# Running with an Exotendon Reduces Knee Contact Loads

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## Summary

An exotendon is a passive spring attached between a runner's feet. Running with an exotendon reduces the energetic cost of transport and alters kinetics. We hypothesized running with an exotendon would also reduce vertical knee joint contact forces when running at a speed of 2.7 m/s. Using muscle-driven simulations that tracked experimental data, we calculated vertical knee joint contact forces with and without the exotendon. These simulations revealed that running with the exotendon reduced vertical knee joint contact forces by 0.9±0.4 BW, which could benefit individuals who wish to reduce knee loading during running.

## Introduction

Reducing peak loads during exercise could promote tissue health, as excessive loading may lead to joint degeneration. The exotendon, a passive assistive device, alters running kinematics and kinetics while reducing energy demands [1, 2]. However, its effect on knee joint loading remains unknown. This study used simulations to estimate vertical knee joint contact forces during running with and without the exotendon. Since the exotendon has been shown to reduce knee extension moments, we hypothesized it would also reduce knee joint loading [1].

## Methods

We collected experimental data from five healthy recreational runners (4 female, 1 male; age: 26±1.3 years; height: 170.9±9.2 cm; mass: 63.5±8.1 kg; mean±standard deviation) running on a treadmill at 2.7 m/s with and without the exotendon [2]. We scaled a full-body musculoskeletal model to each subject, and generated muscle-driven, kinematic-tracking simulations using direct collocation [3, 4]. These simulations solved for the muscle activations required to produce the observed movements and enabled us to calculate vertical knee joint contact forces. To compare natural and exotendon peak contact forces we performed a paired t-test.

## Results and Discussion

Running with the exotendon reduced vertical knee contact force by 0.9±0.4 BW (8.7±3.2%, P=.006, Figure 1A). This reduced total peak load resulted from reductions in the contributions of the quadriceps (1.1±0.7 BW, P=.02), hamstrings (0.8±0.2 BW, P<.001), and intersegmental forces (0.1±0.07 BW, P=.03) to knee loading (Figure 1B-F). The quadriceps muscles are the largest contributors to peak knee joint loading during running, as they primarily support body weight at the knee during stance. Runners demonstrated reduced peak knee flexion angles and extension moments when running with the exotendon [1]. These changes reduced the force generation requirements for the quadriceps and resulted in not only energetic savings [2], but also reduced knee loading.

## Conclusions

Musculoskeletal simulations of experimental running data show that a simple assistive device is capable of reducing knee joint loading at recreational running speeds. This understanding can be used to refine device designs targeted at promoting exercise in populations who might benefit from reduced joint loading.

## References

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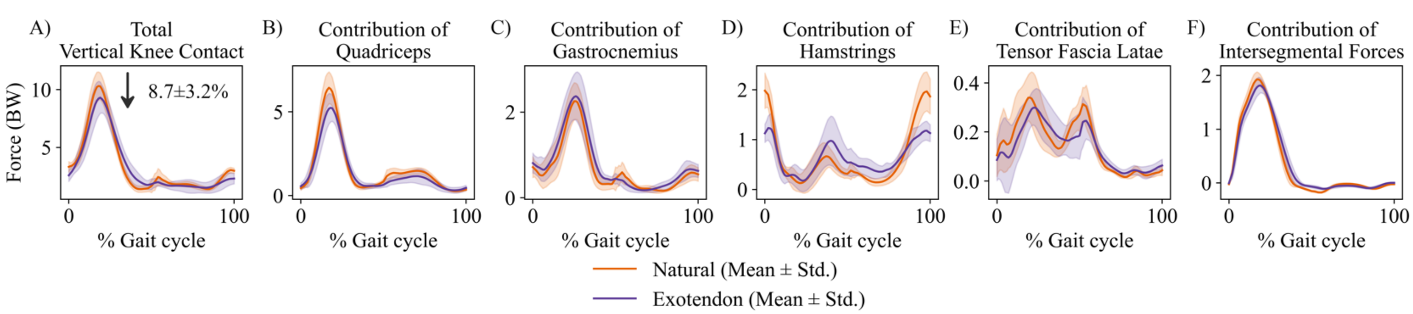


**Figure 1:** Total vertical knee contact forces for running naturally (orange) and with an exotendon (purple) (A) along with contributions of major muscle groups and intersegmental forces (B-F). Means (solid line) and standard deviations (shaded region) for five recreational runners.