Energy Absorption of Lower Extremity Joints During a Drop Vertical Jump Task in Healthy Individuals

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Introduction

- When performing single limb loading tasks (SLL), previous research reports differences in the relative contribution of eccentric loading in the involved limb of anterior cruciate ligament reconstruction (ACLR) individuals compared to the dominant limb of healthy controls [1].
- Double limb loading tasks (DLL) provide an opportunity to distribute eccentric loading between both limbs, which may alter the compensation patterns found in SLL.
  - Previous research found greater loading rates in the involved limb of ACLR female athletes during DLL compared to their uninvolved limb [2].
  - Prior studies found associations between greater ACL loading and high energy absorption in the initial landing phase of a jump task [3].
- While research has found loading differences between the involved and uninvolved limbs of ACLR individuals, there has not been consideration to limb dominance as a factor of the magnitude of eccentric loading between limbs.
- **Purpose:** To describe eccentric loading of the ankle, knee, and hip during a double limb landing task in a healthy cohort–including the **total energy absorption** at each joint as well as the **relative energy absorption contributions** between joints–to help determine expected ranges of these variables.

Participants

- 52 **healthy** individuals

46 Females
6 Males

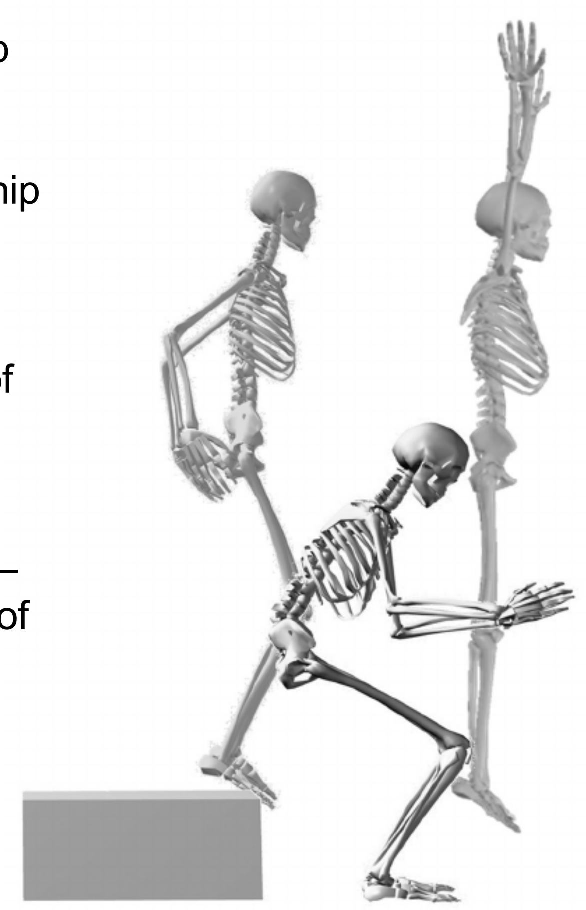
1.715 ± 0.092 meters tall

20.6 ± 2.7 years old

68.6 ± 10.4 kg body mass

Methods

- Individuals completed 8 trials of a double limb drop vertical task
- 3D marker and force plate data were collected
- Sagittal plane joint power of the ankle, knee, and hip were calculated and normalized to body weight (Newtons) and height (meters)
- **Energy Absorption (EA)**:
  - Calculated by integrating the negative portion of the power curve (indicated by the yellow bars underneath the curve in the figure "**Example Power Curve**") where the angular acceleration and net joint moment are in opposite directions–indicating eccentric loading–in the first 100 ms of landing.
  - Measured in Newton·meters
- **Energy Absorption Contribution (EAC)**:
  - Calculated as the percent contribution of each joint relative to the contribution of all 3 joints.
- **Limb Symmetry Index (LSI)**:
  - Calculates symmetry of the non-dominant and dominant joints
  - LSI = $\left(\frac{Dominant}{Non-dominant}\right) * 100$

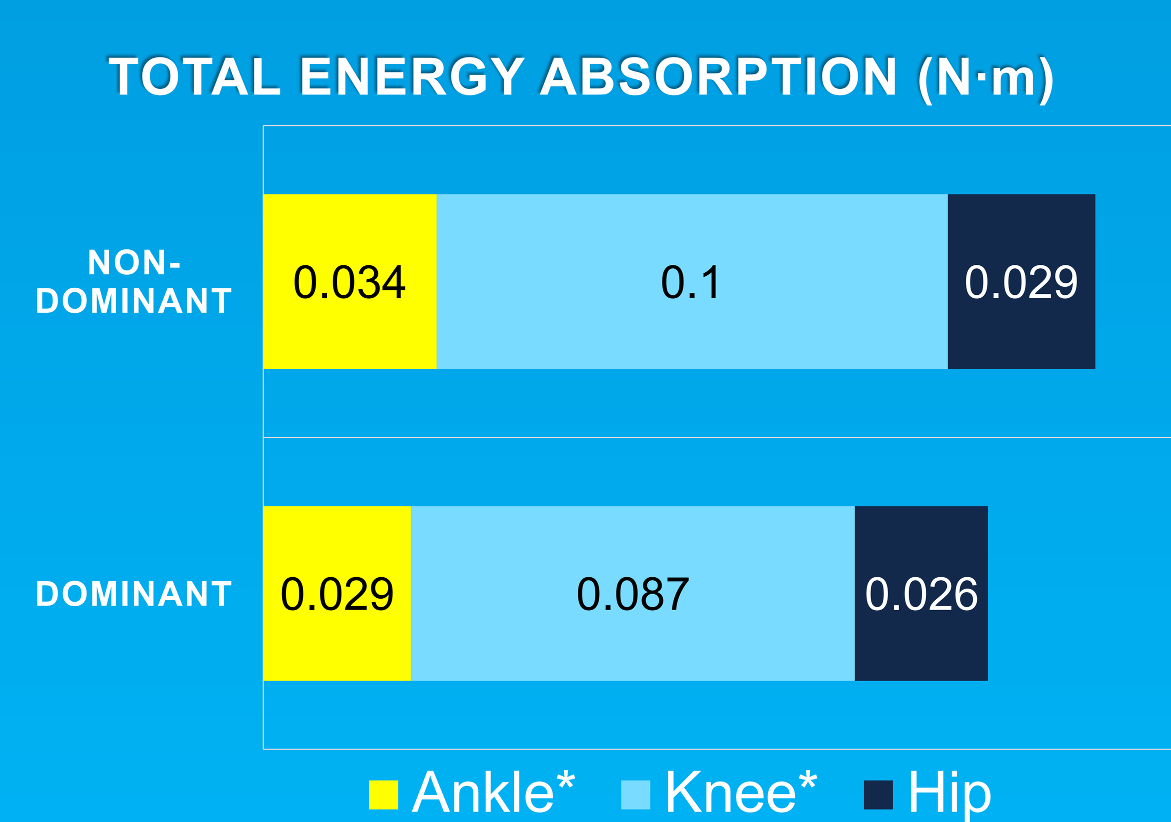


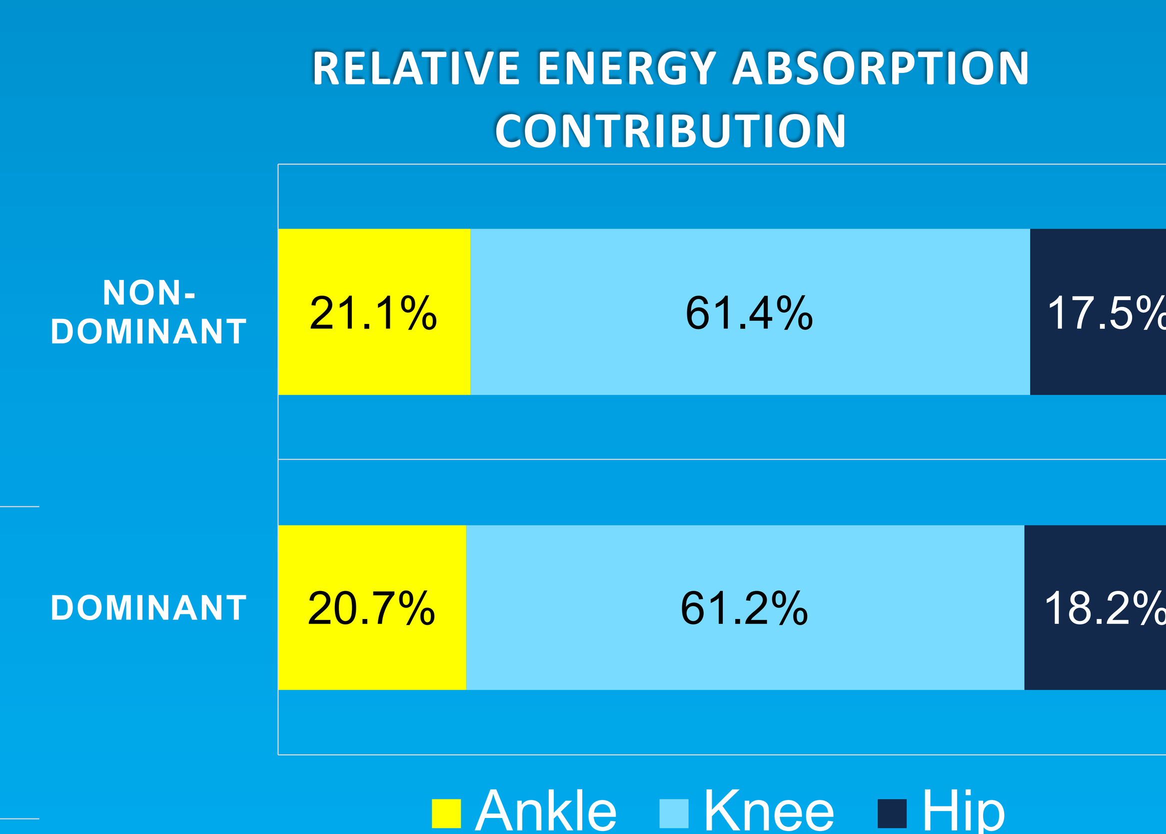
[4]

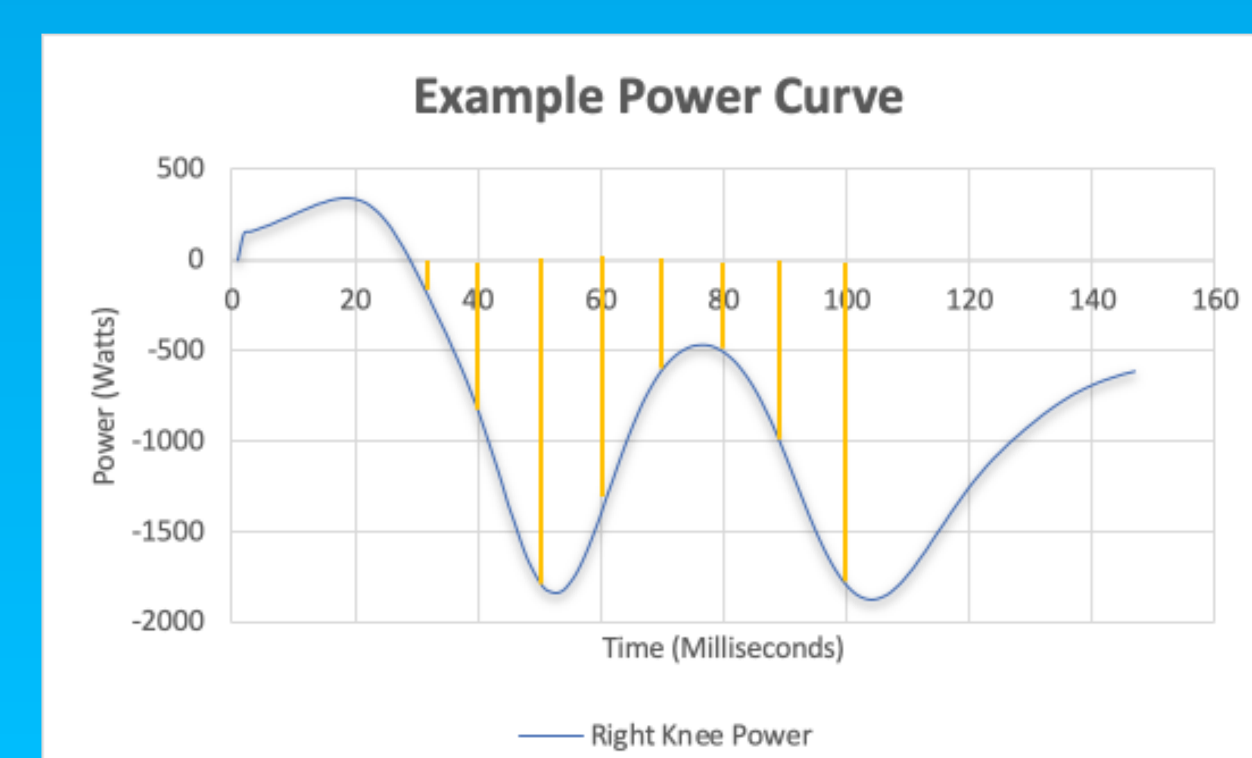
Analysis

- Separate **paired t-tests** were calculated for EA and EAC for each joint between the dominant and non-dominant limbs.
- Statistical significance was set a priori at $\alpha = 0.05$

In healthy individuals, the non-dominant limb absorbs more **total energy** in the ankle, knee, and hip. **Relative energy absorption contribution** strategies are similar between limbs.







Results

Total Energy Absorption (EA)

Limb	Ankle * (N·m)	Knee * (N·m)	Hip (N·m)
Non-Dominant	0.034 ± 0.014	0.100 ± 0.024	0.029 ± 0.015
Dominant	0.029 ± 0.014	0.087 ± 0.025	0.026 ± 0.015
LSI	96.4 ± 41.5	88.4 ± 17.5	106.5 ± 56.7

*significant difference between limbs ($p < 0.05$)

Relative Energy Absorption Contribution (EAC)

Limb	Ankle	Knee	Hip
Non-Dominant	21.1 ± 8.2%	61.4 ± 6.8%	17.5 ± 7.3%
Dominant	20.7 ± 8.5%	61.2 ± 7.4%	18.2 ±. 8.5
LSI	100.7 ± 29.0%	99.9 ± 8.96 %	107.2 ± 36.5 %

No significant differences were found between limbs

Conclusion

- In healthy individuals, EAC strategies are similar in the dominant and non-dominant limbs.
- The non-dominant limb absorbs more total energy (EA) in the ankle and knee, with a trend towards absorbing more total energy in the non-dominant hip.

Clinical Relevance

- Our results aid in determining a range of expected EA and EAC values among healthy individuals during eccentric loading tasks.
- Provided that research has associated greater total EA in the lower extremities with ACL injury risk [3], it is important to investigate our finding that healthy individuals have greater total EA in the non-dominant limb.
  - This finding suggests that the dominant limb in healthy individuals may not be the most valid match to the involved limb in ACLR individuals.
  - Our results indicate that we need to consider if the involved limb is the dominant or non-dominant limb when interpreting load magnitude differences between limbs at the ankle and knee during DLL.
- Future research should explore how EA and EAC are altered in individuals after ACLR. In turn, this will allow researchers to establish LSI thresholds separately for non-dominant and dominant limb ACL tears.

References

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