The Effect Of Mid-flight Trunk Flexion And Extension On Center Of Mass Redistribution And Landing Mechanics

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Introduction

- Anterior cruciate ligament (ACL) injuries are prevalent and potentially devastating [1, 2]. Often, these injuries result from decreased knee and hip flexion angles and increased vertical ground reaction force (VGRF) [3]. Mid-flight medial and lateral trunk bends also influence landing mechanics [4], however the effect of mid-flight trunk flexion/extension is unclear.
- The purpose of the current study was to quantify the effect of mid-flight trunk flexion/extension on center of mass (COM) redistribution and landing mechanics.
- Researchers hypothesized that mid-flight trunk extension would cause anterior motion of the hips and knees relative to the COM, resulting in a mechanically disadvantageous position for landing. Consequently, subjects would demonstrate a stiffer landing with decreased knee and hip flexion.

Methodology

- Ten males and five female recreational athletes (age: 21.84±1.64 years, height: 1.75±0.107m; mass: 74.35±28.7kg) participated.
- Participants completed 3 trials of a jump-landing task starting with one foot on each force plate, jumped for maximum height, and landed with one foot on their respective force plate. There were 3 conditions: reaching back (figure 1), reaching up (figure 2), and reaching forward (figure 3). Figures represent MatLab
- Two Bertec force plates (1600 Hz) were used to define initial landing contact and measure peak VGRF. Using 8 Vicon cameras (160 Hz) and 44 markers, the positions of the hip, knee, and ankle joints relative to the COM at initial foot contact were calculated and normalized to body height. Positive locations represented joints anterior to the COM.

Results

- Reaching backward resulted in lower jump height, more anterior hip and knee positions from COM, smaller hip flexion angles at landing and 100 ms after landing, and decreased knee flexion angles 100 ms after landing compared to reaching up (Table 1).
- Reaching forward resulted in lower height, more posterior hip and knee positions from COM, greater hip and knee flexion and ankle plantarflexion at landing, greater hip and knee flexion 100 ms after landing, and less ankle dorsiflexion 100 ms after landing compared to reaching up (Table 1).

Discussion & Conclusion

- Trunk flexion and extension result in altered joint location distributions and subsequent landing mechanics.
- Landing mechanics elucidated by the reaching back condition in particular may predispose an individual to a landing posture that renders them at risk for ACL injury.
- The decreased hip and knee flexion angles seen in the reaching back condition suggests athletes in this position may need to actively flex the hip and knee joints to return to a safer landing position or adopt effective falling strategies.

References

1. Kay et al. *Journal of Athletic Training,* 52(2), 2017.
2. Hootman et al. *Journal of Ath Train,* 42(2), 2007.
3. Dai et al., *Am J of Sports Med,* 43(2) 2015.
4. Hinshaw et al. *Proceedings of ASB'17*, Boulder, CO, USA, 2017.

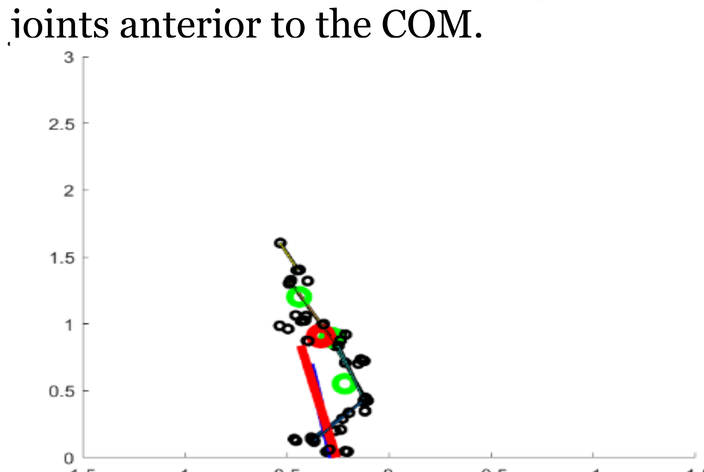

Figure 1. Reaching Back at Landing

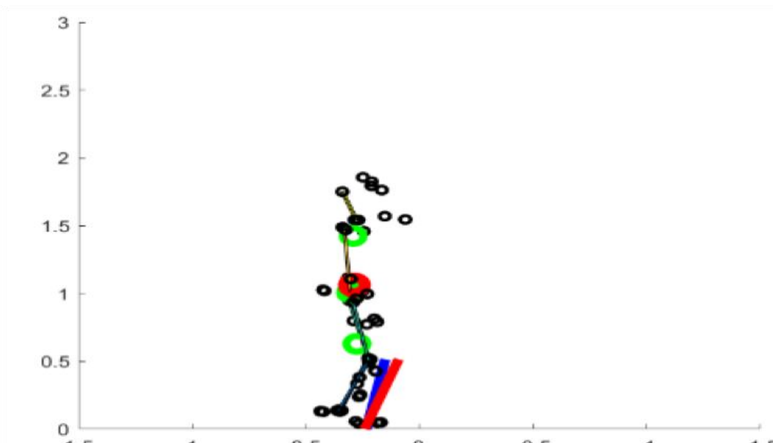

Figure 2. Reaching Up at Landing

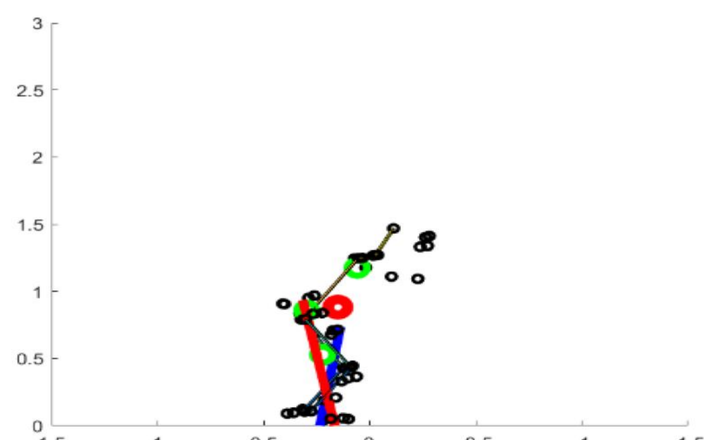

Figure 3. Reaching Forward at Landing

Table 1. Mean ± Standard Deviation for Biomechanical and Performance Variables.

	Jump Height (m)	VGRF (BW)	Hip position-landing (BH%)	Knee position-landing (BH%)	Ankle position-landing (BH%)	Hip flexion-landing (°)	Knee flexion-landing (°)	Ankle plantar flexion-landing (°)	Hip flexion-100 ms (°)	Knee flexion-100 ms (°)	Ankle dorsi-flexion-100 ms (°)
Back	0.48±0.10^{B}	4.2±1.1	3.0±1.6^{A}	4.6±1.7^{A}	-0.6±1.7^{A}	2.7±8.0^{C}	13.5±8.3^{B}	36.5±5.9^{B}	23.0±14.3^{C}	56.6±10.2^{C}	26.9±6.4^{A}
Up	0.52±0.11^{A}	4.4±1.0	-0.3±1.7^{B}	2.7±1.1^{B}	-1.3±1.2^{A}	12.8±6.9^{B}	13.5±8.9^{B}	37.2±10.2^{B}	37.0±11.8^{B}	60.6±10.8^{B}	25.7±4.8^{A}
Forward	0.47±0.10^{C}	4.4±1.0	-7.1±2.6^{C}	0.2±2.5^{C}	-2.5±1.8^{B}	34.8±12.8^{A}	21.7±9.5^{A}	40.3±8.8^{A}	60.6±17.4^{A}	66.5±11.5^{A}	20.5±6.4^{B}

Note: a>b>c at a significance level of 0.05; VGRF: peak vertical ground reaction force; BW: body weight; BH: body height