



# INVARIANT KINEMATIC CONSEQUENCES OF MUSCULAR ANTICIPATION DURING LANDING AND DROP-JUMPING

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## 1. Introduction

When humans execute voluntary movements, their Central Nervous System (CNS) programs muscular anticipation to coordinate joint rotations according to the constraints of the task [1]. In motor tasks with large momentum, such as landing or drop-jumping, the muscular anticipation serves two key purposes: protect the skeletal system [2] and adjust the lower-limb muscles stiffness to modulate energy dissipation or restitution depending on the task [3]. Because the kinematic consequences of the muscular anticipation have been poorly described, the objective of the study was to characterize the evolution of lower-limb joint angles during the anticipation phase to clarify how they contribute to both protect the skeletal system and perform the movement.

## 2. Materials and Methods

10 young healthy subjects (5 females, 25 years old) landed and drop-jumped from a 30 cm elevated platform on two force plates recording the 3D ground reaction forces (GRF) at 2000 Hz. The best trial (out of three) was analysed for each subject in each condition: the lowest vertical GRF peak for landing and the shortest contact time for drop-jumping. The 3D trajectories of 64 reflective markers placed on anatomical landmarks were recorded by 19 infrared cameras at 200 Hz. The knee and ankle sagittal angles were computed with an individualized full-body musculoskeletal model [4] during the 100 ms preceding ground contact (*i.e.* when the vertical GRF exceeded 20 N). The influence of the condition on the angle was tested with a paired t-test using Statistical Parametric Mapping for each joint.

## 3. Results

In all subjects, only the knee joint flexed before

ground contact ( $-47 \pm 15$  ms). No difference was observed between conditions (Fig. 1).

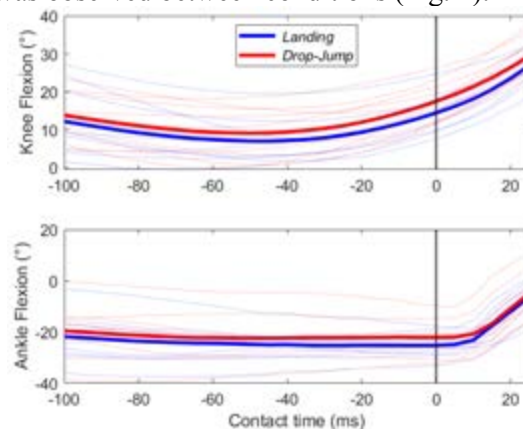


Fig. 1: Knee and Ankle flexion angle for each condition. Vertical lines indicate ground contact.

## 4. Discussion and Conclusions

Contrary to the ankle, the anticipated knee flexion suggests that the knee flexors are recruited to initiate the joint rotation before it is accelerated by the ground contact. This may protect the knee from extending too much and/or lowering the whole-body center of mass to enable upper-body adjustment and maintain balance. The absence of difference across joint angles between conditions suggests that this anticipatory motor command is conservatively used by the CNS to protect the skeletal system.

## 5. References

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