MUSCLE CONTRIBUTIONS TO ACCELERATION OF THE BODY CENTER OF MASS DURING SPRINT START

[1] Ilse Jonkers, [1]Friedl De Groote, [2] Dirk Aerenhouts, [2]Friso Hagman, [1]Sofie Debaere, [2]Bart Vangheluwe, [1]Christophe Delecluse

[1] Katholieke Universiteit Leuven, Belgium;

[2]Vrije Universiteit Brussel, Belgium;

email: ilse.jonkers@faber.kuleuven.be

INTRODUCTION

During a sprint start, the athlete accelerates the body center of mass (COM) forward and upward. Optimal sprinting performance relies on attaining maximal horizontal acceleration, however without compromising the vertical acceleration. The latter is required to attain sufficient height so the athlete can effectively take the following steps. Muscle driven forward simulations in combination with perturbation studies have analyzed the muscle contribution to acceleration of the COM at different walking speeds [1]. The current study is the first to extend these analyses to sprinting performance by analyzing the muscle contribution to the acceleration of the COM during the first contact after the athlete leaves the sprinting blocks.

METHODS

Sprint starts were analyzed in 20 competition athletes using three-dimensional motion analysis (Vicon, 250Hz), two force plates (Kistler, 1000Hz) and surface EMG (8 muscles, 2000Hz). A full body marker placement protocol consisting of 66 markers was used. All data analysis was performed in Opensim [2]: (1) Using inverse kinematics, lower limb, trunk and upper limb kinematics were calculated based on a musculoskeletal model comprising 29 degrees of freedom. (2) Dynamic consistency of the data was enforced using residual reduction analysis. (3) Computed muscle control calculated the excitations of 92 muscle actuators of the lower limbs as well as the torque actuators controlling the arm kinematics. (4) A perturbation analysis was performed for all model actuators (1N over a time window of 0.02s) and the effect on the horizontal and vertical acceleration of the COM was analyzed during the first foot contact. This analysis focuses on the muscle contribution to the horizontal and vertical acceleration of the COM during the first foot contact.

RESULTS

Plantarflexors (SOL and GAS), hamstrings (Lat Ham and Med Ham) as well as hip flexors have the largest contribution to forward acceleration of the COM (Fig. 1-A). Plantarflexors, vasti, rectus femoris (RF) and tibialis posterior (Tib Post) have the largest contribution to upward acceleration of the COM (Fig. 1-B). Whereas most muscles contribute positively to both forward and upward acceleration, opposing effects are observed for the hamstrings, vasti, rectus femoris and tibialis posterior.

DISCUSSION AND CONCLUSIONS

The plantarflexors are efficient for propulsion of the body COM during sprint start as they contribute simultaneously to both forward and upward acceleration. Action of secondary muscles seems less optimal due to the opposing effect on the horizontal and vertical acceleration. Current research relates these muscle contributions to horizontal acceleration of the COM to the performance of the individual athlete.

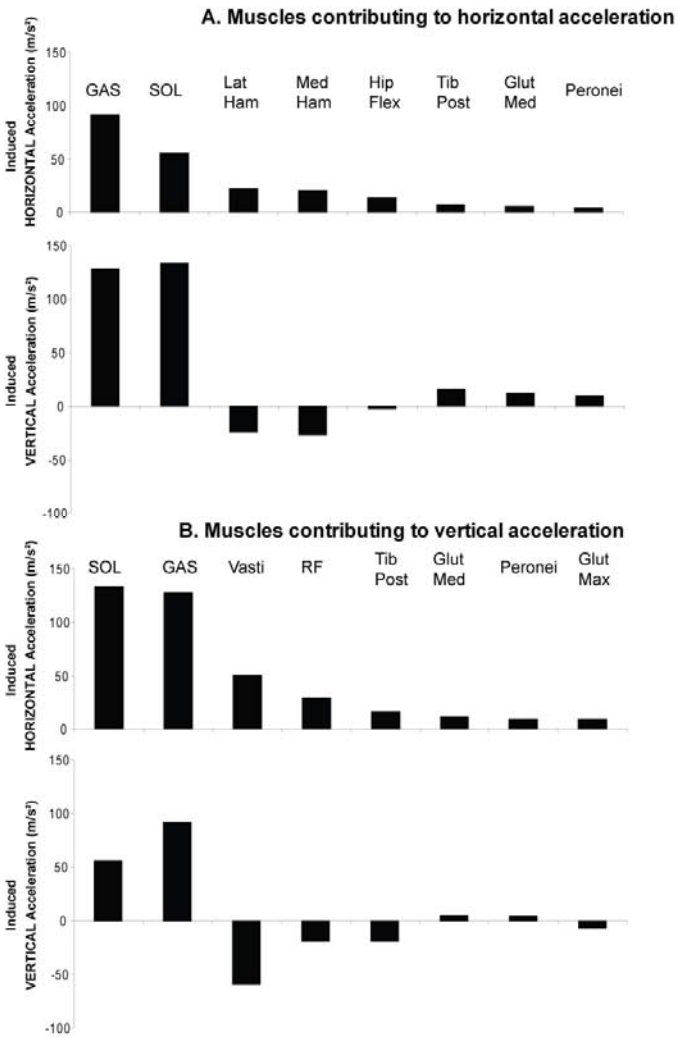

Figure 1: Induced horizontal and vertical acceleration of the main contributors to (A) horizontal and (B) vertical acceleration of the COM calculated by the perturbation analysis.

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