The Science of Running: Factors Contributing to Injury Rates in Shod and Unshod Populations

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Introduction

There has been a recent increase in the popularity of minimalist running shoes, which allegedly resemble barefoot or "unshod" running (e.g. Nike Free or Vibram). It is hypothesized that barefoot training improves strength differently than running in shoes or "shod" by activating both extrinsic and intrinsic muscles of the foot.

It has been suggested that footwear influences foot strike pattern (how the foot initially contacts the ground). Foot strike can be described as rearfoot (RFS), midfoot (MFS), or forefoot (FFS). Minimalist footwear is associated with a more anterior strike pattern than traditional footwear (Goss et al. 2012). With shod running (versus unshod), there is a faster loading rate at initial contact (Squadrone 2009), leading some to conclude that shod running correlates to higher injury rates.

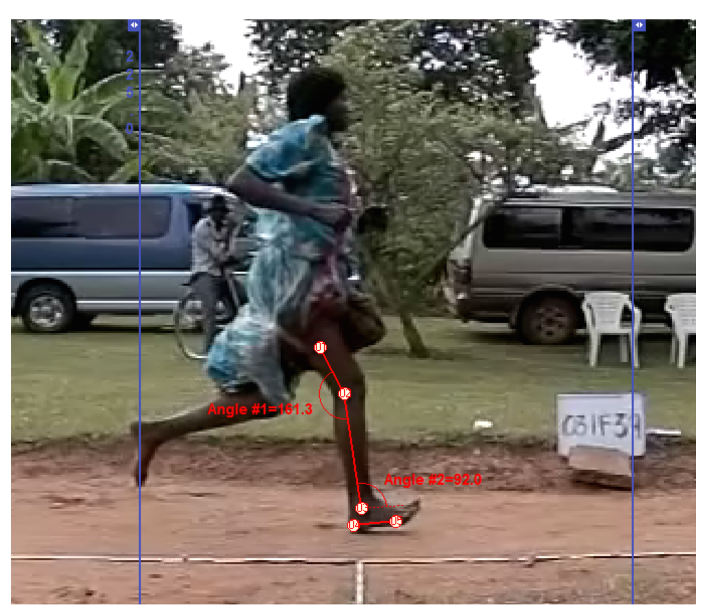
There is limited evidence to assess relationships between foot strike patterns and footwear on injury rates. There are biomechanical differences in loading rates, joint position angles, and EMG activity with different foot strike patterns but not with shod or barefoot running. These data suggest that foot strike patterns play a greater role than the shod condition in running injuries (Shih et al. 2013). This study focuses on how injury rates relate to foot strike patterns in habitually shod and unshod runners.

Hypothesis

Habitually barefoot participants will demonstrate:

- No significant increase in injury rate based on shod or barefoot condition
- No significant increase in injury rate based on foot strike patterns
- No significant difference in injury rate based on mileage walked or run
- No significant difference in injury rate based on hours of sports participation

Methods



Thirty Ugandan participants (15 male, 15 female) who typically wear shoes were compared to 21 participants (9 male, 12 female) who typically do not wear shoes. Participants were interviewed to gain subjective reports of injury history, shoe wearing habits and physical activity level. Markers were then placed on the right leg of each participant, and a high-speed camera (Casio EFX1 Pro) was used to capture footage during walking and running at self-selected speeds. MaxTRAQ software video analysis involved (1) numerical calculation of ankle and knee angles at initial contact and (2) visual categorization of foot strike pattern by three researchers. Chi-squared analysis and paired t-tests were used to compare injury rates, foot strike patterns and running biomechanics.

Results

Injury rates in shod and unshod participants

	Shod Averages (SD)	Unshod Averages (SD)	p-value
Foot Injury Rate	0.17 (+/- 0.38)	0.10 (+/- 0.30)	0.4756
Ankle Injury Rate	0.27 (+/- 0.45)	0.29 (+/- 0.46)	0.8837
Knee Injury Rate	0.23 (+/- 0.43)	0.38 (+/- 0.50)	0.2637
Hip Injury Rate	0.17 (+/- 0.38)	0.10 (+/- 0.30)	0.8224
Combined Injury Rate	0.21 (+/- 0.41)	0.21 (+/- 0.39)	0.9399

Table 1: Habitually shod or unshod injury rates. Self reported orthopedic injury rates were not significantly different between shod and unshod groups for foot, ankle, knee and hip injuries; however, knee injury rates were higher in the unshod group. Total reported injury rates were no different between shod and unshod participants.

Injury rates based on foot strike pattern

	MFS/FFS (SD)	RFS (SD)	p-value
Foot Injury Rate	0.07 (+/- 0.26)	0.17 (+/- 0.38)	0.3543
Ankle Injury Rate	0.33 (+/- 0.49)	0.25 (+/- 0.44)	0.5528
Knee Injury Rate	0.47 (+/- 0.52)	0.22 (+/- 0.42)	0.0839
Hip Injury Rate	0.07 (+/- 0.26)	0.17 (+/- 0.38)	0.3543
Combined Injury Rate	0.23 (+/- 0.38)	0.20 (+/- 0.40)	0.7651

Table 2: Injury rates of midfoot/forefoot strikers (MFS/FFS) as compared to rear foot strikers (RFS). Self-reported orthopedic injury rates were not significantly different between MFS/FFS and RFS for foot, ankle, knee and hip injuries. Total reported orthopedic injury rates were no different between MFS/FFS and RFS patterns.

Injury rates based on mileage walked per day

	0-2 miles/day (n=34)	3+ miles/day (n=17)	p-value
Injury Rate (SD)	0.19 (+/- 0.14)	0.29 (+/- 0.11)	0.4783

Table 3: Total combined injury rates based on mileage walked per day. There was no significant difference between participants who walked 0-2-miles/day and those who walked >3-miles/day.

Injury rates based on mileage run per day

	0-2 miles/day (n=39)	3+ miles/day (n=12)	p-value
Injury Rate (SD)	0.21 (+/- 0.10)	0.23 (+/- 0.24)	0.8187

Table 4: Total combined injury rates based on mileage run per day. There was no significant difference between participants who ran 0-2-miles/day and those who ran >3-miles/day.

Injury rates based on hours of weekly sports participation

	0 hours (n=28)	1-10 hours (n=17)	10+ hours (n=6)	X^2
Foot Injury Rate	0.07	0.18	0.17	0.787
Ankle Injury Rate	0.21	0.35	0.17	0.619
Knee Injury Rate	0.25	0.24	**0.67**	0.102
Hip Injury Rate	0.11	0.18	0.17	0.787
Combined Injury Rate	**0.16**	**0.24**	**0.29**	0.700

Table 5: Injury rates based on hours of weekly sports participation. There was no significant difference between participants based on level of sports participation. However, there was a trend toward higher injury rates with higher sports participation.

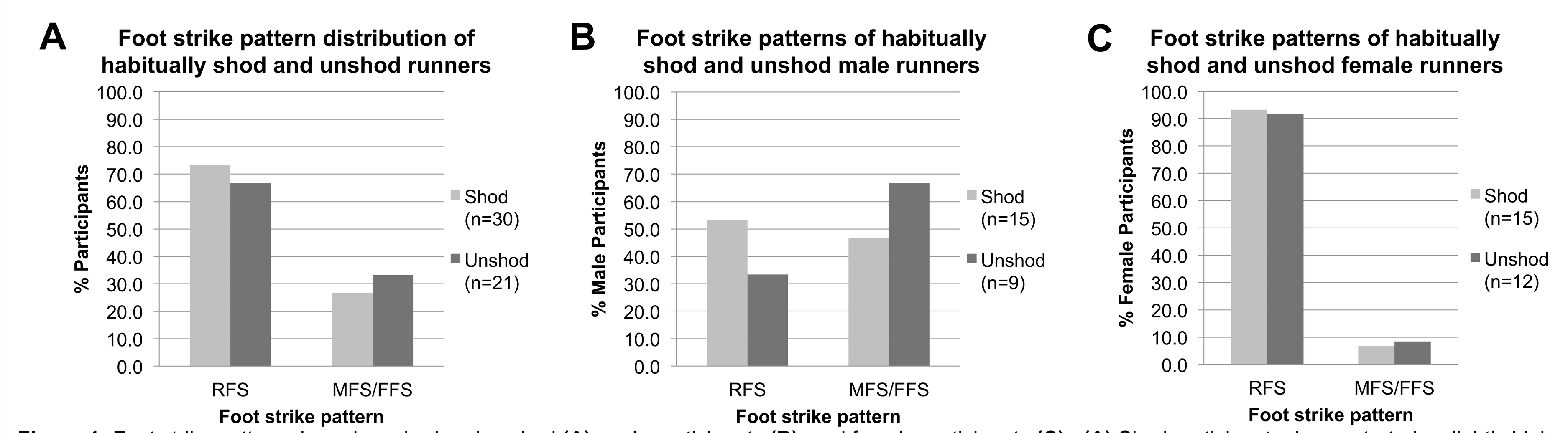


Figure 1: Foot strike patterns based on shod and unshod **(A)**, male participants **(B)**, and female participants **(C)**. **(A)** Shod participants demonstrated a slightly higher percentage of RFS and a slightly lower percentage of MFS/FFS as compared to unshod participants. **(B)** Male participants demonstrated a larger difference between shod and unshod groups, with more shod males being RFS and more unshod males being MFS/FFS. **(C)** Shod and unshod female participants demonstrated no difference between RFS and MFS/FFS patterns with the vast majority (>90%) of female participants being RFS.

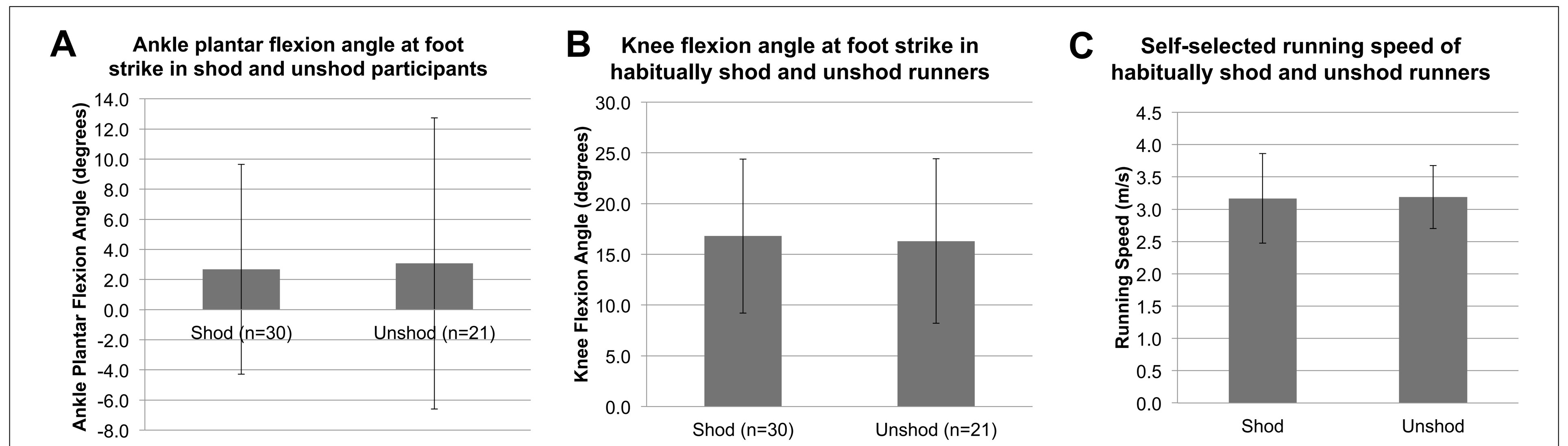


Figure 2: Biomechanics based on shod or unshod condition. Comparisons of ankle plantar flexion angle **(A)**, knee flexion angle **(B)** and self-selected running speed **(C)** at initial contact in shod and unshod runners. Ankle plantar flexion angle, knee flexion angle and self-selected running speed were not different between habitually shod and unshod runners at initial contact.

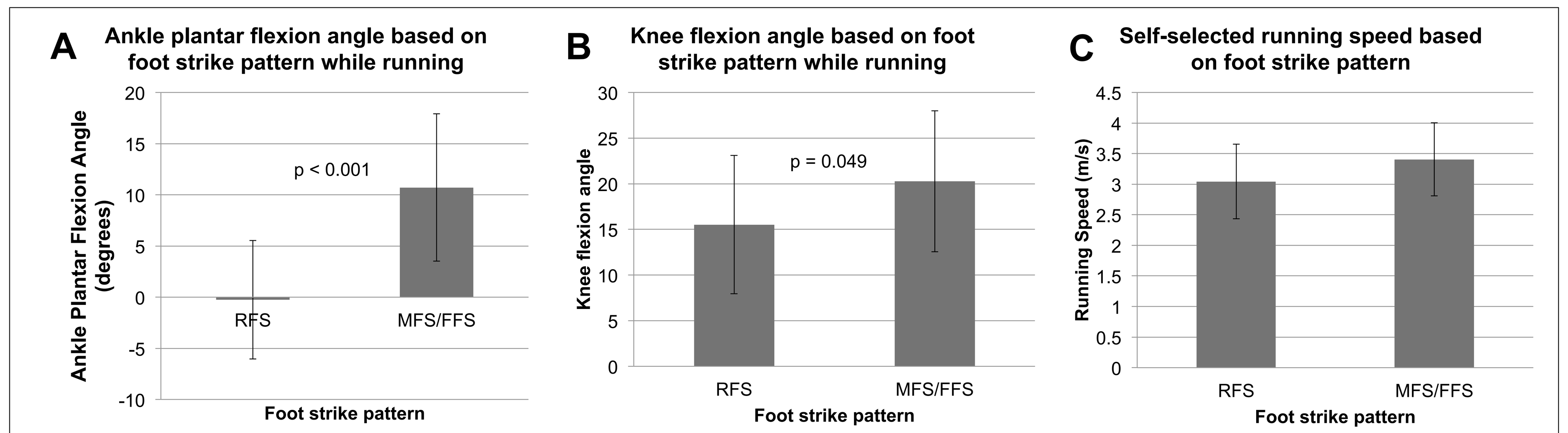


Figure 3: Biomechanics based on foot strike pattern. Comparisons of ankle plantar flexion angle **(A)**, knee flexion angle **(B)** and self-selected running speed **(C)** at initial contact in between RFS and MFS/FFS. Ankle plantar flexion angle and knee flexion angle were significantly greater in MFS/FFS compared to RFS. MFS/FFS were faster than RFS, but the difference was not significant.

Discussion

- ❑ No significant differences in injury rates seen when comparing:
  - ❑ Shod versus barefoot
  - ❑ Foot strike patterns
  - ❑ Mileage walked or run
  - ❑ Sports participation
- ❑ Goss et al. (2012) suggests there *is* a relationship between running mechanics and injury rate However, our study investigates habitually shod and unshod populations, allowing for longer tissue adaptation time.
- ❑ No significant differences in foot strike pattern between shod and unshod groups
  - ❑ There is a higher percentage of male MFS/FFS in the barefoot group as compared to the shod group.
  - ❑ Most females demonstrate RFS patterns.
- ❑ Biomechanical differences at initial contact and self-selected running speed are more attributable to foot strike pattern rather than the shod or unshod condition, which is consistent with biomechanical analysis by Shih et al. (2013).
- ❑ Further research studies are needed to investigate how injury rate is related to tissue adaptation time, physical activity level, gender and degree of footwear support in a population of habitually shod and unshod runners.

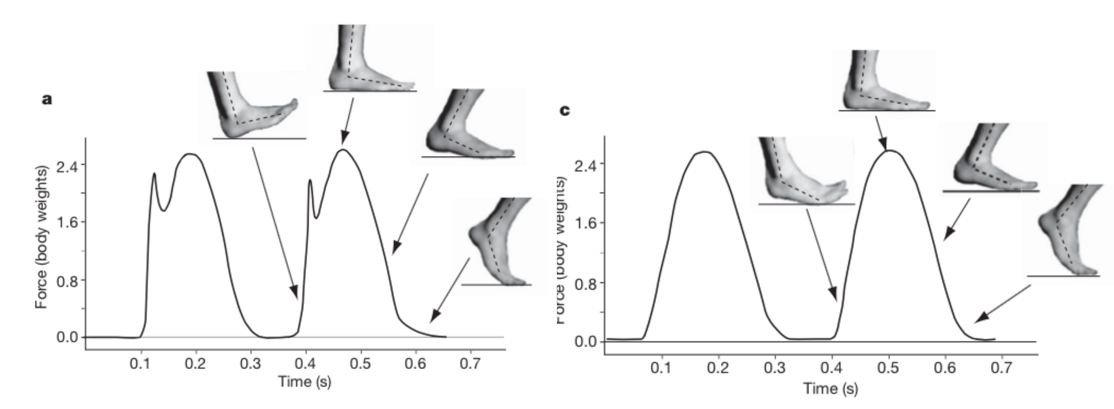


Figure 4: Biomechanics of foot strike pattern and vertical ground reaction force as a result of different foot strike patterns as illustrated by Lieberman et al. (2010).

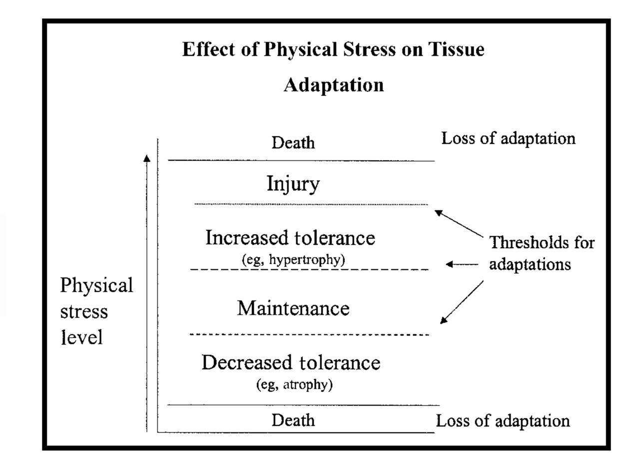


Figure 5: Effect of physical stress on tissue adaptation as modeled by Mueller et al. (2002).

Declarative Statements

- Therapists should educate patients on the insignificance of footwear or foot strike running pattern in regard to injury risk.
- Development of individualized training programs with considerations for tissue adaptation time should be standard of care to reduce risk of injury for runners who desire to change their foot strike patterns or footwear.
- Therapists should educate patients that increasing running mileage to >3-miles per day does not increase injury rate; however, therapists should develop individualized training programs to accommodate the increase in mileage.

References

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