implicated in creating numerous abnormal biomechanical processes throughout the kinetic chain. The use of FODs is one of the most common and effective treatments for the resultant malalignments and symptoms, such as pain (Nawoczenski, Cook et al. 1995; Ball and Afheldt 2002; Gross and Foxworth 2003). It has been shown that FODs significantly increase EMG amplitude (Nawoczenski and Ludewig 1999; Hertel, Sloss et al. 2005) however; varying results exist regarding the effect of foot type and the use of FOD intervention on EMG timing characteristics such as onset and duration (Tomaro and Burdett 1993; Rose, Shultz et al. 2002; Bird, Bendrups et al. 2003). COP measures are commonly utilized to examine abnormalities of the lower extremity as well. Specifically, ESJP has been show to have an affect upon COP, causing an altered path that moves medially earlier in the stance phase (Bowker 1993).

Due to the previous duration specific findings of Tomaro and Burdett (1993), we hypothesized that onset would occur earlier and duration would last longer in the normal foot as compared to a pronated foot. Also, that the use of a FOD would provide results showing

earlier onset and longer duration versus a non FOD group. The results of our study however fail to show any significant difference in the variables of onset and duration in lower extremity musculature regardless of FOD intervention. Although the results proved to be non significant, the EMG onset and duration values are important because they show no change in muscle timing characteristics exist between the normal and pronated group across FOD conditions.

In terms of kinetics, due to the possible resultant trend described in COP path due to ESJP, we hypothesized that the normal foot type group would have significantly less excursion in COP path values than the pronated foot type as well as that a FOD condition would also exhibit less COP excursion in comparison to a pronated foot type under no intervention. Analysis of our data showed the opposite, with significantly more COP excursion by the normal group as compared to the pronated foot type during the first half of stance phase.

EMG

Muscle activity has been shown in several studies to be affected by FODs. Typically this reported effect is with regards to amplitude, not the onset or duration. Few studies have specifically examined the role FODs play on onset and duration of muscle activity during gait. We chose to assess individuals in a dynamic manner by having them walk over ground to the beat of a metronome. A forceplate was used to determine the stance phase of gait from heel strike through toe off.

Typically during gait the TA will have onset before toe off and reach peak activity just afterwards. Then the action of plantarflexion is eccentrically decelerated as stance phase begins, allowing the forefoot to lower smoothly to the ground. The TA will then usually

become inactive as midstance is reached (Michaud 1993). The PL becomes active during midstance causing pronation at the subtalar joint (secondary to the peroneus tertius) in order to stabilize and decelerate resupination during late stance. It also functions to lock the midtarsal joints as propulsion begins (Michaud 1993). The quadriceps as a whole activate during the late swing phase, achieving peak activity just after heel strike as they decelerate knee flexion, and contract until midstance (Michaud 1993). The GM is active from late swing through midstance as it attempts to stabilize the pelvis through stance (Michaud 1993). After comparing the figures of Michaud (1993) and the information on datapac, muscular firing patterns appeared to have similar general appearance characteristics.

We found no statistically significant differences in onset or duration in any of the four tested muscles (Appendix A: Table 5). Our findings conflict with those of Tomaro and Burdett (1993), who found a significant increase in TA duration with a FOD intervention. However, they assessed walking on a treadmill instead of over ground, which may explain the differences between our results. In the current study we observed a trend in VMO duration that appears to demonstrate an earlier cessation of activity. The duration of the VMO appeared to be shorter following the pre test as compared to each post test session and can be seen graphically in Figure 7 (Appendix A). If this assumption is accurate, our findings are consistent with those of Rose et al (2002) in which the VMO was found to have a shorter duration with the use of FODs. However, neither this nor that study achieved statistical significance in this finding. Our methods also varied from theirs as they utilized a single leg perturbation assessment, not over ground walking. The trend suggesting a shorter VMO duration with FODs, can perhaps be explained by the FOD placing the VMO in a more optimal position. This position may actually prevent fatigue that results from prolonged knee

valgus due to increased tibial and femoral internal rotation associated with excessive compensatory subtalar joint pronation.

Kinetic Data-COP

COP can be collected with the use of a forceplate and can provide valuable kinematic data to us as clinicians and researchers. Typically, the path of COP during stance begins at the lateral heel during heel strike progressing along the lateral foot to midstance where it then crosses over the forefoot in preparation for toe off, typically under the first or second metatarsal heads (Neumann, D., 2002). COP data was recorded as subjects walked across the forceplate and was divided into two measurable quantities for analysis, the difference in COP during weight acceptance and during propulsion.

Data from only 30 of our subjects could be analyzed kinetically due to file formatting error, leaving two equal groups of 15. For the first 50% of stance phase there was a significant increase in COP excursion in the normal group compared to the pronated group. Despite the sample size decrease we maintained a power of .80 as we found a significant difference between the groups in COP excursion during weight acceptance (Appendix A: Table 7). A possible cause of these results have been suggested that the normal foot lacks an anatomical medial block in weight bearing thus allowing the foot to collapse medially and not just continuing to bear weight on the lateral border of the foot (Hertel et al, 2002). Care should be taken in comparing our results, as the results from Hertel and colleagues (2002) were from a single leg balance position. These results do confirm what is already known about foot biomechanics in that the normal foot will begin stance in supination, making a gradual transition into pronation, and then resupinate for push off, thereby giving us a greater

COP excursion. The pronated foot will move into pronation rapidly after heel strike and remain there for the duration of stance, thus having a more medial COP path, but less COP excursion due to lack of resupination. The groups in this study varied significantly in their levels of navicular drop (Appendix A: Table 2) suggesting a predisposition for the foot to collapse medially thereby altering the COP path before toe off. Our results suggest that this reduced COP excursion in the pronated foot type group shows the excessive motion allowed by the foot only until full weight acceptance.

Speculation can be made as to what results may have been seen with a larger population than fifteen subjects in the trend towards significance was observed for group when comparing the entire duration of stance phase (Appendix A: Table 7). This result could be suggestive of the extent of alteration different foot types have on COP excursion. If a larger sample size had been used, the trend towards significance may have gained true statistical significance. Very few studies exist that examine the specific impact of foot type and FOD on COP path during walking (especially with EMG), making speculation and generalizations difficult.

Clinical Significance

The results of this study yield some suggestions for possible treatment of lower extremity pathologies. With regards to muscle activity, the shorter VMO duration may signify a possible benefit of the FODs to correct abnormal biomechanics and restore proper muscle function. Also, the findings of this study reinforce the knowledge that a pronated will exhibit excessive motion but little movement will take place after full weight acceptance. Our results speculate further on the importance of FOD intervention to not only restore proper length tension relationships, but to also possibly help assist the pronated foot achieve a greater ability to resupinate and not to stay a state of pronation throughout the entire stance phase. Hypothetically, if this mechanism proved successful, factors such as shock absorption and malaignment would be improved ultimately leading to a possible reduction in injury. Even though research has shown extreme variability in EMG with FOD intervention, greater sample sizes and systematic, yet individualized FOD fabrication may help to alter both onset/duration of muscle activity and COP path in a clinically significant way.

Limitations

We feel there are some contributing factors in the lack of significant findings. First, examination showed considerable variability in our EMG data (Appendix A: Tables 3 and 4). The use of the FOD had no specific intervention criteria, meaning that there was not a set amount of intervention (support) placed upon the subjects. This might possibly lead to varying degrees of change and ultimately more variability. The accommodation period of two weeks was chosen to fit the time frame of the desired study completion and to enhance subject compliance. This time frame may have been inappropriate, possibly yielding more acute FOD intervention results than those that may occur over time. For example, perhaps the trend observed in shorter VMO duration would achieve significance as well as other duration measurements, thus suggesting that FODs help to decrease muscle duration time by reestablishing length-tension relationships and decreasing possible fatigue. Forefoot varus was not objectively quantified during the study. Perhaps examining this deformity more closely would have led to more specific FOD fabrication specifications. A person with a flexible flat foot may not have had appropriate contact area coverage from the FOD due to their allowed motion, whereas a rigid foot may have been given more appropriate support. These FODs could have also possibly corrected a host of abnormalities indiscriminant to the fact that navicular drop was the only qualifying measure. Another objective measurement that may have been added to the data collection was range of motion (ROM) assessment. Particularly examining whether or not individuals exhibited gastrocnemius/soleus complex tightness that may lead to increased toeing out or pronation to achieve ROM. Specifically during data collection, having the subjects hold the EMG cable during walking trials, and utilizing a quartz metronome set to a rate of 92 beats per minute to help standardize walking

trials may have in some ways altered, possibly by restricting arm swing, or forcing a lunge or stutter step to contact forceplate, the normal gait of the subjects, thereby influencing results.

Fava et al. (2003) proposed a possible difficulty in the analysis of onset and duration could be that during dynamic activity, the muscle is already in an excited state making the distinction between "on" and "off" much more difficult than between a resting measure and some active movement. We were confident that our assessment of onset and duration was accurate despite the dynamic nature of our study. Historically, surface EMG has been criticized for validity with regards to issues like cross talk, adipose filtering, and skin movement (Merletti 2004). Even though the muscles were palpated and manually tested to ensure proper placement, and the electrodes were secured with under wrap, the possibility cannot be ruled out that these confounding variables may have influenced our results. Furthermore, there is very little literature examining the use of FODs, EMG, and kinetic data analysis during over ground walking, making the results of our study difficult to fully generalize and compare with existing literature.

Future Research

Further EMG examination could focus locally at a joint under the intervention of FODs. The study could be aimed at discovering whether any change may be more of an injury prevention response due to possibly restored length-tension relationships or just related to fatigue. Available research is variable with regards to types of FODs, the degree of intervention they provide, how long of an accommodation period was used) and the circumstances they are tested under. More collective organization may help explain existing cause and effect relationships. It is also the author's opinion that sport specific or situational

EMG assessment is paramount before generalization. In agreement with Tomaro and Burdett (1993), it is recommended that if possible, EMG testing of the tibialis posterior (TP) specifically, due to its function of a plantar flexor and inverter, and due to its attachment on the navicular itself, be conducted. We could not assess this activity due to the difficulty surface EMG has with the TP. Testing for runners may possibly require altering inclines and speeds rather than just a level walk/run. With athletes in the sports of basketball or volleyball, perhaps dynamic jumping could be the primary focus. A systematic approach to analyzing the effect of a wide variety of FODs on COP could be very informative.

Conclusions

The results of this study indicate there is no difference between a normal and pronated foot with regards to the timing characteristics of muscle onset and duration. There was a trend towards a shorter VMO duration that may be explored further as possibly should all the durations. The COP excursion investigation supports the concept of excessive motion allowed by a pronated foot until full weight acceptance. Similarly, the trend for increased normal foot COP excursion during the entire stance phase further supports this statement because inclusion of this phase takes into account the resupination by the normal foot through toe-off. Our data is suggestive that the decreased COP excursion by the pronated foot shows a lack of resupination late in stance as it remains in a state of pronation. Efforts to improve the motion of a pronated foot by preventing excessive pronation and correcting supination should continue due to possible implications on injury.

Table 1: Demographics

Group		Age (years)			Height (cm)			Weight (kg)		
		Mean		SD	Mean		SD	Mean		SD
Normal	(n=20)	23.20	±	6.57	167.89	±	11.42	63.07	±	12.85
Pronated	(n=19)	22.26	±	2.26	172.65	±	11.16	73.89*	±	14.64

* Denotes significance at $p < .05$ level

Table 2: Navicular Drop

Group	Average (mm)			ICC	SEM (mm)
	Mean		SD		
Normal	4.65	±	2.00	0.98	0.79
Pronated	14.72	±	3.06 *		

* Denotes significance at p <.05 level

Table 3: Muscle Onset/Duration (msec) means (± SD), F, and p values

Muscle	Group	Pre		Post No FOD		Post FOD		Group	Test	Group x Test
		Mean	SD	Mean	SD	Mean	SD	Main Effect	Main Effect	Interaction
TA Onset	Normal	449.83 ±	38.97	454.80 ±	36.23	445.84 ±	50.20	[F(1,37) =.326,	[F(2,37) =.689,	[F(2,37) =.068,
	Pronated	452.66 ±	39.35	461.80 ±	48.39	454.04 ±	42.51	p=.571]	p=.505]	p=.935]
TA Duration	Normal	602.90 ±	63.25	610.99 ±	79.73	594.94 ±	76.51	[F(1,37) =2.214,	[F(2,37) =.175,	[F(2,37) =.972,
	Pronated	650.26 ±	87.32	625.71 ±	116.77	646.22 ±	130.33	p=.145]	p=.840]	p=.383]
PL Onset	Normal	58.53 ±	67.92	83.58 ±	85.30	69.23 ±	88.87	[F(1,37) =.211,	[F(2,37) =.608,	[F(2,37) =.568,
	Pronated	66.71 ±	50.31	66.09 ±	53.68	54.26 ±	80.53	p=.649]	p=.547]	p=.569]
PL Duration	Normal	732.68 ±	100.54	754.21 ±	99.42	701.12 ±	137.84	[F(1,37) =.156,	[F(2,37) =1.571,	[F(2,37) =.750,
	Pronated	729.27 ±	75.67	752.83 ±	120.67	739.35 ±	126.57	p=.696]	p=.215]	p=.476]
VMO Onset	Normal	131.75 ±	40.95	109.65 ±	67.09	110.28 ±	71.76	[F(1,37) =.860,	[F(2,37) =1.480,	[F(2,37) =1.611,
	Pronated	102.53 ±	46.98	104.26 ±	51.14	101.63 ±	43.49	p=.360]	p=.234]	p=.207]
VMO Duration	Normal	436.15 ±	137.17	401.00 ±	125.02	397.13 ±	137.79	[F(1,37) =.032,	[F(1.685,37) =.3.001,	[F(1.685,37) =.137,
	Pronated	441.94 ±	157.74	384.20 ±	97.78	389.84 ±	128.32	p=.859]	p=.065]	p=.838]
GM Onset	Normal	88.42 ±	104.51	54.16 ±	72.78	81.66 ±	74.47	[F(1,37) =.133,	[F(2,37) =1.446,	[F(2,37) =1.147,
	Pronated	88.43 ±	52.40	82.77 ±	76.54	77.57 ±	98.17	p=.717]	p=.242]	p=.323]
GM Duration	Normal	604.01 ±	140.08	542.17 ±	132.42	589.42 ±	123.47	[F(1,37) =.413,	[F(2,37) =1.365,	[F(2,37) =1.835,
	Pronated	613.47 ±	161.92	610.87 ±	128.83	588.04 ±	168.13	p=.524]	p=.262]	p=.167]

Table 4: COP Excursion (mm) means (± SD), F, and p values

Phase	Group	Pre		Post No FOD		Post FOD		Group	Test	Group X Test
		Mean	SD	Mean	SD	Mean	SD	Main Effect	Main Effect	Interaction
Loading to Midstance	N	0.026	± 0.014	0.021	± 0.013	0.020	± 0.011	[F(1,28) =8.430, p=.000]*	[F(1.434,28) =.997, p=.375]	[F(1.434,28) =.321, p=.655]
	P	0.014	0.014	0.007	0.028	0.013	0.012			
Loading to Propulsion	N	-0.026	± 0.017	-0.020	± 0.017	-0.021	± 0.016	[F(1,28) =3.189, p=.085]	[F(1.581,28) =.813, p=.424]	[F(1.434,28) =.114, p=.846]
	P	-0.014	± 0.020	-0.009	± 0.032	-0.014	± 0.016			

* Denotes Significance at the p<.001 level
N=Normal
P=Pronated

Table 5: Effect Sizes

Variable	Group	Pre & Post No	Pre & Post FOD	Post No & Post FOD
TA Onset	Normal	0.08969	0.07201	0.16170
	Pronated	0.16512	0.02502	0.14010
PL Onset	Normal	0.26960	0.11516	0.15444
	Pronated	0.00664	0.13409	0.12745
VMO Onset	Normal	0.26970	0.26207	0.00763
	Pronated	0.02110	0.01106	0.03216
GM Onset	Normal	0.29037	0.05729	0.23309
	Pronated	0.04801	0.09214	0.04413
TA Duration	Normal	0.06046	0.05949	0.05949
	Pronated	0.18378	0.03029	0.15349
PL Duration	Normal	0.14455	0.21185	0.35640
	Pronated	0.15831	0.06771	0.09060
VMO Duration	Normal	0.19594	0.21748	0.02154
	Pronated	0.32232	0.29083	0.03149
GM Duration	Normal	0.29457	0.06948	0.22509
	Pronated	0.01240	0.12130	0.10890
Load to Midstance	Normal	0.00000	0.00000	0.00000
	Pronated	0.00000	0.00000	0.00000
Load to Propulsion	Normal	0.18101	0.13748	0.04353
	Pronated	0.18101	0.01964	0.16137

Figure 1:TA Onset Means

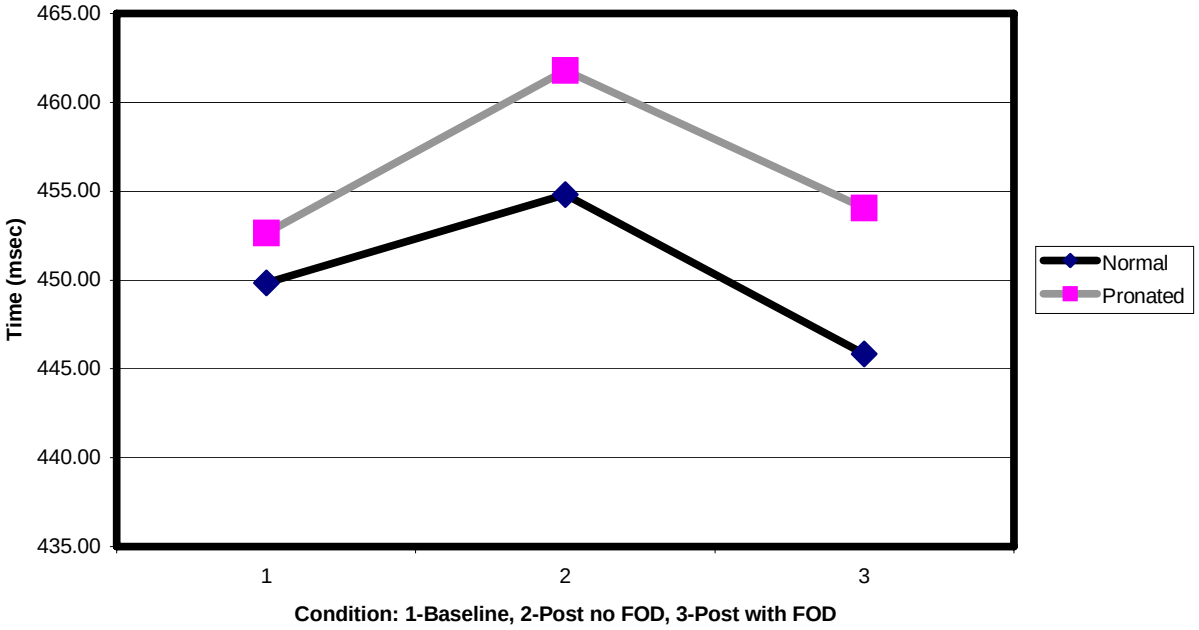


Figure 2:PL Onset Means

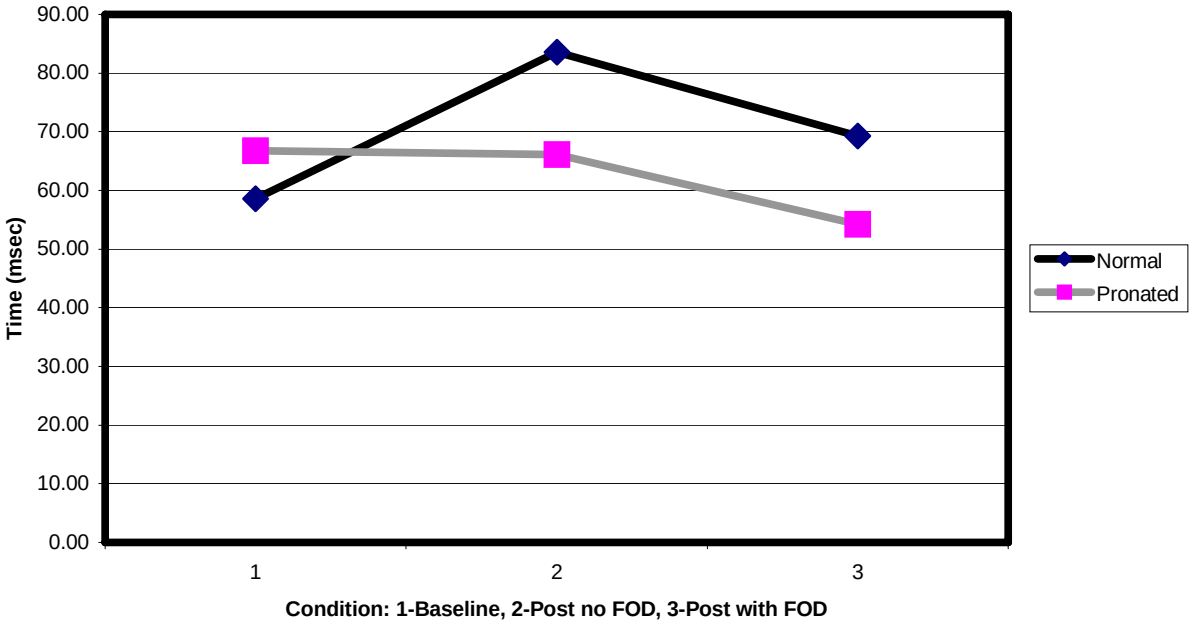


Figure 3:VMO Onset Means

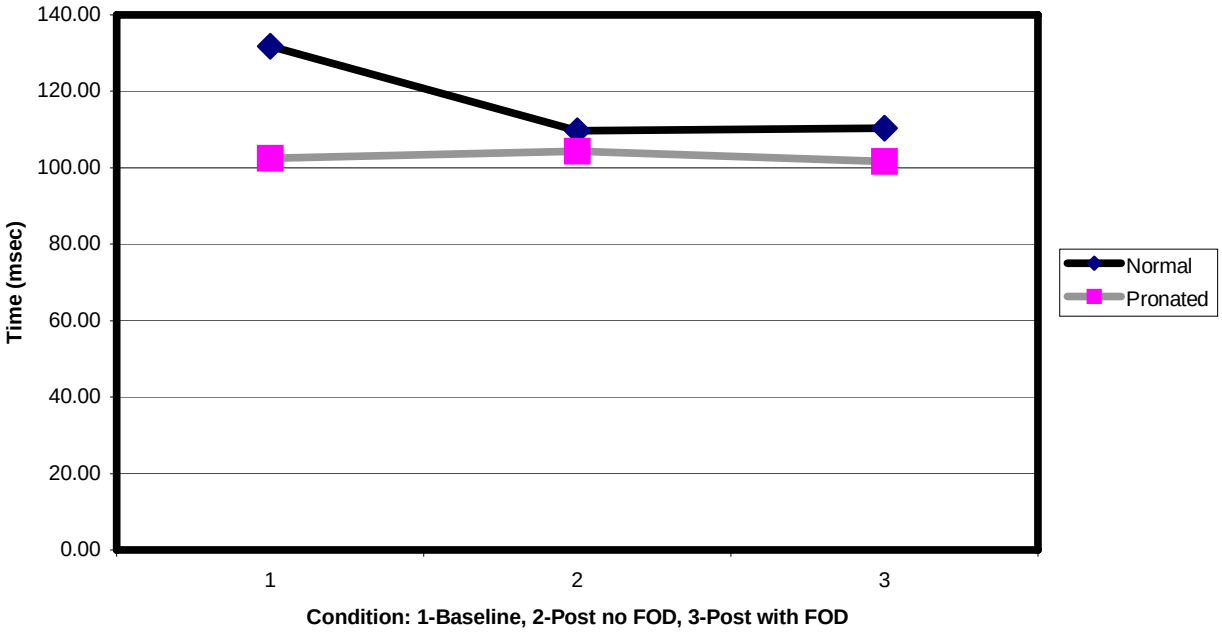


Figure 4:GM Onset Means

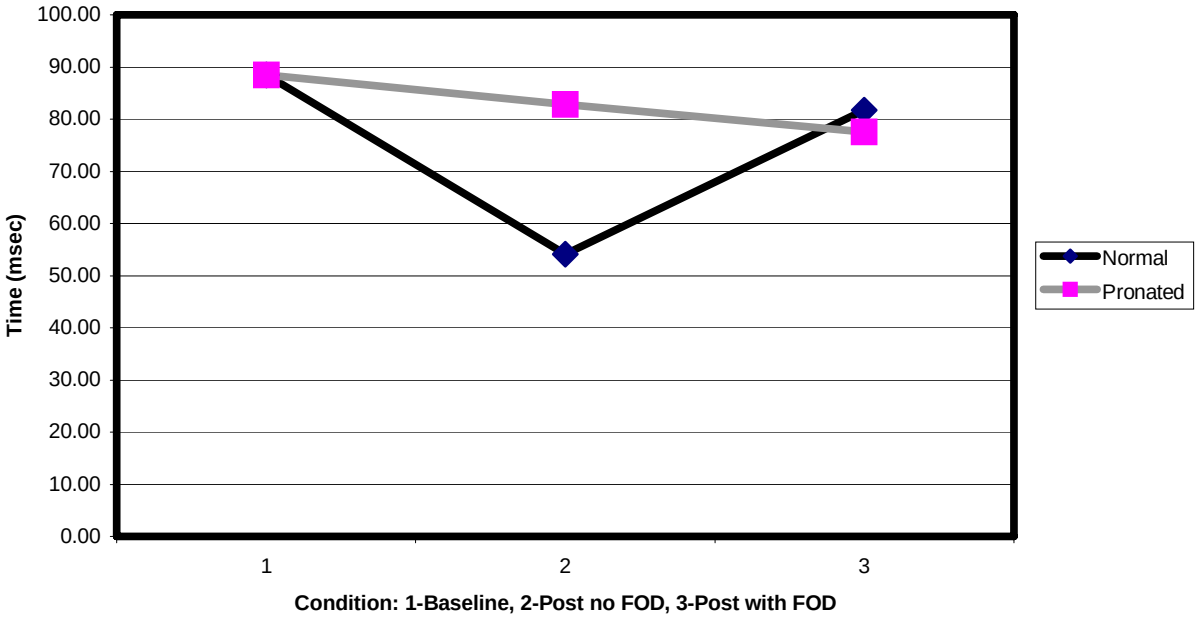


Figure 5:TA Duration Means

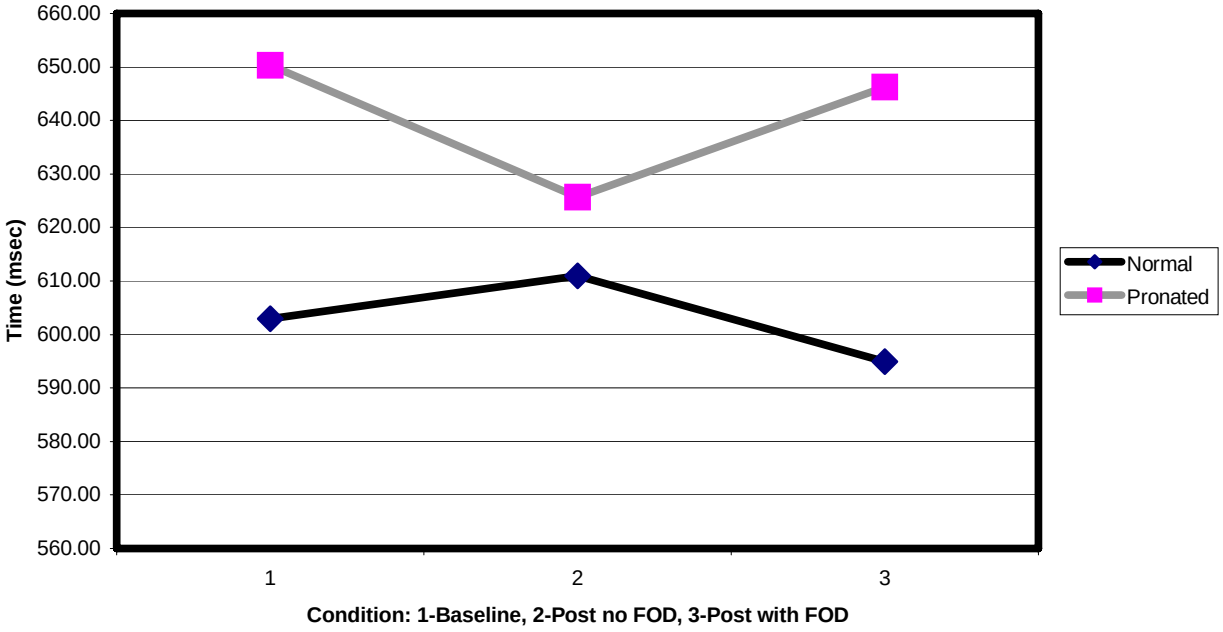


Figure 6:PL Duration Means

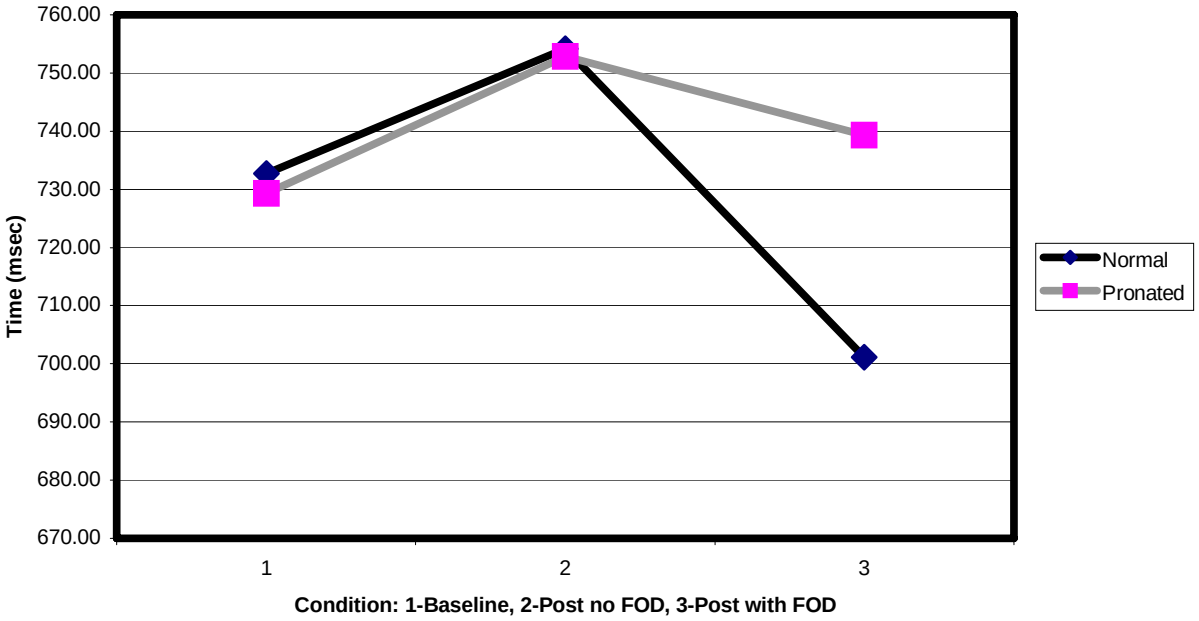


Figure 7:VMO Duration Means

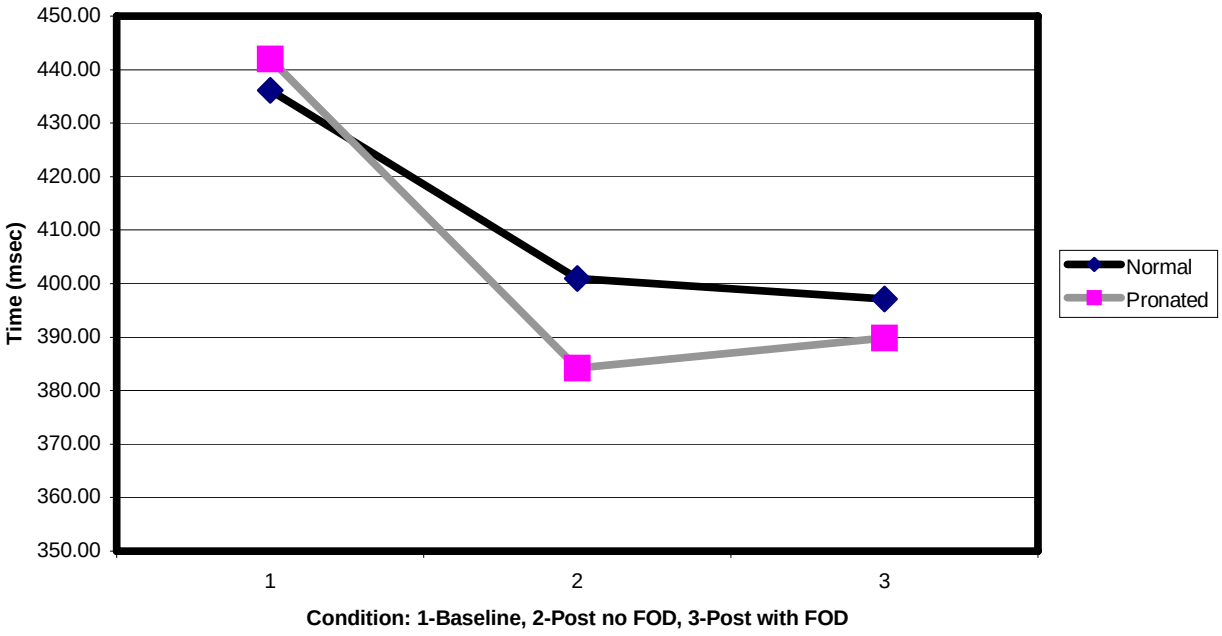


Figure 8:GM Duration Means

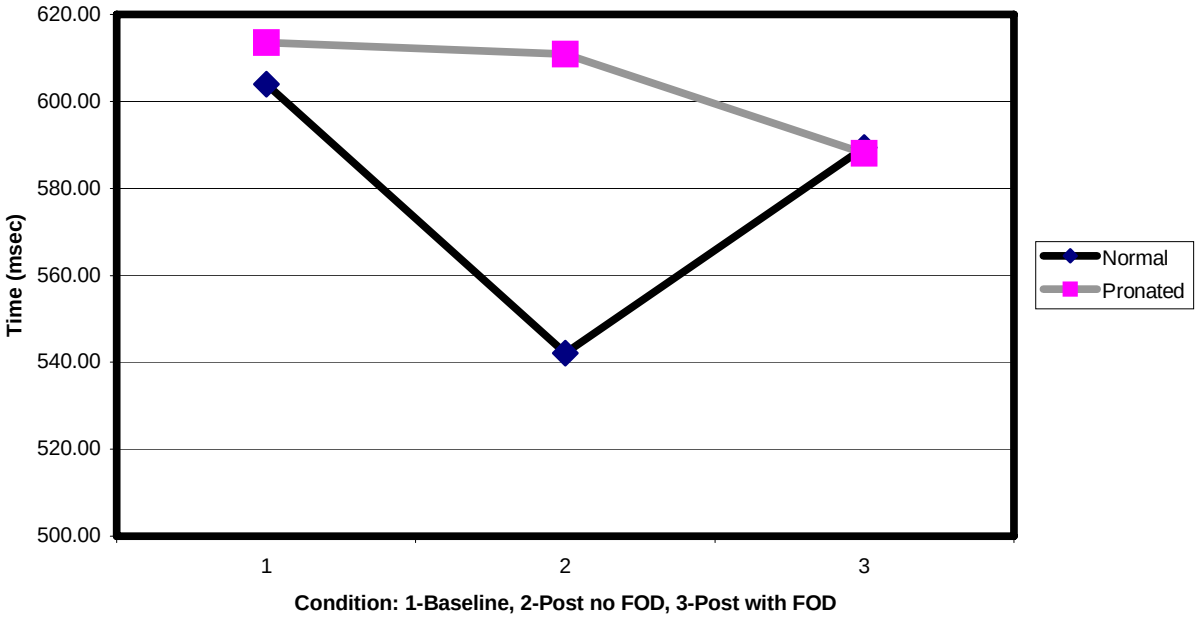


Figure 9:COP excursion Loading to Midstance Means

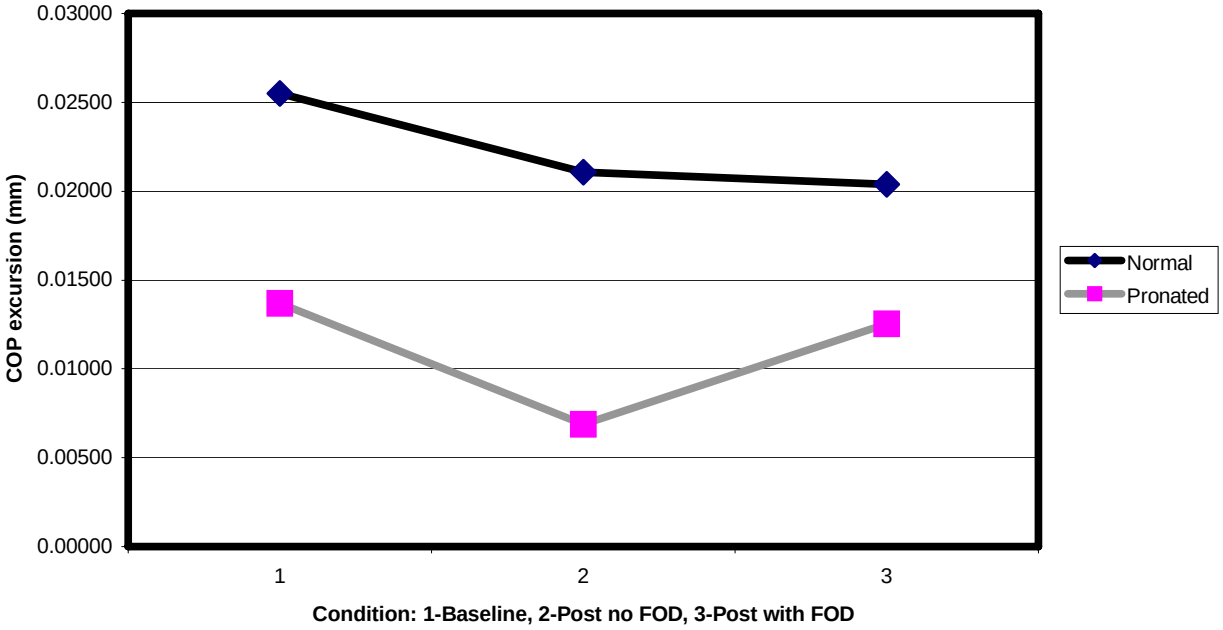
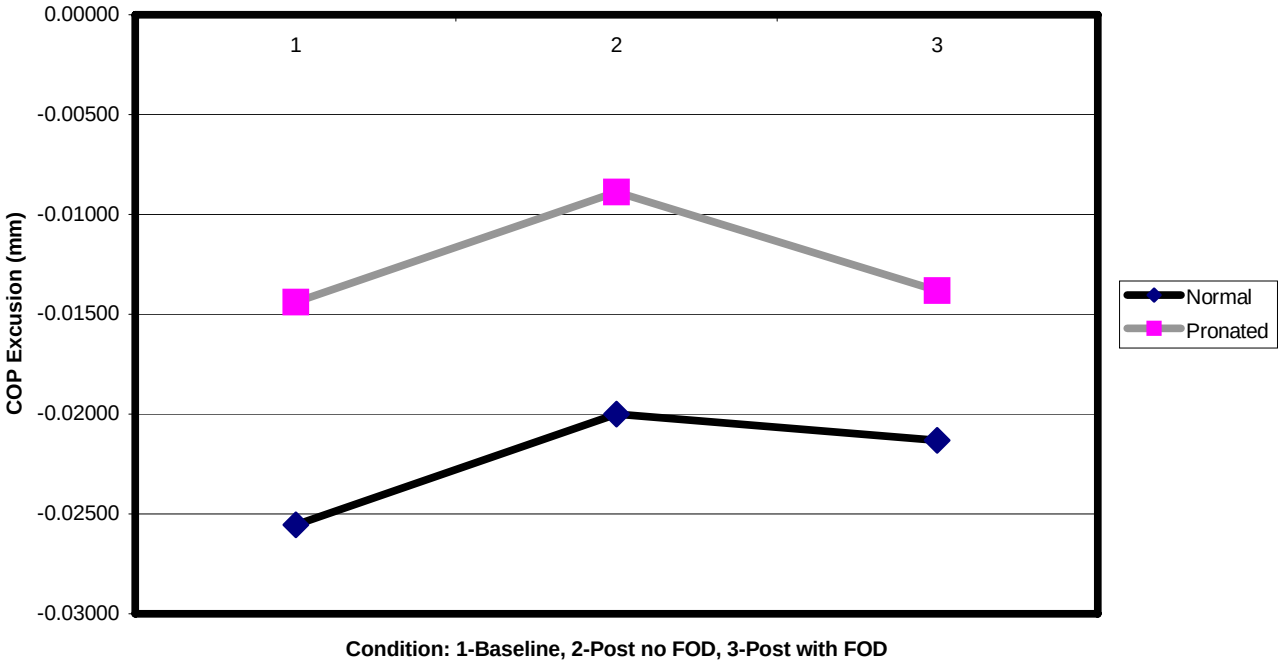


Figure 10:COP Excusion Loading to Propulsion Means



APPENDIX B

IRB Materials

OFFICE OF HUMAN RESEARCH ETHICS
Institutional Review Board

APPLICATION FOR IRB APPROVAL OF HUMAN SUBJECTS RESEARCH
Version 28-Sep-2005

For IRB Use
Behav Bio Dent Nurs PH
IRB Study #_____
Rec'd_____
Full Expedited Exempt

Part A.1. Contact Information, Agreements, and Signatures

Title of Study: The Effect of Foot Type on Lower Extremity Muscle Activity **Date:** 01/12/06

Name and degrees of Principal Investigator: Sean Kupiec, LAT, ATC
Department: EXSS
Mailing address/CB #: c/o Cindy Atkins
209 Fetzer Gymnasium
Chapel Hill, NC, 27599-8700
UNC-CH PID: 710994381 Pager:
Phone #: 919-962-2067 Fax #: 919-962-0489 Email Address: skupiec@email.unc.edu

For trainee-led projects: __ undergraduate _ graduate __ postdoc __ resident __ other

Name of faculty advisor: Kevin Guskiewicz Ph.D, ATC
Department: EXSS
Mailing address/CB #: 8700
Phone #: 919-962-5175 Fax #: 919-962-0489 Email Address: gus@email.unc.edu

Name, phone number, email address of project manager or coordinator, if any:

List **all other project personnel** including co-investigators, and anyone else who has contact with subjects or identifiable data from subjects: Kevin Guskiewicz Ph.D, ATC, Robert Butler Ph.D, ATC, Christopher Hirth MS, PT, ATC, Michelle Boling MS, ATC, Howard Kashefsky DPM

Name of funding source or sponsor:
__ not funded __ Federal __ State __ industry __ foundation __ UNC-CH
X other (specify): This study is not funded, the podiatrist will donate the supplies necessary for foot orthotic device (FOD) fabrication **Sponsor or award number**:

Include following items with your submission, where applicable. Check the items below and **include in order listed**.

- □ This application. One copy must have original PI signatures.
- □ Consent and assent forms, fact or information sheets; include phone and verbal consent scripts
- □ HIPAA authorization addendum to consent form
- □ All recruitment materials including scripts, flyers and advertising, letters, emails
- □ Questionnaires, scripts used to guide phone or in-person interviews, etc.
- □ Focus group guides
- □ Data use agreements (may be required for use of existing data from third parties)
- □ Addendum for Multi-Site Studies where UNC-CH is the Lead Coordinating Center
- □ Documentation of reviews from any other committees (e.g., GCRC, Oncology)

- □ Documentation of training in human research ethics for all study personnel
- □ Investigator Brochure if a drug study
- □ Protocol, grant application or proposal supporting this submission; (e.g., extramural grant application to NIH or foundation, industry protocol, student proposal)

Principal Investigator: I will personally conduct or supervise this research study. I will ensure that this study is performed in compliance with all applicable laws, regulations and University policies regarding human subjects research. I will obtain IRB approval before making any changes or additions to the project. I will notify the IRB of any other changes in the information provided in this application. I will provide progress reports to the IRB at least annually, or as requested. I will report promptly to the IRB all unanticipated problems or serious adverse events involving risk to human subjects. I will follow the IRB approved consent process for all subjects. I will ensure that all collaborators, students and employees assisting in this research study are informed about these obligations. All information given in this form is accurate and complete.

_____ _____

Signature of Principal Investigator Date

Faculty Advisor if PI is a Student or Trainee Investigator: I accept ultimate responsibility for ensuring that this study complies with all the obligations listed above for the PI.

_____ _____

Signature of Faculty Advisor Date

Department or Division Chair, Center Director (or counterpart) of PI: (or Vice-Chair or Chair's designee if Chair is investigator or otherwise unable to review): I certify that this research is appropriate for this Principal Investigator, that the investigators are qualified to conduct the research, and that there are adequate resources (including financial, support and facilities) available. I support this application, and hereby submit it for further review.

_____ _____

Signature of Department Chair or designee Date

_____ _____

Print Name of Department Chair or designee Department

Part A.2. Summary Checklist

Are the following involved?	Yes	No
A.2.1. Existing data, research/patient records, and/or human biological specimens?	__	X
A.2.2. Surveys, questionnaires, interviews, or focus groups with subjects?	X	__
A.2.3. Videotaping, audiotaping, filming of subjects?	__	X
A.2.4. Do you plan to enroll subjects from these vulnerable or select populations: a. UNC-CH students or UNC-CH staff? b. Non-English-speaking? c. Decisionally impaired? d. Patients? e. Prisoners, parolees and other convicted offenders? f. Pregnant women? g. Minors (less than 18 years)? **If yes**, give age range: to years	 X __ __ X __ __ __	 __ X X __ X X X
A.2.5. a. Is this a multi-site study (i.e., involves organization(s) outside UNC-CH)? b. Will any of these sites be outside the United States? ***If yes***, provide contact information for the foreign IRB. c. Is UNC-CH the sponsor or lead coordinating center? ***If yes***, include the ***Addendum for Multi-site Studies where UNC-CH is the Lead Coordinating Center***.	__ __ __	X __ __
A.2.6. Will there be a data and safety monitoring committee (DSMB or DSMC)?	__	X
A.2.7. a. Are you collecting sensitive information such as sexual behavior, HIV status, recreational drug use, illegal behaviors, child/physical abuse, immigration status, etc? b. Do you plan to obtain a federal Certificate of Confidentiality for this study?	__ __	X X
A.2.8. a. Investigational drugs? (provide **IND #**) b. Approved drugs for "non-FDA-approved" conditions? *All studies testing substances in humans must provide a letter of acknowledgement from the UNC Health Care Investigational Drug Service (IDS).*	__ __	X X
A.2.9. Placebo(s)?	__	X
A.2.10. Investigational devices, instruments, machines, software? (provide **IDE #**)	X	__
A.2.11. Fetal tissue?	__	X
A.2.12. Genetic studies on subjects' specimens?	__	**X**
A.2.13. Storage of subjects' specimens for future research? ***If yes**, see instructions within the form **Consent for Stored Samples**.*	__	X
A.2.14. Diagnostic or therapeutic ionizing radiation, or radioactive isotopes, which subjects would not receive otherwise? ***If yes**, approval by the **UNC-CH Radiation Safety Committee** is required.*	__	X
A.2.15. Recombinant DNA or gene transfer to human subjects? ***If yes**, approval by the **UNC-CH Institutional Biosafety Committee** is required.*	__	X
A.2.16. Does this study involve UNC-CH cancer patients? ***If yes**, submit this application directly to **Oncology Protocol Review Committee**.*	__	X
A.2.17. Will subjects be studied in the General Clinical Research Center (GCRC)? ***If yes**, obtain the **GCRC Addendum** from the GCRC and submit complete application (IRB application and Addendum) to the GCRC.*	__	X

Part A.3. Conflict of Interest Questions and Certification

The following questions apply to **all investigators and study staff** engaged in the design, conduct, or reporting results of this project **and/or their immediate family members.** For these purposes, "family" includes the individual's spouse and dependent children. "Spouse" includes a person with whom one lives together in the same residence and with whom one shares responsibility for each other's welfare and shares financial obligations.

A.3.1. Currently or during the term of this research study, does any member of the research team or his/her family member have or expect to have:		
(a) A personal financial interest in or personal financial relationship (including gifts of cash or in-kind) with the sponsor of this study?	__ yes	X no
(b) A personal financial interest in or personal financial relationship (including gifts of cash or in-kind) with an entity that owns or has the right to commercialize a product, process or technology studied in this project?	__ yes	X no
(c) A board membership of any kind or an executive position (paid or unpaid) with the sponsor of this study or with an entity that owns or has the right to commercialize a product, process or technology studied in this project?	__ yes	X no
A.3.2. Has the University or has a University-related foundation received a cash or in-kind gift from the Sponsor of this study for the use or benefit of any member of the research team?	__ yes	X no
A.3.3. Has the University or has a University-related foundation received a cash or in-kind gift for the use or benefit of any member of the research team from an entity that owns or has the right to commercialize a product, process or technology studied in this project?	__ yes	X no

If the answer to ANY of the questions above is *yes*, the affected research team member(s) must complete and submit to the Office of the University Counsel the form accessible at http://coi.unc.edu. List name(s) of all research team members for whom any answer to the questions above is *yes*:

_____

Certification by Principal Investigator: By submitting this IRB application, I (the PI) certify that the information provided above is true and accurate regarding my own circumstances, that I have inquired of every UNC-Chapel Hill employee or trainee who will be engaged in the design, conduct or reporting of results of this project as to the questions set out above, and that I have instructed any such person who has answered "yes" to any of these questions to complete and submit for approval a Conflict of Interest Evaluation Form. I understand that as Principal Investigator I am obligated to ensure that any potential conflicts of interest that exist in relation to my study are reported as required by University policy.

_____ _____

Signature of Principal Investigator Date

Faculty Advisor if PI is a Student or Trainee Investigator: **I accept ultimate responsibility for ensuring that the PI complies with the University's conflict of interest policies and procedures.**

_____ _____

Signature of Faculty Advisor Date

Part A.4. Questions Common to All Studies

For all questions, if the study involves only secondary data analysis, focus on your proposed design, methods and procedures, and not those of the original study that produced the data you plan to use.

A.4.1. **Brief Summary**. Provide a *brief* non-technical description of the study, which will be used for internal and external communications regarding this research. Include purpose, methods, and participants. Typical summaries are 50-100 words.

The purpose of this study is to explore the interaction effect of a foot orthotic device (FOD) on lower extremity muscular activity in individuals with excessive pronation and neutral foot type subjects. The experimental design of this study will have both groups participating in a pre and post-test over a total of three sessions. The first will be for gathering consent and general pronation measurements, FOD digitization, and baseline data collection. The second will be for FOD distribution and instruction. The final session will be for data collection with and without the FOD. This study will include 40 participants over two groups, pronated and neutral, with two conditions each-FOD and no FOD. For this study, the neutral foot type group under the no FOD condition will serve as the control.

A.4.2. **Purpose and Rationale**. Provide a summary of the background information, state the research question(s), and tell why the study is needed. If a complete rationale and literature review are in an accompanying grant application or other type of proposal, only provide a brief summary here. If there is no proposal, provide a more extensive rationale and literature review.

Research has shown that the one factor contributing to lower extremity dysfunction more than any other is excessive subtalar joint pronation (ESJP). ESJP occurs when the threshold of normal limits of pronation, approximately six degrees, is exceeded. This resultant ESJP has been found to facilitate conditions such as medial tibial stress syndrome, or possibly even stress reactions and fractures in the lower extremity. The treatment of choice is often to create a FOD to neutralize the foot from excessive movement during the stance phase of gait, thereby correcting the faulty biomechanical issue. The use of FOD has been shown to decrease symptom severity of lower extremity dysfunction and even eliminate symptoms completely in individuals as high up the kinetic chain as the knee. However, there has been little research investigating the effects of FOD on electromyography (EMG) and kinetics (force plate readings). Research utilizing these measures may help provide a global view of the lower extremity musculature and the effect FOD may have not just at the foot/ankle, but also up the entire kinetic chain. Therefore, this study will explore the interaction effect of FOD on lower extremity muscular activity throughout the kinetic chain in individuals with excessive pronation and neutral foot type subjects. By researching the effect of FOD on the tibialis anterior, peroneus longus, vastus medialis obliqus, and gluteus medius musculature we may better address and correct biomechanical faults that lead to dysfunction. Our specific research questions include:

Research Questions:

1. Is there a significant difference in lower extremity muscle activity as measured by onset and duration of the Tibialis Anterior (TA), Peroneus Longus (PL), Vastus Medialis Obliqus (VMO), and Gluteus Medius (GM) between a pronated group and normal foot type group on the during a walking task:

2. Following a FOD intervention, is there a significant interaction effect between a pronated group and normal foot type group across FOD conditions on lower extremity muscle activity as measured by onset, and duration on the TA, PL, VMO, and GM.

3. Is there a significant difference in ground reaction forces (GRF) as measured by center of pressure (COP), and medial and lateral GRF amplitude between a pronated group and normal foot type group?

4. Following a FOD intervention, is there a significant interaction effect between a pronated group and normal foot type group across FOD conditions on GRF as measured by COP, and mediolateral GRF amplitude?

A.4.3. **Full description of the study design, methods and procedures.** Describe the research study. Discuss the study design; study procedures; sequential description of what subjects will be asked to do; assignment of subjects to various arms of the study if applicable; doses; frequency and route of administration of medication and other medical treatment if applicable; how data are to be collected (questionnaire, interview, focus group or specific procedure such as physical examination, venipuncture, etc.). Include information on who will collect data, who will conduct procedures or measurements. Indicate the number and duration of contacts with each subject; outcome measurements; and follow-up procedures. If the study involves medical treatment, distinguish standard care procedures from those that are research. If the study is a clinical trial involving patients as subjects and use of placebo control is involved, provide justification for the use of placebo controls.

The experimental design of this study will have both groups participating in a pre and post-test. Subjects will report to the Sports Medicine Research Laboratory for all sessions of this study.

First session:

The purpose of the first session will be for completion of informed consent/general health questionnaires, recording demographic information, providing instructions, baseline data collection, and obtaining the necessary data to create custom FOD for the pronated group.

A brief physical exam will be conducted consisting of: recording of mass (kg) and height (inches), palpation and marking of the navicular (bone in foot close to your arch), tibialis anterior (muscle on front of lower leg), peroneus longus (muscle on outside of lower leg), vastus medialis obliqus (muscle on lower portion of thigh), and gluteus medius (muscle on side of hip) will also occur. This exam will be conduct by a Certified Athletic Trainer and a podiatrist (DPM).

During the first session, the Principle Investigator (PI) will evaluate the volunteers and determine which individuals exhibit pronation. Pronation for this study is determined as having a 10 mm navicular drop (ND) in weight bearing stance. The volunteers will be placed

into two groups based on evaluation by the PI: neutral (control) less than 7mm ND, and pronated (experimental) greater than 10mm ND.

Both groups will be fitted for FOD following the measurements above, utilizing an AMFIT Footfax-SL ® Contact Digitizer, and a CAD/CAM Mill Carving Station (Vancouver, WA) will complete FOD fabrication.

Electromyographic (EMG) and COP/GRF data collection will be the final processes to occur during this session. EMG data will be collected from the dominant lower extremity during the stance phase of gate. Dominance will be defined as the leg each volunteer would use to kick a soccer ball. Volunteers will be prepared for electrode placement by utilizing hair clippers, abrading, and cleaning with isopropyl alcohol. EMG onset and duration will be analyzed from each walking trial.

Both groups will perform 5 walking trials with EMG electrodes placed over the peroneus longus, tibialis anterior, vastus medialis obliqus, and gluteus medius. Surface EMG will be collected using an 8 channel Konigsberg EMG system (Konigsberg; Pasadena, CA) during walking trials performed by all subjects. Ag/AgCl Surface electrodes will be placed upon the involved muscles according to procedures by Cram and Kasman (1998): tibialis anterior (TA), peroneus longus (PL), vastus medialis obliqus (VMO), and gluteus medius (GM). Electrode placement will be confirmed with manual muscle testing (MMT).

During each of the walking trials (for both session one and three) subjects will walk along a 20m platform to the beat of a metronome over a force plate (Bertec, Inc., Columbus, OH). The force plate will collect kinetic data regarding COP, and medial/lateral GRF during the subject's stance phase (from heel striking ground through them pushing off of their toes) of gait.

Second session:

All subjects will return in approximately 2 weeks to receive their custom FOD. Also there will be a short counseling session to advise subjects on FOD wear. The wear guidelines will consist of wearing the FOD for 2 hours on the first day, and increasing 2 hours per day until full use is reached.

Third Session:

Once the subjects have received their FOD, there will be a 2-week accommodation period prior to the post-test. During the post-test subjects will perform two counterbalanced walking trials. One of the walking trials will occur with the FOD, while the other will occur without the FOD.

A.4.4. **Benefits to subjects and/or society.** Describe any potential for direct benefit to individual subjects, as well as the benefit to society based on scientific knowledge to be gained; these should be clearly distinguished. Consider the nature, magnitude, and likelihood of any direct benefit to subjects. If there is no direct benefit to the individual subject, say so here and in the consent form (if there is a consent form). Do not list monetary payment or other compensation as a benefit.

All subjects are permitted to keep the custom made FOD that will be fabricated for them during the study. The FOD can potentially correct structural deformities. The corrections made may improve lower extremity function and may reduce or eliminate dysfunction and/or pain associated with that deformity.

The data collected from this investigation will benefit the sports medicine community. Clinicians will better understand the effect of FOD on lower extremity muscle activity and can use the information to help treat patients who may have structural abnormalities due to excessive pronation.

A.4.5. **Full description of risks and measures to minimize risks.** Include risk of psychosocial harm (e.g., emotional distress, embarrassment, breach of confidentiality), economic harm (e.g., loss of employment or insurability, loss of professional standing or reputation, loss of standing within the community) and legal jeopardy (e.g., disclosure of illegal activity or negligence), as well as known side effects of study medication, if applicable, and risk of pain and physical injury. Describe what will be done to minimize these risks. Describe procedures for follow-up, when necessary, such as when subjects are found to be in need of medical or psychological referral. If there is no direct interaction with subjects, and risk is limited to breach of confidentiality (e.g., for existing data), state this.

Risks are minimal in this investigation; however, as with any physical activity, the potential of injury exists. Measures taken to minimize risk include the close supervision of each subject by a certified athletic trainer (principal investigator) during the walking trials, and the allowance for practice trials to become accustomed to the walking pace set by a metronome.

A.4.6. **Data analysis.** Tell how the qualitative and/or quantitative data will be analyzed. Explain how the sample size is sufficient to achieve the study aims. This might include a formal power calculation or explanation of why a small sample is sufficient (e.g., qualitative research, pilot studies).

An *a priori* power analysis was conducted, and determined that each group would require at least 19 subjects to provide a power of 78 (effect size = .80), using EMG pilot data from the UNC Sports Medicine Research Laboratory and confirmed by a published study by Tomaro and Burdett (1993). All data will be analyzed using SPSS 12.0 statistical software, using an *a priori* alpha-level of 0.05. Mixed model repeated measures ANOVA procedures will be performed for each of the research questions. Comparisons will be made between the groups and within the conditions. No stratification of groups will take place.

A.4.7. **Will you collect or receive any of the following identifiers as part of the study data?** Does not apply to consent forms.

__ No X Yes *If yes, check all that apply*:

a. X Names
b. X Telephone numbers
c. __ Any elements of dates (other than year) for dates directly related to an individual, including birth date, admission date, discharge date, date of death. For ages over 89: all elements of dates (including year) indicative of such age, except that such ages and elements may be aggregated into a single category of age 90 and older
d. __ Any geographic subdivisions smaller than a State, including street address, city, county, precinct, zip code and their equivalent geocodes, except for the initial three digits of a zip code
e. __ Fax numbers
f. X Electronic mail addresses
g. __ Social security numbers
h. __ Medical record numbers
i. __ Health plan beneficiary numbers
j. __ Account numbers
k. __ Certificate/license numbers
l. __ Vehicle identifiers and serial numbers (VIN), including license plate numbers
m. __ Device identifiers and serial numbers (e.g., implanted medical device)
n. __ Web universal resource locators (URLs)
o. __ Internet protocol (IP) address numbers
p. __ Biometric identifiers, including finger and voice prints
q. __ Full face photographic images and any comparable images
r. __ Any other unique identifying number, characteristic or code, other than dummy identifiers that are not derived from actual identifiers and for which the re-identification key is maintained by the health care provider and not disclosed to the researcher

A.4.8. **Data sharing.** With whom will *identifiable* (contains any of the 18 identifiers listed in question 7 above) data be shared outside the immediate research team? For each, explain confidentiality measures. Include data use agreements, if any.

___No one
__ Coordinating Center**:**
__ Statisticians**:**
__ Consultants**:**
__ Other researchers**:**
__ Registries**:**
__ Sponsors:
__ External labs for additional testing:
X Journals: The journal(s) will receive only aggregated data with no identifiers
__ Publicly available dataset:
__ Other:

A.4.9. **Confidentiality of the data**. Describe procedures for maintaining confidentiality of the data you will collect or will receive. Describe how you will protect the data from access by those not authorized. How will data be transmitted among research personnel? Where relevant, discuss the potential for deductive disclosure (i.e., directly identifying subjects from a combination of indirect IDs). Describe your plan to destroy identifiers. When will identifiers be destroyed?

Confidentiality will be maintained by utilizing password protection for computerized data. Paperwork confidentiality will be maintained by principle investigator. Data will be maintained in a locked office and transmitted among research personnel via meetings in person.

A.4.10. **Data security for storage and transmission**. Please check all that apply.

For electronic data:
X Secure network X Password access __ Encryption
__ Other (describe):
__ Portable storage (e.g., laptop computer, flash drive)
Describe how data will be protected for any portable device:

For hardcopy data (including human biological specimens, CDs, tapes, etc.):
__ Data de-identified by research team (stripped of the 18 identifiers listed in question 7 above)
_X Locked suite or office
__ Locked cabinet
__ Data coded by research team with a master list secured and kept separately
__ Other (describe):

Part A.5. The Consent Process and Consent Documentation (including Waivers)

The standard consent process is for all subjects to sign a document containing all the elements of informed consent, as specified in the federal regulations. Some or all of the elements of consent, including signatures, may be altered or waived under certain circumstances.

- If you will obtain consent in any manner, complete **section A.5.1**.
- If you are obtaining consent, but requesting a waiver of the requirement for a signed consent document, complete **section A.5.2**.
- If you are requesting a waiver of any or all of the elements of consent, complete **section A.5.3**.

You may need to complete more than one section. For example, if you are conducting a phone survey with verbal consent, complete sections A.5.1, A.5.2, and possibly A.5.3.

A.5.1. **Describe the process of obtaining informed consent from subjects**. If children will be enrolled as subjects, describe the provisions for obtaining parental permission and assent of the child. If decisionally impaired adults are to be enrolled, describe the provision for obtaining surrogate consent from a legally authorized representative (LAR). If non-English speaking people will be enrolled, explain how consent in the native language will be obtained. Address both written translation of the consent and the availability of oral interpretation. *After you have completed this part A.5.1, if you are not requesting a waiver of any type, you are done with Part A.5.; proceed to Part B.*

All subjects will be at least 18 years of age and will not be decisionally impaired, or non-English speaking. Subjects will all complete an informed consent form during the first session of this study.

A.5.2. **Justification for a waiver of *written* (i.e., signed) consent**. *The default is for subjects to sign a written document that contains all the elements of informed consent.* Under limited circumstances, the requirement for a signed consent form may be waived by the IRB if either of the following is true:

a. The only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality (e.g., study involves sensitive data that could be damaging if disclosed). __ yes __ no
Explain.

b. The research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context (e.g., phone survey). __ yes __ no
Explain.

If you checked "yes" to either, will consent be oral? Will you give out a fact sheet? Use an online consent form, or include information as part of the survey itself, etc?

A.5.3. **Justification for a full or partial waiver of consent.** *The default is for subjects to sign a written document that contains all the elements of informed consent.* A waiver might be requested for research involving only existing data or human biological specimens (see also Part C). More rarely, it might be requested when the research design requires withholding some study details at the outset (e.g., behavioral research involving deception). In limited circumstances, parental permission may be waived. This section should also be completed for a waiver of HIPAA authorization if research involves Protected Health Information (PHI) subject to HIPAA regulation, such as patient records.

__ Requesting **waiver of some elements** (specify; see SOP 28 on the IRB web site):
__ Requesting **waiver of consent entirely**
If you check either of the boxes above, answer items a-f.. To justify a full waiver of the requirement for informed consent, you must be able to answer "yes" (or "not applicable" for question c) to items a-f. **Insert brief explanations that support your answers.**

a. Will the research involve no greater than minimal risk to subjects or to their privacy? __ yes __ no
Explain.

b. Is it true that the waiver will *not* adversely affect the rights and welfare of subjects? *(Consider the right of privacy and possible risk of breach of confidentiality in light of the information you wish to gather.)* __ yes __ no
Explain.

c. When applicable to your study, do you have plans to provide subjects with pertinent information after their participation is over? *(e.g., Will you provide details withheld during consent, or tell subjects if you found information with direct clinical relevance? This may be an uncommon scenario.)* __ yes __ not applicable
Explain.

d. Would the research be impracticable without the waiver? *(If you checked "yes," explain how the requirement to obtain consent would make the research impracticable, e.g., are most of the subjects lost to follow-up or deceased?).* __ yes __ no
Explain.

e. Is the risk to privacy reasonable in relation to benefits to be gained or the importance of the knowledge to be gained? __ yes __ no
Explain.

If you are accessing patient records for this research, you must also be able to answer "yes" to item f to justify a waiver of HIPAA authorization from the subjects.

f. Would the research be impracticable if you could not record (or use) Protected Health Information (PHI)? *(If you checked "yes," explain how* not *recording or using PHI would make the research impracticable).* __ yes __ no
Explain.

Part B. Questions for Studies that Involve Direct Interaction with Human Subjects

→ *If this does not apply to your study, do not submit this section.*

B.1. **Subjects.** Specify number, gender, ethnicity, race, and age. Specify whether subjects are healthy volunteers or patients. If patients, specify any relevant disease or condition and indicate how potential subjects will be identified.

Forty volunteers from the student, faculty, and staff population at the University of North Carolina at Chapel Hill will participate in this study. Subjects will be of at least 18 years of age. All subjects must be physically active, defined as exercising at least three times per week for at least thirty minutes.

B.2. **Inclusion/exclusion criteria.** List required characteristics of potential subjects, and those that preclude enrollment. Justify exclusion of any group, especially by criteria based on gender, ethnicity, race, or age. If pregnant women are excluded, or if women who become pregnant are withdrawn, specific justification must be provided.

Inclusion criteria includes: 1) healthy volunteer of at least 18 years of age, 2) presentation of pronation (for pronated group) of at least 10mm, (that is in no way debilitating in ADLs), as determined by PI evaluation. Exclusion criteria includes: 1) previous history of lowerextremity injury in past six months, so that there is no resultant weakness or altered biomechanics 2) previous history of FOD use on regular basis, so that subjects experience a true intervention, 3) participation in a lower extremity rehabilitation or training program during study, so that any adaptations and/or accommodations are due strictly to the intervention, 4) individuals under the age of 18.

B.3. **Methods of recruiting.** Describe how and where subjects will be identified and recruited. Indicate who will do the recruiting, and tell how subjects will be contacted. Describe efforts to ensure equal access to participation among women and minorities. Describe how you will protect the privacy of potential subjects during recruitment. *For prospective subjects whose status (e.g., as patient or client), condition, or contact information is not publicly available (e.g., from a phone book or public web site), the initial contact should be made with legitimate knowledge of the subjects' circumstances. Ideally, the individual with such knowledge should seek prospective subjects' permission to release names to the PI for recruitment. Alternatively, the knowledgeable individual could provide information about the study, including contact information for the investigator, so that interested prospective subjects can contact the investigator.* Provide the IRB with a copy of any document or script that will be used to obtain the patients' permission for release of names or to introduce the study. Check with your IRB for further guidance.

Recruiting subjects will occur in one of two methods. Flyers will be posted throughout Fetzer and Woollen gymnasiums, the physical therapy department of UNC Student Health Services, and the Student Recreation Center. The principal investigator will be approached by individuals who respond to the flyers, and exhibit signs of excessive pronation, about their possible participation in this study. In no manner will subjects be coerced into participation by the PI, participation is strictly voluntary and no compensation will be paid or promised to subjects. The PI may inform individuals that meet the inclusion/exclusion criteria about the

study's purpose and all expectations and procedures and provide them with contact information if they choose to pursue participation.

B.4. **Protected Health Information (PHI).** If you need to access Protected Health Information (PHI) to identify potential subjects who will then be contacted, you will need a *limited waiver of HIPAA authorization*. If this applies to your study, please provide the following information.

a. Will the information collected be limited only to that necessary to contact the subjects to ask if they are interested in participating in the study?

b. How will confidentiality/privacy be protected prior to ascertaining desire to participate?

c. When and how will you destroy the contact information if an individual declines participation?

B.5. **Duration of entire study and duration of an individual subject's participation, including follow-up evaluation if applicable.** Include the number of required contacts and approximate duration of each contact.

The subjects will report for three sessions: the first session is for obtaining consent, baseline EMG and kinetic (forceplate) data collection and FOD digitization.

The second is for FOD distribution and instruction.

The third and final session is for EMG and kinetic (force plate) data collection with each condition.

The pre and post-test sessions will take approximately 1 ½ hour each and the FOD distribution session will take approximately 1 hour. The participation in this investigation is for approximately 1 month due to the time needed to custom make the FOD, and for the accommodation period.

B.6. **Where will the subjects be studied?** Describe locations where subjects will be studied, both on and off the UNC-CH campus.

Subjects will report to the Sports Medicine Research Laboratory (located in Fetzer Gymnasium) for all sessions of this study.

B.7. **Privacy.** Describe procedures that will ensure privacy of the subjects in this study. Examples include the setting for interviews, phone conversations, or physical examinations; communication methods or mailed materials (e.g., mailings should not indicate disease status or focus of study on the envelope).

Setting for interviews will be on an individual subject basis in a private location from general surroundings. Phone conversations will be used for the arrangement of appointments only. Physical examinations will be performed in the Sports Medicine Research Lab by the PI. Other
communication methods will include email through which subjects will also be informed of appointments and any changes in scheduling.

B.8. **Inducements for participation.** Describe all inducements to participate, monetary or non-monetary. If monetary, specify the amount and schedule for payments and how this will be prorated if the subject withdraws (or is withdrawn) from the study prior to completing it. For compensation in foreign currency, provide a US$ equivalent. Provide evidence that the amount is not coercive (e.g., describe purchasing power for foreign countries). Include food or refreshments that may be provided.

Subjects will not receive monetary compensation for participation in this study.

B.9. **Costs to be borne by subjects.** Include child care, travel, parking, clinic fees, diagnostic and laboratory studies, drugs, devices, all professional fees, etc. If there are no costs to subjects other than their time to participate, indicate this.

There will be no cost borne by subjects of this study.

University of North Carolina-Chapel Hill
Consent to Participate in a Research Study
Adult Subjects
Biomedical Form

IRB Study # 05-EXSS-801
Consent Form Version Date: 01/11/06

Title of Study: The Effect of Foot Type on Lower Extremity Muscle Activity

Principal Investigator: Sean Kupiec, ATC, LAT
UNC-Chapel Hill Department: Exercise and Sport Science
UNC-Chapel Hill Phone number: 919-962-2067
Email Address: skupiec@email.unc.edu
Co-Investigators: Kevin Guskiewicz, PhD, ATC; Robert Butler, PhD; Christopher Hirth, MA, PT, ATC; Michelle Boling, MS, ATC; Howard Kashefsky, DPM
Faculty Advisor: Kevin Guskiewicz, PhD, ATC
Funding Source: Donation by Howard Kashefsky, DPM
Study Contact telephone number: 919-962-2067
Study Contact email: skupiec@email.unc.edu

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may refuse to join, or you may withdraw your consent to be in the study, for any reason.

Research studies are designed to obtain new knowledge that may help other people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies.

Deciding not to be in the study or leaving the study before it is done will not affect your relationship with the researcher, your health care provider, or the University of North Carolina-Chapel Hill. If you are a patient with an illness, you do not have to be in the research study in order to receive health care.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study. You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
The purpose of this research study is to explore the effect of foot orthotic devices (FOD), and ultimately foot type, on lower extremity muscular activity in volunteers who display excessive pronation (arch flattens when weight bearing). Excessive pronation is defined as greater than 10mm navicular (bone in foot close to your arch) drop when standing on both

feet and is thought to facilitate excessive compensatory pronation during stance phase of gait (from time heel touches ground until your toe pushes off). This excessive pronation has been linked to various lower extremity dysfunctions and conditions seen in medical facilities. The principle investigator (PI) will determine pronation measurements in all volunteers who participate in this study. By researching the effect of FODs and foot type on the tibialis anterior (muscle on front of lower leg), peroneus longus (muscle on outside of lower leg), vastus medialis obliqus (muscle on lower portion of thigh), and gluteus medius (muscle on side of hip) musculature, we may better address and correct mechanics that lead to dysfunction, rather than treating the symptoms alone.

You are being asked to be in the study because you have been recognized as having a foot type that may facilitate excessive compensatory pronation during your stance phase of gait.

Are there any reasons you should not be in this study?
You should not participate in this study if there is any reason that you will not be able to attend all three sessions. Exclusion criteria includes: 1) previous history of lower extremity injury in past six months, so that there is no resultant weakness or altered motion of your lower extremities 2) previous history of FOD use on regular basis, so that subjects experience a true intervention, 3) participation in a lower extremity rehabilitation or training program during study, so that any adaptations and/or accommodations are due strictly to the intervention, 4) individuals under the age of 18. Also, if you do not feel that you will successfully be able to complete the tasks needed for the study, please do not participate in this study.

How many people will take part in this study?
If you decide to participate, you will be one of approximately 40 people in this research study.

How long will your part in this study last?
If you participate in the study, you will spend approximately 4 hours in total over 3 visits during a 1-month period. The first visit will last approximately 1 ½ hours, the second visit will last approximately 1 hour, and the third visit will last approximately 1 ½ hours.

What will happen if you take part in the study?
During the course of this study, the following will occur. You will be asked to report for 3 sessions over approximately one month. You will be asked to wear a short-sleeved t-shirt, gym shorts, and running shoes. We ask that you wear the running shoes in which you would regularly wear to exercise. You will also be asked to sign this consent form and fill out a general health questionnaire.

During the first testing session the PI will take a measurement to determine if your foot mechanics (motion of the foot when walking) are normal. This measurement will be taken by utilizing an index card and marking the height of your navicular bone (bone in your foot close to your arch) while sitting in a neutral foot position (where equal pressure is on the inside and outside of your foot), and then again in a standing position. (You will be barefoot for these measurements.) The difference in heights will be measured and the resulting distance will be recorded as your navicular drop value. You will also be fitted for a FOD

during the first session. You will be asked to step onto a machine with hydraulic pegs that rise from the base to meet your foot causing an impression of your foot (these pegs will not cause discomfort). This impression is sent into a computer where your data is stored and sent to a carving mill that will manufacture a FOD to your specific needs.

At the conclusion of the first session, you will perform walking trials while the activity of muscles on your leg is collected. Electrodes (small discs that will adhere to your skin) will be placed over the tibialis anterior (muscle on front of lower leg), peroneus longus (muscle on outside of lower leg), vastus medialis obliqus (muscle on lower portion of thigh), and gluteus medius (muscle on side of hip). The principle investigator will use clippers to remove a small area of hair and clean your skin at the electrode placement sites prior to attaching the electrodes. Once you are ready for testing you will walk across the ground to the beat of a metronome. During each trial you will step onto a force plate built into the ground so that we can measure how hard your foot touches down on the floor. You will perform this 5 times while we measure the activity of your leg muscles as you cross the force plate. You will be asked to practice so that you are comfortable with walking to the beat of the metronome and contacting the force plate in stride.

The second session will occur approximately 2 weeks after the first session. During this session you will receive your FOD and be instructed on its use. We ask that you do not increase your activity level during this time period even if you feel improvement with daily activity, and that you also complete a FOD hours/day log to monitor your wear. Following two weeks of wearing your FODs, you will return for a third and final session.

During the third session you will perform the walking trials again (everything the exact same as first session) but under two different conditions, with the FOD in your shoes, and without the FOD in your shoes (5 times each).

Also, during the third session, you will perform the trials in a random order, assigned by flipping a coin to determine whether you will perform the trial with or without the FOD first.

What are the possible benefits from being in this study?

Research is designed to benefit society by gaining new knowledge. The results of this study will help the investigators and the sports medicine community better understand the effects of foot type and FOD on muscle activity and kinetics (the forces your foot places on the ground while walking), and possibly expand their application to a variety of athletes and or physical therapy patients. A benefit to you includes receiving custom FOD which will potentially improve your foot alignment.

What are the possible risks or discomforts involved with being in this study?

This study might involve the following risks and/or discomforts to you:
If you decide to keep and continue wearing your FOD, there is a chance for some initial discomfort resulting from their use. The FOD constructed for you will place your foot in a neutral position, which may not initially be a comfortable position. You will have the option to go back to the Podiatric/PT clinic and have them adjusted for comfort within the first 6 months. FOD must be broken in over time, and initially may cause blisters, foot pain, ankle pain, or knee pain until they are properly adjusted and/or broken in. To avoid initial blistering and discomfort, please be sure to wear socks and to follow the guidelines for initial wear. The guidelines are as follows: the first day the FOD should be worn only for 2 hours,

each day, wear may increase by 2 hours until you reach full use. You will receive information regarding further wear of your FOD before the conclusion of the study if you decide to keep them.

Any study that involves dynamic movements such as walking poses a mild risk for the subjects involved. While very unlikely, potential injuries include: ankle sprains, knee sprains, and/or bruises. The use of FOD in the study should not increase these risks, since they will place your foot and ankle into a neutral (more optimal) position.

You may also experience mild skin irritation due to electrode preparation.

In addition, there may be uncommon or previously unknown risks that might occur. You should report any problems to the researchers.

If you choose not to be in the study, what other treatment options do you have? You do not have to participate in this research study in order to receive treatment. Other procedures/treatments are available at the James Taylor Student Health Services. You can visit your clinic doctor to be evaluated for FOD in the Physical Therapy/Athletic Training Clinic as well. All UNC-Chapel Hill students, faculty, and staff have access to the services provided by the Student Health Service Physical Therapy/Athletic Training Clinic.

What if we learn about new findings or information during the study?
You will be given any new information gained during the course of the study that might affect your willingness to continue your participation.

How will your privacy be protected?
Setting for interviews will be on an individual subject basis in a private location from general surroundings. Phone conversations will be used for the arrangement of appointments only. Physical examinations will be performed in the Sports Medicine Research Lab by the PI. Other communication methods will include email through which subjects will also be informed of appointments and any changes in scheduling.

Confidentiality will be maintained by utilizing password protection for computerized data. Paperwork confidentiality will be maintained by principle investigator. This data will be maintained in a locked office and transmitted among research personnel via meetings in person.

No subjects will be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Chapel Hill will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies for purposes such as quality control or safety.

What will happen if you are injured by this research?
All research involves a chance that something bad might happen to you. This may include the risk of personal injury. In spite of all safety measures, you might develop a reaction or injury from being in this study. If such problems occur, the researchers will help you get medical care, but any costs for the medical care will be billed to you and/or your insurance company. The University of North Carolina at Chapel Hill has not set aside funds to pay you for any such reactions or injuries, or for the related medical care. However, by signing this form, you do not give up any of your legal rights.

What if you want to stop before your part in the study is complete?
You can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study?
You will be receiving a custom pair of FOD for taking part in this study.

Will it cost you anything to be in this study?
No cost will be required of the participants of this study.

What if you are a UNC student?
You may choose not to be in the study or to stop being in the study before it is over at any time. This will not affect your class standing or grades at UNC-Chapel Hill. You will not be offered or receive any special consideration if you take part in this research.

What if you are a UNC employee?
Taking part in this research is not a part of your University duties, and refusing will not affect your job. You will not be offered or receive any special job-related consideration if you take part in this research.

Who is sponsoring this study?
This study has no funding. The podiatrist involved with this study will be donating the supplies necessary to fabricate the FODs.

What if you have questions about this study?
You have the right to ask, and have answered, any questions you may have about this research. If you have questions, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research subject?
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject you may contact, anonymously if you wish, the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

IRB Study # 05-EXSS-801

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Subject's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

_____ _____

Signature of Research Subject Date

_____

Printed Name of Research Subject

_____ _____

Signature of Person Obtaining Consent Date

_____

Printed Name of Person Obtaining Consent

Foot Orthotic Device (FOD) Information Sheet

Please be sure to follow the following recommendations regarding your new FOD:

- Wear the FOD for only 2 hours on the first day.
- You may increase the duration of wear each day by 2 hours (i.e. 2 hours on day 1, 4 hours on day 2, and so on).
- Continue this progression until you are able to wear the FOD all day.
- Make sure to wear socks and to follow this time line strictly to prevent conditions such as blisters, ankle pain, and knee pain.
- If you feel your FOD need to be adjusted in any manner during the first 6 months of use, please feel free to contact the principal investigator or the podiatrist involved with this study. Your adjustment will be free of charge during this time.
- During use with exercise, if you feel pressure points that may be causing blisters, return FOD to PI for adjustment.

Please fill out the following log regarding hours per day that you wore your FOD and return it to the principle investigator upon the final data collection session. Simply fill in a number representing how many hours you wore your FOD during each day.

ID: Number_____

Day 1	
Day 2	
Day 3	
Day 4	
Day 5	
Day 6	
Day 7	
Day 8	
Day 9	
Day 10	
Day 11	
Day 12	
Day 13	
Day 14	

APPENDIX C

Raw Data and Statistical Analyses

Subject	Group	PreTAO	PreTAD	PrePLO	PrePLD	PreVMOO	PreVMOD	PreGMO	PreGMD
1	2	475.301	659.7	84.8	796.3	111.501	480.4	27.8	601.5
2	2	410.6008	736.4	96.8	822.1	66.0008	661	54.5	499
3	1	544.3004	643.8	2.6	874.4	139.3004	343.7	-14	432.4
4	2	431.7008	505.7	15.6	653.6	89.6008	332.1	127.9	643.3
5	1	504.3012	662.9	29.6	826.4012	117.801	366.3	338	842.8
6	2	508.3012	652.8	43.8	742.3	141.9012	813.1	25.9	467.1
7	1	416.9008	736.7	27	737	230.4008	880.1	207.2	898.5
8	2	402.2012	625.5	55.6	748.3	47.0012	272.8	128.3	1096.3
9	2	482.001	832.2	140.1	876.7	131.601	404.8	107.8	578.8
10	2	511.8008	682.5	106.6	786.5	17.1008	512.2	144.3	663.5
11	1	473.3008	574.1	26.7	675.1	135.6008	359	92.5	692.3
12	2	465.6008	614.9	53.3	746	166.5008	533	97.1	589.3
13	2	425.1008	702.9	204.5	816.3	118.9008	304.3	123.6	657.8
14	1	404.001	529.6	68.5	691.1	75.701	445.7	149.4	696.7
15	1	468.0016	664.1	10.7	649.3	102.6008	313.7	34.8	570
16	1	406.2008	547.9	84.7	716.5	82.3008	373.1	3.4	443.9
17	2	414.9008	780.4	2.6	657.7	145.5008	679	67.7	400.9
18	2	509.3008	669	78.4	768.2	13.2008	530.9	152.7	774.1
19	1	471.401	608.7	191.1	825	162.201	443.3	197.8	768.1
20	1	501.801	640.7	121.3	880.3	148.001	544	-18.4	568.8
21	2	428.7008	555	111.4	695.2	96.6008	342.8	148.2	574.8
22	2	468.3008	610.4	44	722.5	59	176.5	109.9	669.2
23	2	413.4008	506.4	23.5	595.4	120.5008	335.4	12.7	470.5
24	1	447.2008	622.6	44	668.5	162.8008	421.8	99.5	530.8
25	1	446.801	573.3	88.3	665.1	118.0012	428.8	-22.3	456.6
26	1	464.701	614.5	142.7	845.3	213.901	501.7	50.6	547.1
27	2	385.2006	589.1	49.1	656	135.1006	398.1	50	535.2
28	1	417.9008	487.1	-140	468.5	153.2008	684.2	62.8	449.7
29	2	430.701	573.8	31.3	690.7	99.401	472.8	48.8	667.7
30	1	385.9008	526.5	80.4	715.5	102.5008	323.3	7	549

31	1	416.2008	523.6	40.5	676.6	131.7008	399.3	127.6	635.3
32	1	476.2012	664.5	65.9	842.9	116.6012	363.4	33.8	584.8
33	2	484.1008	630.9	54.1	707.7	163.8008	426.9	175.9	733
34	1	436.5008	564.1	25.5	685.2	72.4008	361.3	-34.3	396.8
35	2	481.8008	754.9	-0.7	603	156.7008	444.8	1.6	345.2
36	2	471.5008	672.5	72.6	771.7	68.2008	275.9	75.5	688.7
37	1	444.1012	680.1	110.8	771.2	100.8012	457.7	36	603
38	1	431.701	604.3	29	649.9	146.701	410.9	133.8	653.3
39	1	439.2008	588.9	121.3	789.7	122.4008	301.6	283.2	760.2
		PoNTAO	**PoNTAD**	**PoNPLO**	**PoNPLD**	**PoNVMOO**	**PoNVMOD**	**PoNGMO**	**PoNGMD**
1	2	483.4008	634.5	149.3	745.2	182.0008	681.2	38.6	781.3
2	2	468.5014	624.8	151.6	905.8	42.5014	274.1	170.4	716.6
3	1	495.2006	618	135.3	676.7	140.6006	410.9	-3.8	229.4
4	2	433.9008	514.4	55.5	677.3	92.7008	355.6	139.4	647.5
5	1	484.9008	670.9	101.4	844.9	20.0008	229.3	229.9	714.8
6	2	595.5014	760.9	58.3	996.1	136.3014	499.6	71.5	579.7
7	1	499.401	862.2	73.4	817.4	247.601	520.6	22.6	647.9
8	2	471.901	690	46.5	845.6	32.701	304.8	213.1	753.7
9	2	493.4014	724.9	135.9	878.5	148.2014	447.2	132.4	613.7
10	2	493.7008	627.4	83.8	838.1	87.1	254	167	732.2
11	1	451.401	650.2	38.5	721.9	154.801	411.9	101.7	635.8
12	2	455.5014	648.7	118.4	826.5	129.5014	458.2	92.7	738.5
13	2	415.7014	581.8	115.9	781.4	120.9014	414.1	4.9	531
14	1	405.8008	552.2	72.8	745.3	30.2008	236.1	131.2	624.8
15	1	432.9018	621.6	96.4	787.2	129.8018	397.2	-50.2	355.9
16	1	419.6006	535.2	242.7	937.4	58.2006	262.6	2.3	311.9
17	2	478.1012	995.8	65.5	786.4	90.6004	394.8	-21.1	552.8
18	2	478.6012	598	50.8	719.8	-13.4	418	119.2	703.5
19	1	489.4012	716.7	141.1	841	204.7012	582.9	42.4	701.1
20	1	493.8008	636.3	42.7	784	119.3008	401.6	5.5	600.2
21	2	372.801	450.8	-21.9	484.4	107.701	337.3	29.8	419
22	2	495.5012	657.3	-40.9	646.6	71.4004	376.7	90.6	563.9

23	2	382.001	510	26.2	614	191.401	382.4	140.2	596
24	1	419.5008	543.6	40.2	634.7	63.2008	304.5	111.1	565.2
25	1	503.401	610	-40.5	567.9	210.401	572.5	38	597.9
26	1	478.3016	605.5	55.9	800.6	136.2016	504.8	65.5	552.2
27	2	439.9008	570.8	40.9	651	129.0008	344.3	-13.9	446.4
28	1	410.7012	484.6	-105.1	576.8	143.3012	674.2	-25.1	427.4
29	2	425.9014	560.8	60.8	715.9	54.1014	263.9	19.2	575.7
30	1	397.5008	571.3	206	796.2	112.6008	359.8	3.1	609.2
31	1	467.4012	593.6	108.9	758.9	69.7012	357.4	101.6	632.3
32	1	399.2012	541.1	21.8	637.7	125.601	352.9	95.3	490.9
33	2	488.4008	611.1	88.2	734.3	144.2008	406.3	191.5	788.3
34	1	478.1008	611.3	22.8	726.4	51.3008	325	-22.3	507.8
35	2	451.701	550.9	-0.8	634.2	121.101	361.8	-20.1	322.8
36	2	449.7008	575.5	71.7	822.6008	112.9008	325.4	7.3	543.9
37	1	442.1008	567.6	73.8	738.3	8.0004	234.9	-27.4	410.8
38	1	458.301	646.8	242.8	915.2	138.001	381.3	145	641.6
39	1	469.1008	581.1	100.7	775.7	29.5	499.5	116.7	586.3
		PoFTAO	**PoFTAD**	**PoFPLO**	**PoFPLD**	**PoFVMOO**	**PoFVMOD**	**PoFGMO**	**PoFGMD**
1	2	517.0012	724.9	80.8	870.5	105.9012	454.4	47.1	787
2	2	457.8012	649	123.4	863	46.1012	267.6	141	676.6
3	1	287.2006	379.2	98.2	218.6	115.1006	301.7	94.5	503.8
4	2	454.6012	585.9	64.1	698.7	103.9012	424.2	122.1	584.4
5	1	443.001	660.1	-11.5	764.3	97.301	313.5	193	718.8
6	2	464.5012	586.2	54.5	797.6	154.8012	480.5	81.5	600.7
7	1	474.5008	697.5	65.2	793	311.9008	662.5	89.2	756.6
8	2	463.8008	623.9	45.5	818.3	26.5008	286.3	199.8	705.6
9	2	467.7016	631.6	159.8	931.6	189.1016	823.6	21.8	368.4
10	2	463.7008	671.7	90.7	846.6	94.8008	320	166	709.5
11	1	442.6012	616.8	16.7	675.5	77.501	248.1	79.7	611
12	2	483.4014	706.9	134	826.3	116.4014	433.5	155.6	764.4
13	2	345.0008	919.6	32.7	625.1	87.9008	260	168	676.9
14	1	401.0008	572.2	21.5	663.9	57.4008	289.9	188.5	695.3
15	1	487.601	636.5	48.4	812.9	152.201	442.4	-23.5	328.2

16	1	408.5008	517.3	99	718.7	110.3008	332.1	41.5	489
17	2	486.2012	1002.8	61.9	780.3	152.7012	471.6	-179.3	448.8
18	2	481.601	612.2	14	683.4	52.101	447.7	165.9	743
19	1	479.201	609.9	155.4	901.5	173.001	453.6	165.2	772.9
20	1	511.601	640.1	-58.5	627.7	81.601	351.6	26	623.8
21	2	397.0012	511.6	36	567	117.101	378.2	-8	255.6
22	2	464.7006	627.5	4.7	676.9	40.2006	265.4	153.2	689
23	2	394.6008	478.9	-195.7	458.2	104.8008	340.3	35.6	531.2
24	1	468.4008	663.9	42.8	645.3	63.3008	306.9	67.4	481
25	1	498.001	598.9	103.7	702.9	156.401	534.1	5.9	542.2
26	1	488.8014	701.7	91.1	833.4	189.1014	460.6	195.4	762.3
27	2	418.5008	546.7	44.1	650.4	113.7008	332	-0.1	291.4
28	1	382.9008	451.1	-104	561.5	135.6008	773.4	-17.4	436.5
29	2	422.5012	539.7	57.4	694.8	90.5012	317.6	-33.3	486.5
30	1	411.2008	559.3	114.7	784.5	107.8008	337.4	70	596.9
31	1	453.5016	583.5	86.7	747.1	66.8016	359.4	143.9	642.4
32	1	463.0008	607.2	347.1	660.4	140.2008	386.1	106.3	599.4
33	2	518.3008	711.1	155.7	827.9	165.6008	435.7	185.3	783.5
34	1	464.1008	606.1	85.7	722	1.9996	202.3	12.5	454.9
35	2	456.9012	543.7	-48.7	575.5	97.0012	320.6	-9.6	401.1
36	2	469.001	604.2	116.1	855.5	71.801	347.7	61.3	669.2
37	1	438.9012	595.9	64.5	697	64.1012	301.8	-5.6	467.2
38	1	449.6008	588.6	51.5	749.1	129.3008	433.9	22.3	626.6
39	1	463.201	613	66.4	743	-25.401	451.3	178.4	679.6

Subject	Trial 1	Trial 2	Trial 3	AvgND	Group	Age	Height	Weight
1	20	17	17	18	2	26	172.72	98.883
2	15	14	17	15.33333	2	25	182.88	84.822
3	10	9	11	10	1	20	160.02	45.359
4	11	12	11	11.33333	2	23	180.34	96.162
5	6	5	5	5.333333	1	22	170.18	58.967
6	11	13	11	11.66667	2	25	167.64	65.771
7	2	2	6	3.333333	1	21	160.02	61.235
8	14	11	11	12	2	23	193.04	79.379
9	20	19	19	19.33333	2	22	170.18	64.41
10	13	12	17	14	2	23	175.26	77.111
11	7	4	4	5	1	23	170.18	54.431
12	15	14	13	14	2	26	190.5	83.915
13	17	19	18	18	2	21	163.83	54.43
14	6	4	7	5.666667	1	21	157.48	52.163
15	5	6	7	6	1	21	157.48	53.524
16	2	3	3	2.666667	1	49	180.34	95.254
17	15	21	20	18.66667	2	23	167.64	83.915
18	13	11	11	11.66667	2	23	193.04	87.997
19	5	7	6	6	1	23	172.72	54.431
20	5	5	3	4.333333	1	24	137.16	58.967
21	20	23	21	21.33333	2	19	157.48	61.235
22	11	11	13	11.66667	2	20	170.18	65.771
23	11	11	11	11	2	18	167.64	61.235
24	5	4	4	4.333333	1	20	157.48	56.699
25	6	4	5	5	1	18	180.34	56.699
26	6	5	5	5.333333	1	20	170.18	61.235
27	13	15	15	14.33333	2	20	170.18	90.718
28	1	1	1	1	1	21	160.02	56.699
29	14	13	14	13.66667	2	22	157.48	58.967
30	4	4	3	3.666667	1	19	160.02	56.699
31	6	5	7	6	1	29	182.88	78.018
32	6	7	6	6.333333	1	24	175.26	63.503
33	16	17	15	16	2	22	162.56	55.338
34	7	3	2	4	1	21	172.72	65.771
35	13	15	13	13.66667	2	20	160.02	54.431
36	14	14	14	14	2	22	177.8	79.379
37	1	1	1	1	1	20	180.34	72.575
38	5	5	5	5	1	22	175.26	66.224
39	2	3	4	3	1	26	177.8	92.986

Subject	Group	PreL_M	PreL_P	PstNL_M	PstNL_P	PstFL_M	PstFL_P
1	2	-0.02	0.034	0.018	-0.017	0.009	-0.011
2	2	0.016	-0.009	0.015	-0.003	0.014	-0.009
3	1	0.034	-0.054	0.021	-0.033	0.026	-0.035
4	2	0.017	-0.011	0.012	-0.003	0.014	-0.003
5	1	0.039	-0.039	0.032	-0.038	0.037	-0.046
6	2	0.02	-0.02	0.025	-0.028	0.023	-0.032
7	1	0.012	-0.021	0.012	-0.02	0.01	-0.015
8	2	0.011	-0.01	0.01	-0.003	-0.006	0.013
9	2	0.016	-0.015	0.025	-0.027	0.014	-0.014
10	2	-0.002	0.006			-0.003	0.014
11	1	0.012	-0.012			0.016	-0.01
12	2	0.003	0.009	0.002	0.005	0.001	0.01
13	2	-0.003	-0.006	0.004	-0.01	-0.005	-0.007
14	1	-0.001	0.004	-0.001	0.011	0.004	0.009
15	1	0.033	-0.035	0.035	-0.034	0.027	-0.033
16	1	0.023	-0.015	0.023	-0.012	0.024	-0.017
17	2	0.04	-0.059	0.006	0.003	0.012	-0.013
18	2	0.023	-0.015			0.019	-0.009
19	1	0.012	-0.009	0.021	-0.025	0.023	-0.026
20	1	0.029	-0.018	0.026	-0.022	0.023	-0.034
21	2	0.026	-0.02	-0.091	0.091	0.032	-0.029
22	2	0.015	-0.027	0.013	-0.029	0.018	-0.026
23	2	0.024	-0.018	0.026	-0.028	0.031	-0.028
24	1	0.024	-0.028	0.024	-0.02	0.025	-0.022
25	1	0.016	-0.012	0.016	-0.013	0.012	-0.008
26	1	0.027	-0.033	0.028	-0.029		
27	2	0.014	-0.009			0.016	-0.007
28	1	0.015	-0.017	0.021	-0.019	0.023	-0.018
29	2	0.026	-0.035	0.016	-0.029	0.016	-0.023
30	1	0.02	-0.015	0.021	-0.014	0.02	-0.019
31	1	0.029	-0.022			0.024	-0.019
32	1	0.054	-0.044	-0.003	0.012	0	0.004
33	2	0	-0.005	-0.001	-0.003	-0.003	0.007
34	1	0.026	-0.025	0.018	-0.019	0.015	-0.014
35	2	0.014	-0.024	0.023	-0.052	0.018	-0.042
36	2			0.007	0	0.014	-0.007
37	1	0.015	-0.002	0.008	0.009		
38	1			0.026	-0.022	0.025	-0.026
39	1	0.047	-0.055	0.05	-0.054	0.037	-0.046

Descriptives

	Group			Statistic	Std. Error
Age	1	Mean		23.20	1.470
		95% Confidence Interval for Mean	Lower Bound	20.12	
			Upper Bound	26.28	
		5% Trimmed Mean		22.06	
		Median		21.00	
		Variance		43.221	
		Std. Deviation		6.574	
		Minimum		18	
		Maximum		49	
		Range		31	
		Interquartile Range		4	
		Skewness		3.496	.512
		Kurtosis		13.702	.992
	2	Mean		22.26	.518
		95% Confidence Interval for Mean	Lower Bound	21.18	
			Upper Bound	23.35	
		5% Trimmed Mean		22.29	
		Median		22.00	
		Variance		5.094	
		Std. Deviation		2.257	
		Minimum		18	
		Maximum		26	
		Range		8	
		Interquartile Range		3	
		Skewness		-.009	.524
		Kurtosis		-.496	1.014
Height	1	Mean		167.8940	2.55267
		95% Confidence Interval for Mean	Lower Bound	162.5512	
			Upper Bound	173.2368	
		5% Trimmed Mean		168.7689	
		Median		170.1800	
		Variance		130.322	
		Std. Deviation		11.41588	
		Minimum		137.16	
		Maximum		182.88	
		Range		45.72	
		Interquartile Range		17.15	
		Skewness		-.912	.512
		Kurtosis		1.063	.992
	2	Mean		172.6532	2.55937
		95% Confidence Interval for Mean	Lower Bound	167.2761	
			Upper Bound	178.0302	
		5% Trimmed Mean		172.3635	
		Median		170.1800	
		Variance		124.457	
		Std. Deviation		11.15605	
		Minimum		157.48	
		Maximum		193.04	
		Range		35.56	
		Interquartile Range		16.51	
		Skewness		.589	.524
		Kurtosis		-.507	1.014
Weight	1	Mean		63.07195	2.873559
		95% Confidence Interval for Mean	Lower Bound	57.05752	
			Upper Bound	69.08638	
		5% Trimmed Mean		62.26811	
		Median		58.96700	
		Variance		165.147	
		Std. Deviation		12.850948	
		Minimum		45.359	
		Maximum		95.254	
		Range		49.895	
		Interquartile Range		11.113	
		Skewness		1.492	.512
		Kurtosis		1.946	.992
	2	Mean		73.88784	3.359653
		95% Confidence Interval for Mean	Lower Bound	66.82947	
			Upper Bound	80.94621	
		5% Trimmed Mean		73.58021	
		Median		77.11100	
		Variance		214.458	
		Std. Deviation		14.644388	
		Minimum		54.430	
		Maximum		98.883	
		Range		44.453	
		Interquartile Range		23.587	
		Skewness		.149	.524
		Kurtosis		-1.354	1.014

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	Group	N	Percent	N	Percent	N	Percent
Age	1	20	100.0%	0	.0%	20	100.0%
	2	19	100.0%	0	.0%	19	100.0%
Height	1	20	100.0%	0	.0%	20	100.0%
	2	19	100.0%	0	.0%	19	100.0%
Weight	1	20	100.0%	0	.0%	20	100.0%
	2	19	100.0%	0	.0%	19	100.0%

T-Test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Age	1	20	23.20	6.574	1.470
	2	19	22.26	2.257	.518
Height	1	20	167.8940	11.41588	2.55267
	2	19	172.6532	11.15605	2.55937
Weight	1	20	63.07195	12.850948	2.873559
	2	19	73.88784	14.644388	3.359653

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Age	Equal variances assumed	2.071	.159	.589	37	.560	.937	1.591	-2.287	4.161
	Equal variances not assumed			.601	23.623	.554	.937	1.559	-2.283	4.156
Height	Equal variances assumed	.054	.818	-1.316	37	.196	-4.75916	3.61695	-12.08780	2.56949
	Equal variances not assumed			-1.317	36.967	.196	-4.75916	3.61476	-12.08358	2.56526
Weight	Equal variances assumed	2.395	.130	-2.455	37	.019	-10.815892	4.405830	-19.7430	-1.888833
	Equal variances not assumed			-2.447	35.812	.019	-10.815892	4.420929	-19.7836	-1.848200

T-Test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Age	1	20	23.20	6.574	1.470
	2	19	22.26	2.257	.518
Height	1	20	167.8940	11.41588	2.55267
	2	19	172.6532	11.15605	2.55937
Weight	1	20	63.07195	12.850948	2.873559
	2	19	73.88784	14.644388	3.359653

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Age	Equal variances assumed	2.071	.159	.589	37	.560	.937	1.591	-2.287	4.161
	Equal variances not assumed			.601	23.623	.554	.937	1.559	-2.283	4.156
Height	Equal variances assumed	.054	.818	-1.316	37	.196	-4.75916	3.61695	-12.08780	2.56949
	Equal variances not assumed			-1.317	36.967	.196	-4.75916	3.61476	-12.08358	2.56526
Weight	Equal variances assumed	2.395	.130	-2.455	37	.019	-10.815892	4.405830	-19.7430	-1.888833
	Equal variances not assumed			-2.447	35.812	.019	-10.815892	4.420929	-19.7836	-1.848200

Reliability

Case Processing Summary

		N	%
Cases	Valid	40	100.0
	Excluded[a]	0	.0
	Total	40	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.983	3

Item Statistics

	Mean	Std. Deviation	N
Trial 1	9.70	5.543	40
Trial 2	9.60	6.012	40
Trial 3	9.78	5.789	40

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		3784.258	39	97.032		
Within People	Between Items	.617	2	.308	.184	.832
	Residual[a]	130.717	78	1.676		
	Total	131.333	80	1.642		
Total		3915.592	119	32.904		

Grand Mean = 9.69

a. Tukey's test for nonadditivity is undefined for dichotomous data.

Intraclass Correlation Coefficient

	Intraclass Correlation[a]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.950[b]	.917	.971	57.900	39.0	78	.000
Average Measures	.983[c]	.971	.990	57.900	39.0	78	.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.

b. The estimator is the same, whether the interaction effect is present or not.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreTAO
2	PoNTAO
3	PoFTAO

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreTAO	Normal	449.83094	38.966534	20
	Pronated	452.65876	39.347434	19
	Total	451.20860	38.660230	39
PoNTAO	Normal	454.8010	36.2274446	20
	Pronated	461.7958	48.3883456	19
	Total	458.2087	42.1646633	39
PoFTAO	Normal	445.8410	50.1994287	20
	Pronated	454.0432	42.5102180	19
	Total	449.8369	46.1870670	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.854	5.676	2	.059	.873	.937	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	1575.585	2	787.793	.689	.505	.018	1.378	.162
	Greenhouse-Geisser	1575.585	1.745	902.707	.689	.487	.018	1.202	.154
	Huynh-Feldt	1575.585	1.874	840.716	.689	.497	.018	1.291	.158
	Lower-bound	1575.585	1.000	1575.585	.689	.412	.018	.689	.128
test * Group	Sphericity Assumed	154.942	2	77.471	.068	.935	.002	.135	.060
	Greenhouse-Geisser	154.942	1.745	88.771	.068	.914	.002	.118	.059
	Huynh-Feldt	154.942	1.874	82.675	.068	.925	.002	.127	.060
	Lower-bound	154.942	1.000	154.942	.068	.796	.002	.068	.057
Error(test)	Sphericity Assumed	84620.722	74	1143.523					
	Greenhouse-Geisser	84620.722	64.580	1310.327					
	Huynh-Feldt	84620.722	69.342	1220.344					
	Lower-bound	84620.722	37.000	2287.047					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	24010807.8	1	24010807.76	7428.939	.000	.995	7428.939	1.000
Group	1055.216	1	1055.216	.326	.571	.009	.326	.086
Error	119586.382	37	3232.064					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	450.158	7.339	435.286	465.029
Pronated	456.166	7.530	440.908	471.423

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	-6.008	10.515	.571	-27.314	15.298
Pronated	Normal	6.008	10.515	.571	-15.298	27.314

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	351.739	1	351.739	.326	.571	.009	.326	.086
Error	39862.127	37	1077.355					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	451.245	6.271	438.538	463.952
2	458.298	6.820	444.479	472.118
3	449.942	7.467	434.812	465.072

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-7.054	6.274	.804	-22.787	8.679
	3	1.303	8.842	1.000	-20.870	23.476
2	1	7.054	6.274	.804	-8.679	22.787
	3	8.356	7.649	.845	-10.825	27.538
3	1	-1.303	8.842	1.000	-23.476	20.870
	2	-8.356	7.649	.845	-27.538	10.825

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	449.831	8.755	432.092	467.570
	2	454.801	9.521	435.509	474.093
	3	445.841	10.424	424.720	466.962
Pronated	1	452.659	8.982	434.459	470.858
	2	461.796	9.768	442.003	481.589
	3	454.043	10.695	432.373	475.713

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PrePLO
2	PoNPLO
3	PoFPLO

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PrePLO	Normal	58.530	67.9196	20
	Pronated	66.705	50.3129	19
	Total	62.513	59.3528	39
PoNPLO	Normal	83.580	85.2952	20
	Pronated	66.089	53.6804	19
	Total	75.059	71.2814	39
PoFPLO	Normal	69.230	88.8656	20
	Pronated	54.263	80.5278	19
	Total	61.938	84.1291	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.950	1.864	2	.394	.952	1.000	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	4174.365	2	2087.183	.608	.547	.016	1.217	.148
	Greenhouse-Geisser	4174.365	1.904	2192.510	.608	.539	.016	1.158	.145
	Huynh-Feldt	4174.365	2.000	2087.183	.608	.547	.016	1.217	.148
	Lower-bound	4174.365	1.000	4174.365	.608	.440	.016	.608	.118
test * Group	Sphericity Assumed	3899.575	2	1949.788	.568	.569	.015	1.137	.141
	Greenhouse-Geisser	3899.575	1.904	2048.182	.568	.561	.015	1.082	.139
	Huynh-Feldt	3899.575	2.000	1949.788	.568	.569	.015	1.137	.141
	Lower-bound	3899.575	1.000	3899.575	.568	.456	.015	.568	.114
Error(test)	Sphericity Assumed	253836.043	74	3430.217					
	Greenhouse-Geisser	253836.043	70.445	3603.319					
	Huynh-Feldt	253836.043	74.000	3430.217					
	Lower-bound	253836.043	37.000	6860.434					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	515503.721	1	515503.721	56.725	.000	.605	56.725	1.000
Group	1915.007	1	1915.007	.211	.649	.006	.211	.073
Error	336246.045	37	9087.731					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	70.447	12.307	45.510	95.383
Pronated	62.353	12.627	36.768	87.937

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	8.094	17.632	.649	-27.632	43.820
Pronated	Normal	-8.094	17.632	.649	-43.820	27.632

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	638.336	1	638.336	.211	.649	.006	.211	.073
Error	112082.0	37	3029.244					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	62.618	9.611	43.143	82.092
2	74.835	11.482	51.571	98.099
3	61.747	13.601	34.188	89.305

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-12.217	11.843	.927	-41.916	17.481
	3	.871	13.391	1.000	-32.710	34.452
2	1	12.217	11.843	.927	-17.481	41.916
	3	13.088	14.440	1.000	-23.122	49.299
3	1	-.871	13.391	1.000	-34.452	32.710
	2	-13.088	14.440	1.000	-49.299	23.122

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	58.530	13.417	31.344	85.716
	2	83.580	16.028	51.105	116.055
	3	69.230	18.987	30.759	107.701
Pronated	1	66.705	13.766	38.813	94.597
	2	66.089	16.444	32.770	99.409
	3	54.263	19.480	14.793	93.734

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreVMOO
2	PoNVMOO
3	PoFVMOO

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreVMOO	Normal	131.74590	40.952055	20
	Pronated	102.53240	46.984618	19
	Total	117.51368	45.858989	39
PoNVMOO	Normal	109.6509	67.0926276	20
	Pronated	104.2588	51.1399174	19
	Total	107.0240	59.1353327	39
PoFVMOO	Normal	110.2758	71.7580960	20
	Pronated	101.6274	43.4871662	19
	Total	106.0625	59.0727569	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.991	.322	2	.851	.991	1.000	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	2986.582	2	1493.291	1.480	.234	.038	2.959	.306
	Greenhouse-Geisser	2986.582	1.982	1506.603	1.480	.234	.038	2.933	.305
	Huynh-Feldt	2986.582	2.000	1493.291	1.480	.234	.038	2.959	.306
	Lower-bound	2986.582	1.000	2986.582	1.480	.232	.038	1.480	.220
test * Group	Sphericity Assumed	3251.058	2	1625.529	1.611	.207	.042	3.222	.330
	Greenhouse-Geisser	3251.058	1.982	1640.020	1.611	.207	.042	3.193	.329
	Huynh-Feldt	3251.058	2.000	1625.529	1.611	.207	.042	3.222	.330
	Lower-bound	3251.058	1.000	3251.058	1.611	.212	.042	1.611	.235
Error(test)	Sphericity Assumed	74678.437	74	1009.168					
	Greenhouse-Geisser	74678.437	73.346	1018.164					
	Huynh-Feldt	74678.437	74.000	1009.168					
	Lower-bound	74678.437	37.000	2018.336					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	1415160.111	1	1415160.111	200.310	.000	.844	200.310	1.000
Group	6076.470	1	6076.470	.860	.360	.023	.860	.147
Error	261399.788	37	7064.859					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	117.224	10.851	95.238	139.211
Pronated	102.806	11.133	80.248	125.364

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	14.418	15.546	.360	-17.082	45.918
Pronated	Normal	-14.418	15.546	.360	-45.918	17.082

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	2025.490	1	2025.490	.860	.360	.023	.860	.147
Error	87133.263	37	2354.953					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	117.139	7.046	102.862	131.417
2	106.955	9.589	87.525	126.385
3	105.952	9.563	86.575	125.328

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	10.184	7.443	.538	-8.482	28.850
	3	11.188	7.268	.397	-7.039	29.414
2	1	-10.184	7.443	.538	-28.850	8.482
	3	1.003	6.865	1.000	-16.212	18.219
3	1	-11.188	7.268	.397	-29.414	7.039
	2	-1.003	6.865	1.000	-18.219	16.212

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	131.746	9.837	111.815	151.677
	2	109.651	13.386	82.528	136.774
	3	110.276	13.350	83.227	137.325
Pronated	1	102.532	10.092	82.084	122.981
	2	104.259	13.734	76.431	132.087
	3	101.627	13.696	73.876	129.379

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreVMOO
2	PoNVMOO
3	PoFVMOO

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreVMOO	Normal	131.74590	40.952055	20
	Pronated	102.53240	46.984618	19
	Total	117.51368	45.858989	39
PoNVMOO	Normal	109.6509	67.0926276	20
	Pronated	104.2588	51.1399174	19
	Total	107.0240	59.1353327	39
PoFVMOO	Normal	110.2758	71.7580960	20
	Pronated	101.6274	43.4871662	19
	Total	106.0625	59.0727569	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.991	.322	2	.851	.991	1.000	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	2986.582	2	1493.291	1.480	.234	.038	2.959	.306
	Greenhouse-Geisser	2986.582	1.982	1506.603	1.480	.234	.038	2.933	.305
	Huynh-Feldt	2986.582	2.000	1493.291	1.480	.234	.038	2.959	.306
	Lower-bound	2986.582	1.000	2986.582	1.480	.232	.038	1.480	.220
test * Group	Sphericity Assumed	3251.058	2	1625.529	1.611	.207	.042	3.222	.330
	Greenhouse-Geisser	3251.058	1.982	1640.020	1.611	.207	.042	3.193	.329
	Huynh-Feldt	3251.058	2.000	1625.529	1.611	.207	.042	3.222	.330
	Lower-bound	3251.058	1.000	3251.058	1.611	.212	.042	1.611	.235
Error(test)	Sphericity Assumed	74678.437	74	1009.168					
	Greenhouse-Geisser	74678.437	73.346	1018.164					
	Huynh-Feldt	74678.437	74.000	1009.168					
	Lower-bound	74678.437	37.000	2018.336					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	1415160.111	1	1415160.111	200.310	.000	.844	200.310	1.000
Group	6076.470	1	6076.470	.860	.360	.023	.860	.147
Error	261399.788	37	7064.859					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	117.224	10.851	95.238	139.211
Pronated	102.806	11.133	80.248	125.364

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	14.418	15.546	.360	-17.082	45.918
Pronated	Normal	-14.418	15.546	.360	-45.918	17.082

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	2025.490	1	2025.490	.860	.360	.023	.860	.147
Error	87133.263	37	2354.953					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	117.139	7.046	102.862	131.417
2	106.955	9.589	87.525	126.385
3	105.952	9.563	86.575	125.328

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	10.184	7.443	.538	-8.482	28.850
	3	11.188	7.268	.397	-7.039	29.414
2	1	-10.184	7.443	.538	-28.850	8.482
	3	1.003	6.865	1.000	-16.212	18.219
3	1	-11.188	7.268	.397	-29.414	7.039
	2	-1.003	6.865	1.000	-18.219	16.212

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	131.746	9.837	111.815	151.677
	2	109.651	13.386	82.528	136.774
	3	110.276	13.350	83.227	137.325
Pronated	1	102.532	10.092	82.084	122.981
	2	104.259	13.734	76.431	132.087
	3	101.627	13.696	73.876	129.379

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreTAD
2	PoNTAD
3	PoFTAD

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreTAD	Normal	602.900	63.2465	20
	Pronated	650.263	87.3185	19
	Total	625.974	78.6567	39
PoNTAD	Normal	610.990	79.7292	20
	Pronated	625.705	116.7737	19
	Total	618.159	98.4536	39
PoFTAD	Normal	594.940	76.5106	20
	Pronated	646.216	130.3267	19
	Total	619.921	107.9196	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.967	1.223	2	.543	.968	1.000	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	1413.680	2	706.840	.175	.840	.005	.350	.076
	Greenhouse-Geisser	1413.680	1.935	730.444	.175	.833	.005	.339	.076
	Huynh-Feldt	1413.680	2.000	706.840	.175	.840	.005	.350	.076
	Lower-bound	1413.680	1.000	1413.680	.175	.678	.005	.175	.069
test * Group	Sphericity Assumed	7852.897	2	3926.449	.972	.383	.026	1.943	.213
	Greenhouse-Geisser	7852.897	1.935	4057.568	.972	.381	.026	1.881	.210
	Huynh-Feldt	7852.897	2.000	3926.449	.972	.383	.026	1.943	.213
	Lower-bound	7852.897	1.000	7852.897	.972	.331	.026	.972	.160
Error(test)	Sphericity Assumed	299033.743	74	4040.997					
	Greenhouse-Geisser	299033.743	71.609	4175.941					
	Huynh-Feldt	299033.743	74.000	4040.997					
	Lower-bound	299033.743	37.000	8081.993					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	45211773.3	1	45211773.29	2398.701	.000	.985	2398.701	1.000
Group	41732.370	1	41732.370	2.214	.145	.056	2.214	.305
Error	697392.322	37	18848.441					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	602.943	17.724	567.031	638.856
Pronated	640.728	18.184	603.883	677.573

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	-37.785	25.393	.145	-89.236	13.667
Pronated	Normal	37.785	25.393	.145	-13.667	89.236

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	13910.790	1	13910.790	2.214	.145	.056	2.214	.305
Error	232464.1	37	6282.814					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	626.582	12.160	601.942	651.221
2	618.348	15.936	586.058	650.637
3	620.578	17.004	586.124	655.031

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	8.234	13.062	1.000	-24.521	40.989
	3	6.004	15.288	1.000	-32.334	44.341
2	1	-8.234	13.062	1.000	-40.989	24.521
	3	-2.230	14.757	1.000	-39.238	34.777
3	1	-6.004	15.288	1.000	-44.341	32.334
	2	2.230	14.757	1.000	-34.777	39.238

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	602.900	16.975	568.504	637.296
	2	610.990	22.246	565.914	656.066
	3	594.940	23.737	546.844	643.036
Pronated	1	650.263	17.416	614.974	685.552
	2	625.705	22.824	579.459	671.952
	3	646.216	24.354	596.870	695.561

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PrePLD
2	PoNPLD
3	PoFPLD

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PrePLD	Normal	732.675	100.5383	20
	Pronated	729.274	75.6691	19
	Total	731.018	88.1429	39
PoNPLD	Normal	754.210	99.4199	20
	Pronated	752.826	120.6707	19
	Total	753.536	108.8125	39
PoFPLD	Normal	701.115	137.8389	20
	Pronated	739.347	126.5739	19
	Total	719.741	132.1493	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.852	5.755	2	.056	.871	.935	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	22496.823	2	11248.411	1.571	.215	.041	3.141	.323
	Greenhouse-Geisser	22496.823	1.743	12910.354	1.571	.218	.041	2.737	.301
	Huynh-Feldt	22496.823	1.871	12025.342	1.571	.216	.041	2.938	.312
	Lower-bound	22496.823	1.000	22496.823	1.571	.218	.041	1.571	.231
test * Group	Sphericity Assumed	10740.256	2	5370.128	.750	.476	.020	1.500	.173
	Greenhouse-Geisser	10740.256	1.743	6163.559	.750	.459	.020	1.307	.164
	Huynh-Feldt	10740.256	1.871	5741.044	.750	.468	.020	1.403	.168
	Lower-bound	10740.256	1.000	10740.256	.750	.392	.020	.750	.135
Error(test)	Sphericity Assumed	529996.283	74	7162.112					
	Greenhouse-Geisser	529996.283	64.474	8220.307					
	Huynh-Feldt	529996.283	69.219	7656.801					
	Lower-bound	529996.283	37.000	14324.224					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	63148942.4	1	63148942.38	2703.058	.000	.986	2703.058	1.000
Group	3633.467	1	3633.467	.156	.696	.004	.156	.067
Error	864395.316	37	23362.036					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	729.333	19.732	689.352	769.315
Pronated	740.482	20.245	699.462	781.503

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	-11.149	28.271	.696	-68.431	46.133
Pronated	Normal	11.149	28.271	.696	-46.133	68.431

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	1211.156	1	1211.156	.156	.696	.004	.156	.067
Error	288131.8	37	7787.345					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

			95% Confidence Interval	
test	Mean	Std. Error	Lower Bound	Upper Bound
1	730.974	14.306	701.988	759.960
2	753.518	17.663	717.729	789.307
3	720.231	21.220	677.234	763.228

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-22.544	17.277	.600	-65.869	20.781
	3	10.743	22.556	1.000	-45.822	67.309
2	1	22.544	17.277	.600	-20.781	65.869
	3	33.287	17.185	.181	-9.808	76.382
3	1	-10.743	22.556	1.000	-67.309	45.822
	2	-33.287	17.185	.181	-76.382	9.808

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	732.675	19.970	692.212	773.138
	2	754.210	24.657	704.250	804.170
	3	701.115	29.623	641.093	761.137
Pronated	1	729.274	20.489	687.759	770.788
	2	752.826	25.298	701.568	804.085
	3	739.347	30.393	677.766	800.929

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreVMOD
2	PoNVMOD
3	PoFVMOD

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreVMOD	Normal	436.145	137.1692	20
	Pronated	441.937	157.7408	19
	Total	438.967	145.6111	39
PoNVMOD	Normal	400.995	125.0170	20
	Pronated	384.195	97.7773	19
	Total	392.810	111.4253	39
PoFVMOD	Normal	397.130	137.7882	20
	Pronated	389.837	128.3151	19
	Total	393.577	131.5505	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.813	7.445	2	.024	.843	.902	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	54999.461	2	27499.730	3.001	.056	.075	6.002	.566
	Greenhouse-Geisser	54999.461	1.685	32637.580	3.001	.065	.075	5.057	.517
	Huynh-Feldt	54999.461	1.804	30481.207	3.001	.062	.075	5.415	.536
	Lower-bound	54999.461	1.000	54999.461	3.001	.092	.075	3.001	.393
test * Group	Sphericity Assumed	2507.368	2	1253.684	.137	.872	.004	.274	.070
	Greenhouse-Geisser	2507.368	1.685	1487.913	.137	.838	.004	.231	.069
	Huynh-Feldt	2507.368	1.804	1389.607	.137	.852	.004	.247	.069
	Lower-bound	2507.368	1.000	2507.368	.137	.714	.004	.137	.065
Error(test)	Sphericity Assumed	678094.811	74	9163.443					
	Greenhouse-Geisser	678094.811	62.351	10875.474					
	Huynh-Feldt	678094.811	66.762	10156.929					
	Lower-bound	678094.811	37.000	18326.887					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	19499093.7	1	19499093.69	575.602	.000	.940	575.602	1.000
Group	1087.865	1	1087.865	.032	.859	.001	.032	.053
Error	1253411.068	37	33875.975					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	411.423	23.761	363.278	459.568
Pronated	405.323	24.379	355.927	454.719

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	6.101	34.043	.859	-62.877	75.078
Pronated	Normal	-6.101	34.043	.859	-75.078	62.877

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	362.622	1	362.622	.032	.859	.001	.032	.053
Error	417803.7	37	11291.992					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	439.041	23.632	391.157	486.925
2	392.595	18.035	356.053	429.137
3	393.483	21.346	350.232	436.735

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	46.446	24.520	.198	-15.043	107.935
	3	45.558	23.224	.172	-12.681	103.796
2	1	-46.446	24.520	.198	-107.935	15.043
	3	-.889	16.436	1.000	-42.106	40.329
3	1	-45.558	23.224	.172	-103.796	12.681
	2	.889	16.436	1.000	-40.329	42.106

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	436.145	32.990	369.301	502.989
	2	400.995	25.176	349.983	452.007
	3	397.130	29.799	336.752	457.508
Pronated	1	441.937	33.847	373.356	510.517
	2	384.195	25.830	331.858	436.532
	3	389.837	30.573	327.890	451.783

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreGMD
2	PoNGMD
3	PoFGMD

Between-Subjects Factors

		Value Label	N
Group	1	Normal	20
	2	Pronated	19

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreGMD	Normal	604.005	140.0779	20
	Pronated	613.468	161.9246	19
	Total	608.615	149.1766	39
PoNGMD	Normal	542.170	132.4215	20
	Pronated	610.868	128.8342	19
	Total	575.638	133.5671	39
PoFGMD	Normal	589.42	123.465	20
	Pronated	588.04	168.127	19
	Total	588.75	144.954	39

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.864	5.244	2	.073	.881	.946	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	20621.629	2	10310.814	1.365	.262	.036	2.730	.285
	Greenhouse-Geisser	20621.629	1.761	11708.490	1.365	.261	.036	2.404	.268
	Huynh-Feldt	20621.629	1.892	10896.568	1.365	.262	.036	2.583	.277
	Lower-bound	20621.629	1.000	20621.629	1.365	.250	.036	1.365	.207
test * Group	Sphericity Assumed	27727.039	2	13863.520	1.835	.167	.047	3.671	.371
	Greenhouse-Geisser	27727.039	1.761	15742.780	1.835	.172	.047	3.233	.347
	Huynh-Feldt	27727.039	1.892	14651.101	1.835	.169	.047	3.473	.360
	Lower-bound	27727.039	1.000	27727.039	1.835	.184	.047	1.835	.262
Error(test)	Sphericity Assumed	558949.392	74	7553.370					
	Greenhouse-Geisser	558949.392	65.166	8577.263					
	Huynh-Feldt	558949.392	70.022	7982.475					
	Lower-bound	558949.392	37.000	15106.740					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	40884489.5	1	40884489.49	881.445	.000	.960	881.445	1.000
Group	19148.670	1	19148.670	.413	.524	.011	.413	.096
Error	1716188.160	37	46383.464					

a. Computed using alpha = .05

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	578.532	27.804	522.196	634.868
Pronated	604.126	28.526	546.327	661.926

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	-25.595	39.835	.524	-106.307	55.118
Pronated	Normal	25.595	39.835	.524	-55.118	106.307

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	6382.890	1	6382.890	.413	.524	.011	.413	.096
Error	572062.7	37	15461.155					

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

2. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	608.737	24.203	559.696	657.778
2	576.519	20.934	534.103	618.935
3	588.731	23.530	541.054	636.408

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	32.218	20.546	.376	-19.306	83.741
	3	20.006	22.142	1.000	-35.521	75.532
2	1	-32.218	20.546	.376	-83.741	19.306
	3	-12.212	15.825	1.000	-51.897	27.473
3	1	-20.006	22.142	1.000	-75.532	35.521
	2	12.212	15.825	1.000	-27.473	51.897

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	604.005	33.787	535.546	672.464
	2	542.170	29.223	482.959	601.381
	3	589.420	32.847	522.865	655.975
Pronated	1	613.468	34.665	543.231	683.706
	2	610.868	29.982	550.119	671.618
	3	588.042	33.701	519.758	656.326

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreL_M
2	PstNL_M
3	PstFL_M

Between-Subjects Factors

		Value Label	N
Group	1	Normal	15
	2	Pronated	15

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreL_M	Normal	.0255	.01440	15
	Pronated	.0137	.01436	15
	Total	.0196	.01537	30
PstNL_M	Normal	.02107	.013014	15
	Pronated	.00687	.028415	15
	Total	.01397	.022884	30
PstFL_M	Normal	.02040	.010602	15
	Pronated	.01253	.011789	15
	Total	.01647	.011720	30

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.605	13.552	2	.001	.717	.772	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	.000	2	.000	.997	.375	.034	1.994	.215
	Greenhouse-Geisser	.000	1.434	.000	.997	.353	.034	1.430	.186
	Huynh-Feldt	.000	1.544	.000	.997	.359	.034	1.540	.192
	Lower-bound	.000	1.000	.000	.997	.327	.034	.997	.161
test * Group	Sphericity Assumed	.000	2	7.69E-005	.321	.727	.011	.642	.099
	Greenhouse-Geisser	.000	1.434	.000	.321	.655	.011	.460	.091
	Huynh-Feldt	.000	1.544	9.97E-005	.321	.671	.011	.496	.093
	Lower-bound	.000	1.000	.000	.321	.576	.011	.321	.085
Error(test)	Sphericity Assumed	.013	56	.000					
	Greenhouse-Geisser	.013	40.154	.000					
	Huynh-Feldt	.013	43.236	.000					
	Lower-bound	.013	28.000	.000					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	.025	1	.025	73.312	.000	.724	73.312	1.000
Group	.003	1	.003	8.430	.007	.231	8.430	.800
Error	.010	28	.000					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: MEASURE_1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
.017	.002	.013	.021

2. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	.022	.003	.017	.028
Pronated	.011	.003	.005	.017

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	.011*	.004	.007	.003	.019
Pronated	Normal	-.011*	.004	.007	-.019	-.003

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

3. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	.020	.003	.014	.025
2	.014	.004	.006	.022
3	.016	.002	.012	.021

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	.006	.005	.751	-.007	.018
	3	.003	.003	.663	-.003	.010
2	1	-.006	.005	.751	-.018	.007
	3	-.003	.004	1.000	-.013	.008
3	1	-.003	.003	.663	-.010	.003
	2	.003	.004	1.000	-.008	.013

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

4. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	.026	.004	.018	.033
	2	.021	.006	.009	.033
	3	.020	.003	.014	.026
Pronated	1	.014	.004	.006	.021
	2	.007	.006	-.005	.019
	3	.013	.003	.007	.018

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

test	Dependent Variable
1	PreL_P
2	PstNL_P
3	PstFL_P

Between-Subjects Factors

		Value Label	N
Group	1	Normal	15
	2	Pronated	15

Descriptive Statistics

	Group	Mean	Std. Deviation	N
PreL_P	Normal	-.02553	.016898	15
	Pronated	-.01440	.020441	15
	Total	-.01997	.019277	30
PstNL_P	Normal	-.02000	.016924	15
	Pronated	-.00887	.031897	15
	Total	-.01443	.025720	30
PstFL_P	Normal	-.02133	.016016	15
	Pronated	-.01380	.016267	15
	Total	-.01757	.016317	30

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
test	.735	8.327	2	.016	.790	.860	.500

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+Group
Within Subjects Design: test

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
test	Sphericity Assumed	.000	2	.000	.813	.449	.028	1.626	.182
	Greenhouse-Geisser	.000	1.581	.000	.813	.424	.028	1.285	.166
	Huynh-Feldt	.000	1.719	.000	.813	.433	.028	1.398	.171
	Lower-bound	.000	1.000	.000	.813	.375	.028	.813	.140
test * Group	Sphericity Assumed	6.48E-005	2	3.24E-005	.114	.892	.004	.228	.067
	Greenhouse-Geisser	6.48E-005	1.581	4.10E-005	.114	.846	.004	.180	.065
	Huynh-Feldt	6.48E-005	1.719	3.77E-005	.114	.864	.004	.196	.066
	Lower-bound	6.48E-005	1.000	6.48E-005	.114	.738	.004	.114	.062
Error(test)	Sphericity Assumed	.016	56	.000					
	Greenhouse-Geisser	.016	44.256	.000					
	Huynh-Feldt	.016	48.134	.000					
	Lower-bound	.016	28.000	.001					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	.027	1	.027	38.795	.000	.581	38.795	1.000
Group	.002	1	.002	3.189	.085	.102	3.189	.407
Error	.019	28	.001					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: MEASURE_1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
-.017	.003	-.023	-.012

2. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	-.022	.004	-.030	-.014
Pronated	-.012	.004	-.020	-.004

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Normal	Pronated	-.010	.006	.085	-.021	.001
Pronated	Normal	.010	.006	.085	-.001	.021

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

3. test

Estimates

Measure: MEASURE_1

test	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	-.020	.003	-.027	-.013
2	-.014	.005	-.024	-.005
3	-.018	.003	-.024	-.012

Pairwise Comparisons

Measure: MEASURE_1

(I) test	(J) test	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-.006	.005	.904	-.019	.008
	3	-.002	.003	1.000	-.011	.006
2	1	.006	.005	.904	-.008	.019
	3	.003	.004	1.000	-.008	.014
3	1	.002	.003	1.000	-.006	.011
	2	-.003	.004	1.000	-.014	.008

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

4. Group * test

Measure: MEASURE_1

Group	test	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Normal	1	-.026	.005	-.035	-.016
	2	-.020	.007	-.034	-.006
	3	-.021	.004	-.030	-.013
Pronated	1	-.014	.005	-.024	-.004
	2	-.009	.007	-.022	.005
	3	-.014	.004	-.022	-.005

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