KINEMATIC AND KINETIC STUDY OF RUNNING TECHNIQUE AT DIFFERENT HIGH SPEEDS IN BLIND PARALYMPIC AHTLETES

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The purpose of this study was to analyse the running technique of the best five Spanish B1 Blind Paralympic Athletes, at different percentages of sprint velocity: 40, 60, 80 and 100. The results were compared with a control group of top performance sprinters, in order to provide coaches with useful information for the design of learning technique strategies and specific training programmes to improve their athletes' performance. Three-dimensional cinematographic techniques were used for the kinematic analysis. Two force platforms registered ground reaction forces (GRF) for the kinetic analysis. Kinematic variables show clear differences in skill level between both groups. The data of GRF explains the kinematic results and reveal the sprinters' load pattern.

KEY WORDS: Biomechanics, blind athletes, kinematics, kinetics, running, sprinting.

INTRODUCTION: Running is a rapid form of bipedal locomotion used in most physical and sports activities which require speedy body movement. Many authors have researched and published papers on the biomechanics of long-distance running techniques, but there is little literature on medium and high speed running (Dillman, 1975; Frishberg, 1983; Mero *et al.*, 1992; Luhtanen & Komi, 1978; Pink *et al.*, 1994, Saito *et al.*, 1974). The analyses of ground reaction forces have been performed at low running velocities (Cavanagh & Lafortune, 1980; Munro *et al.*, 1987; Miller, 1990) as well as the wide description of the upper limb pattern (Hinrichs, 1990). On the other hand, only a few studies have been published on the kinematic of the running technique of blind athletes by Arnhold & McGrain (1985), Gorton & Gavron (1987) and Pope *et al.* (1986). The performance of the Spanish Blind Paralympic Athletes (B1), which is of a high international standard, is becoming more interesting to the general public as it shows a high level of cultural and sport sageness (Ferro, 1993, 1999). The maintenance or even the improvement of this level is the task which both, coaches and experts, by investigating various fields related to sports, such as, physiology, psychology, biomechanics, etc. The purpose of the present research project is to analyse the running technique of category B1 blind athletes in order to contribute, together with coaches, to enhance our understanding of such techniques and improve their performance. The results ensuing from this study are intended to be applied to: a) describe the variables related to running speed from the kinematic and kinetic perspectives; b) obtain comparative data between B1 athletes and world class sprinters; c) provide coaches with objective information so that they can plan their training sessions and design adequate methods to teach the technique.

METHOD: Kinematic and kinetic analyses of running technique were carried out with a group of B1 blind athletes. The kinematic analysis using three-dimensional cinematographic techniques was performed with two high-speed cinema cameras (*Photosonic 16mm-1PL*) filming at 150 Hz. The kinetic analysis of ground reaction forces was carried out using a force platform (*Dinascan 600 M*) which registered at 1.000 Hz. The individual velocity was controlled with chronometer-photocells (*Seiko*). Five blind (B1) paralympic sprinters took part in the study with the control group (C) consisting of four national top level sprinters. Field movement analysis was carried out in controlled conditions. Two complete strides at four different speeds (40%, 60%, 80% and 100% of maximum velocity) were analysed to study the running technique. Both kinematic and kinetic analysis data were processed with specialised software (*Fotogram-IBV and Dinascan-IBV*). The processing of results consisted of a three-way ANCOVA with repeated measurements: 1°) Group, Intersubject variable (independent groups) with two levels: blind and control athletes. 2°) Support, intrasubject variable (related measurements) with two levels: right and left. 3°) Speed, Intrasubject variable (related measurements) with four levels: 40%, 60%, 80% and 100% of maximum speed. The covariate considered was the individual speed at each percentage.

RESULTS: The kinematic study of running at increasing velocities suggested significant differences between B1 and C athletes and showed the relationship of the biomechanical variables to velocity. Total contact time and initial contact time ("initial braking phase") was longer in B1 (p=0.02) (figure 1), while the duration of the flight phase was shorter (p=0.004) and the vertical oscillation of the centre of gravity (CDG) was lower (p=0.014). In his turn, total contact time, flight phase and vertical oscillation in CDG decreased with increasing velocity in both groups (p<0.001).

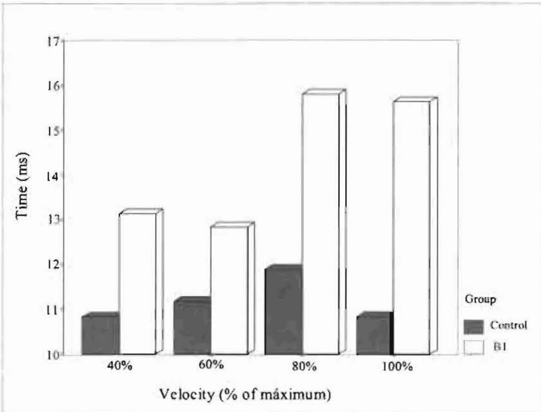

Figure 1. Initial braking phase.

Stride rate was greater in B1 (p=0.006) and went up with increasing velocity (p<0.001), while stride length decreased at sprint (figure 2). The lower limb pattern was studied in both groups. Maximum thigh flexion angle (in the flight phase) was significantly lower in B1 (p<0.003) and increased with higher speeds in both groups (p<0.02). Similar results were obtained for maximum anteroposterior velocity of the thigh segment, which has the higher mass of the lower limb. Knee, thigh and ankle angles were significantly different with the increases in velocity in both groups. The analysis of vertical ground reaction forces (GRF) indicated significant differences between blind and control runners. At sprint velocity the values of average vertical GRF were 1.82 BW and 2.29 BW, respectively, (p=0.001) and the values of "maximum thrust" (so designated to the peak following the "impact" peak in the force record) were 2.96 BW and 3.43 BW, respectively (p=0.008). Stance time for B1 decreased with increases in velocity from 169 ms to 118 ms (p=0.001). The unloading rate of vertical GRF rose with increases in velocity from 29 to 47 BWs^{-1} (p<0.001) being greater in control athletes (p< 0.02). No differences were found between left and right foot contact. The analysis of the braking-propulsion component of the GRF indicates different values between groups (p=0.024), rising in B1 from 55% BW to 82% BW when velocity increased (p<0.001). Medio-lateral GRF indicated a high intersubject variability, suggesting the need of an individual analysis.

DISCUSSION: The previous research done by Arnhold & McGrain (1985); Pope *et al.* (1986) and Gorton & Gavron (1987) using 2D-kinematic analysis, has found, like the present study, significant differences in the running pattern as well as in the stride length and stride rate between blind and control athletes. No previous studies have been found in the literature that used force platforms to analyse ground reaction forces in blind athletes running at maximal speed. In the present study, 3D-cinematography provided the kinematic data; these data are very helpful to understanding the differences between right and left foot contact, and between blind and control groups of athletes through a range of different speeds.

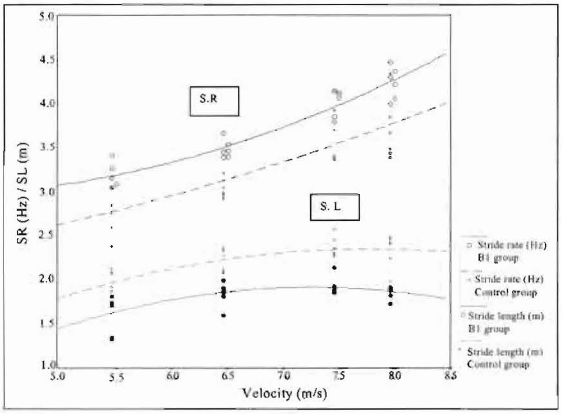

Figure 2. Stride rate – stride length.

Since the athletes are tethered to a guide, the shoulder is prevented from its maximal flexion, which can be avoided with a proper training programme. In the current study we elaborated individual reports which allow us to analyse each subject's technique in relation to their group and to the control group, which is quite helpful for the programming of individualised training workouts.

CONCLUSION: The kinematic variables of running speed: total contact time, time of flight phase, time of initial braking phase, stride length, stride rate, maximum thigh flexion angle and maximum anteroposterior velocity of the thigh segment show clear differences in skill levels between blind paralympic and the top level runners. In both groups, the vertical oscillation of the CDG decreased as velocity increased, and it was significantly lower in B1. The kinetic variables show that B1 had lower average vertical GRF, vertical GRF maximum thrust, vertical linear impulse and unloading rate. These results indicate a poorer skill and less muscular capacity to develop vertical velocity for a longer flight phase; therefore B1 athletes must increase their stride rate to keep their speed level up. With regard to the increases in velocity from 40 to 100% of maximum velocity, the variables which turned out to be significant were time of final braking phase, propulsive phase, stride length, stride rate, lower limb pattern, loading rate, unloading rate, maximum anteroposterior velocity of the thigh segment, vertical linear impulse and anteroposterior GRF. The lower limb pattern, specially the hip and the ankle angles, was affected by the changes in velocity in both groups. The knee flexion angle was less modified except in the swinging phase. In such phase, the thigh and the leg segments come together to obtain the anteroposterior velocity of the CDG as indicated by the increases of maximum anteroposterior velocity of the thigh segment. The instant of maximum anteroposterior velocity of CDG and that of the thigh segment coincided at the take-off instant. The results of the present study have been extremely helpful in improving the knowledge of running technique at medium and high speeds, and specifically that of blind paralympic and top level athletes. The results may be used by coaches in his task of searching training strategies that allow them to introduce improvements in the athlete's performance.

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