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THE EFFECT OF TWO SPORT-SPECIFIC CLEAT PATTERNS ON PEAK PLANTAR PRESSURES DURING TWO RUNNING TASKS ON FIELDTURFTM

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THE EFFECT OF TWO SPORT-SPECIFIC CLEAT PATTERNS ON PEAK PLANTAR PRESSURES DURING TWO RUNNING TASKS ON FIELDTURF™

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Abstract

The purpose of this investigation was to examine the effect of two sport-specific cleat patterns (used interchangeably on FieldTurf™) on peak plantar pressures during two running tasks (side cut and cross cut) on FieldTurf™. Protocols were designed to determine if the turf-specific outsole effectively dispersed peak pressures on certain regions of the foot to a greater degree than a multi-stud outsole. This study was also used to determine if one shoe type would produce faster times during maximal effort sprint trials. Testing was performed on volunteer collegiate and amateur level football and soccer players from The University of Western Ontario. A pressure distribution measuring system for monitoring loads between the foot and the shoe known as the Pedar Mobile System was used in this study to measure peak pressure and maximum force exerted during the cutting motions. Differences between the testing conditions were determined using paired samples t-tests. The analyses demonstrated significant differences between the turf shoe and the multi-stud shoe in peak pressure during both the side cut and the cross cut. The turf-specific shoe was found to reduce the loads in both tasks. No difference was found in maximal sprint effort trials. While the clinical significance of the differences found requires further study, the present findings suggest that turf-specific cleats do, in fact, reduce peak pressure in the forefoot to a greater extent than other types of cleated footwear on FieldTurf™.

Keywords: peak pressure, FieldTurf™, overuse injuries

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Chapter 1

Introduction

An ever-increasing number of people are participating in sporting activities. This increase in participation creates a higher demand for more adequate playing surfaces. The availability of these surfaces may be scarce or unavailable in certain areas and can result in exposure to inadequate natural surfaces and older generation artificial surfaces. Repeated exposure to these inadequate surfaces can lead to overuse injuries such as stress fractures.

Overuse injuries are a persistent problem in certain competitive field sports such as football, soccer, field hockey and lacrosse, resulting in a large proportion of athletes being disabled for lengthy periods of time each season (Scuderi & McCann, 2005). For example, at the national team level, 38% of the members of the 1994 U.S. World Cup Soccer team had a history of stress fractures due to extremely long seasons without any time off (William E. Garret, Thomas P. Knapp, 2001) It was also reported that 97% of the players from the U.S. men's senior national and Olympic soccer teams had extra bony growths, such as osteophytes, as a result of repeated micro and macro trauma (Eils et al., 2004).

Various extrinsic and intrinsic risk factors might be involved in the etiology of these types of injuries. Intrinsic risk factors are factors related to individual biological or psychosocial characteristics and might include age, previous injuries, and inadequate rehabilitation. Extrinsic risk factors are those related to variables of the environment such as exercise load, equipment, and playing field conditions. For example, the shoe, is one extrinsic factor thought to contribute to the risk of overuse injuries (Eils et al., 2004). To date, there is a paucity of quantitative information available that reports foot-loading characteristics during sport-specific movements on FieldTurf™. As such, knowledge about the location and the amount of load acting on the sole of the foot is important for the development of specific shoe/insole designs and may also help to prevent overuse injuries.

The introduction of a new generation of synthetic playing surfaces, for sports like soccer, lacrosse, baseball, and American football, has gained increasing popularity. In the 2005 season of the National Football League over one third of the stadiums consisted of artificial surfaces (12 out of 31, 38.7%) (Ford et al., 2006). These new synthetic playing surfaces, which mimic grass-like conditions with the use of rubber and/or sand infill, allow athletes to compete and practice all year around without having to delay training due to inadequate playing conditions.

The newer playing surfaces are developed and marketed to improve performance, provide more natural field and grass characteristics and reduce injuries (Ford et al., 2006). They are composed of polypropylene fibers of varying lengths, stabilized with ground rubber and/or sand infill, and are supported on an engineered foundation. Though these new artificial surfaces may come closer to a true grass-playing surface than the older turf designs, they still demonstrate different stiffness, friction and elasticity characteristics in comparison to natural grass (Naunheim, Parrott, & Standeven, 2004). The subtle yet noteworthy differences in surface characteristics may affect an athlete's kinetic patterns, thus potentially disrupting their technique during skill specific activities in competition. The slight change in technique due to a change in surface characteristics could affect performance to a level that increases the frequency and severity of athletes' injuries (Nigg & Segesser, 1988).

First and second generation engineered turf surfaces are associated with increased injury rates in athletes that participate in cutting and landing sports, such as football and soccer (Ford et al., 2006). As a result, the notion that all types of artificial turf increase injury frequency and severity is a subject of interest. In a five-year prospective study, Meyers and Barnhill (2004) investigated the incidence, severity and cause of injury on both FieldTurf™ and natural grass in high school football. Based on the findings, it was determined that although similarities existed between surfaces, both exhibited unique injury patterns, which warranted further investigation.

The introduction of new sport surface technologies confirms that studies on the effects of the surface on athletic performance, movement biomechanics and injury risk are both necessary and important (Ford et al., 2006). Due to their relatively low maintenance costs, new generation synthetic playing surfaces have become increasingly popular in professional and amateur sports.

Most biomechanical investigations today are typically limited to the laboratory even though most sport-related injuries particularly to the foot, ankle, and knee occur on the playing surface during practice or competition. For a better overall understanding of how playing surfaces affect athletic performance and injury risk, greater in-depth field investigations need to be conducted. The surface characteristics and related biomechanical alterations may be an important factor related to the frequency and severity of injuries. Thus, these factors create merit for further investigation into injury prevention on artificial turf.

The majority of data available on the mechanical loading of the foot has been collected during walking and running activities in a straight line (Orendurff et al., 2008). However, for the most common activities in field sports, such as running and cutting, very limited data have been collected. It is in such activities that the mechanical loading of the foot is the greatest and of the most concern. As a result, examining stress or pressure distributions between two different cleat configurations used interchangeably on FieldTurf™ will help in further understanding potential risk factors for the development of stress fractures and overuse injuries.

In a study by Queen et al., (2008) 36 athletes ran an agility course five times while wearing four different types of cleats. Plantar pressure data were recorded during a side cut and a cross cut using Pedar insoles. In the cross cut task, statistical differences between cleats were observed in total foot peak pressure, lateral forefoot force-time integral, and lateral forefoot normalized maximum force. In the side cut task, statistical differences between cleats were observed in total foot peak pressure, the medial and middle forefoot force-time integral, and the medial and middle forefoot normalized maximum force. It was concluded that significant differences in forefoot loading patterns existed between cleat types. Based on the results of this study, the investigators stated that it may be beneficial to increase the forefoot cushioning in cleats in an attempt to decrease loading of the foot. This cushioning would need to be added in such a way that it does not affect foot positioning. If this addition changes the foot's positioning in the shoe to a more inverted/everted position it may subject athletes to a greater risk of ankle injuries.

Comprehensive studies, looking at the stresses placed on the foot during athletic activity in a field setting, provide a means to understand foot loading during sport. A better understanding of how cleat design is associated with foot loading may contribute to improved performances in athletes by helping to prevent overuse injuries such as stress fractures in the lower leg.

Chapter 2

Review of Literature

Walking and running in a straight line, to determine shoe-foot pressure interactions at specific anatomic regions of the plantar surface of the foot, have been the general focus of most studies regarding foot pressures. This is an adequate approach for shoes designed for activities in which walking or running straight ahead are the predominant activity. However, it is likely that for several types of sports shoes, straight-line running and walking do not adequately quantify the complete range of plantar pressures experienced during typical sport maneuvers (Orendurff et al., 2008). As such, it is important to look at the pressures exerted on the bottom of the foot during sport-specific tasks.

Many different types of injuries occur in both contact and non-contact sports, however, the foot is reported as the most commonly injured body part (Wong et al., 2007). Stress fractures, prevalent in both contact and non-contact sports, are at times due to excessive loads but mainly due to repetitive loads on the foot. These loads cause an imbalance between bone resorption and bone formation These types of injuries are most typically seen in either elite or professional level athletes with heavy daily training and game schedules (Scuderi & McCann, 2005).

Many shoes are made for specific sports that involve frequent accelerating, cutting, and jumping as well as running straight ahead (soccer, football, lacrosse, field hockey, tennis, etc). As a result, the evaluation of the shoe's performance and the foot's function during typical sport movements seems warranted. The dynamic function of specific anatomic regions of the foot, during typical maneuvers used during field sports, may assist shoe designers to focus on the regions that may require greater cushioning and support during demanding sport movements (Orendurff et al., 2008).

During athletic efforts on new synthetic grass playing surfaces such as FieldTurf™, pressures are exerted differently on the bottom of the foot compared to older generation artificial surfaces as well as compared to natural grass. To assess the effectiveness of cleat type and its effect on performance on FieldTurf™, many questions must be considered. During which athletic tasks are plantar pressures the greatest? Is there scientific evidence that different types of playing surfaces create different effects on plantar loading? If there is evidence, does artificial turf increase the incidence of injury in sport? What are the predominant injuries that athletes face on these types of surfaces? And, does cleat type have an effect on both plantar pressure and performance? Experts in sports medicine have been debating this issue for quite some time looking to find the right balance between injury prevention and optimal performance for athletes who wear cleated athletic footwear.

2.1 Which athletic skills create the greatest plantar pressures?

Knowledge about the location and the amount of load acting on the sole of the foot is important for the development of specific shoe/insole designs. It may also help to prevent overuse injuries. Twenty-one experienced male soccer players were asked to perform a series of athletic movements involving running, cutting, sprinting, and shooting in soccer. These four movements were analyzed for plantar pressures and force-time integrals. Results from this study indicated that in running, the main loading areas were found under the heel, the metatarsal heads, and the hallux. In cutting, the medial heel, medial forefoot, and hallux experienced the greatest amount of pressure. In sprinting, the predominant loading areas were found in the forefoot (medial forefoot and hallux, central forefoot, and second toe). The results of this study showed characteristic loadings patterns of the foot during soccer specific movements. This can also be applied to other sports where the same types of movements are applied such as football. The peak pressures observed during running, cutting, and sprinting were of greatest interest throughout this study. Peak pressures were greatest in the medial forefoot for all three of these movements indicating a potential danger for overloading this specific area of the foot. Excessive loading values of these specific areas suggest that there is an increased potential for the development of overuse injuries and stress fractures. Thus, the specific design of insoles could gain from modifications aimed at reducing the pressure experienced in these areas (Eils et al., 2004).

Orendurff et al., (2008) examined the effect of two different cleat plates on plantar pressures during sprinting cutting, jumping and landing. Ten collegiate-level male athletes were asked to run through a cone outlined course at 75% maximum speed, once wearing a turf shoe, and once wearing a multi-stud cleat in random order. The results showed that accelerating, cutting, jumping, and landing loaded the plantar surface of the foot to a greater degree than running straight, regardless of which shoe was worn. More importantly, the study demonstrated that peak pressures were highest in the medial column of the outside foot during cutting maneuvers. The great toe, the first metatarsal head, the central forefoot, and the heel all demonstrated increased peak pressures above approximately 35 N/cm^2 while the lesser loaded areas consisting of the lateral column, the fifth metatarsal head, and the medial and lateral midfoot regions all had peak pressures below approximately 20 N/cm^2. During the cross cutting maneuvers, peak pressures were highest in the lateral column of the inside foot. The fifth metatarsal head, lateral midfoot, and heel all experienced peak pressures between approximately 23 to 46 N/cm^2. The first metatarsal head, central forefoot, and medial midfoot all demonstrated peak pressures around approximately 20 N/cm^2. Although there is no absolute threshold for the development of overuse injuries, the results of the investigations indicate that certain parts of the plantar aspect of the foot are excessively loaded during specific athletic movements such as running, cutting and sprinting. Peak pressures were significant in the medial forefoot for all 3 of these movements, but were highest during cutting movements in the medial column of the outside foot. The excessive loads encountered create potential danger for overloading the medial aspect of the foot. This is especially prominent in athletes engaged in sports where cutting motions occur often throughout practices and games. This may help to explain the incidence of stress fractures in athletes who compete in field sports (Eils et al., 2004).

2.2 Do different types of playing surfaces create different effects on plantar loading?

New generation artificial playing surfaces such as, FieldTurf™, demonstrate different stiffness, friction and elasticity characteristics than grass (Naunheim et al., 2004). These differences can affect an athlete's kinetic patterns, potentially upsetting their technical performance of skill-specific activities during competition (Dixon, Collop, & Batt, 2000). As a result, it is important to observe the effect that different playing surfaces create on plantar loading during sporting activities.

In a five-year prospective study, Meyers and Barnhill (2004) investigated the differences in injuries on two common playing surfaces (FieldTurf™ and natural grass) in high school football and discovered that each was associated with unique injury patterns. Older generation artificial turf surfaces were associated with an increased amount of overuse injuries due to the increased stiffness of the surface.

Seventeen male football players ran through two identical slalom courses in parallel adjacent regulation football fields composed of a synthetic surface and natural grass surface wearing a multi-stud molded football cleat in a study by Ford et al., (2006). Players were asked to perform a maximal effort sprint on both courses. Cutting steps were analyzed for plantar pressures and force-time integrals for nine separate areas of the foot. The peak pressure was significantly higher during the turf condition within the central forefoot and lesser toes compared to grass; 17.5% and 18.9% higher respectively. In contrast, during the grass condition, the relative load within the medial forefoot and lateral midfoot were 9.8% and 15.5% higher respectively. There were no performance time differences in the slalom course during the maximal efforts on each surface. Additionally, there were no differences regarding the playing surface on force time integral calculated over the entire foot for the cut. It was concluded that the total loading under the entire foot did not change. However, the type of surface did influence plantar loading at specific foot regions. The specific reasons for these differences are unclear, however, it was hypothesized that the turf surface allowed the foot to invert to a slightly greater extent causing higher pressures in the lateral plantar regions. This was most likely due to the less rigid support base provided by the artificial turf surface.

2.3 Does artificial turf increase incidence of injury in sport?

Grass is the traditional surface for both football and soccer, but many regions in the world have a climate that makes development of adequate natural grass surfaces difficult. In addition, some modern stadiums have a roof under which grass surfaces do not thrive. The use of artificial turf has been put forward as a solution to these problems. A comparison between first generation artificial turf and natural grass pitches revealed that the utility of artificial pitches, the ability to use the artificial playing surface throughout the year including during the winter months, was 12 times greater than grass pitches and the maintenance costs only 15% compared to grass surfaces (Ekstrand & Nigg, 1989). As previously stated, first generation artificial turf studies showed that more overuse injuries were associated with this type of surface compared to natural grass. Although this relationship is poorly documented due to small sample sizes and methodological limitations, it still provides evidence regarding overuse injuries on artificial turf. As a result, one particular feature of the new third generation artificial surfaces is improved shock absorption. Even though vast technological improvements have been made to mimic natural grass, these artificial surfaces are not to be considered stable static surfaces. Irreversible changes occur to the surface's physical makeup due to continuous use and exposure. The diminished impact absorption capacity clearly seems detrimental to player safety.

Ekstrand et al. (2006) set out to compare injury risk among elite soccer athletes who played on artificial turf compared with athletes who played on natural grass. In a prospective two-cohort study, male athletes from 10 elite European soccer teams with artificial turf at the home facility and athletes from nine elite European soccer clubs playing on grass at the home facility constituted the study cohorts. A total of 775 injuries were recorded, of which 455 (59%) were traumatic (5.04/1000 hours) and 320 (41%) overuse injuries (3.54/1000 hours).

A comparison between traumatic injuries on artificial turf versus grass was conducted and the analysis showed no difference between surfaces. The principle finding of this study was that both intra-cohort and inter-cohort analyses revealed that the injury incidence was similar when elite-level soccer was played on either artificial turf or natural grass. However, the intra-cohort analysis showed an increased risk of ankle sprain on artificial turf, reaching significant levels in match play. There was no comparison made for overuse injuries.

Shoe-surface interaction is interpreted as the manner in which the shoe and the surface influence one another during game-relevant loading. This interaction includes but is not limited to shock absorption, vertical deformation, and rotational resistance. The shoe-surface interaction for the average player is the variable that is most likely to correlate with injury incidence in a game of football. Injury incidence in football played on older generation artificial turf has often been reported to be higher than in games played on natural grass (J. Orchard, 2002).

Approximately 70% of ACL injuries, occurring on these artificial surfaces occur in noncontact situations (Orchard & Powell, 2003). From an injury prevention standpoint, there are numerous possible causes for these noncontact injuries, but a principal factor implicated in many of them is the interaction between the player's footwear and the playing surface (Livesay et al, 2006).

Livesay et al. (2006) set out to examine the shoe-surface interactions on newer field designs and compared these with more traditional shoe-surface combinations by determining peak torque and rotational stiffness (the rate at which torque is developed under rotation). A device was constructed to measure the torque versus applied rotation developed between different shoe-surface combinations. Data was collected on five different playing surfaces (natural grass, Astroturf™, two types of Astroplay™, and FieldTurf™), using two types of shoes (grass and turf). The highest peak torque was observed by the grass-specific shoe- FieldTurf™ interaction and the lowest peak torque was observed on the grass field by both the grass-specific shoe and the turf –specific shoe. The demonstration of peak torque developed by the grass shoe-FieldTurf™ further illustrates the notion that athletes are at a potentially increased risk of injury when playing/practicing on FieldTurf™ and this risk increases significantly when certain types of cleated footwear are worn; specifically those not designed for this type of surface.

Movement patterns, technical standards, and player impressions were recorded during elite level soccer played on artificial turf versus natural grass by Andersson, Ekblom, and

Krustcup (2008). The aim of the study was to examine the movement patterns, ball skills, and the impressions of Swedish elite soccer players during competitive games on artificial turf and natural grass. No differences were observed between the two in terms of total distance covered, high intensity running, number of sprints, standing tackles or headers per game. However, there were fewer sliding tackles on artificial turf than natural grass. There were more short passes and midfield-to-midfield passes on the artificial turf. The males in the study reported a negative overall impression, poorer ball control, and greater physical effort on artificial turf than natural grass. The negative overall impression and greater perceived physical effort may have lead to overexertion and disrupted kinetic chains resulting in injury. This impression could help explain the increased risk of injury on artificial turf as presented in previous studies (Ekstrand et al., 2006; Livesay et al., 2006).

2.4 Does cleat type have an effect on plantar pressure?

Field composition varies widely between regions and levels of competition, resulting in a variety of different cleat configurations, which allows players to maximize both traction and comfort on all types of surfaces. Shoe manufacturers understand this need and therefore offer a variety of cleat configurations such as turf, multi-stud and 8-stud designed explicitly for artificial turf, artificial turf or hard natural, and soft grass fields (Queen et al., 2008).

When comparing in-shoe foot loading patterns on both grass and artificial turf using a 14-stud molded cleat typically used on both surfaces, the total force-time integral did not display a difference. Whether the athlete was performing on the turf or natural grass, the total loading under the entire foot did not change. However, the type of surface did influence plantar loading at specific foot regions. It was determined that the turf condition had significantly higher peak pressures within the central forefoot (turf: 646.6 +/- 172.6 kPa, grass: 533.3 +/- 143.3 kPa, P=0.017) and lesser toes (turf: 429.3 +/- 200.9 kPa, grass: 348.1 +/- 119.0 kPa, P= 0.043) compared to grass. During the cutting maneuver, the medial forefoot region had a significantly higher relative load (Ford et al., 2006).

In a study by Wong et al., (2007) the difference in plantar pressure between the preferred and non-preferred foot was observed in four soccer-related movements. The preferred foot in this study was defined as the foot with which athletes preferred to receive, control and kick and the non-preferred foot was defined as the foot most often used for support and stabilization. The four movements involved in this study were running, sideward cutting, 45 degree cutting, and jump landing. Across all movements, plantar pressure in the preferred foot was higher than in the non-preferred foot. Higher pressure was found in the preferred foot during the take off phase, while it was found in the non-preferred foot during the landing phase. After analyzing plantar loading during the sport-specific movements researchers determined that the data obtained in the study generally agrees with the findings reported by Eils et al., (2004). Higher peak pressures were found on the medial column of the plantar surface during running and cutting movements in soccer.

Although stress fractures have been previously investigated in running and basketball, few studies related to metatarsal stress fractures in cleated sports have been conducted (Queen et al., 2008). Previous literature has identified second metatarsal stress fractures as the most common stress fracture site, followed by stress fractures of the third, first, fourth, and fifth metatarsal (Kennedy et al., 2005). Studies have also identified recent changes in footwear and/or training surfaces as risk factors for the development of stress fractures (Eils et al., 2004). Therefore, examining stress or pressure distributions between different cleat configurations could aid in understanding potential risk factors for the development of stress fractures based on the cleat plate configuration.

Queen et al. (2008) set out to examine the effect of different cleat plate configurations on plantar pressure during two tasks on FieldTurf™. Thirty-six athletes ran an agility course while wearing four different types of soccer cleats and Pedar insoles to collect plantar pressure data. During the cross cut task the total foot peak pressure (kPa) was significantly lower in the turf cleat compared to three cleat types: hard ground, firm ground and bladed. The lateral forefoot force-time integral (NS) was also significantly different but only between the bladed cleat and the turf cleat.

During the side cut task statistical differences were observed between the different cleat configurations. There was a significant decrease in total foot peak pressure (kPa) between the turf cleat and the other three cleats. Total foot contact area was significantly lower in the firm ground cleat compared to the turf cleat. Lastly, there was a significant decrease in the medial forefoot normalized to maximum force when wearing the turf cleat compared to the firm ground cleat. The plantar pressure distribution results of this study are similar to previous reports (Eils et al., 2004). Across tasks, the statistical differences observed between the turf cleat and the other three types of cleats are most likely due to the additional cushioning provided by the midsole of the turf shoe. In addition, turf shoes were constructed to optimize performance on artificial surfaces through an increase in the number of studs, and a decrease in stud height. This could also aid in explaining the decrease in force and pressure in the turf shoe compared to the three other cleat plates with a rigid sole. The additional cushioning provided by the midsole potentially dissipated force during ground contact, clearly reducing both the maximum force and force-time integral. This cushioning combined with the dense cleat configuration might make the turf shoe more suitable for preventing metatarsal stress fractures. Queen et al., (2008) suggested that although the turf shoe may be more suitable for preventing these types of injuries, it might not be feasible for athletes to compete in turf-specific shoes due to loss of traction.

Studies have found that a decrease in shoe-surface friction leads to slipping, but it also decreases the number of complaints of knee pain from athletes. An increase in shoe-surface friction, attained by decreasing number of studs and increasing stud height can potentially increase player performance, however, it increases the risk of injury due to increased speed and resulting contact force. Again, these findings imply that although the turf shoe minimizes forces in the forefoot during ground contact, it might not be the best choice of footwear in all circumstances.

Previous studies have focused on changing the relationship between the cleat height and number of studs and others on changing the material out of which the sole of the shoe is constructed (Queen et al., 2008). While each of these previous studies has focused on changing the relationship between the cleat and the ground, it is important to try and balance the benefits of injury prevention while maintaining performance.

Queen et al., (2008) came to the conclusion that the turf shoe appears to be the only cleat that decreases the force and pressure beneath the metatarsal heads and therefore could potentially minimize metatarsal injury risk. They did not provide any conclusive evidence that athletes should choose one cleat type over another for the purpose of minimizing injury risk or increasing performance.

2.5 Does cleat type have an effect on performance?

While injury prevention should always be the most important criterion when looking at the implementation/design of new equipment such as footwear, the resultant effect on functional performance is a concern for both the athlete and coaching staff. An athlete who has to compete at the highest level will likely want any advantage he/she can get over the opponent without risking injury. As such, it may not be feasible for athletes to compete in turf shoes due to loss of traction. As previously stated a decrease in shoe-surface friction leads to slipping, but prove beneficial in terms of injury prevention (Queen et. al., 2008). These findings imply that although the turf shoe may minimize the potential for injury, it might not be the best choice of footwear in terms of player performance.

From this review of literature, it can be ascertained that little has been done to determine if the data collected from side cutting and cross cutting movements on FieldTurf™ is reproducible to shoes from other manufacturers. While research information regarding performance on two different surfaces is available; the role of two different types of footwear on one surface has essentially been ignored. Professional athletes on FieldTurf™ wear both types of footwear yet no studies have proven if one provides a performance advantage over the other during a maximal trial effort. Therefore, the present investigation was undertaken to provide information in this area.

Chapter 3

Objectives and Hypotheses

Objectives:

Previous studies have examined the role of cleated athletic footwear and the surfaces with which they interact; few have focused on the two main subject matters of this study. The primary purpose is to examine the effect of two sport–specific outsoles (used interchangeably on FieldTurf™) on peak plantar pressures during two running tasks on FieldTurf™. This study will analyze the influence of cleat patterns on plantar pressures and the performance aspect associated with these patterns. It will add further evidence to the notion that there is, in fact, one specific outsole plate that reduces peak plantar pressures. This study will also determine whether there may be a significant advantage to wearing one specific type of shoe during competition, which would significantly decrease the time required to complete a drill involving a maximal athletic effort with skilled movements that would be seen in football. The overall objective, when combining the two topics of interest in this study, is to find the best cleat configuration for performance and reduction of peak plantar pressures.

Research Question:

i) Does peak pressure on the sole of the foot differ when athletes complete cutting tasks using two different UnderArmour™ outsole configurations on FieldTurf™?

ii) ii) Does the timed completion of the "L-drill" by amateur and varsity level athletes differ when using two different UnderArmour™ outsole configurations on FieldTurf™?

Hypothesis:

i) The turf-specific football cleats will disperse peak pressures on the plantar aspect of the foot to a significantly greater degree than multi-stud football cleats due to the greater number of cleats in contact with the turf.

ii) The multi-stud football cleats will produce significantly faster sprint times than the turf-specific cleats on the "L-drill" due to decreased surface area in contact with the ground, which may allow for faster changes of direction and ability to accelerate.

Chapter 4

Methods and Procedures

4.1 (a) Subjects

Twenty male athletes, between the ages of 18 and 28 years completed this study. In order to participate, subjects had to be actively engaged in soccer, football, or rugby related activities at least two to three times a week and wear men's shoe sizes between 9-11.5. The subjects that participated were collegiate and amateur-level athletes. Subjects were volunteers recruited from the University of Western Ontario in London, Ontario. A summary of the subjects' physical characteristics participating in this study can be found in Table 1.

Table 1 Physical characteristics of subjects participating in study (values given are mean (SD))

	Age (years)	Height (cm)	Weight (kg)	# of Varsity Athletes	# of Amateur Athletes
Males (n=20)	21.1 (1.8)	178.8 (4.9)	77.9 (4.1)	5	15

4.1 (b) Testing Apparatus:

The UnderArmour™ football cleats utilized in this research were selected as the manufacturer recommends them for use on FieldTurf™. Subjects wore the appropriate sized UnderArmour™ cleats (Figure 1a and 1b) and Pedar (Figures 1c) (Novel™, St. Paul, MN, USA) insoles to collect plantar pressure data while performing skilled cutting movements on FieldTurf™. The surface was composed of monofilament polyethylene blend fibers tufted into a polypropylene backing. A bottom layer of silica sand, a middle layer - which is a mixture of sand and cryogenic rubber, and a top layer of only rubber created the composition of the infill. The fibers were meant to replicate blades of grass, while the infill acts as a cushion (Queen et al., 2008). The Pedar Mobile System is a repeatable and reliable pressure distribution measuring system for monitoring local loads between the foot and the shoe (Putti et al., 2007; Kernozek et al., 1996). Insoles were calibrated prior to data collection.

Figure 1a. UnderArmour™ turf cleat

Figure 1b UnderArmour™ multi-stud cleats.

Figure 1c. Subject fitted with cleats and Pedar equipment

4.1 (c) Testing Procedures

All testing was conducted between 12:00 pm and 4:00 pm, Monday to Friday on FieldTurf™ at TD Waterhouse Stadium at the University of Western Ontario. The temperature was approximately 15°C for the duration of the tests. Each participant was required to complete a Demographic Information Form (Appendix D). Subjects did a 5-minute self-paced warm up and 5 minutes of passive muscle stretching prior to beginning trials.

Elastic sensor insoles, which covered the entire plantar surface of the foot, were placed bilaterally inside the shoes to record pressure distributions. Since the shoes were all built by the same manufacturer, the fit of each shoe was similar, therefore, the effect of accommodation time should have been minimal. The order in which subjects completed the skilled movements was pre-arranged and recorded in order to ensure randomization. By doing so, it minimized the chance of order effect.

Subjects were fitted with one of the two shoe conditions, demonstrated the desired techniques for the cross cut and side cut and then allowed to practice until comfortable performing the required skills. Each participant completed each movement five times for a total of ten trials in each shoe condition for a total of 20 trials (Figures 2a & b). The data was collected via a wireless Bluetooth signal that transmits from the insoles to a nearby computer.

After completion of the skilled movement trials, the Pedar insoles were removed and the sprint drill known as the "L" drill was demonstrated. They were allowed three practice trials and then performed the maximal effort sprint drill three times in each pair of shoes (Figure 3). Once again, shoe order was randomized for all 20 subjects to ensure there was no order effect. Subjects were allotted 30 seconds of rest between trials for the cutting drills, 1 minute rest between "L" drill trials and two minutes rest between shoe conditions to minimize the effect of fatigue.

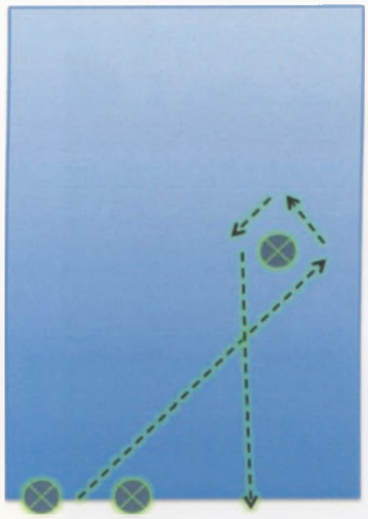


Figure 2 a. Cross Cut Run Pattern

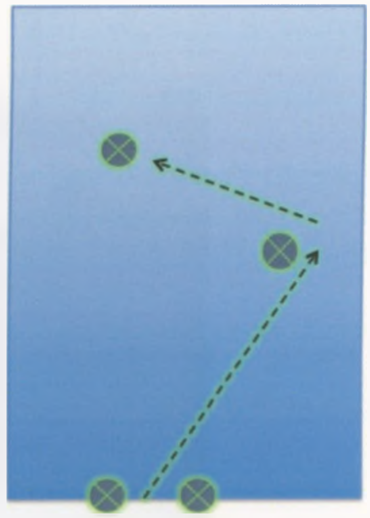


Figure 2 b. Side Cut Run Pattern

Figure 2 c. Cross Cut Movement

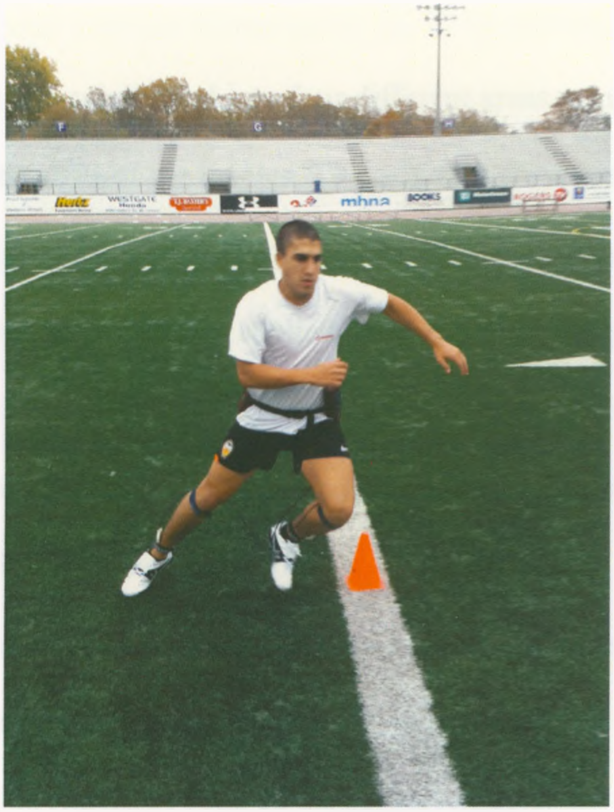


Figure 2 d. Side Cut Movement

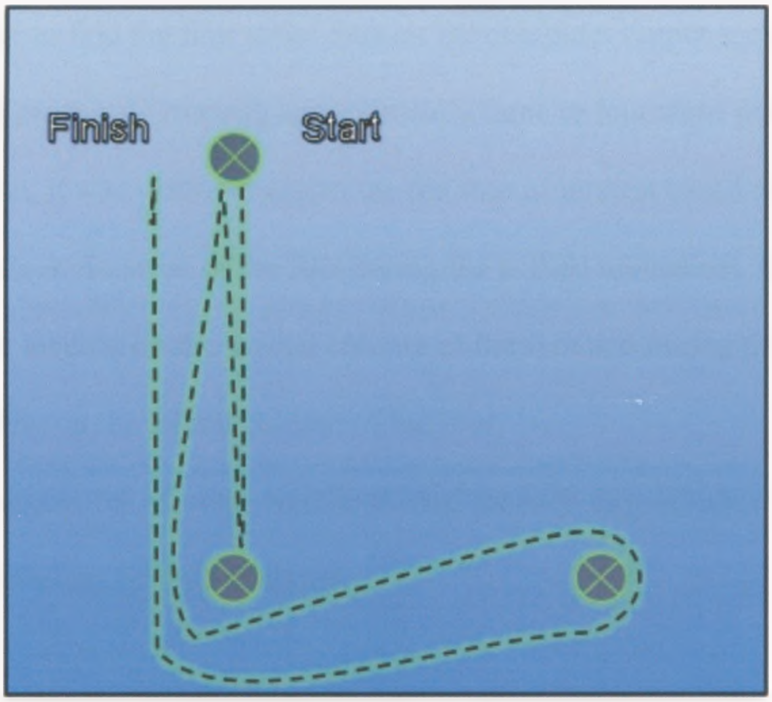


Figure 3. L-Drill Time Trial

4.2 Data Analysis

Each footprint was subdivided into four different areas using a standardized mask that corresponded to the sizes of the insoles. The different areas were: the medial forefoot (MFF), middle forefoot (MidFF), lateral forefoot (LFF) and the rearfoot (Figure 4). The same mask for each insole was applied to all subjects' footprints, thus it was ensured that the same areas of the insole were always compared to each other in the intra-individual comparison. All of the plantar loading variables that were examined were based on the vertical force applied to the foot.

The Pedar system collected data from the moment the subject was instructed to begin the drill. In order to ensure that the data output obtained was solely for the step of interest, a stopwatch was started as soon as the subject initiated his run to the pylon to perform the skilled movement. The stopwatch was stopped at the visually identified time the cut was made by a data collection assistant. The time was recorded and provided an estimate of where to find the foot strike data on the computer output screen. Due to the fact that subjects were only running approximately three to four steps prior to performing the cutting motion, it was viable to determine the step of interest based on the loading characteristics of certain areas of the foot during the skilled movement. During a side cut there was greater loading on the medial column of the foot and during the cross cut there was greater loading on the lateral column of the foot.

Peak pressures for all areas were extracted for each step of interest. An average of the five trials was taken for data analyses.

Statistical analyses were performed using the SPSS software package designed for computer use. A paired samples t-test was computed. A Bonferroni adjustment was completed and the adjusted alpha level was set at 0.0025.

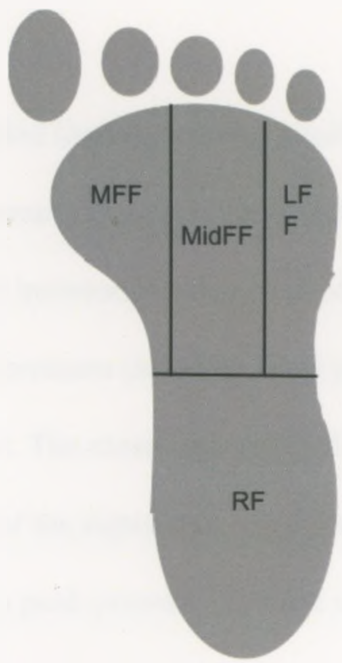


Figure 4. Division of the foot used during statistical analysis. The foot was divided into the rearfoot, medial forefoot (MFF), middle forefoot (MidFF), and lateral forefoot (LFF)

Chapter 5

Results

5.1 (a) Side cut task

Peak pressure analysis revealed loading patterns similar to those shown in previous studies analyzing peak pressures during running tasks. During the side cut task statistical differences were observed between the two cleat configurations when observing the maximum amount of pressure (also known as peak pressure) exerted on specific, segmented areas of the foot. The mean and standard deviation values for peak pressure and force for each section of the dependent variables can be found in Table 2. There was a significant difference in peak pressure between cleats for the side cut task. Specifically, statistical differences in peak pressure were observed between the turf cleat and the multi-stud cleat in the medial forefoot and middle forefoot ($p < 0.001$ and $p < 0.001$ respectively) (Figure 5). During the side cut task in the two different cleat conditions, there were no significant differences found in peak pressure in the lateral forefoot.

Table 2 Peak pressure on the different segments of the foot while wearing the multi-stud /turf shoe during the side cut task (values given are mean (SD))

	Multi-stud	**Turf**	**P-value**
MFF peak pressure (kPa)*	405.97 (82.30)	340.01 (84.44)	p<0.001
MidFF peak pressure (kPa)*	303.33 (53.07)	262.54 (43.45)	p<0.001
LFF peak pressure (kPa)	247.41 (37.73)	235.08 (34.58)	0.003

LFF, lateral forefoot; MFF, medial forefoot; MidFF, middle forefoot

*Significant difference between multi-stud cleat and turf cleat (p<0.0025)

5.1 (b) Cross cut task

During the cross cut task, a statistical difference was observed between the multi-stud cleat and the turf cleat in the lateral forefoot. Table 3 depicts the mean and standard deviation peak pressure values for each of the dependent variables. There was a significant difference in peak pressure at the lateral forefoot between the multi-stud and turf cleat for the cross cut. The lateral forefoot demonstrated significantly different peak pressures between the two shoe types (p< 0.001) (Figure 6). There was no significant difference in peak pressure between shoe types for the medial and middle forefoot and no significant differences were found in regards to maximum force in any area of the foot studied.

Table 3 Peak pressure on the different segments of the foot while wearing the multi-stud /turf shoe during the cross cut task (values given are mean (SD))

	Multi-stud	**Turf**	**P-value**
MFF peak pressure (kPa)	300.42 (63.72)	286.65 (48.07)	0.055
MidFF peak pressure (kPa)	332.73 (50.19)	317.02 (42.05)	0.007
LFF peak pressure (kPa)*	385.76 (46.55)	343.33 (42.99)	P<0.001

LFF, lateral forefoot; MFF, medial forefoot; MidFF, middle forefoot

*Significant difference between multi-stud cleat and turf cleat (p<0.0025)

5.1 (c) L-drill time trial

During the L-drill time trial, no statistical difference (p=0.10) was observed between the multi-stud (8.00+/-0.25 seconds) and the turf cleat (7.83+/-0.24 seconds) configurations. The mean and standard deviation for the multi-stud cleat was 8.00 (0.25) seconds. For the turf cleat, the mean and standard deviation was 7.83 (0.24) seconds (Table 4 & Figure 7). Included below is a table illustrating the timed completion of the L-drill time trial comparing varsity athletes and amateur athletes (Table 5). Figure 8 demonstrates the difference between the multi-stud and turf-cleat L-drill performance time in seconds per subject. Positive values indicated that the subject had a slower completion time utilizing the multi-stud cleat, while negative values indicated that subject had a faster completion time utilizing the multi-stud cleat.

Table 4 Timed trial results while wearing the multi-stud versus the turf cleat (values given are mean (SD))

	Multi-stud	**Turf**
Time (seconds)	8.00 (0.25)	7.83 (0.24)

Table 5 Timed trial results comparing the mean scores of each athlete utilizing the multi-stud and turf cleat in seconds (values given are mean).

Varsity Athletes			**Amateur Level Athletes**		
	Multi-stud	Turf		Multi-stud	Turf
1	7.27	7.70	1	8.02	7.65
2	8.14	8.08	2	7.98	7.67
3	7.72	7.79	3	8.36	8.63
4	8.35	7.75	4	7.83	7.68
5	8.04	7.84	5	7.87	7.64
			6	8.30	7.99
			7	8.12	7.81
			8	8.24	7.64
			9	7.95	7.92
			10	8.04	7.67
			11	7.85	7.62
			12	7.82	7.98
			13	8.12	7.97
			14	8.16	7.92
			15	7.83	7.73

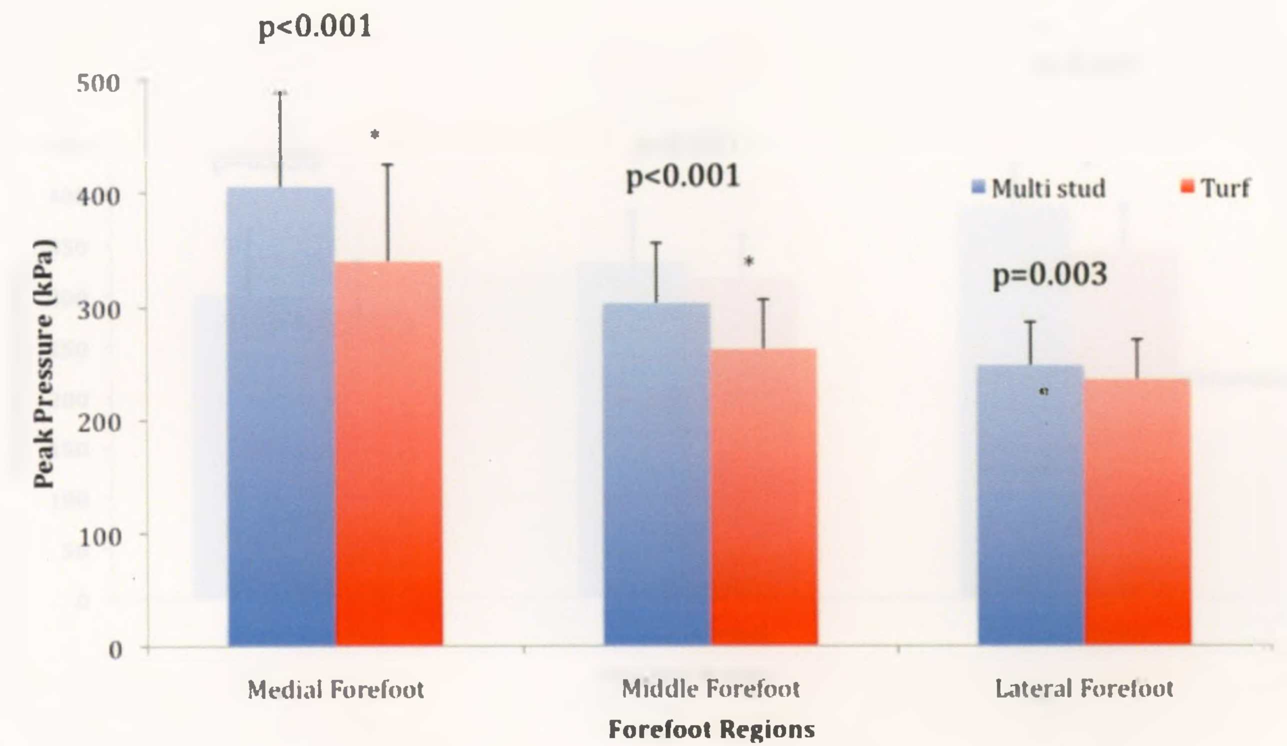


Figure 5. Peak pressure in the three forefoot regions during a side cut. *Indicates a significant difference between shoe types in the medial forefoot and the middle forefoot between multi-stud and turf-specific cleats ($p < 0.0025$).

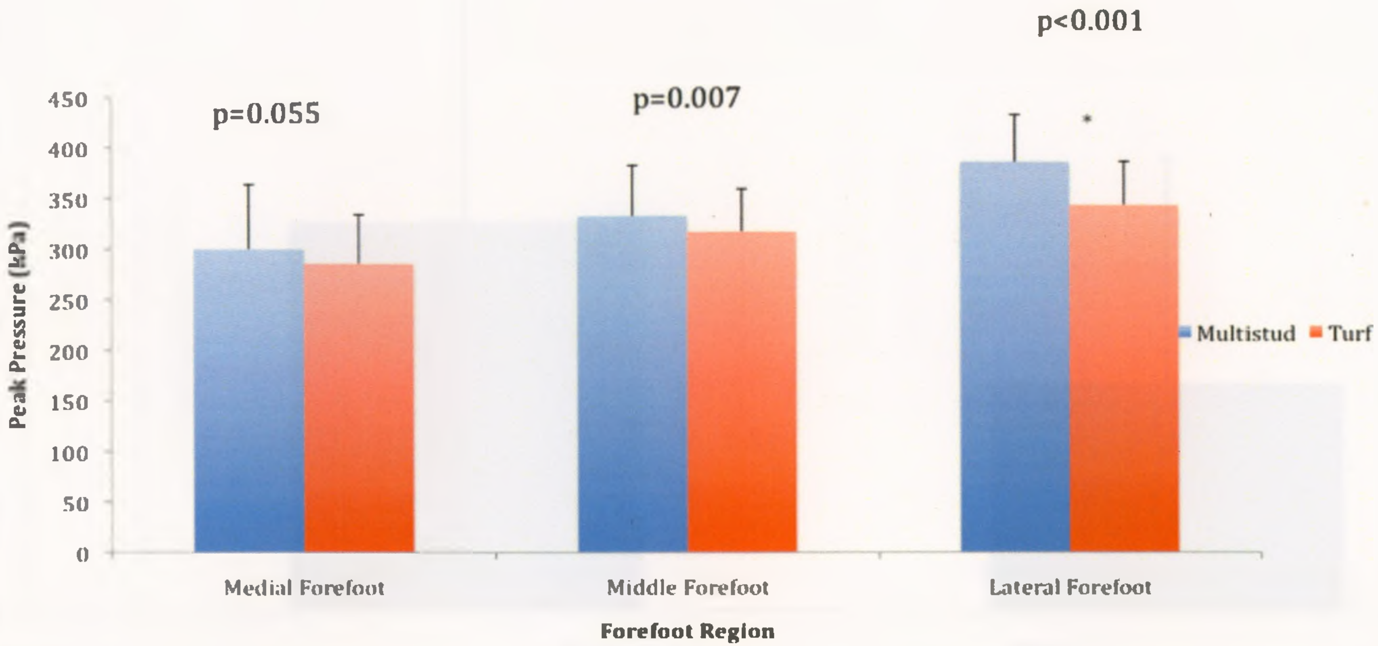
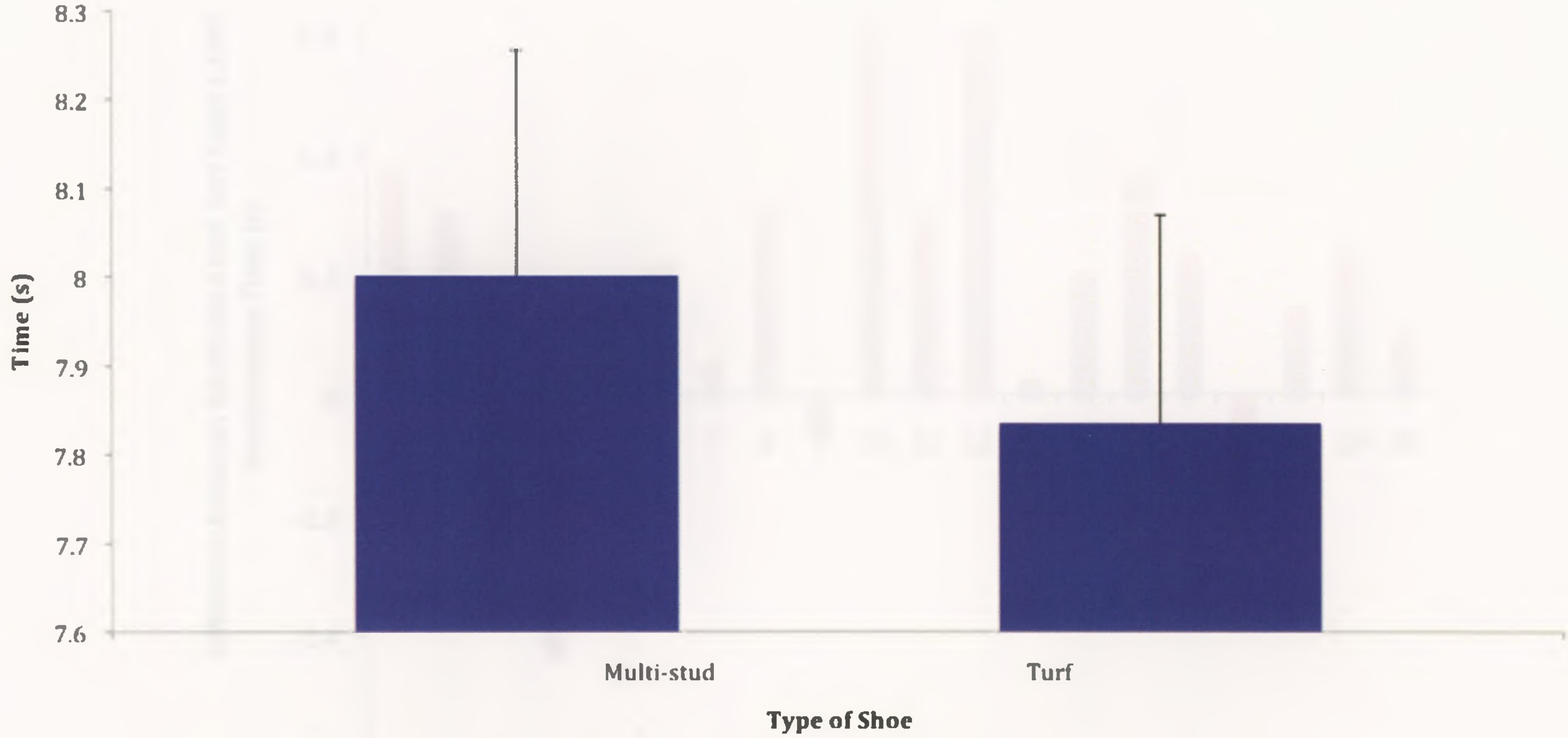


Figure 6. Peak pressure in the three forefoot regions during a cross cut. *Indicates a significant difference between shoe types in the lateral forefoot ($p < 0.0025$).



Note: no significant difference found in this study.

Figure 7. L-drill maximum effort timed trial comparing multi-stud cleats versus turf cleats.

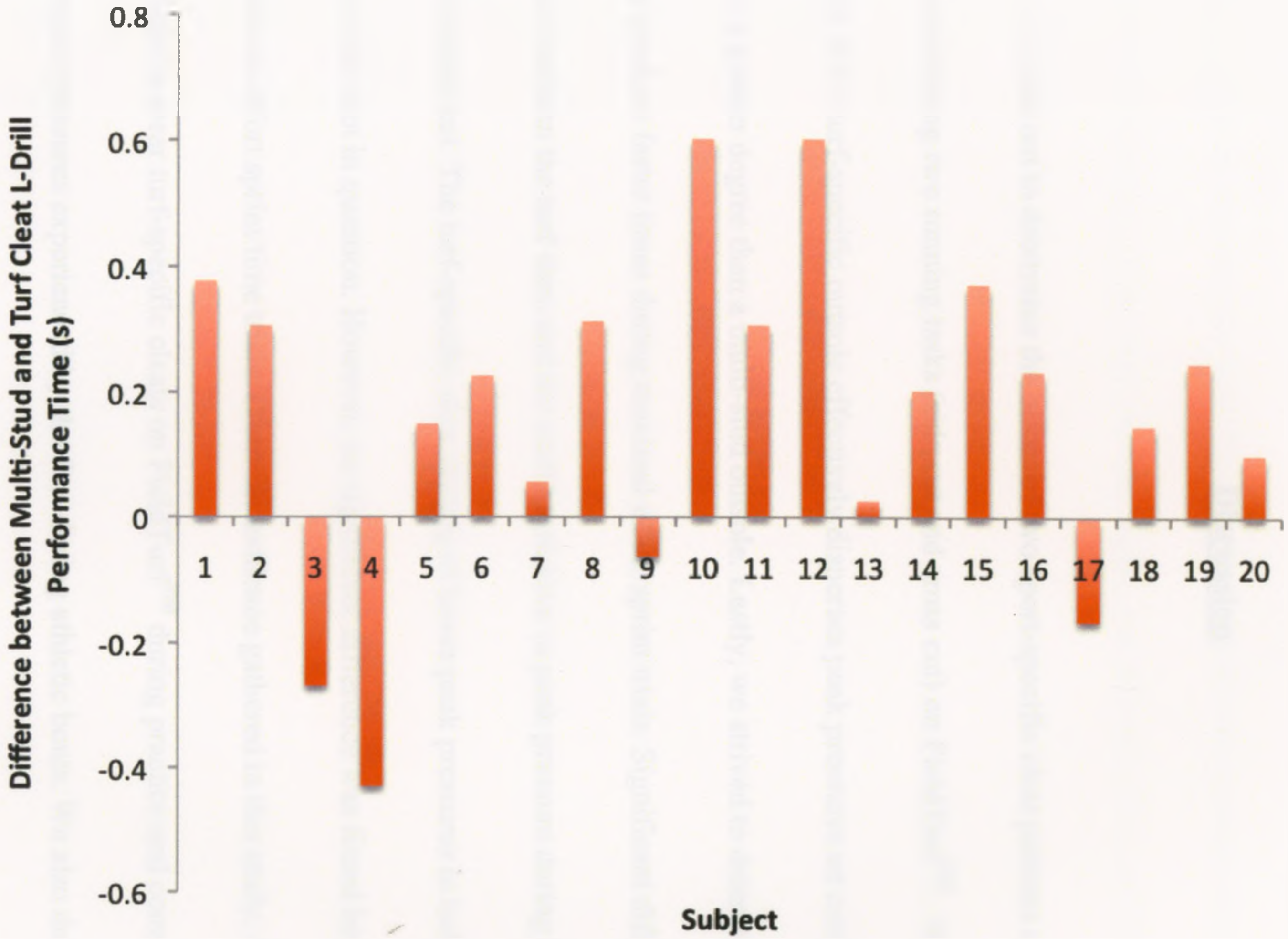


Figure 8. Difference between multi-stud and turf cleat on L-drill performance time per subject (s)
*Note: Subjects #s 4,7,9,10, 14 were varsity athletes.

Chapter 6

Discussion

We set out to determine the effect of two sport-specific cleat patterns on peak plantar pressures during two running tasks (side cut and cross cut) on FieldTurf™. We also set out to analyze if the turf-specific outsole effectively disperses peak pressures on certain areas of the foot to a greater degree than a multi-stud outsole. Lastly, we strived to determine if one shoe type would produce faster times during maximal effort sprint trials. Significant differences were notated between the turf shoe and the multi-stud shoe in peak pressure during both the side cut and the cross cut. The turf-specific shoe displayed lower peak pressures in both tasks on certain areas of the foot in question. However, no significant difference was found between shoe types in maximal effort sprint time trials. From the evidence gathered in this study, it appears to be beneficial to wear turf-specific cleats on FieldTurf™ during practice and competition to decrease the impact pressures experienced by the foot during athletic bouts. We also determined that wearing turf-specific cleats on FieldTurf™ does not appear to hinder performance during maximal effort sprints.

We discovered that significant differences existed between the multi-stud cleat and the turf cleat. There were significant differences in peak pressure in the medial forefoot and middle forefoot during the side cut task. Significant differences in peak pressure were also presented in the lateral forefoot during the cross cut task. Again, this difference is most likely due to the increased number of cleats and addition of the midsole.

The plantar pressure distributions of this study are similar to previous reports (Queen et al., 2008; Eils et al., 2004). Across both the side cut and the cross cut tasks, the statistical differences observed between the turf cleat and the multi-stud cleat are most likely due to an increased number of studs, a decrease in stud height, and a cleat pattern designed to disperse pressure under the more heavily loaded areas of the foot during impact. Also, the additional cushioning provided by the midsole of the turf cleat would be expected to dissipate force during ground contact. The midsole cushioning combined with the dense cleat configuration makes the turf cleat more suitable for preventing metatarsal stress fractures as suggested by previous studies (Queen et al., 2008).

6.1 Clinical Significance

When athletes return to play following a metatarsal or stress fracture, medical staff look for ways to reintroduce them to their respective sports without causing further stress to their recently recovered lower extremities. For athletes returning to play on artificial playing surfaces such as FieldTurf™ it may be more beneficial for them to wear a turf specific cleat to minimize the pressure exerted on the plantar aspect of the foot (Queen et al., 2008). The data from this study verifies the results of the study performed by Queen et al., (2008) that deduces that turf specific cleats minimize the forces experienced during functional cutting tasks to a greater extent than any other type of cleated footwear available on the market.

The clinical significance of these results is difficult to quantify as overuse injuries usually result from repetitive micro trauma. There is no threshold in the literature that indicates what the specific amount of pressure required over an extended period of time causes a stress fracture. The information provided in this study can be used to make injury prevention advancements to cleated athletic footwear.

Studies have found that a decrease in shoe-surface friction leads to slipping, however it also decreases the number of complaints of knee pains and injuries by athletes (Queen et al., 2008). Conversely, an increase in shoe-surface friction (such as that provided by the multi-stud cleat) can potentially increase player performance; however, it can also increase the risk of injury due to increased speed and the resulting contact forces. Although turf shoes minimize forces in the lower leg during ground contact, they may not be the most appropriate cleats for high-level athletes from a performance standpoint.

6.2 L-Drill

Based on the literature researched, there is no previous information regarding timed sprint trials in different cleat configurations available. Although no significant difference was found while completing the drill in the two pairs of cleats, sixteen of the twenty (80%) subjects attained faster times on the L-drill while wearing the turf cleat. Athletes were also compared on the L-drill in terms of the level of competition they were currently participating at. Interestingly enough, there was no difference in performance in each shoe condition between the groups. Once again, most completed the drill quicker while wearing turf shoes. The lack of significance of these timed trials may be a reflection of the small sample size. The clinical importance of these differences is presently unclear. A paucity of research combined with the dynamic environment of elite athletics makes it difficult to determine the importance of a tenth of a second.

Traction is defined by the American Society for Testing and Materials Committee on Sports Equipment and Facilities to be the resistance to relative motion between a shoe outsole and a sports surface (American Society for Testing and Materials, 2006). It is generally accepted that excessive rotational traction may precipitate ankle and knee injuries; however, it also increases high-level performance during any athletic contest (Villwock et al., 2009). Taking this information into consideration, we put forth the hypothesis that the multi-stud cleats would create better rotational traction on the FieldTurf™ surface allowing subjects to change direction and accelerate/decelerate faster. As no significant difference was determined, the commonly used multi-stud cleats may not be as beneficial as previously thought for athletic performance while playing on FieldTurf™. Multi-stud cleats may actually generate a greater potential for injury to the ligaments and bony structures of the lower extremities. This increased potential may be due to excessive rotational traction as well as the inability to disperse pressures on the foot to the same degree as turf-specific cleats. Further epidemiological analysis is required to fully understand the effect of the shoe-surface interaction on performance and injury.

6.3 Performance

An objective peak pressure analysis of the foot was conducted during two different skilled movements regularly performed by athletes in dynamic field sports. Based on the results obtained in this study, we found that the turf cleats disperse a greater peak pressure experienced by the most stressed areas of the foot in comparison to multi-stud cleats. We also found that when performing maximal effort bouts on FieldTurf™, one does not benefit from wearing a shoe with greater rotational traction. This was deduced as both the turf cleat and the multi-stud cleat provided very similar timed results when completing the L-drill. Seeing as there may not be a performance advantage associated with wearing multi-studded cleats, and it has been demonstrated that wearing turf-specific can decrease the loads on certain areas of the foot- it may actually be beneficial to wear turf-specific rather than multi-stud cleats on FieldTurf™ from an injury-prevention standpoint.

6.4 Strengths and Limitations

Strengths of this study include a focus on the specific skilled movements; similar testing conditions on FieldTurf™, and the shoe fit continuity present throughout the study. Specifically, we focused on gathering data for one cutting movement per trial in contrast to other studies, which have had subjects complete several cutting motions per trial, and thus grouped the results together. This allowed for the specific isolation and identification of the skilled movement for data collection. This eliminated any confusion as to whether data was being recorded for foot strikes leading up to/after the movement of interest.

Similar testing conditions were present throughout the entire study. All testing took place in early autumn on FieldTurf™ during similar weather conditions. This ensured little to no variability attributable to the surface conditions. All subjects wore shoes made by the same manufacturer, which reduced the accommodation period required when changing from one pair of cleats to the other.

The limitations of this study include equipment capabilities, lack of a homogenous population, the ability to control intensity levels during the skilled movement trials, the personal preference of each athlete with respect to the outsole, timing deficiencies, low power and no sample size calculation. Previous studies discussed in the literature review were working with the most advanced Pedar equipment. These studies (Eils et al., 2004, Queen et al., 2008, Orendurff et al., 2008, Ford et al., 2006) separated the foot into eight different regions providing greater specificity to the areas analyzed. For our study when dividing the foot into separate regions for analysis, the software limited this division to four regions. As a result, our peak pressure measurements were generalized to a larger area and could have misrepresented the true values experienced by specific localized areas as shown in previous studies.

For the purposes of this study, we used a combination of 20 collegiate and amateur-level male athletes due to availability of subjects. This presented a heterogenous population, which may have affected our data analysis. Ideally, a homogenous study population would have yielded the most accurate results as collegiate-level athletes and amateur-level athletes may be in different physical condition. This difference in physical condition could have influenced the results for both peak plantar pressures as well as L-drill time trials in terms of repeatability of the athletic task.

During both the side cut and cross cut trials it was difficult to ensure athletes were running and performing skilled movements at the same intensity in each trial. To account for this possible variability, athletes were required to complete the task within an allotted time frame to ensure they were running at a consistent speed every trial.

Athletes who are exposed to both types of cleats typically favor one over the other when competing on FieldTurf™. Athletes may have inadvertently raised intensity levels in their cleats of choice due to their comfort level associated with that particular cleat on FieldTurf.

For both the skilled movements involving the Pedar equipment and during the maximal effort sprint time trials, we relied on a man-operated stopwatch. For the skilled movements, the stopwatch was required to aid in identifying the step of interest on the data output screen. For the L-drill time trial, the stopwatch was used to measure how fast each participant completed the drill. There was possibility of encountering measurement error, as it is always the case when working with stopwatches.

For the L-drill, due to the fact that this part of the study had low power and a small sample size, there is a possibility of a Type II error as the null hypothesis was accepted.

6.5 Future Work

Many different sports involve rapid changes of direction with specific cutting maneuvers at high speeds. These movements load the foot to a great degree and as such warrant further investigation. Although significant research has been conducted on the interaction between cleats and surfaces, much has yet to be analyzed to find the optimal balance between performance and injury prevention for an outsole. In order to reach this optimal balance many other areas, including insole design, cleat configurations, and biomechanical analyses of skilled athletic movements require further investigation. All of this information can contribute to the improvement and development of athletic footwear while increasing injury prevention and possibly improving performance levels. Future studies on injury and the shoe-surface relationship will certainly be necessary to more fully understand the risk associated with the different playing fields athletes are exposed to. Further investigation is also required to compare the loading characteristics between elite and amateur-level athletes to determine if one group is predisposed to greater pressures based on loading patterns. Lastly, it will be important to compare both cleat types on FieldTurf from a performance standpoint on a homogenous group of elite athletes, as a tenth of a second to this group can make an immense difference.

Appendix A

Use of Human Subjects-Ethics Approval Certificate

Office of Research Ethics
The University of Western Ontario
Room 4180 Support Services Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
Website: www.uwo.ca/research/ethics

Western

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. R.B. Litchfield
Review Number: 15815E **Revision Number:** 1
Review Date: May 22, 2009 **Review Level:** Expedited
Protocol Title: Comparison of 4 Turf Cleat Plate Configurations on FieldTurf during Two Sport-Specific Running Tasks
Department and Institution: Orthopaedic Surgery, University of Western Ontario
Sponsor:
Ethics Approval Date: May 22, 2009 **Expiry Date:** January 31, 2010
Documents Reviewed and Approved: Revised study team, study methods, participant recruitment, number of study participants and eligibility of participants. Letter of Information and Consent
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. Joseph Gilbert

Ethics Officer to Contact for Further Information			
☐ Janice Sutherland (jsutheri@uwo.ca)	☐ Elizabeth Wambolt (ewambolt@uwo.ca)	☑ Grace Kelly (grace.kelly@uwo.ca)	☐ Denise Grafton (dgrafton@uwo.ca)

This is an official document. Please retain the original in your files.

cc: ORE File
LHRI

Appendix B

Letter of Information

Western
Health Sciences

Title: Comparison of 2 Sport-Specific Outsoles on during 2 Running Tasks on FieldTurf ™

Researchers:

<table>
<tr><td colspan="2">Role:</td><td>Principle investigator</td><td>Study investigator</td></tr>
<tr><td colspan="2">Name:</td><td>Dr. Bob Litchfield</td><td>Dennis Nolivos</td></tr>
<tr><td colspan="2">Title & Position:</td><td>Medical Director</td><td>M.Sc Candidate (student)</td></tr>
<tr><td rowspan="3">Mailing address:</td><td>Building & Street Address</td><td colspan="2">Fowler Kennedy Sport Medicine Clinic
University of Western Ontario</td></tr>
<tr><td>City, Province</td><td colspan="2">London, Ontario</td></tr>
<tr><td>Postal Code</td><td colspan="2">N6A 3K7</td></tr>
</table>

You are being invited to take part in a research study examining the effect of two football-specific outsoles and the pressures exerted on the bottom of the foot during three sport-specific tasks on an artificial grass field known as FieldTurf™. It is important for you to understand why this study is being performed and what it will involve. Please take your time to read and understand all the information provided and feel free to ask any questions if any information is unclear.

It is known that when playing on FieldTurf™, footwear with artificial turf studs dissipate the pressure exerted on specific parts of the foot to a greater extent than other cleated outsoles. The results of this study will determine whether these findings are generalizable across all cleated outsoles. It will also help identify specific configurations, which can decrease and/or distribute the pressure on the foot to a greater extent than the others.

If you decide to take part in this study, you will be asked to complete 2 sport-specific agility drills involving sharp turning at the intensity level one would exhibit during competition and 1 timed-trial drill involving a maximum effort. All testing will be done at T.D. Waterhouse stadium using the Pedar Mobile System. The Pedar Mobile System is an accurate and reliable pressure distribution measuring system for monitoring local loads between the foot and the shoe.

Elastic sensor insoles, which cover the entire plantar surface of the foot, are placed in the shoes to record pressure distributions. Decreased pressure loads in specific foot regions will aid in identifying outsoles that minimize overuse injuries. Attendance is required once only, for approximately one hour. 20 athletes will participate in this study.

You will be fitted with appropriate footwear and the Pedar insoles. You will then be taken through two agility drills and one speed drill. The agility drills are comprised of a sharp turn around 1 pylon and sprinting to another pylon 5 yards away. You will complete each agility drill 5 times in each of 2 different shoes for a total of 20 trials. The timed trial consists of a maximum effort sprint to two cones 5 yards apart. You will complete this timed trial 3 times.

The risk/discomfort associated with running the agility drills course will be fatigue during testing. To diminish the effects of fatigue you will be allotted 30 seconds of rest between trials for agility drills; 2 minutes for timed trial and five minutes rest between shoe conditions. The running of these drills always presents the possibility of an ankle sprain or knee injury. If you are prone to these types of injuries, you will be allowed to bring in a support brace. Proper technique emphasized for agility drills, speed will be emphasized for timed trial. There are no additional risks to you for participating in this study.

If a significant difference is found showing that a specific configuration is more effective than the others at dispersing pressures on the foot, this study could lay the groundwork for future turf-specific outsole design and research. This study will further educate medical staff and athletes about appropriate precautionary measures regarding footwear that can be taken to prevent overuse injuries.

Your participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your academic status or status on your varsity team.

If you have any questions about this study, please contact Dennis Nolivos. If you have any questions about your rights as a research participant or the conduct of the study you may contact Dr. David Hill, Scientific Director, Lawson Health Research Institute.

You will not be identified personally in any publication or communication resulting from this study, and your records will be kept confidential. Any information that you provide will be kept in a locked cabinet in the Wolf Orthopaedic Biomechanics Lab and will be destroyed after completion of the study.

Representatives of The University of Western Ontario Health Sciences Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research.

You will receive a copy of the letter of information about this study to keep.

Appendix C

Letter of Informed Consent

Western
Health Sciences

Letter of Consent

Title: Comparison of 2 football-specific outsoles on FieldTurf™ during 2 sport-specific running tasks

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant:

Name (printed): ______________________________

Signature: ___________________________________ Date: ___________________________

Person Obtaining Consent:

Name (printed): ______________________________

Signature: _______________________________________ Date: _____________________

Appendix D

Demographic Information Form

Western
Health Sciences

Demographic Information Form

Name: ______________________ ______________________
First name Last name

Date of Birth: _____/___/______ (day/month/year)

Height: _______________ Weight: ___________________

Questions:

1. Active in collegiate/amateur/professional sport? Y/N
2. ACL Reconstructive surgery within the last 3 years? Y/N
3. Lower leg injury within the last 3 months? Y/N

Appendix E

Peak Pressure Recording Sheet

Last Name: ____________

First Name: ____________

Telephone: ____________

Age: ____________ **Sex:** ____________

Height: ____________ **Weight:** ____________

SIDE CUT - Peak Pressure (kPa) for MFF

Trial #	Multi-stud Cleat	Turf Cleat
1		
2		
3		
4		
5		
Average		

CROSS CUT - Peak Pressure (kPa) for MFF

Trial #	Multi-stud Cleat	Turf Cleat
1		
2		
3		
4		
5		
Average		

SIDE CUT - Peak Pressure (kPa) for MidFF

Trial #	Multi-stud Cleat	Turf Cleat
1		
2		
3		
4		
5		
Average		

CROSS CUT - Peak Pressure (kPa) for MidFF

Trial #	Multi-stud Cleat	Turf Cleat
1		
2		
3		
4		
5		
Average		

SIDE CUT - Peak Pressure (kPa) for LFF

Trial #	Multi-stud Cleat	Turf Cleat
1		
2		
3		
4		
5		
Average		

CROSS CUT - Peak Pressure (kPa) for LFF

Trial #	Multi-stud Cleat	Turf Cleat
1		
2		
3		
4		
5		
Average		

L-Drill Time Trial

Trial #	Multi-stud Cleat	Turf Cleat
1		
2		
3		
Average		

Appendix F

Photograph Release Form

Western
Health Sciences

Letter of Consent

Title: **Comparison of 2 Sport-Specific Outsoles on Peak Plantar Pressures during Two Running tasks on FieldTurf**

I, Milad Mohib, give permission for Dennis Nolivos to use my pictures for research and study purposes in his Master's thesis. I give consent for him to use my pictures for publication as he sees fit.

Participant:

Name (printed): Milad Mohib

Signature: ______________

Date: 15 OCT 2010

Person obtaining consent:

Name (printed): Dennis Nolivos

Signature: ______________

Date: 15 OCT 2010

The University *of* Western Ontario
Faculty of Kinesiology • University of Western Ontario Sport Medicine
Room 11, Alumni Hall • London, Ontario • CANADA – N6A3K7

References

Andersson, H., Ekblom, B., & Krustrup, P. (2008). Elite football on artificial turf versus natural grass: Movement patterns, technical standards, and player impressions. *Journal of Sports Sciences, 26*(2), 113-122.

Cawley, P. W., Heidt, R. S.,Jr, Scranton, P. E.,Jr, Losse, G. M., & Howard, M. E. (2003). Physiologic axial load, frictional resistance, and the football shoe-surface interface. *Foot & Ankle International / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society, 24*(7), 551-556.

Dixon, S. J., Collop, A. C., & Batt, M. E. (2000). Surface effects on ground reaction forces and lower extremity kinematics in running. *Medicine and Science in Sports and Exercise, 32*(11), 1919-1926.

Eils, E., Streyl, M., Linnenbecker, S., Thorwesten, L., Volker, K., & Rosenbaum, D. (2004). Characteristic plantar pressure distribution patterns during soccer-specific movements. *The American Journal of Sports Medicine, 32*(1), 140-145.

Ekstrand, J., & Nigg, B. M. (1989). Surface-related injuries in soccer. *Sports Medicine (Auckland, N.Z.), 8*(1), 56-62.

Ekstrand, J., Timpka, T., & Hagglund, M. (2006). Risk of injury in elite football played on artificial turf versus natural grass: A prospective two-cohort study. *British Journal of Sports Medicine, 40*(12), 975-980. doi:10.1136/bjsm.2006.027623

Ford, K. R., Manson, N. A., Evans, B. J., Myer, G. D., Gwin, R. C., Heidt, R. S.,Jr, et al. (2006). Comparison of in-shoe foot loading patterns on natural grass and synthetic turf. *Journal of Science and Medicine in Sport / Sports Medicine Australia, 9*(6), 433-440.

Giles R. Scuderi, Peter D. McCann. (2005). Stress fractures. *Sports medicine: A comprehensive approach* (pp. 333-334) Mosby Inc.

Kennedy, J. G., Knowles, B., Dolan, M., & Bohne, W. (2005). Foot and ankle injuries in the adolescent runner. *Current Opinion in Pediatrics, 17*(1), 34-42.

Kernozek T., LaMott, EE., Dancisak, MJ. (1996). Reliability of an in-shoe pressure measurement system during treadmill walking. *Foot Ankle Int, 17*, 204-209.

Livesay, G. A., Reda, D. R., & Nauman, E. A. (2006). Peak torque and rotational stiffness developed at the shoe-surface interface: The effect of shoe type and playing surface. *The American Journal of Sports Medicine, 34*(3), 415-422.

Meyers, M. C., & Barnhill, B. S. (2004). Incidence, causes, and severity of high school football injuries on FieldTurf versus natural grass: A 5-year prospective study. *The American Journal of Sports Medicine, 32*(7), 1626-1638.

Naunheim, R., Parrott, H., & Standeven, J. (2004). A comparison of artificial turf. *The Journal of Trauma, 57*(6), 1311-1314.

Nigg, B. M., & Segesser, B. (1988). The influence of playing surfaces on the load on the locomotor system and on football and tennis injuries. *Sports Medicine (Auckland, N.Z.), 5*(6), 375-385.

Nigg, B. M., & Yeadon, M. R. (1987). Biomechanical aspects of playing surfaces. *Journal of Sports Sciences, 5*(2), 117-145.

Orchard, J. (2002). Is there a relationship between ground and climatic conditions and injuries in football? *Sports Medicine (Auckland, N.Z.), 32*(7), 419-432.

Orchard, J. W., & Powell, J. W. (2003). Risk of knee and ankle sprains under various weather conditions in american football. *Medicine and Science in Sports and Exercise, 35*(7), 1118-1123.

Orendurff, M. S., Rohr, E. S., Segal, A. D., Medley, J. W., Green, J. R.,3rd, & Kadel, N. J. (2008). Regional foot pressure during running, cutting, jumping, and landing. *The American Journal of Sports Medicine, 36*(3), 566-571.

Porter, D. A., Duncan, M., & Meyer, S. J. (2005). Fifth metatarsal jones fracture fixation with a 4.5-mm cannulated stainless steel screw in the competitive and recreational athlete: A clinical and radiographic evaluation. *The American Journal of Sports Medicine, 33*(5), 726-733. doi:10.1177/0363546504271000

Putti, B. A., Arnold, G., Cochrane, L., & Abboud, R. (2007). The Pedar in-shoe system: repeatability and normal pressure values. *Gait and Posture, 25*, 401-405.

Queen, R. M., Charnock, B. L., Garrett, W. E.,Jr, Hardaker, W. M., Sims, E. L., & Moorman, C. T.,3rd. (2008). A comparison of cleat types during two football-specific tasks on FieldTurf. *British Journal of Sports Medicine, 42*(4), 278-84; discussion 284.

William E. Garret, Thomas P. Knapp. (2001). Principles & practice of primary care sports medicine: Stress fractures., 429-438.

Wong, P. L., Chamari, K., Chaouachi, A., Mao de, W., Wisloff, U., & Hong, Y. (2007). Difference in plantar pressure between the preferred and non-preferred feet in four soccer-related movements. *British Journal of Sports Medicine, 41*(2), 84-92.