KINEMATICS OF ASSISTED AND RESISTED SPRINTING AS COMPARED TO NORMAL FREE SPRINTING IN TRAINED ATHLETES

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The purpose of this study was to examine the kinematics of sprinting under assisted (or overspeed) and resisted conditions as compared to normal sprinting during the acceleration and top-speed phases of a sprint. Six volunteer subjects completed 3 trials of each of 4 conditions: assisted sprinting (AS); free sprinting (FS); resisted sprinting (RS); and, sprint start (SS). One trial per subject per condition was randomly selected for kinematic analysis. Video (60 Hz) was collected in the sagittal plane for two full strides and analysed in 2D using an 8-point, 6-segment model with APAS software. Statistical analysis found no significant differences between AS and FS for any kinematic parameters. No significant differences were found between RS and SS for any kinematic parameters. AS differed significantly ($p<0.05$) from both RS and SS for average running speed, stride length, ground contact time, and trunk angle. Further research is needed to clarify the usefulness of AS and RS as training techniques to improve sprint performance.

KEY WORDS: sprinting, kinematics, assisted, overspeed, resisted.

INTRODUCTION: Sprinting can be defined as the ability to run at maximum speed for a short duration. Maximum running speed is an important factor for success in many sports. Different modalities of training have been employed in the development of maximum running speed. 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.

Two commonly used forms of speed training are assisted (or overspeed) and resisted sprinting. During assisted sprinting, the athlete runs while being pulled along by some type of device, often an elastic cord or a rope-and-pulley system. During resisted sprinting, the athlete runs against some type of resistance, often in the form of a weighted object or a parachute that the athlete tows behind them. It has been speculated by coaches that these training methods will induce changes in an athlete's sprinting ability. Despite the popularity of both resisted and assisted 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.

Knicker (1997) examined the effects of external resistance on sprinting mechanics and found that even small resistance loads could result in considerable changes in kinematics and coordination of muscular activity as seen in EMG patterns of lower limb muscles. He also noted that resisted sprinting was "similar but not identical" to the acceleration phase of a sprint. Corn and Knudson (2003) looked at kinematics of the acceleration phase of a sprint under free and assisted conditions. They found that towing with an elastic cord during the acceleration phase resulted in significant differences in running speed, stride length and touchdown distance of the contact foot between the free sprint and the assisted sprint (Corn & Knudson, 2003). Mero and Komi (1987) examined electromyography (EMG) and ground reaction forces (GRF) during sprinting from sub- to supra-maximal speeds; the supra-maximal speeds were achieved by way of a towing system. The analysis of GRF showed that the average resultant force during the braking phase of ground contact increased significantly from sub- to supra-maximal speeds, but no significant differences were found in the propulsion phase (Mero & Komi, 1987). A training study by Majdell and Alexander (1991) examined the effects on sprint kinematics of overspeed training as compared to conventional sprint training. After a 6-week training program, they found no significant differences in kinematics between the training methods with the exception of ground contact time, which was reduced by the overspeed training approach (Majdell &

Alexander, 1991).

The purpose of this study was to examine the basic kinematics of sprinting under assisted and resisted conditions as compared to free sprinting in the acceleration and top-speed phases. It was hypothesized that: (1) the kinematics of the assisted and free sprint conditions would not differ significantly; (2) the kinematics of the resisted sprint and sprint start conditions would not differ significantly; and, (3) the assisted condition would result in the greatest stride length and trunk angle, and the shortest ground contact time.

METHOD: Subjects were recruited from the University of Alberta track and field team. One female and five male subjects volunteered to take part in the study (age 21.8 1.7 years, height 1.78 0.08 m, mass 77.0 8.6 kg). All of the subjects had some experience with assisted and resisted sprint training methods. Subjects were instructed in the use of the specific assistance and resistance sprint training devices 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 indoor track facility at the University of Alberta, Edmonton AB. The subjects were video taped while performing under each of the experimental conditions (i.e., sprint start, free sprint, resisted sprint and assisted 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 24 trials.

For the free sprinting condition (FS), 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 resisted sprinting condition (RS). Resistance was from a resistance chute of approximately 1 m2 attached to a waist belt (Kytec medium economy chute). For the sprint start condition (SS), the blocks were setup 20m prior to the filming area. In the assisted sprinting condition (AS), the athletes were towed 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 assistance of the towing device. The athletes were towed with a rope-and-pulley overspeed system (Stroops Double-Time overspeed trainer) operated by a certified coach with extensive experience in the use of such a training device.

Video of the subjects was collected using standard two-dimensional videography with JVC 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). Subjects were fitted with lightweight retro-reflective hemispherical markers 1cm in diameter over the joint centres on the right side of the body. Video was analysed with the APAS motion analysis system. The video was analysed using a 6-segment spatial model representing the forearm, upper arm, trunk, thigh, shank, and foot on the right side of the body (see Figure 1). The data was smoothed using a Butterworth digital filter with cut-off frequencies of 6 Hz in the horizontal and 8 Hz in the vertical. Analysis of variance was used for statistical analysis of the kinematic measures to identify trends across the four conditions.

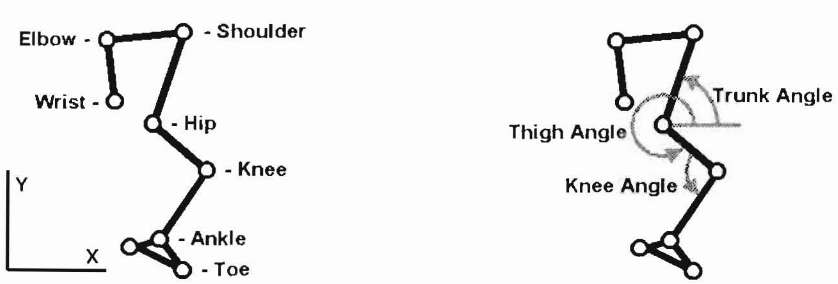

Figure 1: (a) Spatial model used for kinematic analysis, and (b) angular definitions.