EFFECT OF THE STARTING BLOCK POSITION ON THE KINETIC ENERGY OF 100 M SPRINTERs.

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SUMMARY
The aim of this study was to test the influence of three different antero-posterior distances between the blocks (bunched, medium and elongated) on the kinetic energy of well-trained sprinters during the block phase and the subsequent acceleration. This was performed using a 3D kinematic analysis of the whole body. Ten trained sprinters started using the three different positions and realised four maximal 10m sprints start. They were equipped with 63 passive reflective markers, and an opto-electronic Motion Analysis® system (12 digital cameras 250 Hz) was used to collect the 3D marker trajectories. During the pushing phase on the blocks, the velocity of the center of mass (VCM) and the kinetic energy of the segments (KE) were calculated. The results demonstrated that the elongated start, compared to the bunched or medium start, induced an increase of VCM at block clearing and a decrease of the performance at 5 and 10 m. Both results were explained by a greater pushing time on the block in elongated condition. The KE of the segments presented small variations depending on the type of start and could not explain the variation in the VCM.

INTRODUCTION
One of the most popular variables that is usually modified by the sprinters is the horizontal distance between the blocks. There are the bunched start (spacing generally <30cm), the medium start (30 to 50cm) and the elongated start (>50cm). Biomechanical studies shown that the velocity of the centre of mass (VCM) at block clearing is higher when the inter-block spacing is increased as a result of a more effective force-impulse [2, 3]. The position and the velocity of the CM depend on the position and the velocity of the different body segments. To understand the contribution of each segment in the translational movement of the CM during the sprint start, the use of a whole body 3D model is essential to have some information about the influence of the movement in the three planes. Recent works realised from a 3D biomechanical approach [5], showed that the use of the kinetic energy (KE) supplies useful information concerning upper and lower limbs contributions to the translation of the body in the forward direction during the starting block phase. However, no studies analysed the influence of block spacing on KE and their relationships with the position and the velocity of the CM.

MATERIAL AND METHODS
Ten trained sprinters started using three different starting positions in the starting blocks (bunched, medium and elongated). They were equipped with 63 passive reflective markers, and an opto-electronic Motion Analysis® system (12 digital cameras 250 Hz) was used to collect the 3D marker trajectories during the pushing phase on the blocks and the first step. The reaction time (RT) was measured with a reactime™ (Microgate, Bolzano, Italy). The time at 5m and 10m (T5 and T10) was recorded using photocells (Microgate, Bolzano, Italy). A segment coordinate system (SCS) was defined on each body segment based on the markers. The orientation of their axes was carefully carried out using the ISB recommendations [6, 7]. From the reconstructed spatial trajectories of the markers, the segment mass, position of the centre of mass and inertia tensor were estimated from scaling equations [1]. The rotation sequence proposed by the ISB to describe the lower and the upper limbs joint movements was used. For this study, 16 rigid segments were used in order to model the body. During the pushing phase on the blocks and the first step, the VCM and the KE were calculated. Rear and front joints were respectively associated with the side of the rear and the front legs in the starting blocks.

RESULTS
The results showed that, in the position “on your marks” and “set”, more the inter-block spacing was great and more the center of mass was behind the start line. The elongated start, compared to the bunched or medium start, induced an increase of VCM at block clearing and a decrease of the performance at 5 and 10 m. The main effect of the inter-block spacing on the kinetic energy is observed during the starting block phase (fig. 1). Indeed, the maximal kinetic energy (KEmax) of the upper limb is lower in the elongated start (fig. 1). The study of each body segment shows that the KEmax of front forearm and front hand are lower in the elongated start (respectively for bunched, medium and elongated, 16.5 ± 5.9 J, 16.0 ± 5.2 J and 13.6 ± 5.7 J; p ≤ 0.05 for the front forearm and 11.2 ± 4.2 J, 10.8 ± 3.8 J and 8.7 ± 3.8 J; p ≤ 0.05 for the front hand). In another way, the rear leg and foot, tends to be lower in the bunched condition (respectively for bunched, medium and elongated, 32.9 ± 7.4 J, 38.7 ± 9.1 J and 35.8 ± 8.7 J; p ≤ 0.05 for the rear leg and 12.3 ± 3.4 J, 14.0 ± 3.7 J and 13.7 ± 4.0 J; p ≤ 0.05 for the rear foot).

DISCUSSION AND CONCLUSION
The modification of the posture during the starting block phase causes a modification of the KE. Indeed the variations observed concern mainly the joints and segments linked to the rear block for the lower limbs and for the upper limbs, the joints and segments linked to the front block. It seems that the KE of the lower limbs is modified towards the rear block and the KE of the upper limbs is modified towards the opposite side of the moved block. Moreover, as it was hypothesized, the results demonstrated that the elongated start, compared to the bunched or medium start, induced an increase of the velocity of the CM at block clearing and a decrease of the performance at 5 and 10 m. Both results
were explained by a greater pushing time on the block in elongated condition. Finally, the KE of the body presented small variations depending on the type of start and could not explain the variation in the VCM.

Figure 1: Kinetic energy of the total body, head-trunk, upper and lower limbs. *Significant effect of the inter-block spacing (ANOVA) on the maximal kinetic energy of the considered system. The standard deviation corresponds to the data of the medium start. Vertical bars correspond respectively to the hands clearing, rear foot clearing, block clearing and landing of the first step.

REFERENCES


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