The Effects of Whole Body Vibration on Landing Biomechanics Linked to Secondary Injury Risk in Individuals With Anterior Cruciate Ligament Reconstruction

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BACKGROUND

Anterior Cruciate Ligament (ACL) ruptures are very common injuries. Individuals who have ruptured their ACL have demonstrated poor quadriceps function, marked by reductions in strength and activation. Quadriceps dysfunction may lead to aberrated jump landing biomechanics as the quadriceps is crucial for attenuating force during a jump landing. Aberrant jump landing biomechanics have been linked to an increased risk of lower extremity injury.[1] Studies have demonstrated that whole body vibration (WBV) improves quadriceps function[2] and gait mechanics. However, the effects of WBV on landing biomechanics are unknown.

PURPOSE

To compare jump landing biomechanics in individuals with anterior cruciate ligament reconstruction (ACLR) before and after whole body vibration.

METHODS

Participants

- 34 individuals between the age of 18 and 35 (20.9 ± 3.5) years and between 6 months and 5 (2.63 ± 1.25) years post-unilateral ACLR with no neurological disorders or recent lower extremity injuries.

Procedures

Intervention protocol

- This study consisted of two data collection sessions, at least a week apart, where participants would receive a control intervention in one session and the WBV intervention in the other.
- A counterbalancing scheme determined the intervention order as well as the jumping task order.

Landing Biomechanics Assessment

- Three-dimensional kinematics and kinetics were obtained via 3D motion capture system (Vicon) interfaced with two in-ground force plates (Bertec) sampled at 200Hz and 2,000 Hz respectively.
- Single leg (SL) and Double leg (DL) jumping tasks were completed from a 30 cm box half their high away from the imbedded ground force plates.

Intervention

- WBV: For 1 minute participants performed a half squat on the Power Plate vibration platform receiving a 30Hz stimulus, then rested for 2 minutes. This cycle was repeated 6 times.
- Control: Participants completed the same intervention as WBV, but no stimulus was applied.

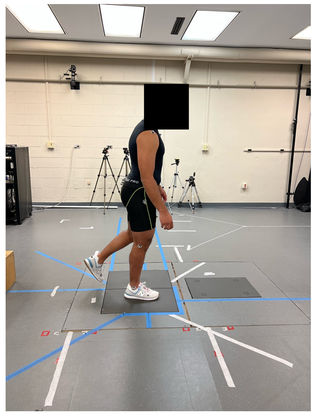

Figure 1: SL landing

Figure 2: WBV intervention

Statistical Analyses

- A 2 (condition: WBV, Control) x 2 (time: Pre, Post) ANCOVA controlling for time post-ACLR was used to evaluate all outcomes for involved/ACLR (INV) and uninvolved (UNINV) limbs separately (α = 0.05).
- Significant interaction effects were further evaluated via Bonferroni corrected pairwise comparisons between time points and conditions (α = 0.0125).

RESULTS

2 x 2 ANCOVA

- For the UNINV limb SL landing biomechanics, there were significant interaction effects for vertical ground reaction force (vGRF) (*P* = 0.014; Figure 3) and peak adduction moment (*P* = 0.046; Figure 4).
- There were no significant condition x limb interaction effects for any of the INV limb SL landing biomechanics outcomes (*P* = 0.134 – 0.774)
- No significant condition x limb interaction effects for any of the INV or UNINV limbs in the DL landing biomechanics (*P* = 0.066 – 0.973)

Post Hoc

- *Post Hoc* evaluation showed that UNINV vGRF was smaller after WBV compared to the control (*P* = 0.001; Figure 5). However, no comparisons of the UNINV limb adduction moment were significant (*P* = 0.120 - 0.363).

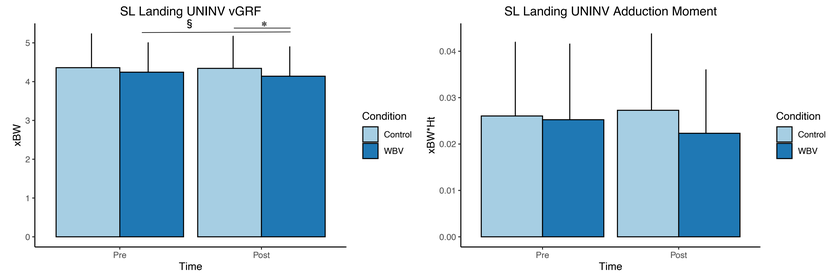

Figure 3. UNINV Limb vGRF during SL Landing Condition x Time Interaction (Mean ± 1 SD)
* Indicates significant difference between conditions at Post-test
§ Indicates trend towards significant difference between Pre-WBV and Post-WBV (P = 0.032)

Figure 4. UNINV Limb Adduction Moment during SL Landing Condition x Time Interaction (Mean ± 1 SD). No *post hoc* pairwise comparisons between conditions or time points were statistically significant (*P* = 0.120 – 0.363).

	***P* Value**	**Δ Pre to Post**
Pre-Control – Post-Control	0.064	-0.018
Pre-WBV – Post-WBV	0.032	-0.109
Pre-Control – Pre-WBV	0.719	-0.132
Post-Control – Post-WBV	**0.001***	-0.224

Figure 5: Pairwise Comparisons for UNINV vGRF during SL Landing.
* indicates significant difference

DISCUSSION

- WBV acutely reduces uninvolved limb vGRF during single leg jump landing tasks.
- Decreasing vGRF using WBV presents clinical implications as lower vGRF may be associated with a reduced risk of ACL injury[3].
- This study only investigates the acute effects of WBV, thus future studies should investigate the effects of repeated WBV on landing biomechanics longitudinally.

REFERENCES

1. Ward SH, Blackburn JT, Padua DA, et al. Quadriceps Neuromuscular Function and Jump-Landing Sagittal-Plane Knee Biomechanics After Anterior Cruciate Ligament Reconstruction. J Athl Train. 2018;53(2):135-143. doi:10.4085/1062-6050-306-16A.S. McIntosh, K.T. Beatty, L.N. Dwan, D.R. Vickers, Gait dynamics on an inclined walkway,, J. Biomech. 39 (2006) 2491–2502. https://doi.org/10.1016/j.jbiomech.2005.07.025.
2. Pamukoff DN, Pietrosimone B, Lewek MD, et al. Whole-Body and Local Muscle Vibration Immediately Improve Quadriceps Function in Individuals With Anterior Cruciate Ligament Reconstruction. Arch Phys Med Rehabil. 2016;97(7):1121-1129. doi:10.1016/j.apmr.2016.01.021
3. Leppänen M, Pasanen K, Kujala UM, et al. Stiff Landings Are Associated With Increased ACL Injury Risk in Young Female Basketball and Floorball Players. The American Journal of Sports Medicine. 2017;45(2):386-393. doi:10.1177/0363546516665810

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