# TRANSITIONING FROM ROAD RUNNING TO TRAIL RUNNING

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The purpose of this experiment was to discover possible biomechanical differences in running gait, foot-strike patterns, and ground reaction forces between running over uneven terrain (i.e., a trail) and smooth terrain (i.e., road). Participants ran repeatedly over an artificial, rough trail and a smooth, smooth section. Video analysis was used to determine any differences in gait and foot-strike patterns. A force platform was used to determine ground reaction forces. A repeated measures ANOVA revealed no significant difference in gait or ground reaction forces, while a Chi-Squared analysis revealed significantly more forefoot strikes while running over uneven, rough terrain.

**KEYWORDS**: foot-strike patterns, step length, stride frequency, terrain

**INTRODUCTION:** Running is an increasingly popular recreational activity. A subset of running, trail running, is gaining popularity. A recent survey by the Outdoor Foundation showed that 4.8 million runners participated in trail running in 2009, and 13% of these tried trail running for the first time in that year. Trail runners now make up 10% of the running community (Outdoor foundation, 2010). Currently, there is only anecdotal information on the transition from road to trails, and this information is mostly about what to bring and wear on a run. There is no information on how to properly navigate obstacles.

Running mechanics have been shown to change when running over uneven terrain (Hebert-Losier, Mourot, & Holmberg, 2015; Muller & Blickhan, 2010). Running over obstacles is a very complex motor skill that involves numerous components and degrees of freedom. (Stergiou, Jensen, Bates, Scholten, & Tzetzis, 2001a; Stergiou, Scholten, Jensen, & Blanke, 2001b). When these degrees of freedom are mastered a stable gait may be achieved. (Stergiou et al., 2001b). When examining intra-limb coordination, Stergiou and colleagues (2001) found that an obstacle 15% of the standing height of the subject caused the subject to land using a forefoot strike as opposed to a heel strike (Stergiou et al., 2001b). They hypothesized that this transition is a subconscious preventative mechanism to lower the ground reaction force on the heel (Stergiou et al., 2001b). This study, however, used regularly spaced obstacles that would not occur during trail running. Therefore, the purpose of the present study was to examine possible biomechanical differences in running gait, foot-strike patterns, and ground reaction forces between running over uneven, irregular terrain (i.e., a trail) and smooth terrain (i.e., road).

**METHODS:** Ten recreational runners (6 males, 4 females) were recruited for this study. All participants completed all trials on the same day during the same testing period. Each participant signed a written consent prior to receiving a brief oral description of the test's purpose and methods to establish compliance with the guidelines developed by the Institutional Review Board (IRB). By approving this study (HS14-621) the IRB of Northern Michigan University ensured that all subjects were treated fairly, ethically, and within their human rights.

Following written consent, measures of height and weight were collected. In addition participants were asked to estimate the number of miles they ran in the last six months as well as the percent of time spent running on trails (see Table 1). Participants were then asked to complete 18 running trials of approximately 50 meters. Participants completed 3 trials at 3 self-selected paces of slow, moderate, and fast on both terrain conditions (smooth, and uneven, irregularly rough).

The running section consisted of a 2.44 meter (8 foot) wooden platform. The wooden platform was divided along the length into two equal sections, one side was smooth representing running over smooth terrain, the other, representing the uneven terrain, had wooden boards and modular climbing holds randomly attached as obstacles. The height of the obstacle ranged from 2 cm-6 cm. (See figure 1)

**Figure 1: Photo of the running section. Left represents the uneven terrain right the even terrain.**

This section was elevated to match the height of an AMTI force plate (Accupower, AMTI, Watertown, MA). The force plate was used to measure ground reaction forces at 300 Hz immediately following the running (i.e., the next foot-strike following the running section was onto the force plate). Another wooden platform of the same dimension without obstacles was placed immediately before the running sections and immediately following the force platform to ensure a level surface prior to the running sections and following the force platform. Participants were asked to run over the running sections as natural as possible and encouraged not to change gait in order to hit the force platform.

The running trials were performed in front of a video camera (Casio High Speed Exilim, Tokyo, Japan) recording at 240 Hz from a sagittal view. Video analysis was performed using MaxTRAQ Standard Version 2 (Innovision Systems Inc. Columbiaville, MI, USA). Using this software the researcher was able to determine step length, stride frequency, and foot-strike pattern. Step length was defined as the distance from the back of the shoe on one foot contact to the back of the shoe on the next contact with the opposite foot. Stride frequency was defined as the time elapsed from the point of contact with one foot to the point of contact with the other. Foot-strike patterns were determined by the angle of foot in the frame before contact: if the toe was elevated in comparison to the heel, then the foot-strike was considered to be a heel strike; if the toe was equal in height or lower than the heel, it was considered a forefoot strike.

All data were entered to SPSS Version 21 (SSPS Inc., Chicago IL, USA) for statistical analysis. An alpha of .05 was considered statistically significant ($p \leq 0.05$). A Chi-squared analysis was used to determine if step length and stride frequency on the uneven terrain differed by ten percent or more when compared to the mean of the trials on the even terrain. A Chi-squared analysis was also used to determine significant differences in foot-strike patterns between terrain conditions. A repeated measures ANOVA with a Bonferroni post hoc comparison was used to determine differences in ground reaction forces between the trials, speeds, and terrain conditions.

**RESULTS:** The Chi-squared analysis of step length revealed that there were significantly more trials on the uneven terrain in which the subjects decreased their step length by ten percent from the smooth terrain (p=.044). Chi-squared analysis revealed significantly less trials of the uneven terrain where the subject decreased their stride frequency by ten percent when compared to the even terrain (see table 2). The Chi-squared analysis of foot-strikes revealed significantly more forefoot strikes on the uneven terrain (see table 3). There were no significant differences observed for ground reaction forces between terrains. The mean and standard deviation for the uneven terrain and smooth terrain was 1750.83±446.73, 1697.18±388.522 respectively.

**Table 1**
**Depicts the Range, mean, and standard deviation (S.D.) for the weight, height, number of kilometers ran in the past 6 months and the percent of training kilometers on a trail**

| | Range | Mean | S.D. |
|---|---|---|---|
| Weight (kg) | 57.2-104.0 | 73.79 | ± 14.61 |
| Height (cm) | 162.5-189.2 | 177.08 | ± 9.855 |
| Training (km) | 16.1-2333.55 | 686.56 | ±49.58 |
| 0n trail (%) | 0-80 | 40.6 | ± 30.81 |

**Table 2**
**Depicts the number of trials on uneven terrain in which the step length and stride frequency differed by 10% of the mean on the smooth terrain. * Significantly different than same. ** Significantly different than lower.**

| Step Length | | | Stride Frequency | | |
|---|---|---|---|---|---|
| Lower | Same | Higher | Lower | Same | Higher |
| 44* | 27 | 19** | 15* | 42 | 33** |

**Table 3**
**Depicts the total number of foot-strikes for each speed condition and terrain condition.**

| | | Number of foot-strikes | | Significance |
|---|---|---|---|---|
| | | Uneven | Smooth | |
| Slow | Toe | 50 | 6 | <.0001 |
| | Heel | 25 | 64 | <.0001 |
| Moderate | Toe | 48 | 6 | <.0001 |
| | Heel | 21 | 52 | <.0001 |
| Fast | Toe | 38 | 6 | <.0001 |
| | Heel | 25 | 52 | <.0001 |

**DISCUSSION:** The purpose of the present study was to examine any biomechanical differences in running gait, foot-strike patterns, and ground reaction forces between running over uneven, rough terrain (i.e., a trail) and smooth terrain (i.e., road).
The present study showed there were significantly more trials in which the subjects shorten their step length when running over irregular uneven terrain. This is consistent with the findings by Hebert-Losier (2015) in which they examined the effect of surface condition on

running biomechanics in elite and amateur orienteering athletes (Hebert-Losier et al. 2015). Shortening the step length when running over difficult terrain is consistent with the common perception among coaches that “fast feet” are necessary for rapid and safe running (Herbert-Losier et al., 2015).
Stergiou and colleagues observed that when clearing objects less than or equal to 12.5% of the standing height of the subject, the foot retained the usual heel strike contact (Stergiou et al., 2001a; 2001b). Two separate studies showed that an obstacle height of 15% of the standing height of the subject was adequate in producing a behavioral change in that subject (i.e., changing the type of landing from a heel strike to a forefoot strike) (Scholten et al., 2002; Stergiou et al., 2001b). Although the present study did not control the obstacle height relative to the subject’s height, the maximum 6 cm high obstacles were nowhere near the reported 15% threshold (i.e., they were about 3% of the standing height of the shortest participant). Notably, the present study illustrated a change in foot-strike pattern behavior based on characteristics other than obstacle height. It is possible that the orientation of the obstacles and the distance between obstacles also played a role in modified foot-strike patterns.
The small number of subjects in the present study can be viewed as a significant limitation to the experimental design. In addition, due to the short running distance, 2.44 meters, gait stability could not be observed and therefore it was impossible to adequately determine improved gait stability in the habitual trail runners. Therefore no learning effect could be observed. However, this transition from heel strike to forefoot strikes was observed in all subjects and this transition may not be dependent on experience.

**CONCLUSION:** In conclusion, when introducing uneven, rough terrain into a running program, certain behavior changes may be observed. These alterations tend to include shortened step lengths and forefoot landings. By shortening their stride and landing on the forefoot, runners optimize agility and lateral movement (Jeffreys, 2006), which may be needed to navigate trails. Ultimately, using these strategies may encourage runners to optimize their foot placement and minimize injury.

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