**Influence of Various Heights and Surfaces on Neuromuscular Strategies During Drop Landings.**

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# **INTRODUCTION**

Drop landings are a common component of sport and exercise training programs and often play an important role in successful sport performance [1]. In order to absorb and distribute ground reaction forces, controlling one’s body during the landing offers substantial challenges. In drop landings, the goal is to decrease the body’s momentum, absorb impact forces, stabilize the body, and prevent harmful joint rotations [2]. Previous research on drop landing strategies in gymnasts from various heights onto surfaces simulating gymnastics landing mats [3, 4] focused on lower body kinematics and loading rates. Additionally, some attention has been given to identifying changes in landing techniques using joint angles and muscle activation comparisons from different heights [5], but this approach did not examine muscle co-activation. The aim of the current study was to examine muscle activity during landing, including co-activation, across various drop heights and landing surfaces. In addition, joint angles were evaluated to examine the relationships between joint kinematics of the lower extremity during variations of drop landings. Therefore, the goal of this study was to better understand how drop height and landing surface influence muscle co-activation and limb position at contact during a drop landing.

# **METHODS**

Simultaneous capture of motion, force, and electromyographic (EMG) data of 14 adults (mass = 72.2 ± 13.7 kg, height = 1.8 ± .1 m, age = 22 ± 2 yrs) were collected. Participants were excluded if they currently had a musculoskeletal injury of the lower extremity had an injury within the previous three months. Surface electrodes were placed on the following muscles of the non-dominant side: rectus femoris (RF); vastus lateralis (VL); medial hamstrings (MH); gastrocnemius (GAS); tibialis anterior (TA). Following electrode placement volunteers were asked to perform a maximum voluntary contraction (MVC) using isometric settings on an isokinetic dynamometer (Biodex Medical Systems, Shirley, NY). The trial with the greatest EMG amplitude for the muscle of focus was used later to normalize EMG amplitude during landing. Participants dropped from two plyometric boxes; a tall box (61.5 cm) and a short box (30.5 cm) onto the force plate. In addition to landing on the rigid force platform, they landed on a compliant surface, which was a viscoelastic foam pad commonly used to disrupt proprioceptive feedback (Airex AG Specialty Foams, Sins, Switzerland). For each condition, participants completed three trials for a total of 12 drops. The trial sequence was randomized.

The landing phase was defined as beginning 150 ms prior to initial contact, and ending when the velocity of the center of mass returned to zero. DC-bias was removed from the EMG signals. Then EMG signals were full-wave rectified low-pass filtered (cut-off 15 Hz), and normalized to the appropriate MVC. Kinematic data were computed using VICON’s plug-in-gait model (VICON, Denver, CO). Muscle co-activation groups were chosen based on primary muscle functions at the joints of interest. GAS and TA were examined because of their actions at the ankle joint. RF, VL, and MH were examined because of hip and knee actions, and all muscles that cross the knee joint were included in the third co-activation measure (RF, VL, MH, and GAS). Muscle onset and cessation were identified manually by a single experimenter and durations of co-activation were calculated using custom software (MATLAB r2010a, MathWorks, Lowell, MA). Two-way repeated measures ANOVAs were used to determine differences in joint angles at landing and muscle co-activation between surface conditions and drop height. Significant (*p*< .05) results are reported.

# **RESULTS AND DISCUSSION**

Regarding lower extremity joint angles at contact, significant differences in hip (*F*1,13 = 6.84, *p* = .021) and knee angles (*F*1,13 = 8.09, *p* =.014) were found for surface conditions, suggesting participants’ hip and knee joints were more flexed when landing on a rigid surface (Figure 1). This is consistent with previous findings [4] and Lee et al. [5] suggest this strategy may be used to aid in reducing the force experienced by increasing the duration of landing. At the ankle, a significant main effect was identified for drop height and an interaction was found. Thus, the increase in ankle plantarflexion from rigid to compliant surface was greater when dropping from the tall box as compared with the small box (*F*1,13 = 4.72, *p* = .049).

**Figure 1**: Hip flexion, knee flexion, and ankle plantarflexion at contact.

Co-activation between GAS and TA and among RF, VL, and MH were not affected by changes in surface or drop height. The combined co-activation among all muscles considered that cross the knee (RF, VL, MH, and GAS) revealed a significant main effect for surface condition (*F*1,13 = 5.68, *p* = .033).

When landing on the compliant surface the decreased joint flexion, coupled with greater co-activation of muscles crossing the knee joint suggest participants adopted a strategy with greater leg stiffness. However, when landing on a rigid surface, increased hip and knee joint flexion coupled with decreased muscle co-activation suggests a less stiff leg at landing.

**Figure 2**: Muscle co-activation durations, expressed as a % of the landing phase. GAS-TA were co-active an average of 45-50% for the four conditions, RF, VL and MH were co-activated approximately 37-47%. However, when adding GAS to the RF, VL and MH combination, co-activation for all muscles at the knee decreased to between 23-31%.

# **CONCLUSIONS**

Findings from this study suggest that drop height had minimal influence on preferred landing strategies as evidenced by the lack of significant effects on all variables except the ankle angle. Landing on different surfaces, however, did indicate a change in preferred landing strategies, specifically participants adopted a strategy that was more consistent with a stiffer leg when landing on a compliant surface.

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