Effects of Variations in Stride Frequency on Oxygen Consumption, HR and RPE During Decline Running

Annelise Kalmbach, Kaycie Makimoto, Dr. Nate P. Bachman and Dr. Gannon White
Colorado Mesa University, Grand Junction, CO

Abstract: Small variations in grade are found throughout road running races, but steep downhill or uphill grades are more common in many courses on trails. These variations from level running and moderate declines (< 5%) present a unique challenge and may utilize different stride mechanics to optimize running economy. The purpose of this study was to examine how variations in preferred stride frequency (PSF) affected physiological indicators during downhill running. Participants included eight recreationally active college students and methods involved having each participant run at level, -5% and –10% grades. Each variation in grade started with PSF and then either a 10% below or above PSF trial in a randomized order. Speed was set at a self-selected conversational pace during level running and used for all trials. Oxygen consumption was not significantly different between PSF and +10%, but did increase significantly at a –10% PSF. These results suggest that while a PSF or up to a 10% increase in SF are similar with regards to metabolic costs, a 10% decrease from PSF is more demanding for maintaining energy over longer runs with varying declines.

Introduction: Maintaining an optimal stride frequency (SF) and stride length are essential for better running economy. We naturally tend to select a preferred stride frequency (PSF) close to our optimal stride frequency (OSF), with experienced runners being closer to optimal than inexperienced runners who typically select a PSF below their OSF during level running [1]. In downhill running, stride length typically increases which may result in a new PSF, but are there changes to metabolic indicators when deviating from PSF on declines?

Methods:

- Participants included eight recreationally active college students (6 females, 2 males) between the ages of 19 and 22 (20.5 ± 1.1 yrs old).
- Participants selected a conversational pace during level running and this speed was used for all trials. Then for each level of incline (i.e., level, -5%, & -10%), a PSF was determined and a ± 10% of PSF was calculated and maintained by running to the beat of a metronome.
- Data from the last 30 seconds of each trial was averaged for VO_2 and HR. Two-way ANOVAs were used with each dependent variable (i.e., HR, RPE and VO_2) and if significant, Bonferonni post-hoc tests were used.

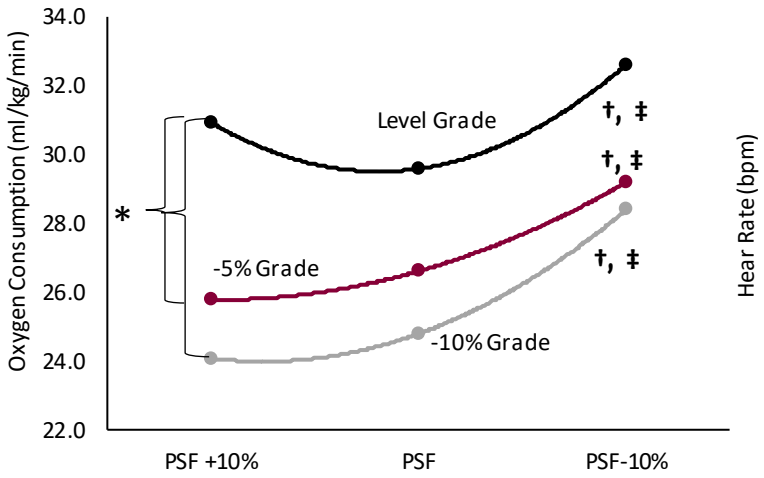

Figure 1: Mean oxygen consumption at each stride frequency and grade. * Across all stride frequencies, oxygen consumption significantly decreased from the level to both –10% ($p < 0.01$) and –5% ($p < 0.01$), but not between –5% and –10% ($p > 0.05$). † $p<0.01$ vs PSF+10%. ‡ $p<0.01$ vs PSF.

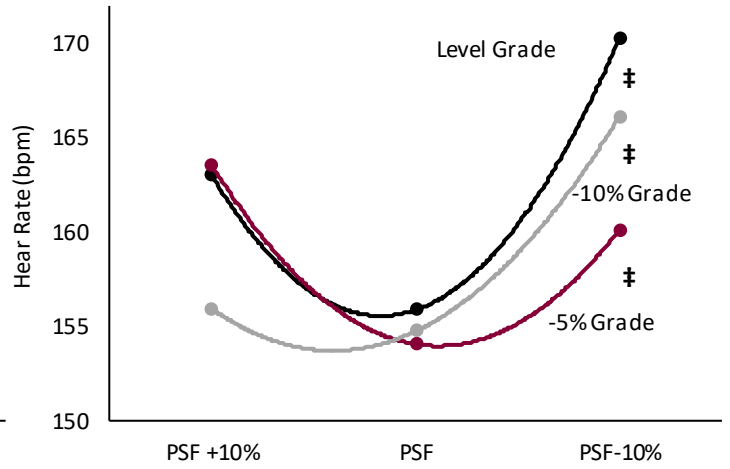

Figure 2: Mean heart rate at each stride frequency across the different grades of running. There was no significant difference between incline and heart rate ($p > 0.05$), but stride frequency did have an impact on heart rate. ‡ $P<0.05$ vs. PSF.

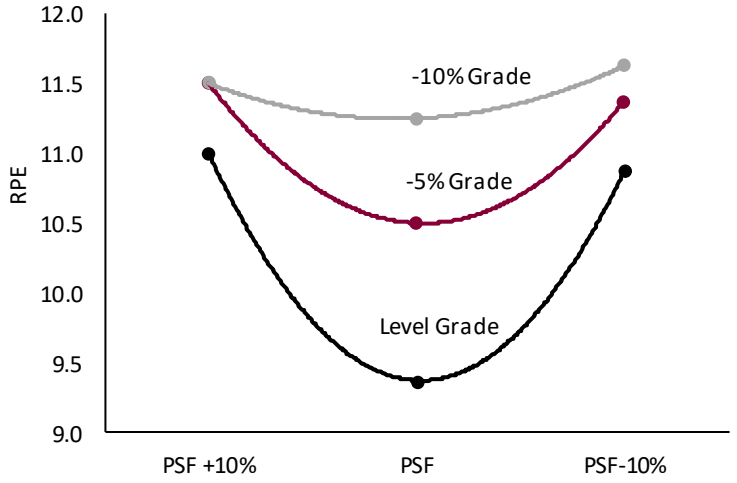

Figure 3: Mean RPE at each stride frequency across the different grades.

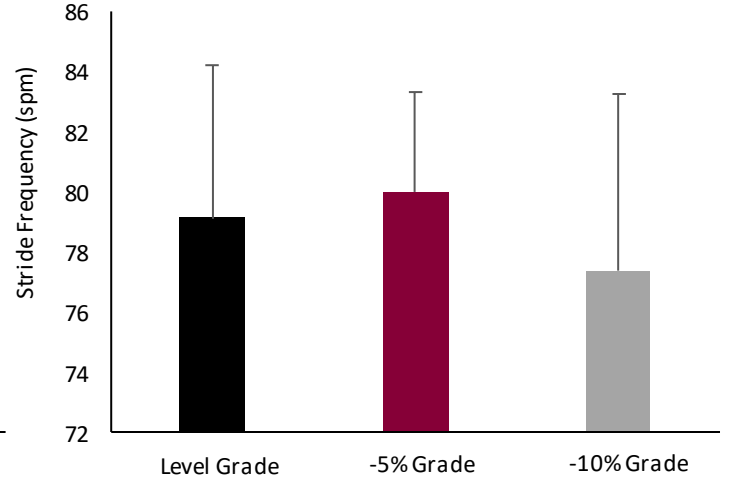

Figure 4: Mean PSF across the different grades. Error bars represent standard deviation.

Conclusions:

- In our study, the -10% PSF led to a significant increase in metabolic cost from the PSF and the +10% PSF across the three grades. There was no significant differences between the PSF trials and +10% trials on any grade (Figure 1).
- Although we expected a decrease in PSF during the -5% and -10% grades from the level trial, observed differences were not significant (Figure 4).
- Our results were similar to a past study on variations in SF in both uphill and downhill running involved variations from PSF of ±8% and ±15% on level, a 3-degree uphill and a 3-degree downhill grade [2]. They found that the intermediate stride frequency (i.e., PSF) on all grades was the most economical.
- The increased metabolic cost of the lower stride frequency (i.e., over-striding) could have practical applications in trail running performance. A past study on trail running with uphill and downhill segments found that the downhill segments had the greatest within-group variation [3]. Ability to adjust to difficult descents was crucial to overall performance, where they identified an increase in SF during downhill running and the ability to vary SF as important factors to successful performances [3].

Practical Application: These results suggest that lower SFs commonly associated with over-striding significantly increase metabolic costs, which can thereby negatively affect running performance.

References:

1 Oeveren, B., Ruiter, C., Beek, P., & Dieën, J. (2017). Optimal stride frequencies in running at different speeds. *PLOS ONE*, *12*(10), e0184273.

2 Snyder, K., & Farley, C. (2011). Energetically optimal stride frequency in running: the effects of incline and decline. *Journal Of Experimental Biology*, *214*(12), 2089-2095.

3 Björklund, Glenn, et al. (2019). Biomechanical adaptations and performance indicators in short trail running. *Frontiers in Physiology 10*, 506.