A Video Analysis of Kinematic Parameters on up and Down Slope Sprinting Compared with Level Track Sprinting for Athletes

[a]Govindarao Itraju, [b]G.Vinod Kumar,

[a]Ph.D Scholar, Department of Physical Education and Sports, Pondicherry University, Puducherry, India

[b]Associate Professor, Department of Physical Education and Sports, Pondicherry University, Puducherry, India

Abstract

The purpose of this study was to examine the upward slope and downward slope sprinting compared with level track sprinting for athletes during the acceleration and top-speed phases of a sprint by the video analysis. 10 volunteer subjects completed 3 trials of each of 4 conditions: upward slope sprinting (USS); downward slope sprinting (DSS); level track sprinting (LTS); and, sprint start (SS). One trial per subject per condition was randomly selected for kinematic analysis. Video coverage was collected in the sagittal plane for 20mts full strides and analysed in Ariel Performance Analysis System (APAS) software. Statistical analysis found no significant differences between uphill sprinting and downhill sprinting for any kinematic parameters. No significant differences were found between USS and SS for any kinematic parameters. USS differed significantly ($p>0.05$) from both DSS and SS for average running speed, stride length and ground contact time, Further research is needed to clarify the usefulness of uphill sprinting and downhill sprinting as training techniques to improve sprint performance.

KEYWORDS: sprinting, kinematics, upward slope sprinting, downward slope sprinting.

INTRODUCTION

Sprinting speed is defined with the frequency and the length of strides (Mann and Herman, 1985; Ae et al., 1992; Delecluse et al., 1998; Brűggemann et al., 1999; Gajer et al., 1999; Ferro et al., 2001). These parameters are mutually dependant with their optimal ratio enabling maximal sprinting speed. The increase of speed can be achieved by increased length or frequency of strides. The increase of both parameters simultaneously is quite difficult due to mutual dependency. Therefore an increase in one factor will result in an improvement in sprint velocity, as long as the other factor does not undergo a proportionately similar or larger decrease (Hunter at el., 2004). Increased frequency results in shorter stride length and vice versa. Therefore the increase in stride length must be directly proportional with the decrease of stride frequency, especially at the beginning of the race – the initial acceleration phase (Mackala, 2007). This relationship is individually conditioned with the processes of neuro-muscular regulation of movement, morphological characteristics, motor abilities and energy substrates (Mann and Sprague, 1980; Mero et al., 1992; Harland and Steele, 1997; Novacheck, 1998; Coh et al., 2001; Prampero et al., 2005).

While the biomechanics of sprint running have been relatively well researched (e.g., Mero et al., 1992), there have been very few investigations of the biomechanics of the various drills and exercises commonly used in training for speed. Thus, there is a lack of understanding as to the benefits and/or effectiveness of many of the drills and exercises used in this type of training. Despite the popularity of both uphill and downhill methods of sprint training, and the commercial availability of various devices for carrying out the training, the evidence to support these training methods has been largely anecdotal. As a result, it remains unclear as to what biomechanical, neuromuscular and physiological changes may be induced by this type of training, as well as its effectiveness in improving sprint performance.

There have also been positive claims for the benefits of training on combined uphill and downhill sloping surfaces, although again these claims have not been substantiated with published experimental data.1,5 Only Paradisis and Cooke have assessed the effects of 6 wk combined uphill–downhill sprinting training, on sloping surfaces of 3° and showed improvements on MRS and step rate by 3.5% and 3.4% respectively. In addition, the horizontal training and control groups did not produce any statistically significant changes.

Statement of the Problem

The purpose of this study was to examine the basic kinematics of sprinting under upward slope and downward slope conditions as compared to standard level track sprinting in the acceleration and over speed phases.

METHODOLOGY

Selection of Subject

The athletes who were sprinters represented in the intercollegiate level of completion are selected for this study. Subjects were recruited from the Aditanar group Institution, Tiruchendur, Tamilnadu, India of track and field team. Ten male subjects volunteered to take part in the study (age 19 to 23 years, height 1.61 ±0.14m, mass 58.0 ±12.0 kg). All of the subjects had some experience with upward slope and downward slope sprint training methods. Subjects were instructed in the use of the specific over speed sprint training to be used in the study. Once the study had been explained to the subjects, signed consent was obtained. The data collection took place at the track facility at the Dr.Sivanthi Aditanar College of physical education, Tiruchendur, Tamilnadu.

Materials and Methods of Collection of Data

The subjects were videotaped while performing under each of the experimental conditions (i.e., sprint start, sprint, upward slope sprint and downward slope sprint). The order of the conditions was randomised to reduce any order effect. Subjects performed a block of three trials for each of the four conditions, resulting in a total of 12 trials per subject. One trial per condition per subject was selected for kinematic analysis, giving a total of 40 trials.

For the standard level track sprinting condition (LTS), subjects were given a 30m acceleration zone prior to the filming area to reach top running speed. This same set-up was used in the upward slope sprinting condition (USS) and downward slope sprinting condition (DSS). For the sprint start condition (SS), the starting blocks were setup 20m prior to the (video take) filming area. In the downward slope sprinting condition (DSS), the athletes were started for 20 meters before entering the filming area – the shorter acceleration zone was used since the athletes could reach top speed sooner due to the support running. The athletes were sprint their maximum over speed to complete the distance. Video of the subjects was collected using standard two-dimensional videography with digital video cameras (60Hz). Two cameras were positioned with overlapping fields of view to allow a sagittal plane view of the entire subject for at least two full running strides (approximately 10 meter field of view). The close videography was taken from 10 meters maximum marked area for analysis. Video was analysed with the APAS motion analysis system. The data was smoothed using a video cutter and filter for frequencies. Analysis of variance was used for statistical analysis of the kinematic measures to identify trends across the four conditions.

RESULTS

The mean values for average running speed, stride rate, stride length and support time are presented in Table 1. The downward slope sprinting (DSS) condition resulted in an average increase of 6.8% in average running speed as compared to the level track sprinting (LTS) condition. The upward slope sprinting (USS) condition resulted in an average decrease of -7.1% in average running speed as compared to the level track sprinting (LTS) condition. The average running speed for downward slope sprinting (DSS) was significantly faster than that of upward slope sprinting (USS) condition ($p<0.05$) but not from level track sprinting (LTS).

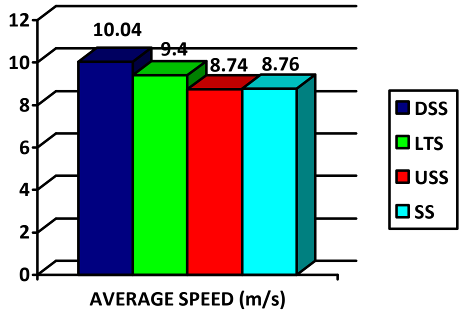
Average running speed can be viewed as the product of stride rate and stride length. Stride rate was not significantly different between any of the conditions. Stride length was significantly greater in downward slope sprinting (DSS) as compared to upward slope sprinting (USS) and sprint start (SS). Ground support time was significantly shorter in downward slope sprinting (DSS) as compared to upward slope sprinting (USS), No significant differences were found between DSS and LTS for these parameters. Similarly, no significant differences were found between USS and SS for these parameters.

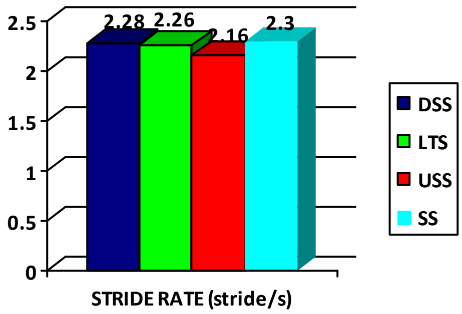
Table: Mean and Standard Deviation of Basic Kinematic Parameters

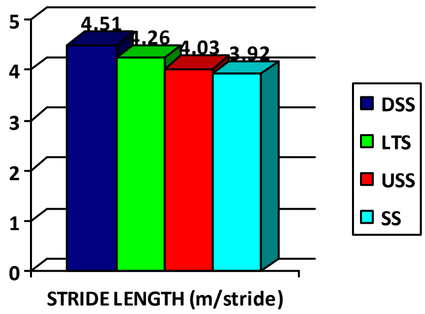
Experimental Condition	Average Speed (m/s)	Stride Length (m/stride)	Stride Rate (stride/s)	Support Time (s)
Downward Slope Sprinting (DSS)	10.04 (0.77)	2.28 (0.14)	4.51 (0.30)	0.103 (0.012)
Level Track Sprinting (LTS)	9.40 (0.68)	2.26 (0.14)	4.26 (0.31)	0.114 (0.012)
Upward slope Sprinting (USS)	8.74 (0.72)	2.16 (0.12)	4.03 (0.28)	0.122 (0.008)
Sprint Start (SS) (Acceleration phase)	8.76 (0.60)	2.30 (0.17)	3.92 (0.19)	0.123 (0.014)
Overall	9.24 (0.85)	2.25 (0.14)	4.18 (0.35)	0.116

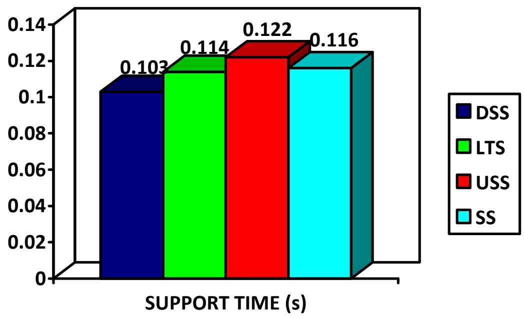
				(0.014)

Figures









DISCUSSION

The present data suggest that the greater average running speed in DSS versus LTS (10.04 m/s vs. 9.04 m/s) might be due to increases in stride length (4.51 m/s vs. 4.26m/s), although no significant differences were noted in running speed and stride length between DSS and LTS. It seems logical that the longer stride length in DSS would be due to the external force of the body weight falling towards running face. No significant differences were found between USS and SS for any of the kinematic parameters. USS and SS were very similar in average running speed (8.74 m/s vs. 8.76 m/s), stride length (4.03 m vs. 3.92 m), and support time (0.122 s vs. .123 s). This suggests that the kinematics of USS is similar to SS. The present study supports the notion that downhill sprinting has similar kinematics to cinder track sprinting, and that uphill sprinting has similar kinematics to the acceleration phase of sprinting (start sprint). Further research is required to clarify what, if any, benefits may be gained from the use of these training modalities in regards to long-term changes in sprinting mechanics leading to improved sprint performances.

CONCLUSIONS

1. The results of this study indicate that downward slope sprinting (DSS) has similar kinematics to standard level track speed sprinting (LTS).
2. Downward slope sprinting (DSS) does not have greater stride rates than level track sprinting (LTS).

3. Upward slope sprinting (USS) has similar kinematics to the acceleration phase of a sprint (start sprinting SS).
4. Coaches and athletes should carefully consider the biomechanical parameters and neuromuscular patterns associated with any sprint training modality before committing extensive training time to these special methods.

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