AN ELITE ATHLETE'S INITIAL UPHILL BATTLE

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INTRODUCTION: Maximal performance demonstrated in many athletic competitions hinges on an athlete's ability to accelerate. This acceleration is enhanced through the maintenance of optimal mechanics (e.g. forward trunk lean) facilitating production of high ground reaction forces behind the center of gravity (Bellon, 2016). As such, any attempt to improve an athlete's acceleration must develop the athlete's ability to demonstrate optimal kinematics. This establishes the need to integrate a skill development curriculum within the training agenda.

Procedural memory development states that the repetition of complex tasks will elicit adaptations that allow the task to be repeated in an autonomous manner (Gerrig, 2013). The inherently short durations of foot strike during acceleration demonstrates the value of leveraging the concept of procedural memory development during speed development curriculum. Short to long sprint training provides such a curriculum. Quite simply, the athlete first must master short sprints before executing these skills over lengthier durations or distance.

Several tools have been utilized in speed training curriculum in attempts to extend the time an athlete is exposed to accelerative positions. The most popular and researched tool to this point has been sled towing which has demonstrated usefulness in extending acceleration phase kinematics (Bentley, Atkins, Edmundson, Metcalfe, & Sinclair, 2014). However, the practical application of sled towing is limited by the need for equipment and appropriate loading strategies.

Incline sprinting eradicates the practical limitations of sled towing, thus providing more feasible implementation for the coach. Slawinski and colleagues (2008) provided an overview of the kinematics of incline sprinting, and demonstrated that the incline had significant impact on body positions and kinematics. What remains unclear is what phase of flat ground sprinting are reflected by these kinematics. The phase of acceleration in flat ground sprinting related to the kinematics of incline sprinting may establish where incline sprinting best fits into the speed development curriculum. However, such a comparison has not yet been made. Therefore, the purpose of the study was to explore the use of incline sprinting in maintaining kinematics like those demonstrated during flat ground sprinting. We hypothesized incline sprinting kinematics would mirror the early acceleration phase of flat ground sprinting.

METHODS: Data were collected over two days with a Team USA Bobsled athlete. During day one of data collection, the athlete performed three 20-meter sprints on a flat track as part of ongoing monitoring, the following day data were collected during speed development training on a 5-degree incline. During each session, 20 meters of Optojump (Microgate, Bolzano, Italy) track was placed on either side of the running lane to collect foot strike kinematic data. In both conditions the athlete started from a crouched start position with the following characteristics: lowered center of mass, staggered foot position, trunk inclined forward, weight shifted so that shoulders are slightly ahead of lead foot, lead foot 30-cm behind the start line, and opposite hand raised to head height. The crouched start allows the athlete to have similar positioning to the block start in track and field, with approximate rear and front knee angles of 135- and 90-deg respectively (Mann & Murphy, 2015).

The mean and standard deviation for the kinematic variables of step length (SL), step rate (SR), ground contact time (GCT), and flight time (FT) were calculated for each step in both the flat and incline condition. Effect sizes were then calculated, using Cohen's d, for each step in each condition to examine the similarity of the kinematics of each flat acceleration step to each incline acceleration step (Hopkins, 2002). Similarity between flat sprinting and incline step kinematics were determined by effect size, whereby a smaller value indicates greater kinematic similarity.

RESULTS: Table 1 and Figure 1 display the flat sprinting step with the greatest similarity to each incline sprint step with related effect size included in Table 1.

Table 1.

Most similar flat acceleration step to each incline step for kinematic variables

Incline Step	Stride Rate	ES	Stride Length	ES	Ground Contact Time	ES	Flight Time	ES
Step 1	Step 1	2.55	Step 1	2.03	Step 1	-3.06	Step 1	2.69
Step 2	Step 1	0.49	Step 2	1.09	Step 1	-0.72	Step 1	0.63
Step 3	Step 1	-0.62	Step 3	1.11	Step 1	1.45	Step 2	-0.48
Step 4	Step 2	0.28	Step 3	-1.33	Step 2	1.01	Step 3	0.09
Step 5	Step 4	-0.02	Step 4	-0.77	Step 3	0.04	Step 3	0.46
Step 6	Step 2	-0.14	Step 5	-0.17	Step 3	-0.74	Step 4	0.95
Step 7	Step 4	0.07	Step 6	0.73	Step 3	0.34	Step 3	0.05
Step 8	Step 2	0.04	Step 6	-0.42	Step 3	0.19	Step 4	-0.52
Step 9	Step 2	-0.21	Step 7	-0.73	Step 4	0.70	Step 5	0.05
Step 10	Step 5	0.06	Step 7	-1.01	Step 5	-0.13	Step 5	0.06
Step 11	Step 6	0.01	Step 8	0.57	Step 6	0.36	Step 6	-0.52

Note: Similarity of flat acceleration steps to incline acceleration steps determined by lowest observed effect size between each inline acceleration step and all flat acceleration steps.

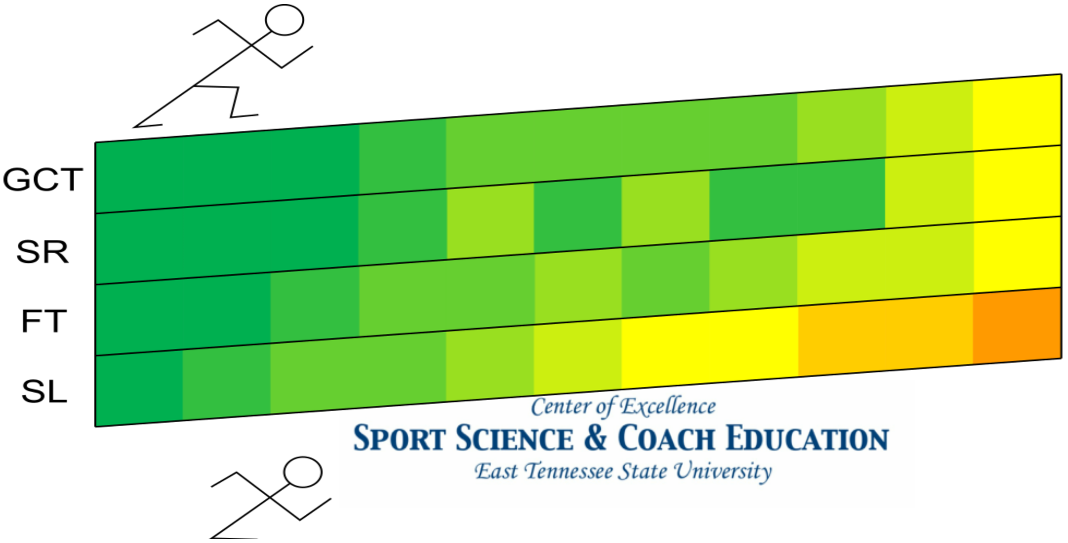

Figure 1. Most similar flat acceleration to incline step by kinematic variable.

DISCUSSION: The purpose of this study was to evaluate the kinematic similarities between incline sprinting and early acceleration phase flat ground sprinting. The primary kinematic variables examined in the present study were SR, SL, GCT, and FT, all of which demonstrated similarities to early acceleration values of flat-ground sprinting throughout the duration of the incline trials. Nagahara and colleagues (2014) identified that the first breakpoint, where there is a significant change in center of gravity height, occurs at approximately the fifth step. Based on the observed effect sizes, sprinting on the incline may allow the athlete to maintain kinematics typical of the phase from the start to the first breakpoint. By prolonging this initial phase of sprint performance, the athlete is allowed to develop higher levels of proficiency in the proper positions, force application, and stride turnover associated with accelerative abilities (Nagahara, Matsubayashi, Matsuo, & Zushi, 2014). Therefore, the incline sprint may be a useful tool to implement during the early phase of a short to long sprint progression, where the primary emphasis is the athlete's acceleration mastery, capitalizing on the concepts of procedural memory development.

Recall that procedural memory development entails that in skill mastery, proficiency is first required in sequenced parts of the whole (Gerrig, 2013). For that reason, when building programming for sprint mastery, it is logical to begin with a proper starting position, which the crouch start provides. A crouch start elicits similar kinematics to block clearance, including similarities in hip, knee, and torso angles (Shinohara & Maeda, 2015). This similarity allows the athlete to properly initiate the sprint and execute an effective first step, which would be the initial lesson in developing sprint ability (Čoh, Tomažin, & Štuhec, 2006). In the present study, the first step kinematics of the crouch starts on the flat and incline are not similar, most likely due to the differing heights of the ground at contact. This difference is misleading, however, as the development of start position skill is inherently present through the execution of repetitions in series. Further, the kinematic characteristics of the flat-ground first step do appear within incline sprinting. Despite a dissociation of time points, the presence of similar kinematics, combined with the repetition-based mastery of crouch start may allow the athlete to develop initial step proficiency through the summation of parts consistent with procedural memory development (Gerrig, 2013).

In addition to the need to learn proper positions in the development of acceleration is the need for the athlete to understand how to effectively produce force from these positions. Due to the extended ground contact time afforded by the incline, the athlete has a longer opportunity to produce concentric force. This is supported by previous studies, which have demonstrated concentric force production is favored during incline sprinting (Gottschall & Kram, 2005) Further, eccentric forces have been shown to be dampened by incline sprinting, which is also favorable for the athlete in allowing the coach to introduce these more stressful characteristics of sprinting at later stages of a curriculum. This affords the athlete adequate time to develop strength through resistance training and other means before being exposed to high rates and magnitudes of eccentric forces. Such a structure of training may allow the athlete to not only acquire skills in a progressive manner, but encounter higher magnitude stressors at a point of greater physical development.

This research supports the use of the incline sprinting during the early portions of a short to long speed development program, specifically emphasizing characteristics of acceleration prior to the first breakpoint (Nagahara et al., 2014). Not only does performing incline sprinting demonstrate favorable kinematics for maturing accelerative abilities, but may also provide the athlete with a less physically stressful environment in which to learn. While the present study provided evidence of favorable aspects of an acceleration curriculum, further research should explore pre- and post-effects of incline training on flat-ground sprint performance. Additionally, other developmental methods, including alternative training means or the transfer of characteristics of a specific warm-up to sprint mastery should be investigated.

REFERENCES

Bellon, C. (2016). The Relationship Between Strength, Power, and Sprint Acceleration in Division I Men's Soccer Players. *Electronic Theses and Dissertations*. Paper 3087. http://dc.etsu.edu/etd/3087.

Bentley, I., Atkins, S., Edmundson, C., Metcalfe, J., & Sinclair, J. (2014). A review of resisted sled training: implications for current practice. *Professional Strength and Conditioning*(34).

Čoh, M., Tomažin, K., & Štuhec, S. (2006). The biomechanical model of the sprint start and block acceleration. *Facta universitatis-series: Physical Education and Sport, 4*(2), 103-114.

Gerrig, R. J. (2013). *Psychology and life*: Pearson Higher Education AU.

Gottschall, J. S., & Kram, R. (2005). Ground reaction forces during downhill and uphill running. *Journal of biomechanics, 38*(3), 445-452.

Hopkins, W. G. (2002). A Scale of Magnitudes for Effect Statistics. Retrieved from http://www.sportsci.org/resource/stats/index.html

Mann, R., & Murphy, A. (2015). *The Mechanics of Sprinting and Hurdling: 2015 Edition*: CreateSpace Independent Publishing Platform.

Nagahara, R., Matsubayashi, T., Matsuo, A., & Zushi, K. (2014). Kinematics of transition during human accelerated sprinting. *Biology open, 3*(8), 689-699.

Shinohara, Y., & Maeda, M. (2015). The role of the starting block in sprinting and its influence on a crouch start *Japan J. Phys. Educ. Hlth. Sport Sci., 60*(December), 667-684.

Slawinski, J., Dorel, S., Hug, F., Couturier, A., Fournel, V., Morin, J., & Hanon, C. (2008). Elite long sprint running: a comparison between incline and level training sessions. *Medicine and science in sports and exercise, 40*(6), 1155.