Musculoskeletal Adaptations to Aging & eXercise Lab

# Muscle Strength and Power Imbalances and Injury Risk in Division I Softball Athletes

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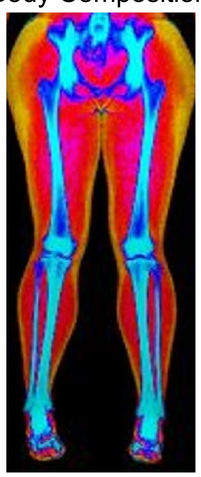
## ABSTRACT

Softball requires development of lower body strength and power but specific demands may lead to asymmetries. These adaptive imbalances such as hamstrings to quadriceps (H:Q) ratio may impact performance and increase risk of anterior cruciate ligament (ACL) injury, potentially altering an athletes' career. **PURPOSE**: To compare body composition and lower body strength, power, and imbalances using Dual-energy X-ray Absorptiometry (DXA) body composition scans and isokinetic dynamometry, respectively between softball athletes and matched controls. **METHODS**: Twenty softball athletes (n=20) were matched with age- (±2yrs) and weight- (±2.5kg) controls who were physically active ≥3 d/wk. All participants provided voluntary informed consent, filled out physical activity frequency questionnaires, and completed a total body DXA scan to asses total body and regional muscle and fat tissue mass. They then tested their dominant and non-dominant quadriceps and hamstrings strength and power at three different velocities (60, 120, 180 deg/sec). Group comparisons were conducted using a univariate analysis after controlling for individual leg muscle mass, Cohen's *d* effect sizes were calculated, and α=0.050. **RESULTS**: Athletes (20.0±1.7 years old, 163.0±34.1cm, 72.2±7.3kg) and controls (20.2±1.0years old, 166.7±7.5cm, 71.5±7.2kg) were similar for age, height, bodyweight (all p≥0.643), and average resistance training frequency per week (p=0.611; *d*=0.16). Athletes indicated greater total body and dominant and non-dominant leg lean mass (all p≤0.050; *d*=0.64-0.75) but were similar for leg fat mass (all p≥0.095; *d*=0.47-0.53) to controls. Athletes demonstrated greater torque at all speeds for both quadriceps and hamstrings (all p≤0.022; *d*=0.47-1.32) after correcting for leg lean mass. Quadriceps strength asymmetry was similar (p≥0.992; *d*=0.00) but power was different (p≤0.038; *d*=0.65) between groups. Strength and power H:Q ratio were superior in athletes for their dominant leg (all p≤0.050; *d*=0.61-0.76) but similar in their non-dominant leg (all p≥0.563; *d*=0.19-0.57) compared to controls although all athletes fell below the optimal ratio percentage of 65% (all ≤51.6%). **CONCLUSION**: These data suggest sport-related demands superiorly develop lower body strength and power but may elicit asymmetrical imbalances, increasing risk of ACL injury. Findings of this nature provide insight to performance and sports medicine staff on career-impacting injury risk and support assessment of regional, isolated tissue and torque characteristics.

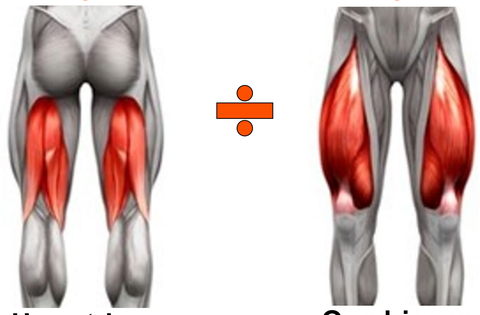
## METHODS

- Softball demands frequent use of dominant muscle groups, potentially leading to asymmetries and injury risk.
- Softball athletes (n=20) and age & weight matched Controls (n=20) completing injury and training questionnaires, DXA scans, and Biodex muscle strength and power testing.
- Baseline and lean mass corrected independent *t*-test; Cohens *d* effect sizes; α=0.050.

**DXA**
Lower Body
Body Composition



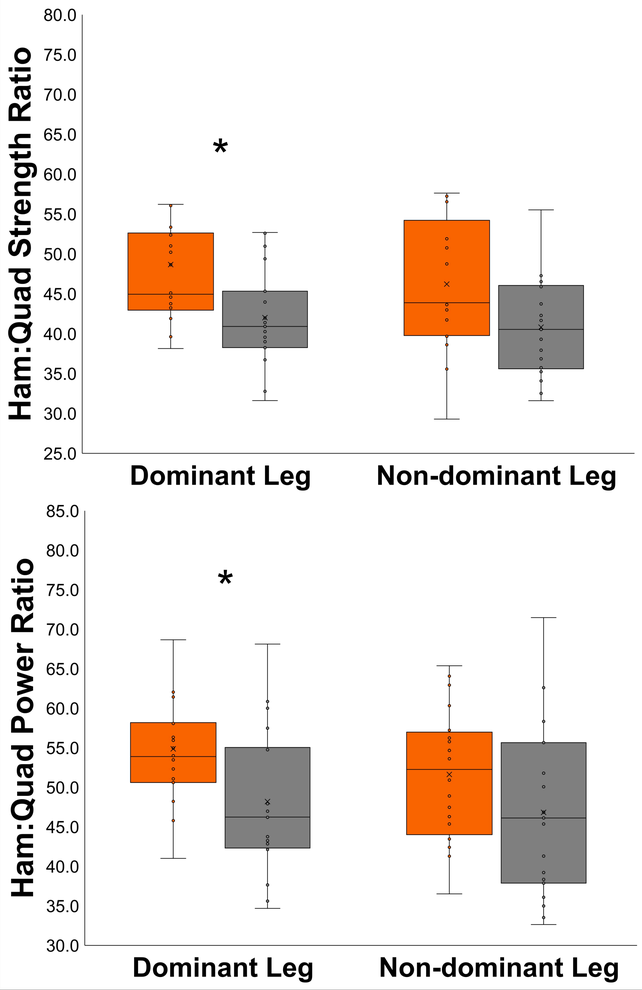
**Biodex**
Strength and Power

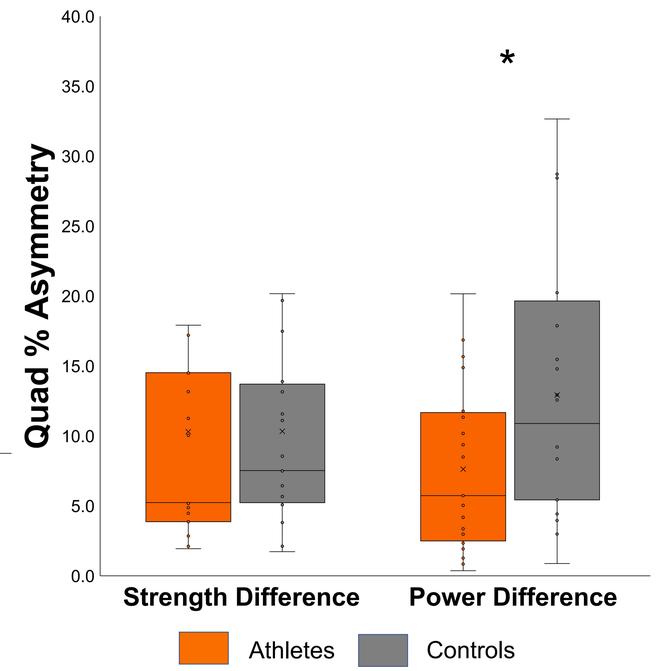


**Hamstrings** Muscles

**Quadriceps** Muscles

## ISOKINETIC DYNAMOMETRY RESULTS







Athletes had better ham:quad strength (**top left**) and power (**bottom left**) ratios for their dominant leg (***d*≥0.76; p≤0.015**) but not their non-dominant leg (***d*≥0.19; p≥0.067**) compared to controls.

The quadriceps % asymmetry **(top right)** was similar between groups for strength (***d*=0.00; p=0.992**) but athletes indicated a smaller asymmetry for power (***d*=0.65; p=0.038**) compared to controls.

## ANTHROPOMETRICS, DXA, AND QUESTIONNAIRES

**Table 1.** Anthropometrics, training questionnaire responses, and DXA body composition results. All data represented as means (SD).

| Measures | Softball (n=20) | Controls (n=20) | p | Cohen's *d* |
|---|---|---|---|---|
| Age (years) | 20.0 (1.7) | 20.2 (1.0) | 0.739 | 0.11 |
| Weight (kg) | 72.2 (7.3) | 71.5 (7.2) | 0.783 | 0.09 |
| Height (cm) | 163.0 (34.2) | 166.7 (7.5) | 0.643 | 0.15 |
| Resistance Training (days/wk) | 3.5 (1.1) | 3.8 (1.9) | 0.611 | 0.16 |
| **Plyometric Training (days/wk)** | **1.9 (1.8)** | **0.0 (0.0)** | **≤0.001** | **1.20** |
| **Dominant Leg Lean Mass (g)** | **8937.4 (845.2)** | **8261.4 (838.5)** | **0.015** | **0.75** |
| Dominant Leg Fat Mass (g) | 4389.0 (776.5) | 4861.9 (960.2) | 0.095 | 0.53 |
| **Non-dominant Leg Lean Mass (g)** | **8647.2 (858.3)** | **8066.4 (857.5)** | **0.039** | **0.65** |
| Non-dominant Leg Fat Mass (g) | 4372.9 (766.3) | 4775.3 (920.4) | 0.141 | 0.47 |

## TAKE HOME POINTS

**Muscle asymmetry was similar for strength but less for power between groups, identifying a sport-driven muscle speed adaptation.**

**Superior H:Q ratio in athletes' dominant leg indicate a reduced ACL injury risk compared to controls, but still fell below optimal levels.**

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