Higher Ground Reaction Forces Do Not Signify Higher Tibia Bone Forces During Advanced Rehabilitation Exercises

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Summary

Tibial bone injuries are common, require long recovery time, and have high reinjury rates. Rehabilitation focuses on a progressive reloading of the bone culminating in a return to dynamic activities (running). Ground reaction forces (GRFs) are often used to infer the loading on the tibia and to guide rehabilitation. However, GRFs do not account for the contribution of calf muscle contraction on bone load. Here we explored the relationship between GRF and tibia load for common advanced rehabilitation exercises. We found that tibia load does not scale with GRF across different exercises. Tasks that clinicians consider high impact (e.g., countermovement jumps) did not result in higher tibia load than those considered low impact (e.g., low pogo jumps). Providing clinicians with a greater understanding of the actual load placed on the tibia during dynamic activities could assist in optimizing rehabilitation programs that progressively reload the tibia after injury.

Introduction

The tibia is a common site for injury, both for stress fractures in athletes [1] and for other fractures due to traumatic incidents. Recovery after injury relies on progressive increases in tibia load (i.e., force). GRF is sometimes assumed to be a surrogate for force on the tibia but has been shown to not accurately represent the true bone load across a wide range of running conditions [2]. However, the relationship between GRF and tibia load has not yet been explored for other advanced exercises (e.g., jumping) which creates a blind spot for clinicians seeking to develop rehabilitation programs to prepare individuals for higher demand activities. The purpose of this study was to explore this relationship between GRF and tibia load for common advanced rehabilitation exercises.

Methods

Following institutional review board approval, twenty individuals (10F/10M) without injury were recruited to complete a series of advanced rehabilitation exercises: running, single- and double-limb countermovement jumps (SL-CMJ/DL-CMJ), single- and double-limb low pogo jumps (SL-LP/DL-LP), double limb high pogo jumps (DL-HP), and drop vertical jumps (DVJ).

Vertical GRFs were measured using a dual-belt instrumented treadmill (Bertec) sampling at 2000 Hz and were then filtered with a 4th order lowpass Butterworth filter at 50 Hz.

Tibia compression load was calculated using methods in [2] that include contributions from both GRFs and surrounding muscles, which were estimated with ankle moment and Achilles tendon moment arm. Peak vertical GRF and peak tibia load were extracted from the data and converted into Body Weights. We averaged across the middle third of steps for running (during a 1 minute trial) and the middle 7-10 repetitions for all other exercises for each participant.

Results and Discussion

Group average peak GRF and tibia load for all tasks are shown in Figure 1. Double limb high pogo (DL-HP) jumps and single limb countermovement jumps (SL-CMJ) are considered by clinicians to be a high impact exercise, and these resulted in the largest GRF; however, single limb low pogos (SL-LP), which are considered a lower impact exercise, resulted in the largest tibia load. The peak GRF and peak tibia load differed substantially in terms of general trends, absolute force magnitudes, and relative force magnitudes between exercises.

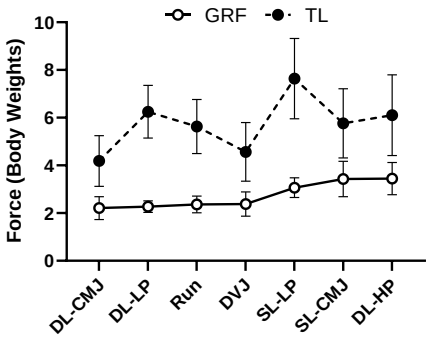

Figure 1. GRF and tibia load (force) across tasks.

Conclusions

We found that tibia load does not scale with GRF across common rehabilitation exercises. Thus, using GRF as a surrogate measure for tibia load is not recommended. Nor is it advised to assume high impact exercises lead to higher tibia bone load. Exercises like low pogo jumps are lower impact from a GRF perspective, but actually result in high tibia bone load due to calf muscle contractions. Understanding tibia load may help clinicians to optimize progressive rehabilitation programs after injury.

Acknowledgments

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References

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