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Short communication

Footstrike patterns among novice runners wearing a conventional, neutral running shoe

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ABSTRACT

Introduction: It has been suggested that striking on the midfoot or forefoot, rather than the rearfoot, may lessen injury risk in the feet and lower limb. In previous studies, a disparity in distribution in footstrike patterns was found among elite-, sub-elite, and recreational runners.
Purpose: The purpose of this study was to investigate the footstrike patterns among novice runners.
Methods: All runners were equipped with the same conventional running shoe. Participants were video filmed at 300 frames per second and the footstrike patterns were evaluated by two observers. The footstrike was classified as rearfoot, midfoot, forefoot, or asymmetrical.
Results: A total of 903 persons were evaluated. The percentages of rearfoot-, midfoot-, forefoot-, and asymmetrical footstrike among men were 96.9%, 0.4%, 0.9%, and 1.8%, respectively. Among women the percentages were 99.3%, 0%, 0%, and 0.7%, respectively.
Conclusion: Nearly all novice runners utilize a rearfoot strike when taking up running in a conventional running shoe. Hereby, the footstrike patterns among novice runners deviate from footstrike patterns among elite and sub-elite runners.

1. Introduction

It has been suggested that forefoot (FFS) and midfoot strike (MFS) gaits may protect the feet and lower limbs from some of the injuries experienced by a high percentage of runners, whereas rearfoot strike (RFS) during running have been suggested to be an important predictor for development of running related injuries [1,2]. The proportion of runners utilizing different footstrike patterns has been investigated among elite and sub-elite runners. Hasegawa et al. [3] found the proportion of RFS, MFS, and FFS to be 74.9%, 23.7%, and 1.4%, respectively. In a study by Larson et al. [4] the footstrike patterns among recreational and sub-elite runners were found to be 94.4% (RFS), 3.6% (MFS) and 1.9% (FFS), which corresponds well to the findings by Kasmer et al. [5]. The findings by Hasegawa et al. [3] and Larson et al. [4] indicate that the main part of runners utilize a rearfoot strike. However, there seems to be a difference in the distribution of RFS, MFS, and FFS between the elite, and the group of sub-elite/recreational runners in the two studies. This suggests that runners at different levels utilize different footstrike patterns. If this is true, the proportions of the three footstrike patterns may be different among novice, elite and recreational runners.

To our knowledge, no studies have been conducted to investigate the footstrike patterns among inactive persons taking up running. Therefore, the aim of this study was to investigate the footstrike patterns among novice runners wearing a conventional running shoe. Furthermore, we investigated if visual evaluation of video recordings was a feasible method to gather information about footstrike pattern.

2. Methods

Video recordings of footstrike patterns were gathered at University of Aarhus, Denmark among healthy persons between the ages of 18 and 65. Preceding the video recording, participants were equipped with the same neutral conventional running shoe (Supernova glide 3 male/female, Adidas, Herzogenaurach,

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Germany), and instructed to run a 500 m distance. Hereafter, the participants were instructed to run 27.5 m in a laboratory runway turn around and run back to the start. A digital camera (Exilim EX-F1, Casio, Tokyo, Japan) recording at 300 frames per second (FPS) was located perpendicular to the runway at 14 m from the starting point. The camera was mounted on a self-constructed welded stationary stand, ensuring the same camera position during the data collection period. The middle of the lens was set 15 cm above the floor. The camera recorded the footstrike pattern before and after the turning point, hereby obtaining video of both lateral and medial side of each foot. A photocell timing module (ALGE Timing, Lustenau, Austria) was used to measure running pace. The participants were instructed to run at a self-selected comfortable pace equivalent to the pace they had at the 500 m trial.

The videos were evaluated with the use of the motion tuner program Kinovea version 0.8.15. Each video was evaluated independently by two observers. The footstrike pattern for each participant was evaluated four times; two times on each foot. The evaluations from lateral and medial point of view were compared for both right and left foot between the two observers. In case of disagreement on footstrike pattern, the two observers met in a consensus meeting. The video was re-viewed by both observers, and an agreement on the categorization of footstrike was made. If no agreement was reached after a second evaluation, the participant was excluded.

To categorize the footstrikes four categories were used; RFS, MFS, FFS, and asymmetry. These categories were based on the categories suggested by Hasegawa et al. The definitions of RFS, MFS, and FFS were quoted verbatim from Hasegawa et al. [3]. RFS was defined as "a footstrike in which the point of the first contact of the foot with the ground was the heel or rear third part of the sole only and in which the midfoot or forefoot portion did not have any contact at footstrike". MFS was defined as "a footstrike in which the point of the first contact of the foot with the ground was not only the rear third of the sole but the midfoot or entire part of the sole". FFS was defined as "a footstrike in which the point of the first contact of the foot with a ground was the forefoot or front half of the sole and in which the heel did not have any contact at the footstrike. Footstrike patterns are shown in Fig. 1. If a participant was categorized with more than one type of footstrike on either right foot, left foot, or both feet, their footstrike was categorized as being asymmetrical.

2.1. Statistical analysis

Descriptive data for the demographic characteristics was presented as counts and percentage for dichotomous data, and as mean, standard deviation and 95% confidence interval for continuous data. Evaluations on footstrike patterns were considered as data on an ordinal scale and were presented as counts and percentage stratified by gender. Kappa statistics was employed to quantify the inter observer agreement on footstrike patterns.

Table 1
Demographic characteristics of the included and the excluded participants.

Variable	Unit	Included $n=903$	Excluded[c] $n=27$	p
Gender (counts)	Men/women	456/447	10/17	0.17[a]
Age (mean ± SD)	Years	37.1 ± 10.2	40.3 ± 11.0	0.11[b]
Height (mean ± SD)	m	1.75 ± 0.09	1.73 ± 0.10	0.33[b]
Weight (mean ± SD)	kg	80.3 ± 16.2	85.7 ± 18.0	0.09[b]
BMI (mean ± SD)	kg/m^2	26.2 ± 4.4	28.6 ± 4.5	0.006[b]
Running pace (mean ± SD)	km/h	11.8 ± 1.8	N/A	N/A

SD: standard deviation; kg: kilogram.
[a] Chi^2 test used.
[b] Students t-test with equal variances used. N/A: not available. p value indicates if there were differences between included and excluded participants.
[c] Three participants excluded from analysis due to data loss on the demographic variables.

3. Results

A total of 933 runners were recorded. Of these, 30 persons were excluded. Data on demographic characteristics were lost on three persons. The remaining 27 persons were excluded due to walking ($n = 18$), inadequate running style ($n = 1$), no video recording, ($n = 3$), ran in the wrong direction ($n = 1$), wrong or missing label number on video ($n = 3$), and video to dark to visualize footstrike pattern ($n = 1$). Finally, 903 runners were included in the analysis. Demographic characteristics of the 903 runners included and the 27 excluded persons where demographic characteristics were obtained are presented in Table 1. The average pace of the 903 participants recorded was 11.8 ± 1.8 km/h.

A total of 3612 recordings were evaluated by both observers. The kappa values of inter observer agreement on footstrike patterns were 0.76 and 0.82 on the left foot, and 0.85 and 0.92 on the right foot. There was disagreement on 18 footstrike patterns on right, left, or both feet of 13 participants. After consensus meeting both observers agreed on the footstrike patterns of all 903 participants. The number and percentage of footstrike patterns among men and women are presented in Table 2. For men, the RFS, MFS, FFS, and asymmetry were 96.9%, 0.4%, 0.9%, and 1.8%, respectively, respectively. Among women, the RFS, MFS, FFS, and asymmetry were 99.3%, 0%, 0%, and 0.7%.

4. Discussion

A total of 98.12% of male and female runners utilize a footstrike on the rearfoot in the current study. Hereby, the frequency novice runners utilizing a RFS seem to be greater than the frequency of rearfoot strikers among elite and recreational runners, as Hasegawa et al. [3], Larson et al. [4] and Kasmer et al. [5] found the frequency of rearfoot strikers 74.9%, 88.9% and 93.7%, respectively.

Fig. 1. Rearfoot strike, midfoot strike and forefoot strike.

Table 2
Distribution of footstrike.

Footstrike patterns	Men $n = 456$		Women $n = 447$		Total $n = 903$	
	n	Percentage	n	Percentage	n	Percentage
RFS	442	96.93	444	99.33	886	98.12
MFS	2	0.44	0	0	2	0.22
FFS	4	0.88	0	0	4	0.44
Asym	8	1.75	3	0.67	11	1.22

RFS: rearfoot strikers; MFS: midfoot strikers; FFS: forefoot strikers; Asym: asymmetry strikers (different footstrike patterns on the same foot in two different trials or two different footstrike patterns on right and left foot).

The video recordings of each participant were evaluated by two observers. The inter observer agreement was ranging from 0.76 to 0.92. The Kappa value can drop from 0.92 to 0.72 if few footstrikes of the 1806 footstrikes included are rated differently by the two observers. In the worst case scenario (Kappa = 0.72) the raters disagree on 7 of 1806 footstrikes (0.4%). In the best case (Kappa = 0.92) the raters disagree on 2 of 1806 footstrikes (0.1%). We conclude that the subjective evaluating of footstrike pattern is a feasible method which could be used in future studies with the purpose to examine the footstrike patterns. Subjective evaluation is an easy and cheap method to apply in contrast to methods used in other studies [6].

Research is needed to investigate the possible influence of footstrike patterns on injury development among novice runners. When recruiting novice runners wearing a conventional shoe, researchers should expect a majority of these runners to utilize a RFS.

5. Conclusions

Nearly all novice runners utilize a rearfoot strike when taking up running in a conventional running shoe. Visual evaluation of video recordings seems to be a feasible method to gather information about footstrike pattern.

Conflict of interest

All authors hereby state that they are in no way influenced by financial and personal relationships with other people or organisations that could inappropriately influence (bias) their work.

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