THE TOUCH-DOWN AND TAKE-OFF ANGLES IN DIFFERENT PHASES OF 100 M SPRINT RUN

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The variation in running velocity over a 100 m dash has been studied extensively in the last decade. Very few studies, however, have dealt with the changes in technique occurring between the second acceleration (from the normal sprinting position of run the maximal velocity until is reached), maximal velocity and deceleration phases. The purpose of this study was to quantify the touch-down (TD) and take-off (TO) angles in a 100 m sprint run, before, during and after the maximal velocity phase. Ten sprinters were filmed during these phases using a high-speed video camera operating at 250 Hz in a 100 m dash. The results of this study suggest that the Trunk Angle at TD influenced the TD angle. Furthermore, the horizontal distance between the centre of gravity and the Foot at TD, is an important technical characteristic influencing the stride length and the stride rate which provoke the running velocity variation.

KEY WORDS: sprint, running velocity, touch-down angle, take-off angle.

INTRODUCTION: The majority of the running velocity curves reported in literature display the same general pattern, with three distinct phases (Gundlach, 1963; Murase et al. 1976, Simonsen *et al.*, 1985, Muravec *et al.*, 1988, Brüggeman & Glad, 1990, Van Coppenolle *et al.*, 1990; Ito M. *et al.*, 1992). They considered an acceleration phase, a maximal velocity phase and a final deceleration or endurance phase. However, a more detailed model should be used to account the need of developing training strategies. Delecluse *et al.* (1995) refers to three main sources of variation in sprint performance, the initial acceleration, the continued acceleration and maintaining maximum velocity. Therefore, a 100 m dash event can be divided into the following phases: 1) Start - from the static position on the starting blocks to the take off. 2) First Acceleration - from the take off of the blocks to the normal sprinting position. 3) Second Acceleration - from the normal sprinting position of run until the maximal velocity is reached. 4) Maximal Velocity - From the moment when maximal velocity is achieved until the moment in which the maximal velocity is no longer maintained. 5) Deceleration - From the moment when the maximal velocity is no longer maintained, until the leaning forward of the body goes across the finish line. 6) Finish- when the body goes forward across the finish line. The horizontal velocity variations during a 100 m sprint have been associated with changes in running kinematics. Objective information concerning the structure and nature of those variations is necessary in order to optimize the training process. Coaches usually use some of these parameters – for instance stride length (SL) and stride rate (SR) - to assess racing proficiency. But those parameters depend on several other kinematic characteristics of movement. The purpose of this study was to quantify the touch-down (TD) and take-off (TO) angles in a 100 m sprint run, before, during and after the maximal velocity phase.

METHODS: Ten sprinters (age 23,5± 2,12 years; height 1,747 ± 0,057m; weight 72,2± 3,82kg, 100 m personal record 10,66±0,32) were filmed (250 Hz; MotionScope Redlake Imaging PC 1000) in the sagittal plane while running, wearing spike shoes, on an outdoor synthetic track surface, during the three different situations organized to simulate the conditions found in a 100m dash. They were filmed: 1) Between 30 and 35 meters of a 40 m maximal run (second acceleration - ACC), 2) Between 50 and 55 meters of a 60 m maximal run (maximal velocity - MAX), 3) Between 90 and 95 meters of a 100 m maximal run (deceleration phase - DEC). The great variability of distances selected by different investigators for the occurrence of the maximal velocity is due to the different athletic level of the studied subjects. The distance selected in our study (45 – 55 m) is in agreement with the distances select in studies that used subject of similar level. (Gundlach, 1963; Ikai, 1968; Vardaxis and Hoshizaki 1989; Nakano *et al.* 1995; Locateli and Arsac, 1995). Twenty-one landmarks for each subject were then digitized for two strides per trial to enable later analysis of the kinematic characteristics of the sprint motion using the APAS system. The timing of each ten meters intervals (25-35m; 45-55m) of each trial was recorded using photocells, while an anemometer provided a measurement of wind velocity throughout testing. All data are expressed as mean ± SD. Correlations were performed with Pearson Product Moment and ANOVA for repeated measures was used to test the statistical significance of differences. Significance was set at the 0.05 level.

RESULTS AND DISCUSSION: The wind conditions did not differ among trials. Timing of the trials showed no differences between the 40 m point in the three conditions as well as for the 60 m point in the two conditions. The expected increase ($p \leq 0.001$) of horizontal velocity (VxCG) from ACC to MAX, by 0.65 m.s-1 (ranging from 1.54 to 9.15%, correspond to 6.17 ± 2.44%), was accompanied by an increase of 0.16±0.11m ($p \leq 0.001$), in the SL and a stabilization in the SR. Higher values of SR were observed during the second acceleration phase, before maximal velocity has been reached. The increase of SL is confirmed by the results of literature against the stabilisation of the SR that the literature does not corroborate. The expected decrease ($p \leq 0.001$) of VxCG from MAX to DEC, by 0.63 m.s-1 (ranging from 1.07 e 11.55% correspond to 6.10 ± 3.22%), was accompanied by a decrease ($p \leq 0.05$), in SR and a stabilization in SL in spite of decrease in 40% of the subjects.

Table 1. Average and standard deviation values of each stride movement, characteristics analyzed in the three experimental situations.

Parameters	ACC	MAX	DEC
Horizontal Velocity [VxCG] (m.s^{-1})	9.80±0.40 ###	10.44±0.34	9.81±0.54 ###
Stride Length [SL] (m)	2.084±0.104 ###	2.241±0.136	2.181±0.164 **
Horizontal Distance in Contact [DxCGContact] (m)	0.850±0.051 #	0.899±0.070	0.887±0.042 *
Horizontal Distance in Fly [DxCGFly] (m)	1.235±0.069 ##	1.344±0.089	1.293±0.140 *
Horizontal Velocity at TD [VxFootTD] (m.s^{-1})	1.058±0.470	1.731±1.87	2.21±1.91 *
Horiz Dist between CG/Foot at TD [DxCG/FootTD](m)	0.260±0.072	0.266±0.117	0.338±0.089 *
Stride Rate [SR] (Hz)	4.71±0.23	4.67±0.27	4.52±0.27 * #
Stride Time [ST] (s)	0.213±0.011	0.215±0.012	0.222±0;014 * #
Contact Time [CT] (s)	0.088±0.055	0.086±0.068	0.091±0.042
Flying Time [FT] (s)	0.125±0.007	0.128±0.007	0.132±0.013 *
Trunk Angle at TD (°)	78.36±2.21 #	79.80±2.04	81.82±1.96 **
Trunk Angle at TO (°)	81.32±2.04 #	82.73±2.30	84.10±2.72 *
Knee Ângle at TD (°)	155.91±5.54	157.04±3.82	158.22±4.08
Knee Ângle at TO (°)	153.26±7.29	156.17±4.27	156.27±4.78
TD Angle (°)	102.58±2.21 #	99.93±1.96	104.90±2.06 * #
TO Ângle (°)	61.30±1.84	61.76±2.29	62.91±7.11

Significant difference from ACC *** $p \leq 0.001$, ** $p \leq 0.01$; * $p \leq 0.05$. Significant difference from MAX ### $p \leq 0.001$, ## $p \leq 0.01$; # $p \leq 0.05$.

Between ACC and DEC there was no change in the running velocity, but the athletes showed an increase ($p \leq 0.01$) in SL, and a natural decrease ($p \leq 0.05$) in SR. The **TD** Angle contemplates the height of CG in TD and the distance between the vertical projection of CG and the CG of the foot at TD, corresponding larger angles to larger break forces, because of the different orientation of the forces. The inclination of the trunk [*Trunk Angle at TD* and *Trunk Angle at TO]* is correlated to each other in the three analyzed phases and with *TD Angle and TO Angle.*

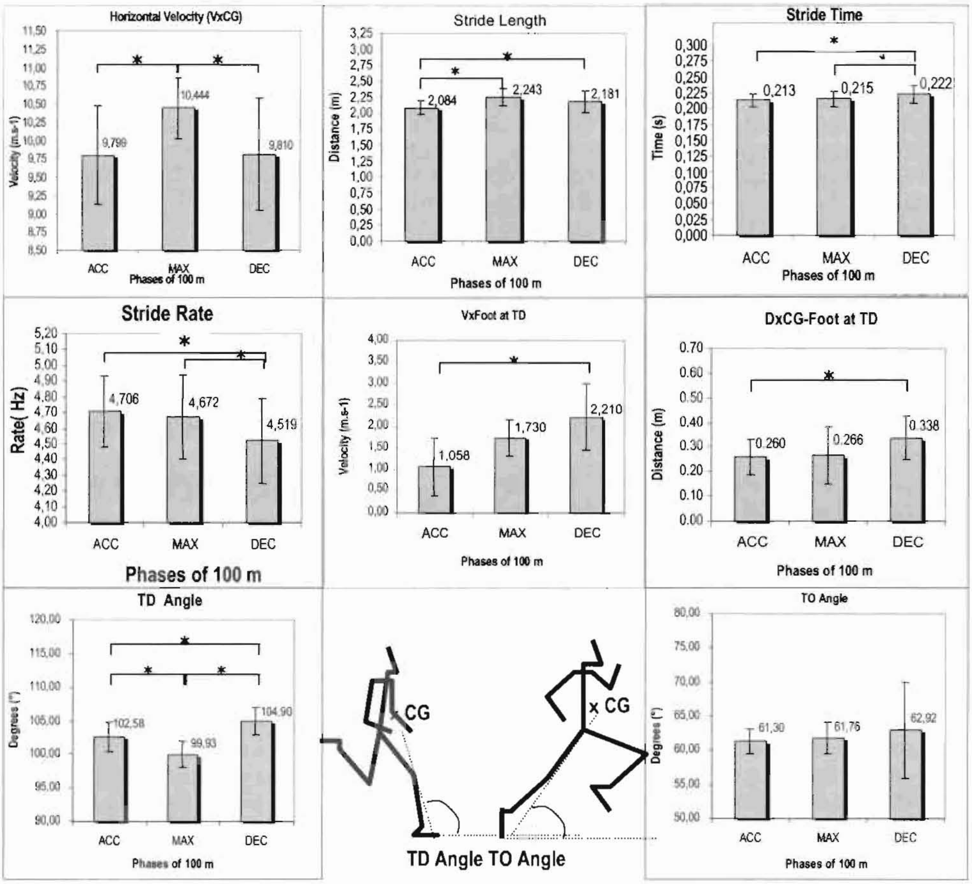

Figure 1. Grafic representations of selected kinematics parameters (Stride Length, Stride Time, Contact Time, Stride Rate CG Ângle at TD, CG Ângle at TO, Dx between CG - Foot at TD) and the representation of GG angle at TD and TO (measured between horizontal and the line defined by body CG and contact foot CG). (* $p \leq 0{,}05$).

The explanation for the biggest SL in DEC (between ACC) may lie on the major *DxCG/FootTD*, where we found a significant difference ($p \leq 0.05$). These distances stay constant between ACC and MAX (p=0.875) and between MAX and DEC (p=0.093), in spite of a slight increase in 90% of the subjects. The correlations between *DxCG/FootTD* and *DxCG/FootTD* in the three phases analyzed, [ACC (r=0.671 and p=0.035), MAX (r=0.690 and p=0.027) and DEC (r=0.694 and p=0.027)], reveal that these two parameters have an effect on each other, in the alterations verified alongside all phases. We found a negative correlation between *VxCG* and both the *DxCG/FootTD* and the *DxCG/FootTD*, in ACC (r=-0,670 and p=0,034; r=-0,694 and p=0,026), revealing that a bigger distance implies a lower VxCG. A reference (ideal) distance for this parameter is difficult to obtain. The length of the leg, the SL and SR should also be taicen into account. Naturally, the capacity to produce force is important in such a way that a higher impulse, with smaller CT corresponds to the same SL. We found in the *TD Angle* a significant decrease between ACC and MAX ($p \leq 0.01$) the increase between ACC and DEC ($p \leq 0.01$) and between MAX and DEC ($p \leq 0.01$). The interpretation for this behaviour seems to be the larger the angle, the lower the *VxCG*.

The *DxCG/FootTD* seems to influence also that angle like the *Trunk Angle at TD* because of the correlations found in the three phases analyzed (ACC r=0.990; MAX r=0.995; DEC r = 0.890; $p \leq 0.001$).

CONCLUSION: The results of these study suggest that SL have a decisive role in reaching high levels of velocity in MAX and that the SR is the main factor to keep the highest velocity in DEC. The coach needs to emphasize the development of optimal coordination between SL and SR, using a model of run, in order to optimize the performance. The Trunk Angle at TD influences the TD angle and also Horizontal Distance between CG and the Foot at TD is an important technical characteristic influencing the runing velocity variation.

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