

# DO PRONATORS PRONATE?

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## INTRODUCTION

Millions of people are involved in running and jogging activities. From those, between 37 and 56 % are injured during the period of one year (van Mechelen, 1992, etc.). Previous injuries, excessive mileage, excessive impact forces and excessive pronation have been proposed as major reasons for the development of running injuries (Cavanagh and LaFortune, 1980, etc.). The sport shoe can influence impact forces and foot pronation. Consequently, the concepts of "cushioning" and "movement (or rearfoot) control" were developed and strategies were studied to reduce potentially harmful impact forces and excessive foot pronation through appropriate running shoe design.

The topic of this investigation was pronation. For the last two to three decades, pronation was and still is one major characteristic that potential buyers of a sport shoe consider. Many customers come into a sport shoe store and claim that they are pronators or even that they are "over pronators". However, despite the fact that most runners and certainly the sales force in sport shoe stores use the term pronation frequently, it is not well defined what a pronator actually is and many questions around the topic pronation remain unanswered including the questions: Is a self-selected pronator a person that pronates excessively while barefoot running? Is a self-selected pronator a person that pronates excessively in a neutral shoe? Thus, the purpose of this investigation was to determine the relationship between self-selected pronators and their foot eversion during heel-toe running.

## METHODS

Forty-two male and forty-one female subjects were recruited for this investigation. All subjects were regular runners running a minimum of 10 km/week ( $36.5 \pm 20.2$  km/week). Subjects were self-classified as either pronator or normal runners. Of the forty-two males runners recruited, 20 classified themselves as pronators, 20 as normals and 2 as supinators. Of the forty-one females recruited, 21 classified themselves as pronators and 20 as normals. All subjects were free from recent lower extremity injury or pain. Informed written consent in accordance with the University of Calgary's Ethics Committee was obtained from all subjects.

Data were collected on the left foot of each subject while running barefoot and with a neutral shoe. Kinetic data were collected with a Kistler force platform sampling at 2400 Hz. Kinematic data were collected simultaneously with the kinetic data using a Motion Analysis six video camera system at 240 Hz. Spherical reflective markers were placed on the thigh, shank and shoe for kinematic data collection. For the barefoot condition, three markers were placed on the calcaneus.

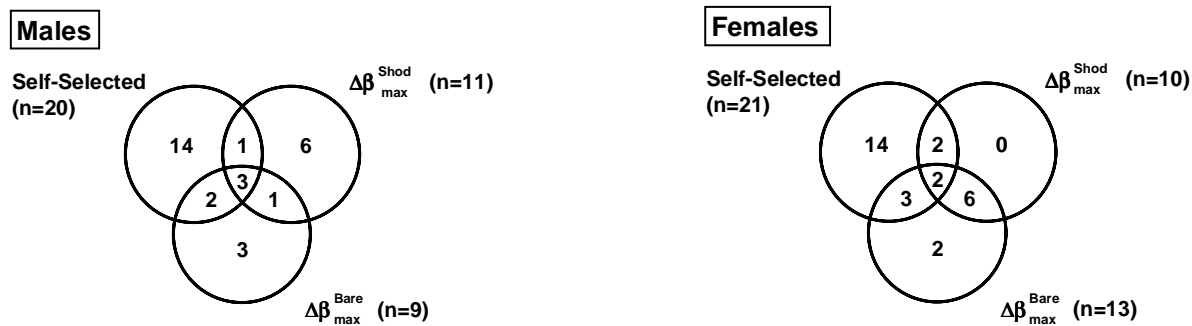
For each subject, five barefoot trials were collected first followed by five trials with the neutral shoe. The running speed of the subjects ( $4 \pm 0.2$  m/s) was monitored with photocells placed just before and just after the force plate. A standing neutral trial prior to each set of running trials was used to define the joint centers. The ankle joint center was defined by additional markers placed on the medial and lateral malleoli. The knee joint center was defined by additional markers placed on the lateral and medial epicondyle and the middle of the patella. Prior to calculation of any variables a fourth-order low-pass Butterworth filter was used to filter the kinematic data (cutoff frequency of 12 Hz) and the kinetic data (cutoff frequency of 100 Hz). Five trials were included in each average. Rarely, trials were excluded on the basis of being extreme outliers due to difficulty in tracking.

## RESULTS AND DISCUSSION

Subjects can be classified as pronators based on different criteria. One criterion is self-selection. In this investigation 20 males and 21 females classified themselves as pronators, 20 males and 20 females classified themselves as normals. Another criterion is the amount of foot eversion a subject experiences when running barefoot ( $\Delta\beta^{\text{Bare}}$ ). In this investigation, subjects who had a change in eversion ( $\Delta\beta_{\text{max}}$ ) of greater than or equal to  $15^\circ$  during barefoot running were classified as barefoot pronators. The benchmark of  $15^\circ$  was chosen to approximate the 25% of the subjects with the highest barefoot eversion (9/40 males and 13/41 females). Another criterion to classify pronation is the amount of eversion a subject has when running shod ( $\Delta\beta^{\text{Shoe}}$ ). In this investigation, subjects who had a change in eversion of greater than or equal to  $16.5^\circ$  during running in the neutral shoe were classified as shoe pronators. The benchmark of  $16.5^\circ$  was chosen to approximate the 25% of the subjects with the highest shod eversion (11/40 males and 10/41 females).

The relationship between barefoot eversion, shod eversion and self-selected pronation is illustrated in Figure 1 for both males and females. Out of the 20 males who classified themselves as pronators, two subjects had high barefoot eversion but not high shod eversion, one subject had high shod eversion but not high barefoot eversion and three subjects had high eversion in both barefoot and shod conditions. Thus, only three males satisfied all three pronation criteria. Fourteen of the 20 males (70%) who were self-selected pronators did not have high eversion when running either barefoot or shod. Also, ten male subjects had high eversion in either the barefoot or shod condition but considered themselves as normal.

Out of the 21 females who classified themselves as pronators, three subjects had high barefoot eversion but not high shod eversion, two subjects had high shod eversion but not high barefoot eversion and two subjects had high eversion in both barefoot and shod conditions. Thus, only two females satisfied all three pronation criteria. Fourteen of the 21 females (67%) who were self-selected pronators did not have high eversion when running either barefoot or shod. Also, eight female subjects had high eversion in either the barefoot or shod condition but considered themselves as normal.



**Figure 1:** Venn diagrams showing the relationship between self-selected pronation, shod eversion and barefoot eversion.

The above results lead to the following conclusions: Barefoot eversion, shod eversion and the perception of pronation are variables that do not describe the same phenomenon. People who consider themselves to be pronators may not be pronators. People who consider themselves to be normal may be pronators.

Since eversion does not determine whether individuals assess themselves as pronators, it may be that they are classifying themselves based on another variable. Typical variables which have been associated with pronation in the literature include tibial rotation due to the coupling mechanism between foot and shank (Hintermann et al., 1994) and arch height (Hamill et al., 1989). The normal males had significantly higher unloaded arch heights than the self-selected pronator males (Table 1). The normal females also had higher unloaded arch heights than the self-selected pronator females, although the difference was not significant. When comparing loaded arch heights, self-selected pronators tended to have lower arch heights than self-selected normals. For both males and females, the differences were close to significant. It has been shown that there is no correlation between arch height and pronation (Nigg et al., 1993). This was also found in this study. Correlations ( $R^2$ ) between arch height and eversion ranged from 0.0003 to 0.0084 depending on whether loaded or unloaded arch height and barefoot or shod eversion were compared. Even though there is no correlation between pronation and arch height, it appears that subjects with low arches consider themselves to be pronators. Thus it can be concluded that self-assessed pronation may be related to arch height.

**Table 1:** Comparison of arch heights between self-selected pronators and normals. Data are presented for fully loaded (weight fully on measured foot) and for unloaded (all weight on opposite foot) conditions. Measurements are presented for the left foot.

		Arch heights					
		Full load	No load				
		[mm]	[mm]	Full load	No load		
				[mm]	[mm]		
<b>Males:</b>	<b>Normals (20)</b>	26.0	29.4	<b>Females:</b>	<b>Normals (20)</b>	24.0	27.7
	<b>Pronators (20)</b>	23.6	26.6		<b>Pronators (21)</b>	21.5	24.8
	<b>p-value</b>	<b>0.096</b>	<b>0.045</b>		<b>p-value</b>	<b>0.085</b>	<b>0.082</b>

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