MUSICAL FEEDBACK FROM PRESSURE-SENSING INSOLES FOR ASYMMETRIC GAIT RETRAINING

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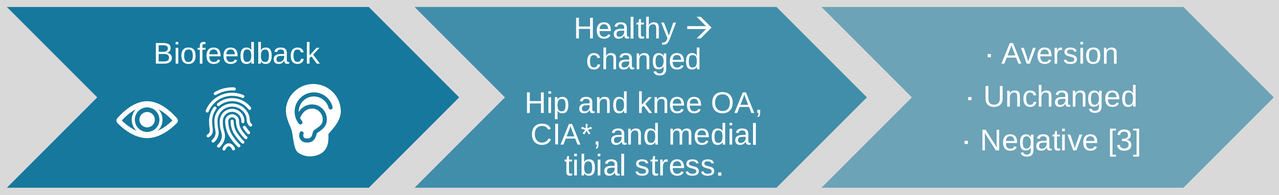
INTRODUCTION

- Ankle fracture → avoidance behavior, load bearing lateralization and reduced ankle range of motion. [1]
- Asymmetric gait → joint overloading, pain, risk of fall, may drive progression of osteoarthritis (OA). [1,2]



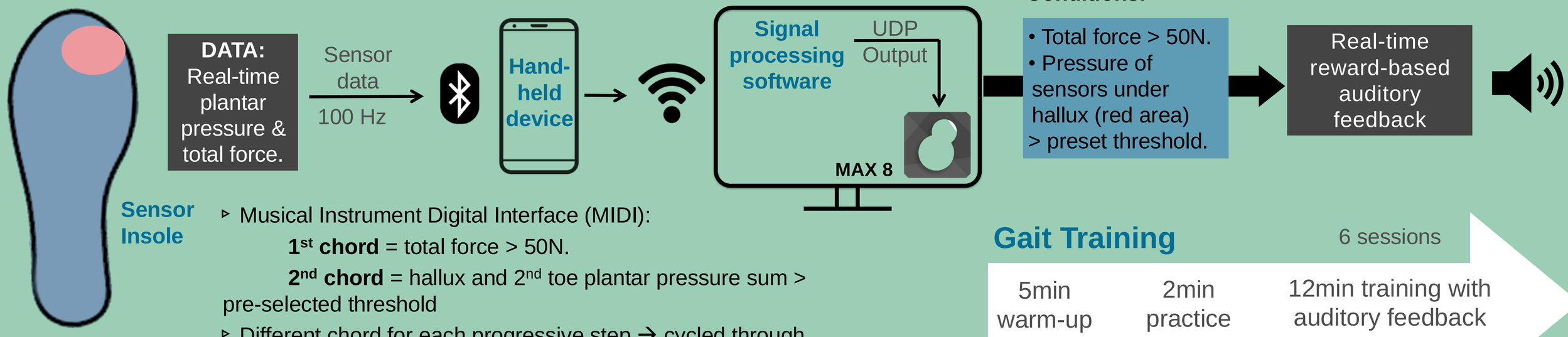
*CIA: chronic ankle instability

- Gait retraining requires constant guidance
- New approach = progressive, reward-based **auditory feedback** based on wireless pressure-sensing insoles.

PURPOSE: deliver musical feedback based on plantar pressure data that leads to a more symmetric weight-bearing, improved ankle range of motion, and higher pressure under the toes during terminal stance between the affected and healthy legs.

METHODS

- Case report: 56-year-old male; trimalleolar fracture on the right ankle.
- 2 months post-op = released for full weight-bearing.



- Musical Instrument Digital Interface (MIDI):
  1st chord = total force > 50N.
  2nd chord = hallux and 2nd toe plantar pressure sum > pre-selected threshold
- Different chord for each progressive step → cycled through 4-bar progression of Pachelbel's *Canon in D.*
- Sound modulation every 3min (upward) = engagement.

Gait Training — 6 sessions

5min warm-up	2min practice	12min training with auditory feedback

RESULTS

- Cadence, speed, and stride length increased (**Table 1**).
- Mean pressure under toes nearly doubled on the affected side ($p < 0.001$).
- Less plantar flexion during swing phase at baseline → increased after training (**Fig.1**).

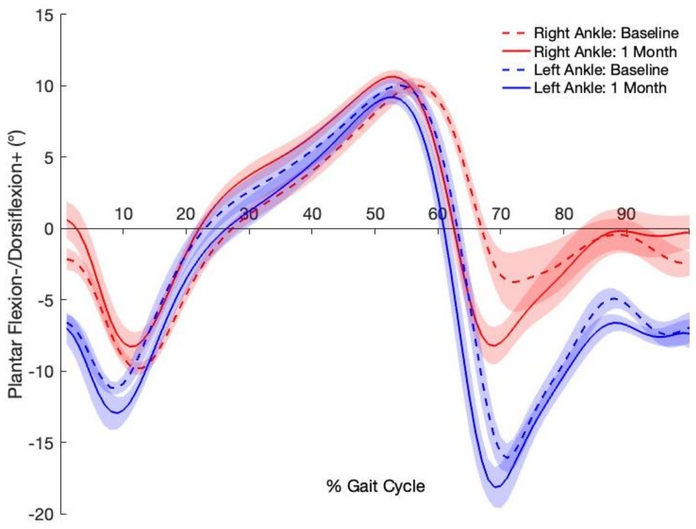


Figure 1. Ankle joint angle at baseline and after one month of training.

Table 1. Summarized gait parameters of the healthy (left) and affected (right) limb at baseline and after training

	Baseline		After Training	
Mean cadence	47.7 strides/min		50.6 strides/min	
Mean speed	0.90 m/s		1.02 m/s	
	Left	***Right***	***Left***	***Right***
Mean stride length (m)	1.23 ± 0.03	1.23 ± 0.04	1.36 ± 0.04	1.37 ± 0.05
Stance % of gait cycle	65.6 ± 1.3	60.0 ± 1.4	64.1 ± 3.8	60.8 ± 2.6
Mean pressure under toes at terminal stance (N/cm^2)	16.03	5.85	14.32	9.27
Total force, 1st peak (N)	817.4 ± 47.1	750.9 ± 38.7	763.8 ± 51.4	669.5 ± 55.3
Total force, 2nd peak (N)	899.1 + 41.4	730.5 ± 33.1	817.4 ± 43.9	727.8 ± 54.1

- Mean fraction of stance phase significantly increased for the affected leg ($p = 0.003$); was significantly different between limbs at both time points ($p < 0.001$).
- Mean total force was higher for the healthy side at baseline and showed a decrease after training (**Fig.2**).

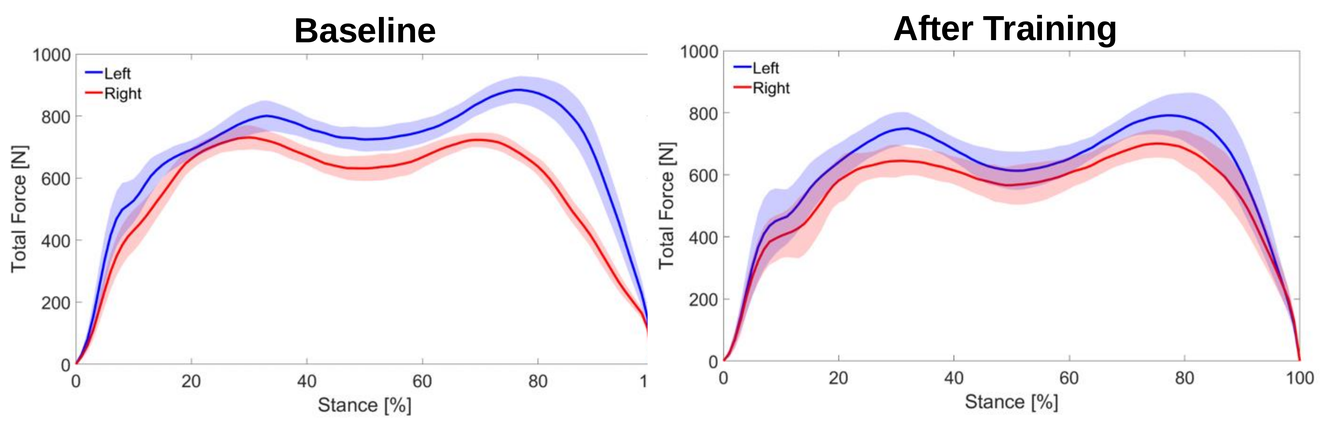


Figure 2. Mean total force curves throughout stance phase at baseline (left) and after training (right). Healthy limb shown in blue, affected shown in red. Error bands represent +/-1 SD.

DISCUSSION

- Patient walked faster with longer stride lengths after training with the auditory feedback.
- Auditory feedback was able to provide clues to apply more pressure under the toes, but mean pressure did not reach the level of the healthy limb.
- Range of motion is more closely related to healthy side after training.
- The affected side closely resembled the healthy one on the mean total force, particularly at terminal stance where the largest differences were observed at baseline.

CONCLUSIONS

Reward-based and progressive musical auditory feedback resulted in a more symmetric distribution of forces during stance, improved plantar flexion and higher toe pressure. Potential to become an evaluation and intervention tool.

ACKNOWLEDGMENTS

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REFERENCES

1. Mirando et al., Diagnostics, 2022. 2. Drongelen, et al., Frontiers in Bioengineering and Biotechnology, 2013. 3. He et al., Gait posture, 2019

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