PERFORMANCE DETERMINING FACTORS IN ELITE SPRINTERS DURING SPRINT START AND TWO FOLLOWING SUCCESSIVE SUPPORTS

Sofie Debaere[1], Ilse Jonkers[1], Dirk Aerenhouts[2], Friso Hagman[2], Bart Van Gheluwe[2], Christophe Delecluse[1]

[1] Department of Biomedical Kinesiology, Faculty of Kinesiology and Rehabilitation Sciences, Katholieke Universiteit Leuven, Belgium,
[2] Department of Biometry and Biomechanics, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Belgium.

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INTRODUCTION: Sprint start out of the blocks and successive acceleration are technically challenging as the athlete goes from a bended to a forward leaning position. Therefore, the body center of mass (COM) has to be accelerated forward and upwards. Optimal sprinting performance relies on attaining maximal forward acceleration. However, adequate vertical acceleration must be generated to reach sufficient height to prepare for the following step (Weyand, 2000). Horizontal acceleration is mainly determined by the horizontal ground reaction force that will affect sprint velocity and therefore final sprint performance (Mero, 1988). Kinematics and kinetics of the start action and maximal sprinting were intensively studied; however little is known on the transition from the set position to the running position during the first two strides. This study aims to identify the factors in the start action as well as in the first and second contact after block clearance that determine sprinting performance in terms of speed and acceleration.

METHODS: Sprint starts were analyzed in 19 elite athletes (8 males and 11 females) of the Royal Belgian Athletics Association. All participants gave their written informed consent to participate. After an individual warm-up and a static trial, each athlete completed three, ten meter sprints out of starting blocks on a tartan surface. Best out of three trials was included for further processing.
Kinematics were assessed by three-dimensional motion analysis (Vicon, Oxford Metrics, UK). Data were collected using 12 MX3 cameras (250Hz) which were positioned around the start action (starting block and the first two strides). A full body marker placement protocol consisting of 66 markers was used. An instrumented starting block with load cells mounted on the back of each starting block registered bilaterally the horizontal force-time characteristics during the entire starting action. Ground reaction forces were measured during the first two contacts using 2 force plates (Kistler, 1000Hz) embedded in the track. After initial processing in Nexus, further data analysis was performed in Opensim (Delp, 2007). By means of inverse kinematics, lower limb, trunk and upper limb kinematics were calculated based on a scaled musculoskeletal model comprising 29 DOF. Hip flexion/extension, hip ab/adduction, knee flexion/extension and ankle plantar and dorsiflexion were included in the current analysis. For the two contacts, only kinematics of the support limb were reported. Based on the force signal, impulses were calculated and normalized with respect to the athlete's body weight. Correlation analyses were performed using Statistica 8.0. Significance level was set at 0.05.

RESULTS AND DISCUSSION: During set-position before gunshot, no significant correlations were observed between the kinematics and acceleration or speed at take off from the block.

During the remaining start action, positive correlation between knee extension of front leg and ankle plantar flexion of front and rear leg were found with block acceleration (Correlations respectively $r = 0.58$, $r = 0.53$ and $r = 0.50$). No correlation with hip extension was retained. Hip adduction of the front leg was negatively correlated with acceleration (r = -

0.50). Excessive adduction of front leg at end of block contact impairs the transfer of the body weight towards the rear leg therefore hindering the acceleration.

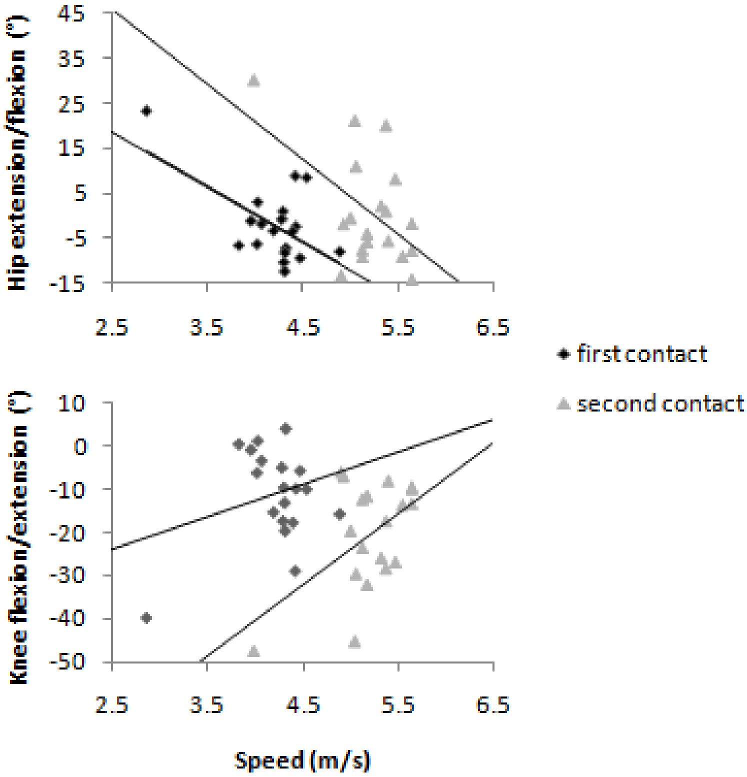

Figure 1. Scatterplot of hip flexion/extension and knee flexion/extension at toe off of first and second contact.

During first contact: initial hip flexion correlated positively with the breaking impulse (r = 0.48) and negatively with speed at the end of first contact (r = -0.46). During the remainder of support, increased hip flexion would generate a higher braking impulse (r = 0.48 for the whole group and r = 0.65 for women). At toe off, hip extension correlated positively with speed at takeoff. During second contact, breaking impulse correlated with knee extension (r = 0.82) at initial contact. In male runners, a strong correlation was found between hip extension and breaking impulse (r = 0.97), whereas in the full group, takeoff speed is positively influenced by both hip and knee extension. At toe off, hip and knee extension as well as plantar flexion in the ankle joint were positively correlated with takeoff speed (resp. r = 0.78; 0.78 and 0.75).

CONCLUSION: Different kinematic factors influence the braking impulse for first (hip flexion) and second (hip and knee extension) initial contact. No correlations were found with the propelling impulse for both contacts. Speed at toe off will be affected by similar kinematic parameters (extension of lower limb joints).

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