# Influence of Hip Strength and Range of Motion on Landing Kinematics Across Maturation Groups in Youth Athletes


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## Introduction

- ACL injuries are increasing in the youth population and appears to coincide with physical maturation.[1]
- Changes in landing patterns through maturation are suggested to contribute to increased risk of knee injuries in youth athletes.
- Factors contributing to altered landing kinematics throughout maturation are unknown.
- Hip range of motion (ROM) and strength are known to influence landing kinematics.
- It is unknown if these factors contribute to maturational changes in landing kinematics.

## Purpose

To determine if hip strength and ROM are associated with lower extremity kinematics during a jump landing (JL) task, across stages of maturation.

## Methods

**PARTICIPANTS**

- One hundred and four (41 male, 63 female) youth athletes (13.4±3.1yrs, 159.0±16.2cm, 52.1±17.0kg) volunteered to participate.

**ASSESSMENT OF PUBERTAL MATURATION**

- The validated modified Pubertal Maturational Observational Scale (PMOS) was used to determine stage of maturation.[2]
  - Participants were dichotomized into 3 maturational categories: pre-pubertal, pubertal, post-pubertal. (Figure 1)

**Pubertal Maturation Observational Scale**

Please mark an "X" next to any statement in the appropriate checklist (Female or Male) that you agree with regarding your child.

**Female Characteristic Checklist**

| Agree? | Characteristic |
|---|---|
| | The adolescent has grown 3 to 3.5 inches in the past 6 months or is past this growth spurt. |
| | The adolescent has begun breast development. |
| | The adolescent has begun menarche. |
| | The adolescent has evidence of darker underarm hair or shaves. |
| | The adolescent has evidence of darker hair on her legs or shaves. |
| | The adolescent's calves are becoming defined. |
| | The adolescent has evidence of acne. |
| | There was evidence of sweating after physical activities. |

**Male Characteristic Checklist**

| Agree? | Characteristic |
|---|---|
| | The adolescent has evidence of darkening of facial hair or shaves. |
| | The adolescent's voice has gotten deeper or is currently breaking. |
| | The adolescent has grown 3 to 4 inches in the past 6 months or is past the growth spurt. |
| | The adolescent's biceps are becoming defined. |
| | The adolescent's calves are becoming defined. |
| | The adolescent has evidence of acne. |
| | There was evidence of sweating after physical activities. |
| | There is darkened underarm hair. |

**Figure 1. Pubertal Maturational Observational Scale**

## Methods

**ASSESSMENT OF HIP ROM**

- Hip internal rotation (IR) and external rotation (ER) ROM were measured with a digital inclinometer by testers who established an acceptable level of reliability ($ICC_{2,k}$> 0.85), a priori. (Figures 2-4)

**Figure 2. Hip ABD Range of Motion**

**Figure 3. Hip IR Range of Motion**

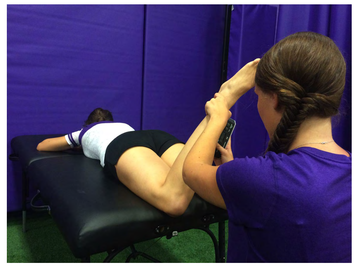

**Figure 4. Hip ER Range of Motion**

**ASSESSMENT OF HIP STRENGTH**

- Isometric strength of the hip extensors (EXT), external rotators (ER), and abductors (ABD), were evaluated by testers with known reliability ($ICC_{2,k}$>0.80), using a hand-held dynamometer and stabilization straps. (Figures 5-7)

**Figure 5. Hip EXT Strength**

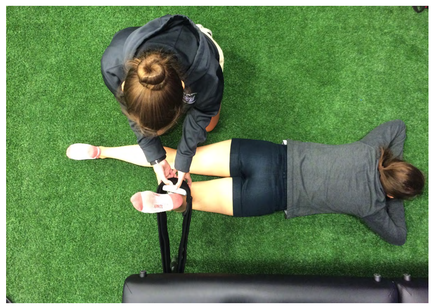

**Figure 6. Hip ER Strength**

**Figure 7. Hip ABD Strength**

**DOUBLE-LEG JUMP LANDING TASK**

- A three-dimensional motion analysis system (Flock of Birds, Ascension Technologies; Burlington, VT) interfaced with *Motion Monitor* software (Innovative Sports Training; Chicago, IL), was used to assess hip and knee kinematics on the dominant limb during three JL trials.
- The JL task required participants to jump from a 30-cm high box set 50% of their height away from a force plate platform and rebound for maximum vertical height upon landing. (Figure 8)

**Figure 8. Sagittal View of a JL Task**

**DATA REDUCTION AND ANALYSIS**

- Peak isometric hip strength was normalized to body weight (%BW), while ROM was recorded to the nearest degree.
- Frontal and transverse plane hip and knee joint angles at initial contact (IC) (GRF≥10N), peak joint angles (IC to peak knee flexion), and joint excursions (peak minus IC) during the deceleration phase of the JL tasks were used for analysis.
- Separate step-wise, multiple linear regressions determine the extent to which hip strength and ROM predicted hip and knee kinematics during the JL task.

## Results

**Pre-Pubertal** (10 males, 15 females) PMOS<2

**Pubertal** (11 males, 10 females) PMOS = 2-5

**Post-Pubertal** (20 males, 38 females) PMOS >5

- No significant predictors

- ↓ EXT strength → ↑ KIR @ IC
- ↓ ER strength → ↑ HIR @ IC
- ↓ ABD+EXT strength → ↑ peak KER
- $R^2$ = 18.5 – 30.9%, $P < 0.05$

- ↓ ER ROM → ↑ KIR @ IC
- ↓ ER ROM → ↑ peak KIR
- ↑ IR ROM → ↑ HADD @ IC
- ↑ IR ROM → ↑ peak HADD
- ↑ IR ROM → ↑ HIR disp.
- $R^2$ = 13.4 – 18.4%, $P < 0.05$

## Summary and Conclusions

- In pre-pubertal athletes, hip strength had more of an influence on landing kinematics, while hip ROM had more of an influence in the post-pubertal athletes.
- These findings suggest that intervention/prevention programs should focus on hip strengthening prior to puberty and incorporate ROM exercises as youth athletes mature.
- Future studies should examine the longitudinal relationship between hip function and landing biomechanics, and the effectiveness of interventions that are specific to pubertal stage.

## References


1. Gianotti SM, et al. Incidence of anterior cruciate ligament injury and other knee ligament injuries: a national population-based study. *J Sci Med Sport.* 2009;12: 622-627..
2. Davies PL & Rose JD. Motor skills of typically developing adolescents: awkwardness or improvement? *Phys Occup Ther Pediatr.* 2000; 20: 19-42.



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