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Determination of the foot strike pattern in runners belonging to a running team

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Abstract

Background*:* The number of runners has been increasing as well as the number of injuries related to this sport. Knowing the foot strike patterns of the runners has become necessary since there is a possible relationship between the landing pattern of the foot against the ground during running and the increased incidence of musculoskeletal injuries in runners**. Research question***:* The objective of this study was to determine the distribution of the foot strike patterns in recreational runners during typical training running pace. **Type of study***:* Cross-sectional study. **Methods:** This is a cross-sectional study conducted with recreational runners who practice with running coach. A high-speed camera (image acquisition frequency of 250 Hz) was used to analyse the foot strike pattern and photocells were used to register the runners´ speed. The foot strike patterns were classified into three categories: rearfoot, midfoot and forefoot. The description of the foot strike pattern and the characteristics of participants were done through descriptive statistics. Intra-class and inter-class confiability was evaluated by agreement percentage. **Results***:* Fifty-three runners, with an average speed of 12.6 km/h, were evaluated, and 98.1% of the runners showed a rearfoot strike pattern. Only one runner touched the ground with the midfoot first, and none were forefoot strikers. The evaluation method for determining foot strike pattern showed an agreement percentage of 96.2% and 100% intra-class and inter-class confiability, respectively. **Conclusion:** The results of the study showed that the adult recreational runners who train with a one running coach, almost exclusively demonstrate a rearfoot strike pattern during running. **Keywords:** foot strike, landing, running, injuries, prevention

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Introduction

Running is one of the most popular sports throughout the world, but the number of injuries related to this sport is high, with injury rates ranging between 19-79%[1]. Many studies have investigated risk factors for running-related injuries, but there is limited evidence that the majority of factors, such as type of training running surface, anatomic factors, and type of foot, can be regarded as risk factors for running injuries[1-6]. The literature demonstrates that only weekly running distance and previous injuries, with significant evidence, can be regarded as risk factors for running injuries[1]. Not even the relationship between vertical force and injury has shown this conclusively. While some studies demonstrated a correlation between high rates of vertical force and running injuries[7, 8], others have failed to find this correlation[9, 10].

Given the absence of evidence of risk factors that explain the great number of injuries in runners, special attention has been given to the part of the foot that strikes the ground first, since the foot is the segment of the body that directly receives the forces from the ground[11-13]. It is believed that the main cause of the running-related injuries is the overload that occurs when the foot strikes the ground, leading to a marked increase in the vertical forces that are transmitted to the lower limbs[14]. In this way, the adoption of such foot strike strategies during running might be responsible for a greater protection of the musculoskeletal system against injuries[12].

Despite the importance of the foot strike pattern during running, only three studies[11,13,15] have evaluated the distribution of the foot strike patterns among runners. All studies were undertaken during races, with the foot strike evaluation done only on stride. They evaluated only elite half-marathoners and race participants, excluding recreational runners who do not to practice for or participate in specific races. Therefore, the main objective of this study was to determine foot strike pattern distribution among recreational runners during typical training running pace.

Methods

A descriptive cross-sectional study was undertaken in order to identify the foot strike pattern of recreational runners who practice with a running coach. Individuals were invited to participate in the study in areas where there are high numbers of people who are practicing running. They had to be older than 18 years of age, had to wear shoes during the evaluation, and had to have been running for at least 6 months. There were no restrictions regarding weekly running distance. All participants signed an informed consent form, and the study was approved by the ethics committee of the University of the City of São Paulo. Participants completed a form with information about their demographic characteristics (age, weight, height and gender), practice time, presence of pain at the time of the evaluation and history of injuries during the last 6 months. It was decided to include information about pain experienced at evaluation or a recent injury because of its possible influence on foot strike patterns of runners.

After completing the forms, all participants were driven to the place where the image acquisition was performed. It was a 50-meter long track and a camera (Casio EX FX1) was located halfway along the path for taking high-speed pictures (image acquisition frequency of 250 Hz and 250.s^{1} of shutter speed). The camera was positioned on a 15 cm high tripod, 2 metres away from the running line. The participants were instructed to run at a speed that they found comfortable. A pair of emitting photocells (TC-Timing System) were positioned next to the camera 2 metres away from it on each side and

the receptor photocells were placed 4 metres away from each of the emitting ones, in front of each of them (Figure 1). The participants ran twice along the path for a total of 200 metres.

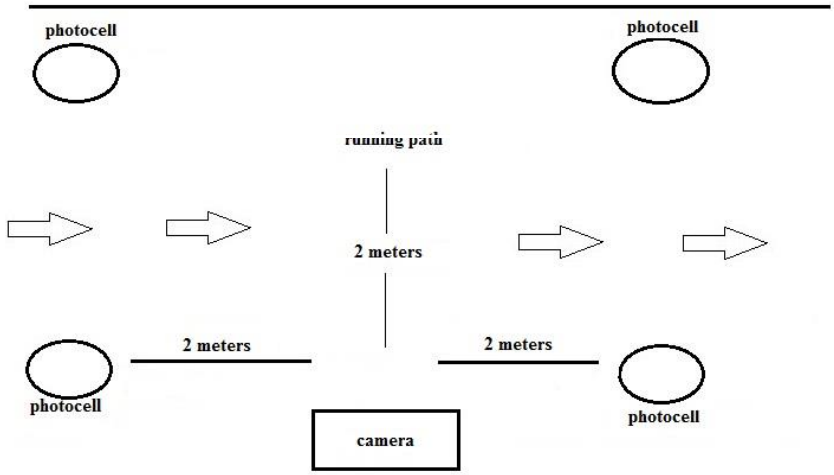

Figure 1: Schematic representation of the area for the image acquisition during running

Image analysis

The videos with foot strike images were captured and later analysed. The four times that the participants crossed the camera were recorded and evaluated and the analysis was done according to the lateral view of the foot. When there were different types of foot strike patterns in one participant, the most frequent pattern was chosen. Foot strike pattern was defined by the part of the foot that strikes the ground first and can be classified as[8]: rearfoot (Figure 2a), when the runner lands with the heel first; (2) midfoot (Figure 2b), when the runner lands with the heel and ball of the foot simultaneously; and (3) forefoot (Figure 2c), when the ball of the foot lands before the heel comes down. Two independent evaluators analysed and classified foot strike images, and when necessary, a third evaluator solved any discrepancies.

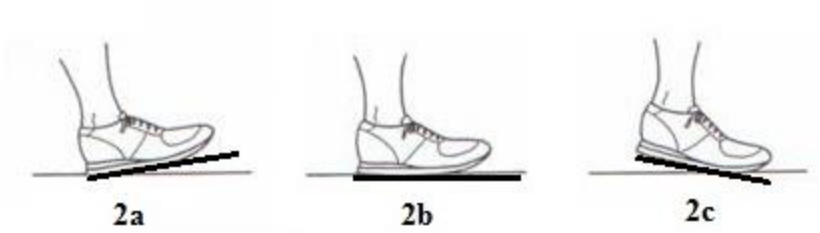

Figure 2: Foot strike patterns during running

Statistical analysis

A descriptive statistical analysis with a simple frequency distribution and percentage calculation for categorical data and measures of central tendency and dispersion for continuous data was performed to examine the foot strike patterns and the participants' characteristics. Evaluation of normality of continuous data (age, weight, height, body mass index, time of practice and average speed during evaluation) was done through the analysis of the symmetry of the curve. Data with normal distribution were shown in mean and standard deviation, while data with non-normal distribution were reported in median and interquartile range. Intra-class and inter-class confiability were evaluated by means of an agreement percentage. Analyses were done in SPSS 17.0 software.

Results

The foot strike pattern was analysed in 53 runners (Table 1). The runners had a mean age of 42 years (SD = 11), with a median running period of five years (IQ = 7). Nearly 20% of runners had a history of a musculoskeletal injury in the previous six months and 19% had pain at the time the running evaluation was undertaken. The foot and ankle were the anatomic areas most commonly reported by runners who had pain at the time of the evaluation. The knee was the anatomic area most affected in musculoskeletal injuries in the previous six months.

Table 1. Characteristics of the runners included in the study

Age (years)	42 (10.9)
Weight (Kg)	68.6 (11.8)
Height (cm)	171 (0.09)
BMI (Kg/cm²)	23.1 (0.3)
Self-selected speed (Km/h)	12.6 (2.3)
Practice time (years)*	5 (7)
Gender	
Men	62.3% (33)
Women	37.7% (20)
Pain at the moment of evaluation	
Yes	18.9% (10)
No	81.1% (43)
Musculoskeletal injury in the previous 6 months	
Yes	20.8% (11)
No	79.2% (42)

The continuous data with normal distribution are shown with a mean value and standard deviation
*The continuous data with abnormal distribution are shown with median value and interquartile range.
Categorical data are shown in percentage and number of runners.

Regarding the distribution of foot strike patterns (Table 2), 52 runners (98.1%) touched the ground with the heel (rearfoot pattern) first. Only one runner touched the ground with the ball of the foot and heel simultaneously (midfoot pattern) and no runner touched the ground with the ball of the foot first. The mean speed of runners was 12.6 km/h (SD = 2.3). The evaluation method for identifying foot strike pattern had a 96.2% and 100% inter-class and intra-class confiability, respectively.

Table 2. Distribution of foot strike patterns of runners

Foot strike pattern	n	%
Rearfoot	52	98,1
Midfoot	1	1,9
Forefoot	0	0

Discussion

The results of the present study showed that the majority of recreational runners who participated in this study were rearfoot strikers. Only one runner had a midfoot strike pattern and none of the runners had a forefoot strike pattern. The mean speed of the runners was approximately 12 km/h and nearly 20% of the runners reported pain at the time of the evaluation.

The results of the present study differ from those found by Larson et al[15], Kerr et al[13] and Hasegawa et al[11], who found that 88%, 80% and 75% of their participants were rearfoot strikers, respectively. This difference can be explained by the characteristics of this study's sample that was comprised of recreational runners who ran at a slower average speed (12.6 km/h) than did the elite half-marathoners studied by Hasegawa et al[11] (17.7 to 19.6 km/h), and the runners from Kerr et al[13] (12,4 to 19,9 km/h). When the results of the present study were compared with the results from Larson et al[15], in which participants ran at a pace of around 11 km/h, it was noted that the difference for the rearfoot strikers' rate was smaller. This supports the theory that the foot strike pattern may be speed-dependent.

The results of this study are interesting because most of the participants were rearfoot strikers and it should be noted that all participants in this study received running orientation from coaches. Foot strike pattern may be not only influenced by the runner´s speed but also from the information the runner could have received. Professionals that work with runners (coaches, physiotherapists and doctors) have been advocating that the "correct" way of running would be to make contact with the ground first with the heel, asking the runners to produce the movement popularly known as "heel-toe running", even if studies have demonstrated that the impact forces are higher in this foot strike pattern than in midfoot and forefoot strikers during running[12, 16-18].

The type of shoe sole used by the runners would also possibly influence the foot strike pattern during running[12]. Over time, shoe companies has been increasing the thickness and cushioning in the heel region leading to a better feeling of comfort, furthering the adoption of the rearfoot pattern. The efficacy of the use of these special running shoes on running injury prevention has been questioned since these running shoes were invented. Marti et al[19] in 1984 stated that no special shoe for running had a prophylactic effect on musculoskeletal injuries in runners. It is curious though that for more than three decades there has been an artefact for running (running shoes) with the idea of protection from injuries, even though there is no scientific evidence that proves the efficacy of shoes in the prevention of injuries[20-22].

A limitation of this study is that all participants had been provided with a running orientation, and the coaches usually guide the runners to adopt a rearfoot strike pattern. The method of image acquisition was the same one used in other studies published in this subject area[11, 13, 15]; but these authors used a camera image acquisition frequency of 250 Hz, which is better than the cameras used in the previous two studies, where the cameras had a frequency of 120Hz and 60hz respectively[11, 13]. The precision in the evaluation of the landing pattern of the foot during running is directly related to the increased frequency of image acquisition[23]. This study presents important information on the issue of foot strike pattern, because none of the previous studies in the literature had found such a high

proportion of rearfoot strike patterns as high as found in this present study. Future studies are needed to establish the factors that really determine the foot strike pattern and to see if there is an association between foot strike and running-related injuries.

Conclusion

The results of this study showed that the participants (who were adult recreational runners that trained with a running coach and ran at a pace of around 12km/h) have almost exclusively a rearfoot strike pattern during running. Only one runner demonstrated a midfoot strike pattern and no runner had a forefoot strike pattern.

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