FlyBand® ExoBoots Enhance Ankle Mechanics: Bracing Level-Dependent Effects on Joint Kinematics and Moments During Walking

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Summary

Lateral ankle sprains are the most common musculoskeletal injury (MSKI) among soldiers, accounting for over three million limited duty days annually in U.S. Service members. Adherence to bracing during rehabilitation is poor due to discomfort and restricted functionality. FlyBand® ExoBoots were designed with a hidden articulating exoskeleton that can provide adjustable levels of ankle stability while preserving anteroposterior mobility. Gait analysis was conducted using an instrumented walkway and motion capture system. Significant main effects for boot type were found in frontal plane ankle moment ($p<0.001$) and ankle angle ($p<0.001$). FlyBand boots maintained comparable ankle support in the frontal plane while allowing for natural gait mechanics in the sagittal plane. These findings suggest FlyBand boots are a viable alternative to conventional boot/bracing combinations for rehabilitation from ankle sprains.

Introduction

Lateral ankle sprains are a common and costly MSKI in soldiers [1]. To reduce the likelihood of treatment non-compliance and incidence rates of chronic ankle instability (CAI), an effective solution should balance soldiers' medical and functional needs. The purpose of this study was to compare ankle gait parameters between FlyBand boots and conventional military boots. We hypothesized that both sets of boots will limit motion in the frontal plane, but the FlyBand would allow more natural motion in the sagittal plane.

Methods

Ten service-aged adults completed a gait analysis wearing six boot-brace combinations: two boots (Conventional, FlyBand) and three bracing levels (Low, Mid, High). Participants walked along a 15-meter path at a self-selected pace while kinematics data were captured using a 17-camera motion capture system (Motion Analysis Corp, Santa Rosa, CA; 100 Hz). Each subject wore a formfitting bodysuit, and 33 retro-reflective markers were placed on specific anatomical landmarks [2]. A two-way repeated-measures ANOVA using statistical parametric mapping (SPM) was used to test main effects of boot type, bracing level, and interactions between the two on ankle angles, moments, and powers during gait.

Results and Discussion

A significant main effect of the boot was observed for inversion/eversion angle (0-2% and 17-25% of gait cycle, $p=0.024$ and $p<0.001$, respectively) and ankle moment (20-25%, $p<0.001$). More inversion at heel strike (0-2%) was observed while wearing the FlyBand boots; however, more eversion angle and moment during mid stance phase (17-25%) was also observed in the FlyBand boots (Figure 1). There were no significant differences between bracing conditions for ankle angle, moment, or power during overground walking. However, there were significant interactions between boot type and bracing level on plantar/dorsiflexion angle (94-100%, $p=0.007$), and moment (10%, $p=0.046$). FlyBand ExoBoots allowed greater peak eversion moments and smaller peak inversion moments at the high bracing level. Ankle power showed no significant effects.

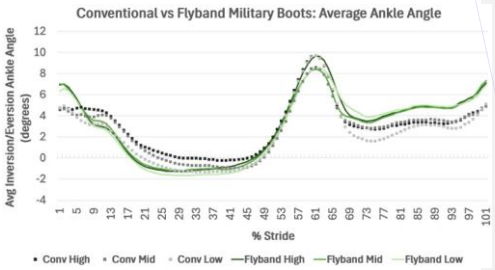

Figure 1. Significant main effects were observed for inversion/eversion angle. FlyBand boots showed increased inversion at heel strike (0-2%, $p=0.024$) and greater eversion angle and moment during the foot flat phase (17-25%, $p<0.001$)

Conclusions

These results suggest FlyBand ExoBoots provide comparable ankle support in the frontal plane to the corresponding conventional boot condition, while maintaining more natural movement in the sagittal plane. The FlyBand design maintains natural gait mechanics without negatively impacting ankle function, making it a viable alternative to conventional boots.

Acknowledgements

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References

[1] Molloy, J.M. et. al. (2020). Military Med., 185(9-10)
[2] Fallahtafti, F., et. al. (2024). Int. J. of Cardiology, 407.

Commented [CR5]: Edited this sentence for clarity, to me it sounded like you were saying there were no differences between boots as well as between brace levels, when the results up to this point report significant differences between boots.

Commented [ke1]: We just need the registered trademark on the first incidence of FlyBand. I've removed the rest for improved readability. ExoBoot is also not trademarked, so I took off the TM.

Commented [ke2]: This feels a bit too broad of a statement and doesn't reflect the main characteristics/design features of the ExoBoot. It also doesn't describe what the exoboot is.

Suggested edits:
FlyBand ExoBoots were designed with a hidden articulating exoskeleton that can provide adjustable levels of ankle stability while preserving anteroposterior mobility.

Commented [JW6]: I know you are over a page, consider organizing this section in a way that makes it convey all the relevant info with less words.

Commented [SM7]: Can you add a take-home from this graph? What was the significant finding? You might want to have a graph for inversion angle. Also the x axis label needs to say which ankle angle as we measured them in 2 planes...

Commented [JW8R7]: 1.you need to summarize the most important finding(s) are form the figure and place that in your caption.
2. I am not sure what ankle angle you right? PD or IE? Specify which you have and if it is not Inversion, change it- based on her comment.
3. three connects to 2 she meant to day y axis instead of x, also it would be great to have the actual values for the x-axis if you could

Commented [JW3]: You may not have room for this put a phrase stating why you think this is the case would make this hypothesis stronger and give you something to tie into your conclusion

Commented [ke9]: Are these the right citations?

The first one seems to be for: Effects of footwear condition on maximal jumping performance? I'd think we'd want to reference MSKI statistics for the military - usually we reference something like:
Molloy JM, Pendergrass TL, Lee IE, Chervak MC, Hauret KG, Rhon DI. Musculoskeletal Injuries and United States Army Readiness Part I: Overview of Injuries and their Strategic Impact. Military Medicine. 2020;185(9-

Commented [JW4]: would you have a p-value for moth IN/EV angle and ankle moment or no?