We extracted all steps from the daily insole data. For each step, we estimated Achilles tendon loads using our established algorithm and calculated 4 mechanical variables: load peak, impulse over a step, average load rate from heel strike to peak, and maximum load rate. We compared the daily average of these load variables longitudinally to step counts, self-reported events, and clinical events to explore their inter-relationships. We also correlated the 4 load variables to determine whether they provide unique insights into Achilles tendon loading versus each other.

Results and Discussion

The insole recorded up to 70 steps each day on a total of 116 days. In general, peak Achilles tendon loading increased gradually over the course of rehabilitation, but in a non-linear manner with large variations especially between week 12-19 (Figure 1). Many “sharp” changes in peak load corresponded to events possibly causing or resulting from altered tendon health. For example, rapid load increases in late week 12 was immediately followed by days of reported pain and swelling. A particularly high step count (20k+) was followed by a large decrease of the Achilles tendon peak load measured at the end of the same day. The insole was also able to identify tendon load changes according to patient instructions. For example, by intentionally “trying to push off” during gait, the patient increased her peak Achilles tendon load by 65% and peak load rate by 45% (Figure 2). This result supports the feasibility for Achilles tendon load to be modified instantly and interactively via instructions or biofeedback.

Finally, Achilles tendon load rates and impulse strongly correlated with peak loads ($R^2 > 0.85$). The strong correlations with other mechanical variables suggest peak load is sufficient for tracking Achilles tendon loading.

Significance

Longitudinally monitoring Achilles tendon loading is challenging because 1) it is limited by the scarce frequency of clinical visits, and 2) lab-based gait measurements do not faithfully...
reflect real-world biomechanics. This first-of-kind case study shows the value and feasibility of using instrumented insoles to track day-to-day Achilles tendon loading in the real world. Our innovative paradigm can empower future studies to leverage accessible tools (e.g. biofeedback systems) and deliver personalized rehabilitation according to quantitative guidance, thereby optimizing long-term Achilles tendon healing and functional recovery.

Acknowledgments
NIAMS R01AR078898. We thank Drs. Anahid Ebrahimi and Keith Knurr for their help with data acquisition and processing. This work was also submitted for presentation at the 5th North American Congress on Biomechanics (NACOB) on August 21-25, 2022 in Ottawa, Canada.

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