Initial foot contact patterns during steady state shod running

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Introduction

In steady state running three different initial foot contact patterns (IFCP) are possible: initial rearfoot (IRFC), midfoot (IMFC) or forefoot (IFFC) contact. One of the most commonly used methods to characterize IFCP is the strike index (Cavanagh and Lafortune 1980). The strike index (SI) method is based on center of pressure (COP) calculation from force plate data and the localization of this COP@IFC on the plantar side of the foot based on kinematic data. However the calculation of COP from force plate data is less accurate when only small forces are exerted (Bobbert *et al.* 1990) which is the case at IFC.

Purpose of the study

The purpose of this study was to accurately assess the IFCP during steady state shod running for a large group of long distance runners using a combined high speed pressure plate and force plate system as such a system should give a more accurate COP at low vertical ground reaction forces.

Methods

Fifty-five healthy runners between 18 and 58 years (40♂: 28.6 ±8.1 years, 71.9 ±5.8 kg, 1.79 ±0.05 m and 15♀: 28.2 ±8.3 years, 59.4 ±4.5 kg, 1.67 ±0.05 m) were recruited. Runners ran at 3.2 m/s over a 35m runway. All subjects wore the same neutral running shoes based on the Li Ning Magne (ARHF041) that were modified with a flattened outsole (to improve plantar pressure measurements) and filled midfoot (resulting offset ~1.15 cm). Ground reaction forces and plantar pressures were recorded for 3 successful left and right foot contacts by a 2m plantar pressure measurement plate (500Hz, Footscan, RSscan) mounted on top of a 2m force plate (1000 Hz, AMTI) providing instant dynamic calibration of the Footscan. Ground reaction forces were filtered using a Butterworth low pass filter with a cutoff frequency of 80 Hz. We determined COP position using pressure plate data. IFCP was determined for each foot contact by determining a SI based on the location of the COP on the plantar side of the shoe sole at initial contact (SI@IC). SI@IC is the distance along the longitudinal axis of the foot of the COP at initial contact versus the rearmost part of the shoe (normalized to shoe length). With this method a value of 0-0.333 indicates IRFC, a value of 0.334-0.666 indicates IMFC and a value of 0.667-1 indicates IFFC.
We also came up with an alternative SI using the COP position at the instant of maximal loading rate (SI@MLR) of the vertical ground reaction force component (Fvert) to have a SI at an instant with a certain minimal amount of functional loading, which is not the case at the instant of IFC. Using this method we will use the terms rearfoot strike (RFS), midfoot strike (MFS) or forefoot strike (FFS) according to the obtained SI.

Results and discussion

Based on the SI@IC for both left and right foot 45 subjects were classified as IRFC and 10 as IMFC (table 1). Most subjects showed a COP pattern similar to a typical IRFC or IMFC (fig. 1) although 11 of 45 left and 13 of 45 right IRFC subjects showed COP patterns that were characterized by an initial point of contact at the RF zone followed by an initial fast anterior COP movement along the lateral shoe margin into the MF zone. During this phase small forces are acting upon the foot. These atypical patterns lie somewhere in between the typical IRFC and the typical IMFC pattern.

The atypical IRFC pattern, according to SI@IC, is classified as a MFS using the SI@MLR while the typical IRFC and IMFC are still classified as respectively RFS and MFS (fig. 1). Consequently based on SI@MLR more subjects are classified as MFS (table 1).

Table 1. Number of subjects per IFCP group using the SI@IC and SI@MLR method for the left and the right feet.

	Left feet		Right feet	
	SI@IC	**SI@MLR**	**SI@IC**	**SI@MLR**
RF	45	34	45	30
MF	10	20	10	23
FF	0	1	0	2

Although in the atypical IRFC patterns initial contact is made in the RF zone, these should not be categorized as RFS. After the fast anterior movement the COP moves medially and slightly posteriorly in the MF zone, just as in typical MFS patterns. Using the alternative SI@MLR these atypical IRFC patterns are classified as MFS. Therefore, the SI@MLR seems to result in a more functional classification.

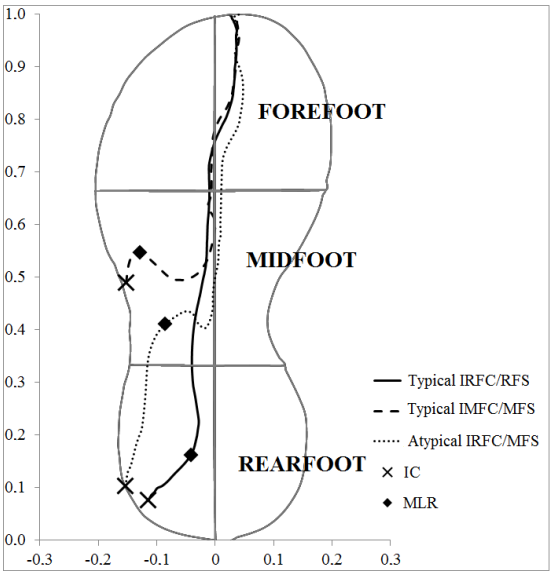

Figure 1. COP patterns for a typical IRFC/RFS and IMFC/MFS and an atypical IRFC/MFS subject. Y and X axis give the COP position expressed as a % of foot length. SI@IC is marked with '**X**' and SI@MLR with '♦'.

The mean Fvert at the instant of MLR was 649 ±200N. The method of determining a SI at the instant of Fvert at 10% of maximal Fvert by Williams and Cavanagh (1987) would result in SI values in between the two currently presented methods.

Conclusion

Based on both SI@IC and SI@MLR the main part of runners is classified as IRFC/RFS. Using the alternative SI@MLR the atypical IRFC patterns are classified as MFS which concurs with the COP trajectories.

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