# Title

Does Foot Posture Index predict injury incidence rate and severity in recreational runners?

# Abstract

### Purpose

The purpose of this research project is to see if there is a relationship between Foot Posture Index (FPI), injury incidence rate (IR) and severity (TOTALDL) in recreational runners.

### Design/methodology/approach

115 recreational runners (defined as men running under 40 miles per week and women running under 30) completed a retrospective questionnaire regarding training volume, rest days and injury in the previous year. FPI scores were taken and the results were analysed. Male and female data was analysed separately to avoid biomechanical differences confounding the data.

### Findings

There appears to be a relationship between FPI score and injury incidence rate and severity in male and female recreational runners. However the relationship is more significant for negative FPI scores than for positive FPI scores. This is highlighted by the following statistical analyses:

* **The more extreme the FPI score, the greater number of days training days lost to injury:** Analysis performed on FPI score and the total number of training days lost to injury (TOTALDL) showed R squared values of .637 (male) and .793 (female) calculated with quadratic regression.
* **The more extreme the FPI score, the greater the injury incidence rate**: Regression analysis carried out on FPI score and the injury incidence rate (IR) shows R squared values of .370 (Male) and .562 (Female).
* **Positive FPI scores showed more significant Pearson’s correlation**: For positive FPI scores, the male data analysed with Pearson’s correlation show scores of .746 (FPI & TOTALDL) and .590 (FPI & IR). The female data shows figures of .694 (FPI & TOTALDL) and .676 (FPI & IR), all with a statistically valid significance of less than .001.
* **Negative FPI scores showed less significant Pearson’s correlation**: For negative FPI scores, the male data analysed with Pearson’s correlation show scores of -.704 with a significance level of .077 (FPI and IR) and -.599 with a significance level of.155 (FPI and TOTALDL). The female data showed figures of -814 with a significance of .186 (FPI and TOTALDL) and -479 with a significance of .521 (FPI and IR).

### Research limitations

Sample sizes of the negative FPI scores were too small to get statistically valid data. However there does seem to be a relationship between FPI and TOTALDL as well as FPI and IR for both male and female runners. Shortcomings with the collection methodology mean that the results should be viewed with caution and further research on this topic is recommended.

### Originality/value

This project seeks to examine the clinical use of the FPI scoring methodology and apply the fully validated measurement system to a “real world” population. This project would be of interest to osteopaths and other healthcare professionals with an interest in treating recreational runners.

# Introduction

Recreational runners are one of the largest sporting groups in the UK (Adidas, 2006) and have a well documented propensity towards lower limb injury. The incidence of lower extremity running injuries in published reports ranges from 37% to 79%(Lun, et al., 2004)(Major, et al., 2000)(Chorley, et al., 2002)(Neely, 1998) (Kaufman, et al., 1999) (Marti, et al., 1988). Recreational running is one of the most popular sports in the UK with 5-10% of the UK population (2-4 million people) taking part in athletics (track and field, informal road running) and up to 25% (15 million people) take part in sporting activities that involve running(Adidas, 2006). With between 125,000 and 1,000,000 injured runners seeking advice about injury annually, proper assessment of foot biomechanics could be a valuable tool for osteopaths in order to give appropriate advice and treatment to this population.

The osteopathic profession has many different methods of assessing foot biomechanics ranging from visual assessment (DiGiovanna, et al., 2005 p. 502) to more complex goniometric assessment (Eisenhart, et al., 2003). Much osteopathic literature relating to assessment of the foot remains in the realms of accepted wisdom rather than the outcomes of clinically trialled methods (see major osteopathic text books such as Kuchera & Kuchera (1991) or DiGiovannna et al (2005)). At present there remains no universally accepted method of assessment (Razeghi, et al., 2002) and laboratory-based objective studies of lower limb function such as radiography or video gait analysis represent the gold-standard (Redmond, et al., 2006). However these methods are complex, time-consuming, require expensive equipment and are impractical for the osteopathic clinical setting. Likewise visual assessment or footprint analyses are regarded as unreliable methods for assessing the foot (Razeghi, et al., 2002).

Huson (1997) points towards the foot as being a major part of the “kinematic chain”. Huson proposes that the configuration of the joints in the lower extremity allows maximum stability in the “chain” with minimal muscular effort and the overall balance of stability between the joints allows us efficient bipedal movement. This model points towards several conclusions:

“1. Changes in the kinematic condition of a particular closed articular chain in the human body have immediate effects on the kinematics of other joints.

2. These effects can be observed even at a great distance, thus affecting the kinematic behaviour of the whole chain.” (Huson, 1997 p. 130)

If we take the guiding osteopathic principles of “the body is a unit” and “structure and function are reciprocally inter-related”, it becomes clear that effective analysis of the foot is key to osteopathic assessment of the lower extremity because proximal dysfunction could have an origination in poor foot biomechanics.

The Foot Posture Index (FPI) (Redmond, et al., 2006) is a novel and quick method to assess foot biomechanics in the clinical situation, which has been fully validated against the Rasch statistical model (Keenan, et al., 2006).

This paper seeks to determine whether there is a relationship between FPI score, injury incidence rate (IR) and severity (TOTALDL) in a population of recreational runners.

# Methods

## Subjects

The study proposal was reviewed and approved by the College of Osteopath Research Ethics Board. A total of 115 recreationalrunners were recruited through face-to-face contact in one runningshoe store in London. The sample size was set at 100 and 15 participants were excluded from the study. With 100 participants there is an 80% probability that the study would detect a relationship between the independent (FPI) and dependant variables: injury incidence rate (IR) and severity or total days lost to injury (TOTALDL) at a two sided 5.000% significance level, if the true change in the dependent variables is 0.283 standard deviations per one standard deviation change in the independent variable (Schoenfeld, 1995).

To be included, subjects had to be over 18 and running less than30 miles per week for women and 40 miles per week for men. To minimise the influenceof injuries from other sports, subjects who regularly trained or participated morethan four times per week in other sports were excluded fromthe study.

## Design

Subjects who met the inclusion criteria wereprovided with an explanation of the study. If the subject agreed to participate, verbal consentwas obtained and the subject completed a standardquestionnaire on age, height, weight, current running mileage, past musculoskeletalinjuries, cross training and rest days (see appendix c). FPI measurements were performed following the methodology in appendix d. FPI scores ranged from -12 (highly supninated) to +12 (highly pronated), with 0 to +5 representing a neutral foot. All measurements were performed by one investigator. Data was collected in the London running shoe shop.

### The Questionnaire

The questionnaire was divided into three sections:

1. **Demographics**: The age, sex, height, and weight of the subjects were recorded.
2. **Training**: The questionnaire pertained to the previous 12 months of training. This period was chosen to cover one competitive season. Participants were asked to provide details of their weekly mileage, numbers of days spent cross-training and the number of rest days in an average week.
3. **Injuries**: An injury was defined as ‘‘any musculoskeletal problem causing cessation of training for at least one day, reduction in training mileage, taking of medicine, or seeking of medical aid.’’ (Fordham et al, 2004 p301). Separate sections of the questionnaire were completed for two categories of injury:
   * Stress or overuse injuries: resulting from gradual accumulation of physical stress during training
   * Traumatic injuries: occurring in a brief moment of time or accident

Information on the anatomical site, the number of days of training lost, and the seeking of medical help were recorded. The anatomical sites recorded were: neck, shoulder, arm (including elbow/wrist/hand), thoracic spine, lumbar spine and pelvis, groin, front of thigh, hamstrings, knee, calf, shin, Achilles tendon, ankle, foot, other.

Data was entered into an electronic form, which allow direct transfer of data for statistical analysis and minimised transcription errors.

## Dependant Variables

The variables measured by the study were FPI score (FPI), injury incidence rate (IR) and severity of injury, measured as total number of days training lost (TOTALDL).

IR was calculated following methodology of Rauh et al (2006) this is expressed in the formulawhere i =TOTALO+TOTALT, AE (Athletic Exposure) =MPW\*52.

A full list of variables is listed in appendix e. Other variables of secondary interest are: height, weight, age, number of rest days and number of days spent cross-training.

## Null Hypothesis

The null hypothesis is that there is no relationship between FPI, injury incidence rate and severity in recreational runners.

## Data Analysis

Data analysis was carried out using SPSS 17.0 statistical analysis software. No data was taken from subjects that did not fall within the inclusion criteria.

All participants were scored on an FPI scale from -12 to +12. Participants that had sustained no injuries during the previous year were given scores of 0 for TOTALDL and IR.

Assessment of the severity of a sport-related injury usually reflects either theduration of the symptoms or, as in this study, training timelost due to injury following the methodology of Lun et al (2004).

Male and female data sets were analysed separately to avoid confounding of data due to sexual biomechanical variance, this follows the recommendation of Lun et al(2004) who felt their study could have been confounded by the pooling of male and female data.

When considering the data, it was felt that the small number (n=4)of traumatic onset injuries in the data set were acting as confounding factors, for example one female subject had fallen over and broken an arm in a non-running situation resulting in an abnormally high TOTALDL score. Therefore, all cases with a traumatic injury (TOTALT) score of =>1 were excluded from the dataset.

Statistical tests were carried out on the complete data set, including separate calculations for all of the positive and negative FPI scores. This analysis included analysis of Pearson’s correlation between FPI and IR, FPI and TOTALDL.

# Results

Out of 115 prospective candidates for this study, 10 were excluded because of excessive weekly mileage and a further 5 were excluded because of excessive participation in other sports. Of the 100 candidates measured, 4 were excluded due to traumatic injuries that might have confounded the data.

### Injury incidence and characteristics

Of the total (n=96), 65 (67.8%) runners sustained some form of injury. 30 of these were female and 35 male.

Injury incidence was expressed as a value of IR, following the methodology of Rauh et al (2004) as described previously. The average IR for male participants (8.8) was slightly lower than female participants (11).

### Site of injuries

In male runners the most commonly injury was to the shin (28%) followed by the knee (10%) the lumbar spine and pelvis (10%). This is similar to female runners whose most commonly injured sites were the shin (30%) followed by the knee (10%) the lumbar spine and pelvis (6.5%).

### Average FPI score by number of overuse injuries

The dataset was broken down into male and female participants and then further separated into those with positive FPI scores (neutral to pronated feet) and runners with negative FPI scores (neutral to supinated feet). These datasets were then split by the number of overuse injuries and the mean FPI scores were calculated for each category. This is shown in table 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Overuse injuries | 0 | 1 | 2 | 3 |
| Male | | | | |
| Positive FPI | 2.43 | 4.44 | 8.43 | 10.5 |
| Negative FPI | -0.4 | n/a | -6 | -7 |
| Female | | | | |
| Postive FPI | 2 | 7.3 | 8.6 | 10.88 |
| Negative FPI | n/a | **-3** | -10 | -9.5 |

Table . FPI score by number of overuse injuries

### Pearson’s Correlation

The Pearson’s correlation between positive FPI, TOTALDL and IR are summarised in table 2 and table 3 for male and female participants respectively. The Pearson’s correlation between negative FPI, TOTALDL, and IR are summarised in table 4 and table 5 for male and female participants respectively.

|  | | | | |
| --- | --- | --- | --- | --- |
|  |  | FPI score | IR | TOTALDL |
| FPI | Pearson’s Correlation |  | .590\*\* | .746\*\* |
| Sig. (2-tailed) | .000 | .000 |
| N | 43 | 43 |
| TOTALDL | Pearson’s Correlation | .746\*\* | .621\*\* |  |
| Sig. (2-tailed) | .000 | .000 |
| N | 43 | 43 |
| \*\*. Correlation is significant at the 0.01 level (2-tailed). | | | | |
| a. Sex = Male | | | | |

Table 2 Pearson’s correlations for FPI, IR and TotalDL male participants with positive FPI

|  | | | | |
| --- | --- | --- | --- | --- |
|  |  | FPI | IR | TOTALDL |
| FPI | Pearson’s Correlation |  | .676\*\* | .694\*\* |
| Sig. (2-tailed) |  | .000 | .000 |
| N |  | 43 | 43 |
| TOTALDL | Pearson’s Correlation | .694\*\* | .788\*\* |  |
| Sig. (2-tailed) | .000 | .000 |  |
| N | 43 | 43 |  |
| \*\*. Correlation is significant at the 0.01 level (2-tailed). | | | | |
| a. Sex = Female | | | | |

Table 3: Pearson’s correlation for FPI, TotalDL and IR female participants with positive FPI

|  | | | | |
| --- | --- | --- | --- | --- |
|  |  | FPI | TOTALDL | IR |
| FPI | Pearson’s Correlation | 1 | -.599 | -.704 |
| Sig. (2-tailed) |  | .155 | .077 |
| N | 7 | 7 | 7 |
| IR | Pearson’s Correlation | -.704 | .637 | 1  7 |
| Sig. (2-tailed) | .077 | .124 |
| N | 7 | 7 |
| a. Sex = Male | | | | |

Table 4: Pearson’s correlation for FPI, TotalDL and IR male participants with negative FPI

|  | | | | |
| --- | --- | --- | --- | --- |
|  |  | FPI | TOTALDL | IR |
| FPI | Pearson’s Correlation | 1 | -.814 | -.479 |
| Sig. (2-tailed) |  | .186 | .521 |
| N | 4 | 4 | 4 |
| IR | Pearson’s Correlation | -.479 | -.005 | 1  4 |
| Sig. (2-tailed) | .521 | .995 |
| N | 4 | 4 |
| a. Sex = Female | | | | |

Table 5: Pearson’s correlation for FPI, TOTALDL and IR female participants with negative FPI

### Regression analysis

| Linear regression was carried out on the positive FPI set and the negative FPI set. Logarithmic and quadratic regression was carried out on the complete data set.  **Model Summary and Parameter Estimatesa**  Dependent Variable:Total days training lost   |  | | | | | | | | | --- | --- | --- | --- | --- | --- | --- | --- | | Equation | Model Summary | | | | | Parameter Estimates | | | R Square | F | df1 | df2 | Sig. | Constant | b1 | | Linear | .556 | 51.417 | 1 | 41 | .000 | -.870 | 1.517 | | The independent variable is FPI. | | | | | | | |   a. Sex = Male |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |



### Figure 1: linear regression for male positive FPI and TOTALDL



Figure 2: linear regression for male positive FPI and IR

| **Model Summary and Parameter Estimatesa** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Dependent Variable:Total days training lost | | | | | | | |
| Equation | Model Summary | | | | | Parameter Estimates | |
| R Square | F | df1 | df2 | Sig. | Constant | b1 |
| Linear | .481 | 38.053 | 1 | 41 | .000 | -2.158 | 1.808 |
| The independent variable is fpi score. | | | | | | | |
| a. Sex = Female | | | | | | | |



Figure 3: linear regression for female positive FPI and TOTALDL



Figure 4: linear regression for female positive FPI and IR

Linear regression analysis was carried out on the negative FPI scores, however the low power in these sets gave very poor significance levels to these calculations.

The quadratic and cubic regression for male participants between FPI and TOTALDL are provided in Figure 5 and female participants in Figure 6. While the quadratic and cubic regression for male participants between FPI and IR can be seen in Figure 7 and female participants in Figure 8.

| **Model Summary and Parameter Estimatesa** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Dependent Variable:Total days training lost | | | | | | |
| Equation | Model Summary | | | | |
| R Square | F | df1 | df2 | Sig. |
| Quadratic | .637 | 41.231 | 2 | 47 | .000 |
| Cubic | .637 | 26.960 | 3 | 46 | .000 |
| The independent variable is fpi score. | | | | | | |
| a. Sex = Male | | | | | | |



Figure 5: Quadratic and cubic regression of FPI and TOTALDL for male participants

| **Model Summary and Parameter Estimatesa** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Dependent Variable:Total days training lost | | | | | | |
| Equation | Model Summary | | | | |
| R Square | F | df1 | df2 | Sig. |
| Quadratic | .793 | 82.210 | 2 | 43 | .000 |
| Cubic | .808 | 58.884 | 3 | 42 | .000 |
| The independent variable is fpi score. | | | | | | |
| a. Sex = Female | | | | | | |



Figure 6: Quadratic and cubic regression of FPI and TOTALDL for female participants

| **Model Summary and Parameter Estimatesa** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Dependent Variable:Injury Rate | | | | | | |
| Equation | Model Summary | | | | |
| R Square | F | df1 | df2 | Sig. |
| Quadratic | .370 | 13.782 | 2 | 47 | .000 |
| Cubic | .370 | 8.993 | 3 | 46 | .000 |
| The independent variable is fpi score. | | | | | | |
| a. Sex = Male | | | | | | |



Figure 7: Quadratic and cubic regression of FPI and IR for male participants

| **Model Summary and Parameter Estimatesa** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Dependent Variable:Injury Rate | | | | | | |
| Equation | Model Summary | | | | |
| R Square | F | df1 | df2 | Sig. |
| Quadratic | .562 | 27.546 | 2 | 43 | .000 |
| Cubic | .595 | 20.544 | 3 | 42 | .000 |
| The independent variable is fpi score. | | | | | | |
| a. Sex = Female | | | | | | |



Figure 8: Quadratic and cubic regression of FPI and IR for female participants

# Trends and patterns identified

When viewed in a non-critical way it seems that there is some correlation between the FPI scores and both injury incidence rate and severity.

When spilt into positive and negative FPI scores, the male data analysed with Pearson’s correlation show scores of .746 between positive FPI and TOTALDL, and .590 between positive FPI and IR. Both of these figures have a statistically valid significance of less than .001 (See table 2). Likewise the female data shows figures of .694 (FPI & TOTALDL) and .676 (FPI & IR) respectively, all with a statistically valid significance of less than .001 (See table 3). Therefore it does seem likely that as both male and female runners FPI score increase, the frequency and severity of injury also increases.

It is more difficult to derive anything from the negative FPI scores as the small data set reduces the statistical validity, however there does seem to be a relationship between these variables for both male and female runners (see tables 4 and 5), albeit with poor statistical validity due to the low power in the datasets.

One of the major differences between the male and female participants is the lower R squared value in the FPI/IR regression for male participants, which can be explained by male participants running more miles per week than female participants.

It also seems that as FPI increases, the overall number of overuse injuries also increases (see table 1). Likewise as FPI decreases past zero, the number of overuse injuries also increases.

# Discussion

### Original aims and objectives

The original aim of this paper was to seek to determine whether there was a relationship between FPI score, injury incidence rate and severity in a population of recreational runners.

In some ways this project has taken the first step towards establishing a statistically valid relationship between FPI score, injury incidence rate and severity in a population of recreational runners. However these findings are at odds with other studies that show no correlation between static measurements of foot biomechanics and injury incidence rate and severity (Lun, et al., 2004). This is discussed below.

### Existing knowledge base

The main difference between this study and Lun et al (2004) is that individual injuries were plotted against different static measurements. The static measurement used by Lun et al for foot biomechanics was a subjective, non-validated methodology. It used visual assessment of the foot to categorise it into supinated, neutral or pronated. The initial literature search highlighted this method as having a very poor intra and inter-rater reliability (Razeghi, et al., 2002). It would appear that FPI, with its multi-planar approach to assessing the foot, yields a greater spread of data that allows more subtle variation between foot types.

### Validity

A number of weaknesses can be identified with this study:

* All of the injuries were pooled together when performing correlation analysis. Lun et al (2004) plotted each injury type against the different static biomechanical data sets and found little difference between the injured and non injured groups.
* The rather broad-brush approach that this study takes does not allow other biomechanical measurements, such as leg length or q-angle, to be taken into account as confounding factors.
* As Lun et al’s (2004) study was prospective, careful monitoring of exact symptom duration and symptom type was possible. This was not possible for this study due to its retrospective nature, which meant that subjects may not have been accurate about their exact condition or about time lost from training.

### Reliability

One area of difficulty when collecting the data was the nature of the environment (a London running shop). The assessor felt that cases were often self selecting because people were frequently asked to participate after performing the standard video gait analysis offered in store. This may have unconsciously led the assessor to only ask prospective candidates that he felt were suitable for inclusion, leading to a rather too perfect set of results.

### Further research

A further, prospective study could be carried out over a discrete time-frame, allowing greater accuracy in data collection. This study could consider including:

* increased specificity regarding the exact nature and severity of each injury
* time-hazard studies could be performed on several different groups comprising a wide range of FPI scores
* a control group with neutral feet could be included
* a wider variety of runners from different backgrounds should be sought, such as running clubs
* higher numbers of supinated feet should be included, in order to add more significance to the results.

# Conclusions

There appears to be a relationship between FPI score and injury incidence rate and severity in male and female recreational runners. However the relationship is more significant for positive FPI scores than for negative FPI scores. Further research is required to definitively show this because this study has a number of methodological problems that should be addressed before the results can be viewed with confidence.

Further research into FPI scoring and its relationship to injury could mean that it becomes a valuable tool that would be of benefit to the osteopathic community. FPI scoring is a quick and easy method of foot assessment that provides useful clinical data about foot biomechanics without the need for expensive or complex equipment.

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