Harvard Biodesign Lab

A UNI-LATERAL SOFT EXOSUIT FOR THE PARETIC ANKLE CAN REDUCE GAIT COMPENSATIONS IN PATIENTS POST-STROKE

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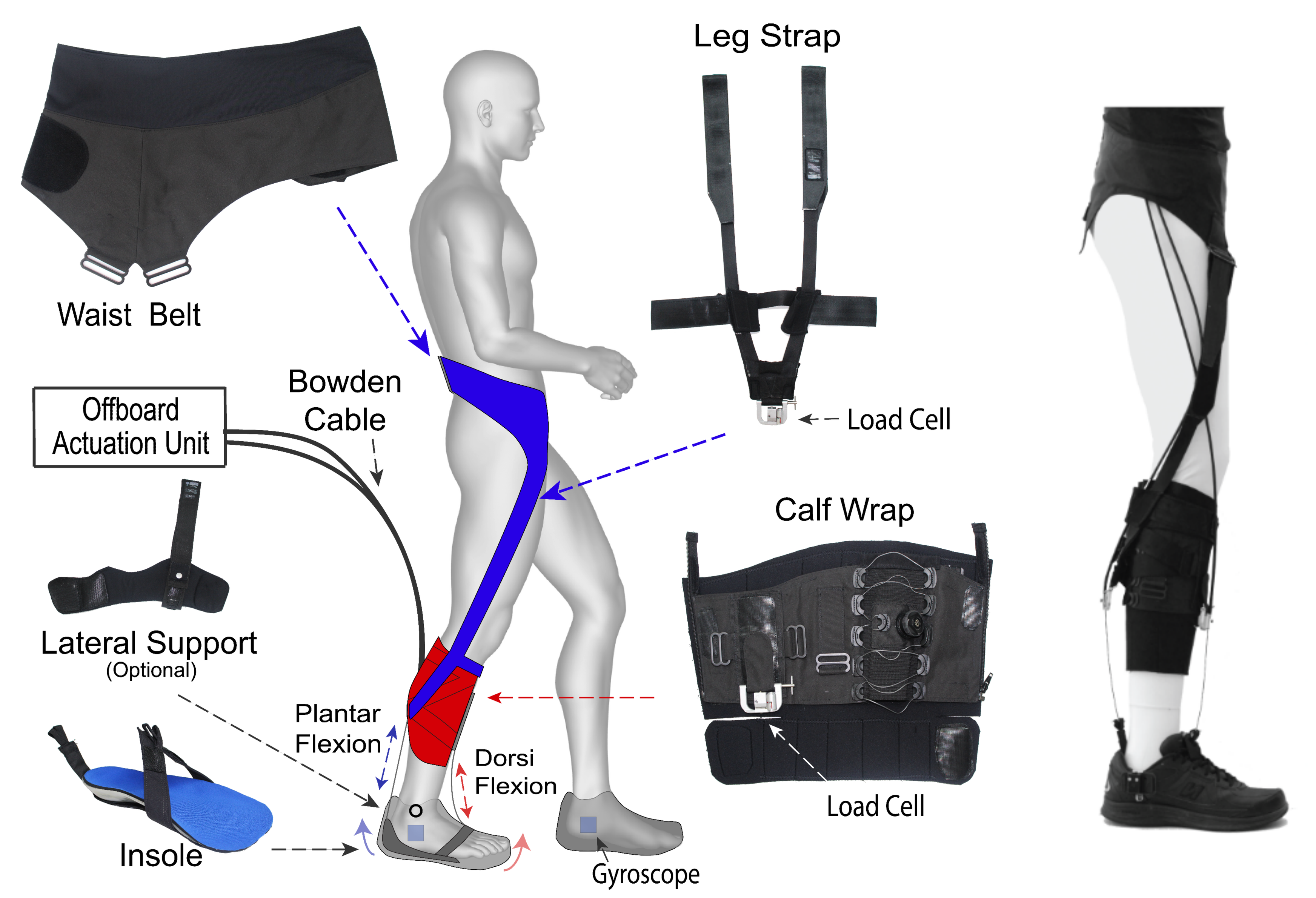
MOTIVATION

- Abnormal ankle kinematics and kinetics are characteristic of hemiparetic gait commonly leading to the development of ambulatory compensations such as hip circumduction and hiking to advance the limb during swing phase [1].
- Hip compensations are mechanically inefficient and energetically costly, which can have a negative impact on functional walking [2-4].
- Devices such as Ankle Foot Orthoses provide support to the ankle, but have been shown to reduce ankle push-off and gait adaptability [5].
- The development of adaptive wearable assistive technology that enhances the function of the paretic limb during both swing and stance phase is warranted.

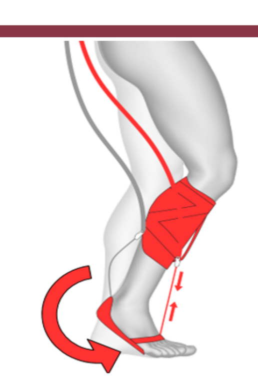
SOFT WEARABLE ROBOT (EXOSUIT)



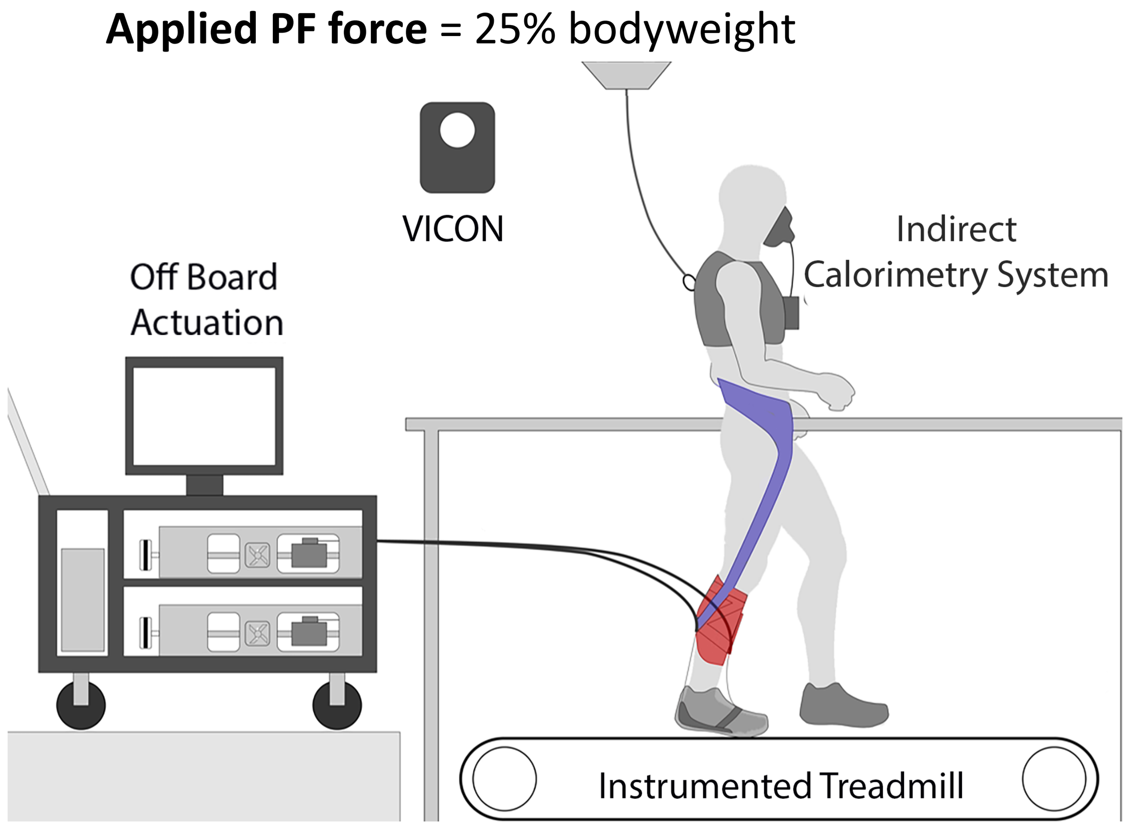
Functional textile anchors (waist belt, leg strap, calf wrap, and lateral support module) interact with an in-shoe insole to generate assistive ankle plantarflexion and dorsiflexion forces when the contractile elements of the exosuit (i.e. Bowden Cables) are contracted [6].

METHODS

Applied PF force = 25% bodyweight



Applied DF Force : adjusted per subject to achieve neutral ankle angle during swing



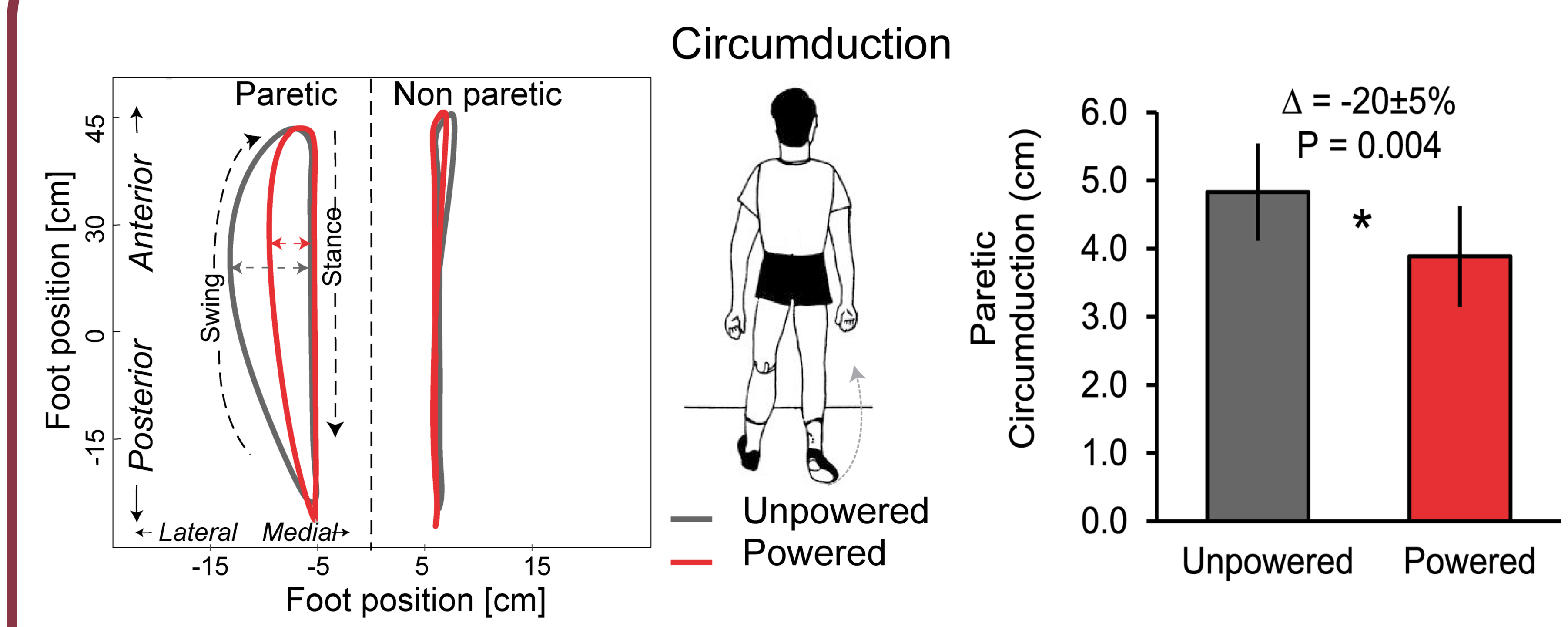
Walking Conditions

Condition 1 (8 min)
Exosuit **Unpowered**

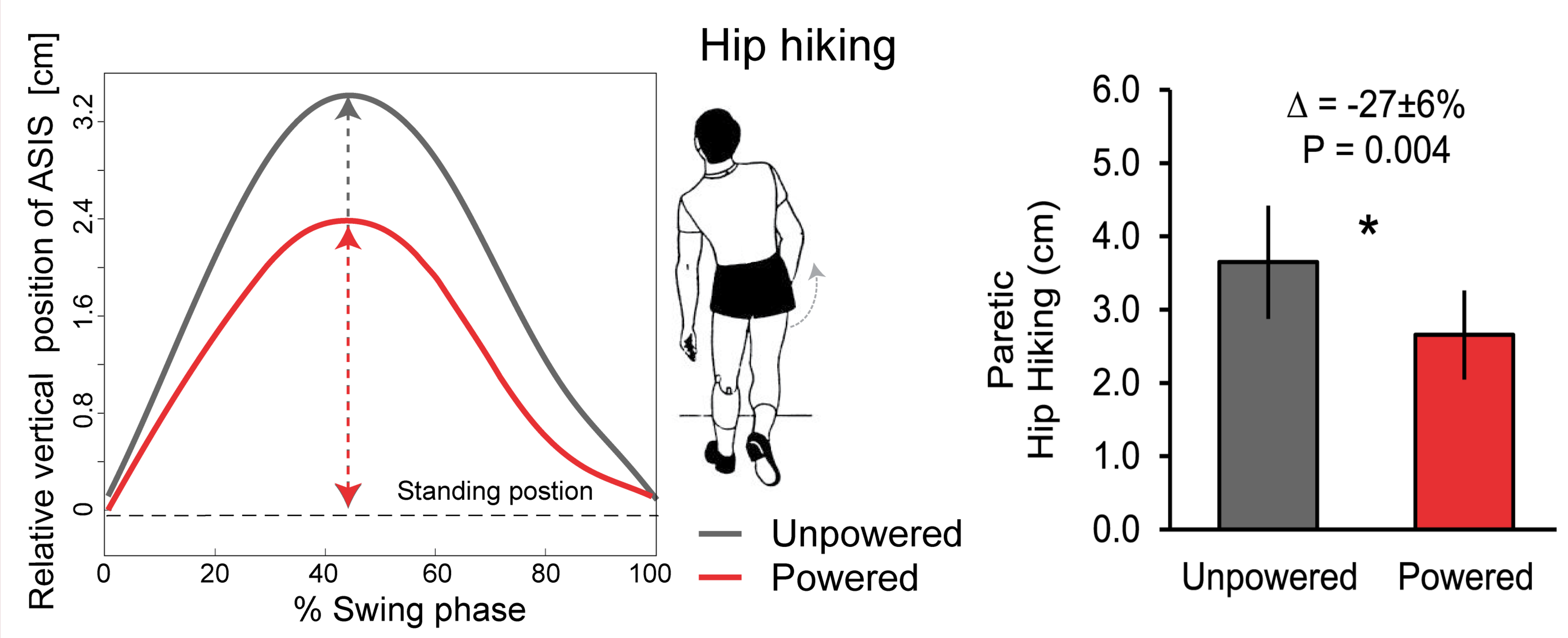
Condition 2 (8 min)
Exosuit **Powered**

8 Participants (4 Female)
Age: 49.0±4.0 y | **Weight:** 77 ± 16 kg
Walking Speed: 0.95±0.25 m/s | **Time since stroke:** 4.4±1.5 y

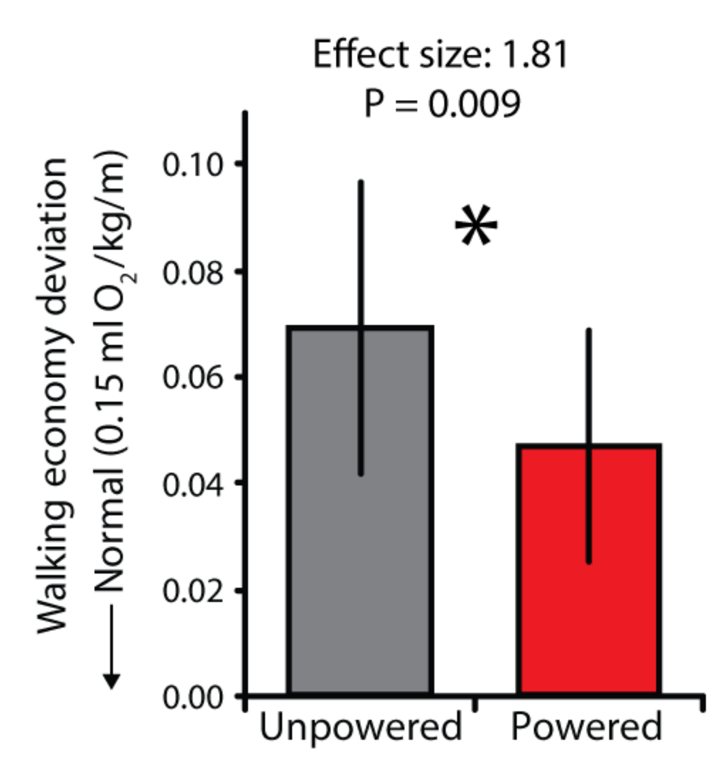
RESULTS & DISCUSSION



Reductions in paretic hip circumduction **(−20 ± 5%)** and hip hiking **(−27 ± 6%)** observed when comparing exosuit unpowered to powered conditions.



These findings speak to the modifiability of non-desirable kinematic behaviors when deficits in key paretic limb biomechanical functions are targeted.



A reduction in compensatory motions may explain the observed reductions in metabolic cost **(−32 ± 9%)** when wearing the exosuit.

The immediate compensatory and metabolic reductions observed are an assistive effect of the exosuit. Further research should focus on understanding the therapeutic benefits from translating and integrating this technology into gait rehabilitation.

CONCLUSIONS

- Reduced compensatory behaviors and increased walking efficiency during treadmill walking are a desirable finding which helps inform the development of a gait assistive robot. The exosuit presents an exciting opportunity for soft wearable robots in post stroke rehabilitation.
- Future developments in the exosuit technology that allow for direct assistance of knee and hip flexion may contribute to even greater reductions in frontal plane compensations, warranting investigation.

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FUNDING

DARPA, ReWalk Robotics, Wyss Institute, Harvard John A. Paulson School of Engineering and Applied Sciences, American Heart Association / American Stroke Association, NSF