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Research Article

Is Foot Type an Indicator of Anterior Cruciate Ligament Injury in Football Players?

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I N F O

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A B S T R A C T

Background: Prevention of sports injuries requires a comprehensive analysis of intrinsic and extrinsic factors of injuries in athletes. Pre-participation, evaluation, biomechanical assessment and new technology are helpful in providing useful information about the cause and mechanism of sports injury and strategies for injury prevention. However, there have been only few previous investigations which can conclusively correlate certain foot types with specific knee injury.

Objective: To determine any relationship between foot type and ACL injury.

Method: A case-control study design was adopted for this clinical study to investigate foot- type as a risk factor for ACL injury. 35 professional football players with a surgical history of ACL reconstruction and 35 professional football players without any history of ACL injury participated in our study. Foot types were determined by measuring their medial longitudinal arch angle and rearfoot-leg eversion angle. Questionnaire which included other variables of ACL injury were filled and analysed to eliminate their interference in this study. Odds ratio was used as reliable statistical tool to estimate the relative risk.

Result: There was a significant relationship between pronated foot type as a risk factor for ACL injury.

Conclusion: This suggests that pronated foot is a risk factor for ACL injury in football players.

Keywords: Foot Types, ACL Injury, Pronation

Introduction

As the benefit of sports participation outweighs the risk of injury, people are more enthusiastic about exercises and sports activities. As a consequence of this increased athletic activity, sporting injuries are on the rise, particularly to the lower limb, and rupture of the anterior cruciate ligament has been the most common.[1]

Not only do injuries cause a decrease in physical activity, but they can also result in long periods of time away from work and sports. In addition to this, it has been estimated

that the cost of sporting injuries worldwide is $1 billion annually.[2] So, prevention and intervention of sports injuries are in focus now.[2]

When carrying out the studies, it is important to look at the different extrinsic and intrinsic risk factors that could contribute to the susceptibility of an athlete to injury and it is important to describe the inciting event or mechanism of injury.[3]

Across many sports, including American football, soccer and basketball, the National Collegiate Athletic Injury Surveillance System for 2004-2005 found that the most common injury sites in all these sports were the ankle, knee, thigh and lower leg.[4,5]

According to Mckenzie et al., 1985 a runner with excessively pronated feet is more likely to be predisposed to injuries such as tibial stress syndrome, patellofemoral pain syndrome and posterior tibialis tendinitis and a runner with a pes cavus foot type may suffer from iliotibial band friction syndrome, peroneus tendonitis, stress fractures, trochanteric bursitis and plantar fasciitis.[6]

It is apparent that little research has been carried out surrounding the possible connection between foot type and knee injury. Therefore, the purpose of this study was primarily to find certain foot type as risk factor for anterior cruciate ligament injuries in football. This. in turn, will provide an insight to injury prevention aspect of physical therapy and to the field of podiatry as insoles could be used to correct the biomechanics of the foot. There is less evidence which could conclusively co-relate between foot type and sport injury.

Hypotheses

Alternative Hypothesis

- **Alternative Hypothesis 1:** There will be a significant correlation between supinated foot types and ACL injury.
- **Alternative Hypothesis 2:** There will be a significant correlation found between pronated foot types and non-ACL injury.
- **Alternative Hypothesis 3:** There will be a significant correlation between neutral foot types and ACL injury.

Null Hypothesis

- **Null Hypothesis 1:** There will be no correlation between supinated foot type and ACL injury
- **Null Hypothesis 2:** There will be no correlation between pronated foot type and ACL injury.
- **Null Hypothesis 3:** There will be no correlation between neutral foot type and ACL injury.

Ethical approval/Informed Consent: The study was a retrospective non-experimental type for which prior consent of participants had been taken.

Methods

Seventy professional male football players were recruited for this study; 35 of them had history of ACL rupture for which they had gone through surgery in past. The other group of 35 age (years)-, weight(Kg)-, height(Cm) and game level matched- footballers without any injury to their ACL throughout their carrier was assigned in control group.

35 ACL injured group (age = 28.17±1.75 year; ht = 176.4±6.75cm; wt = 65.88±3.27kg) of male football players were in injured group.

35 Uninjured group (age = 27.74±1.29 Year; ht = 177.76±6.32 cm;wt = 65.25±3.0kg).

Two measurements for quantification of foot types were used as suggested by Genova and Gross7: The medial longitudinal arch angle (MLA) and rear-foot-leg (eversion) angle.

Procedure

The participants were asked to complete a questionnaire. The questionnaire is devised to include as many variables as possible. The purpose of collecting this qualitative data through these questionnaires was to eliminate variables and quantitatively adjust through simple statistical treatment to see their interference in this study.

Then. their feet were marked with sketch pen to obtain reference for various landmarks, which were used to measure rear foot to leg angle (eversion angle) and Medial-Longitudinal Arch angle (MLA).

The MLA and eversion angle were measured for both feet for each subject. The distal calcaneal mark was made at base of the calcaneus, and the proximal calcaneal mark was 3 cm above the distal mark. The distal leg mark was 6 cm above the palpated proximal margin of the calcaneus, and the proximal leg mark was 8 cm above the distal leg mark. These marks were used as reference points for future calculated bisections of the leg.

The distal calcaneal bisection was performed with the subjects in prone because otherwise the calcaneal fat pad might be displaced with the subject standing and might alter the osseous bisection of the calcaneus. Straight edge calipers were placed at the medial and lateral calcaneus at the level of distal calcaneal mark to measure the width of the calcaneus and then mark the distal bisection point on it.

The distance between the subject's Anterior Superior Iliac Spine (ASIS) was obtained to establish a consistent position for each subject to assume for all static standing measures. This measure was used as a reference to establish the distance between the lateral borders of the subject's feet for all static standing calcaneal measures.

With the subject in the static standing position, calipers

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were used to establish the midpoints of the remaining 3 lower extremity marks previously described. At the proximal calcaneal mark, the caliper arms were placed at the medial and lateral calcaneus, 0.5 cm anterior to the proximal calcaneal mark. The distal leg bisection was made by placing the medial and lateral caliper arms 1 cm anterior to the distal leg mark. The proximal bisection was made by placing the medial and lateral caliper arms at the most medial and lateral points of the proximal leg at the level of proximal leg mark.

A line connecting the 2 leg points and a line connecting the 2 calcaneal points was drawn using a pen and a scale. The most medial aspects of the medial malleolus, the navicular tuberosity, and the first metatarsal head were marked with the sketch pen on both legs of each subject.

Two weight-bearing measurements were made, based on the work of Jonson and Gross and Dahle et al. The standing calcaneal eversion angle was measured for both legs with the goniometer as the acute angle between the leg and calcaneal bisection lines {ICC (intraclass correlation coefficient) = 0.88 for intratester and ICC =0.86 for intertester reliability}.[8]

The MLA angle was measured as the obtuse angle formed by a line connecting the medial malleolus and the navicular tuberosity and the most medial aspect of the first metatarsal head (ICC for intratester and intertester reliability were 0.90 and 0.81, respectively).[8]

On the basis of the measurements of these two angles, a subject's foot was classified as pronated; if the rear foot leg (eversion) angle was equal to more than 100 and the MLA angle was less than 1340. A foot was considered supinated if the rear foot eversion angle was less than 30 and the MLA angle was greater than 1500. A foot was classified as neutral if the eversion angle was between 30 and 90 and the MLA angle was between 1340 and 1500. In injured group, only injured foot was measured to see their foot type and both feet were measured in uninjured group and subjects having same foot type for both feet were included in the control group.

The data collected was presented in the tabular form (2x2, contingency table), and an statistical analysis was performed using SPSS version 15.0. The measure of association between certain foot types and occurrence of ACL injury in this case-control study design was calculated by means of Odds Ratio (OR) at 95% of Confidence interval.9 All the hypotheses were tested for acceptance/denial. Odds Ratio is a valid and reliable method of estimating the relative risk.[9]

Result

A significant odds ratio (OR>1) of 6.44 was calculated. At 95% confidence interval, the lower limit was found to be 2.13, suggesting significant relationship between pronated foot and ACL injury. The results accepted the hypothesis that there is a correlation between pronated foot type and ACL injury. Pronated foot type was considered a risk factor for ACL injury by estimation of risk by odds ratio (Table 1, 2).

Table 1.2x2 contingency table for pronated foot vs ACL injury

	GroupA (ACL Injured)	GroupB (Uninjured)	Total
Pronated Foot	20	6	26
Other Foot Types	15	29	44
Total	35	35	

Table 2.Risk estimate for pronated foot

95% confidence interval			
Risk estimate	Observation	Lower limit	Upper limit
Odds ratio	6.44	2.13	19.45
Risk ratio	2.25	1.422	3.58

Table 3.Odds ratio for other foot type

95% confidence interval			
Foot Types	Odds ratio	Lower limit	Upper limit
Supinated	0.59	0.188	1.908
Neutral	0.25	0.094	0.713

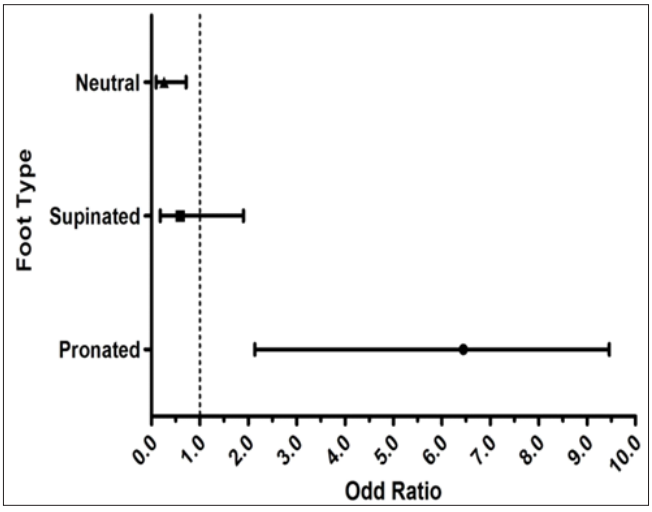

Figure 1.Foot type vs Odds ratio

A non-significant odds ratio for supinated and neutral foot lead to rejection of other two hypothesis (Table 3).

Discussion

The aim of this study was to find a most reliable method for quantification of foot type and to correlate foot type with Anterior Cruciate Ligament (ACL) injury in football players. The purpose of this co relational study was to

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establish certain foot type as a risk factor for ACL injury in footballers. On extensive review of literature no study was found to conclusively correlate foot morphology with specific knee injury like ACL injury. The impetus to undertake this research study was due to an increasing incidence of ACL injury in football.

Three experimental hypotheses were designed for this study. Calculating the measure of association between presence of the risk factor and occurrence of injury in case-control studies is the so called odds ratio9; the ratio of odds of presence in injured subjects to the odds of presence in the uninjured.

The three hypotheses generated for this study were examined one by one to see their denial or acceptance. Two of the hypothesis were found to be statistically insignificant for supinated foot type:(OR<1) 0.59 with 95% Confidence Interval (CI) lower limit value is 0.18 which is below 1 and similarly for neutral foot (OR<1) 0.25 and at 95% CI lower limit value of 0.09, which is much below 1. Therefore were rejected, however the hypothesis that there would be a correlation between a pronated foot type and ACL injury was accepted as the results were statistically significant.

Pronated Foot Type and ACL Injury

A significant odds ratio (OR>1) of 6.44 was calculated. At 95% confidence interval, the lower limit is found to be 2.13, suggesting significant relationship between pronated foot and ACL injury. We used the 95% confidence interval because of the convention that a p-value of 5% (0.05) was the convention for rejecting the null hypothesis in a significance test. 100% minus 5% equals 95%. At 95% confidence interval, the lower limit value is 2.13, which is significant because the lower limit value must not be less than 1 to say that the risk factor must have a play in causing the injury in question.

The hypothesis that there is a correlation between pronated foot and ACL injury was therefore accepted.

Biomechanical Explanation of Results and its Relationship with Literature

Faulty postural alignment has a preloading impact on the ligaments, subjecting them to complete structural failure under external forces well below critical stress limits.[10,11] According to Ireland et al., a mechanism for complete structural failure of the ACL is a situation in which the body is in a position of forward flexion, the hip in adduction, the femur in internal rotation, the knee in 200 to 300 of flexion, the tibia in external rotation, and the foot in pronation.[12]

Fu and Stone noted that the most noncontact ACL injury mechanism observed in athletes participating in soccer, football, and skiing is with tibia in external rotation and the knee in valgus.[13] Mechanism producing ACL injury are related to foot fixation, hyperextension, and torsional stresses. Injuries occurring as a result of these mechanisms often include a component of deceleration/ landing forces.[10]

Excessive foot pronation can alter the kinematics of lower-extremity and may increase the chances of musculoskeletal injury.[4,11,15] Movement dysfunction of the foot is studied in relation to Subtalar Joint (STJ) because of its significant role in force attenuation. The STJ is a single axis joint that acts like a mitred hinge connecting the talus and the calcaneus.[15] The joint also includes the posterior surface of the navicular bone, which articulates with the head of the talus. In normal gait kinematics, at the time of heel strike, there is eversion through the STJ that reaches a maximum as the foot is loaded during the contact phase of the gait (foot-flat position) until heel rise and lift off.[15] Eversion through the STJ is one of the components of foot pronation. Excessive motion of the STJ in the direction of eversion influences more pronatory effects of the foot. The occurrence of pronation, to a degree, is important during the support phase of the gait since it provides proper shock absorption to the stresses of standing, walking, jogging, sprinting.[14]

Pronation is referred to as the decelerating phase of movement and is accompanied by tibial internal rotation.[14,12] An important observation is whether foot remains pronated during the period of heel rise and lift-off. If excessive or prolonged pronation of the foot occurs beyond the first half of the stance phase, the tibia undergoes additional internal rotation, resulting in abnormal forces transmitted upward through the kinetic chain. The ACL tightens with tibial internal rotation.[12] Therefore, excessive foot pronation may produce a preloading effect on the ACL. An association has been shown between excessive pronation tendencies and ACL injuries.

Following Studies had Similar Finding as our's on Comparison

Woodford Rogers et al.[16] measured navicular drop in an ACL-injured group consisting of 14 football players and 8 gymnasts and an age-, sex-, and sport-matched control group. The investigators found that the ACL injured group had greater amounts of navicular drop, suggesting increased pronation. Beckett et al.[17] found that the subjects with ACL injuries had greater amounts of pronation as measured by navicular drop than non injured and concluded that that hyperpronation of the foot and ankle may increase the risk of ACL injury. They reported a mean navicular drop of 6.9 mm in 50 healthy subjects as compared with a mean of about 13 mm in patients with ACL injuries. Similarly, Loudon et al.[18] studied the relationship between static posture and ACL injury in female athletes. Of these variables assessed, excessive pronation as measured by the navicular drop test was significant discriminator between the ACL-injured and noninjured groups.

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But the study done by Joanne et al.[19] contradicts the factor of hyperpronation as measured by navicular drop test as a predictor of ACL injury, and not regard it as a predisposing factor to noncontact ACL injuries.

Qualitative Data

A questionnaire was used in this study to gain demographic information about the subjects and also included questions about some variable factors for ACL injury. This is an important step in an observational epidemiological study done retrospectively because the control over extraneous factors is impossible. But the information about such extraneous factors is collected and quantitatively adjusted when they are known to be present.[9] Their height, weight, and age were taken into consideration for matched assignment of footballers in control group.

The matched assignment and analysis of some variable factors, information about which was gathered through questionnaire helped in eliminating some of the extraneous factors of ACL injury for this particular piece of research.

Dominant Foot type and ACL Injury

From the results ACL injuries found to occur in the same leg for the side foot was dominant. So there could be a link, this must be taken into consideration, when linking ACL injury to particular foot type.

Type of Boot worn and ACL Injury

The results of this study had shown that there is not any one favoured type of boot worn to relate with ACL injuries.

Warm-up Before a Game

The result demonstrates the number of participants that do and not do warm up before training and a game have equal chances of getting or not getting ACL injury.

Clinical Relevance

This study could be a productive focus point for helping construct a model of prevention against ACL injuries in certain foot types. The inclusion of foot type quantification in pre-participation evaluation of athletes and prescription of functional orthosis in accordance can be helpful in prevention of ACL injury.

Limitation

This study is not without limitations, although many of the variable factors suggested to be a problem in previous studies have been eliminated. To eliminate further variable factors, the questionnaire would have to be modified and include more variables as question.

The information gathered for this study was retrospective, so it is important to consider that after the passage of time the player's recollection may be impaired.

This study has also only focused on one demographic group and that is male footballers. This study also can be seen as gender bias; however, literature states that female are more prone to ACL injuries.[20] Due to this suspected additional predisposing factors in females, it was important they were eliminated from this study, as they have been a variable factor. Further research into why females are more prone to the injury needs to be carried out, so that future research on foot type and ACL injury can then include both males and females in the study.

Conclusion

With injury being on the rise, preventative methods are vital and any research that highlights or eliminates factors that may contribute to such injuries are of great importance to the field of sports medicine. The conclusion to be drawn from this research is that footballers with pronated foot type are at relatively higher risk of ACL injury than other foot types. These significant findings were calculated on the basis of Odds ratio showing a value of 6.44 at C.I. of 95%. This result is in support of correlating certain foot type as an intrinsic risk factor for ACL injury which is common in footballers.

Conflict of Interest: None

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Appendix

Questionnaire

Thank you for taking the time to participate in this study. All the information collected during this study will be kept confidential and so please answer all questions as accurately as possible. If you are unsure about a question please do not hesitate to ask for advice.

Please be reassured that you are under no obligation to participate in this study and if at any time you wish to withdraw from the research, you have the right to do so.

When filling in the questionnaire please delete where appropriate and for the questions that require a written answer, please enclose as much detail as you wish.

Personal Details

1. What is your height? ……ft…….inches
2. How much do you weigh? …….kg
3. Date of Birth? ……./……/…… Age(years)…….
4. At what level of football do you/did you play? Amateur / Semi-Professional / Professional.
5. How often do you/did you train each week?……
6. Do you/did you always warm up before training and before a game? Yes/ No
7. Did you have your knee injury diagnosed by a doctor? Yes/No
8. How old were you when you injured your cruciate ligament?……
9. Did the cruciate ligament injury occur when playing football? Yes/No
10. What type of boots were you wearing when you injured your cruciate ligament? Screw in Studs / Blades/ Moulded Studs
11. Previous to your cruciate ligament injury, did you suffer from any other injury? If Yes, please give details: …… ……
12. Have you had a cruciate ligament injury to one or both knees? One / Both (If both please continue to question 14)
13. If you have had only cruciate ligament injury to one knee, which knee suffered the injury? Left/ Right
14. Are you right or left footed? Right/ Left
15. Which cruciate ligament did you injure? Anterior Cruciate Ligament / Posterior Cruciate Ligament
16. How long have you played football for?…….. Years.

You have now reached the end of the questionnaire

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