Assistance Effect of an Evolved Heel-Raising Unit for Walking Disabilities

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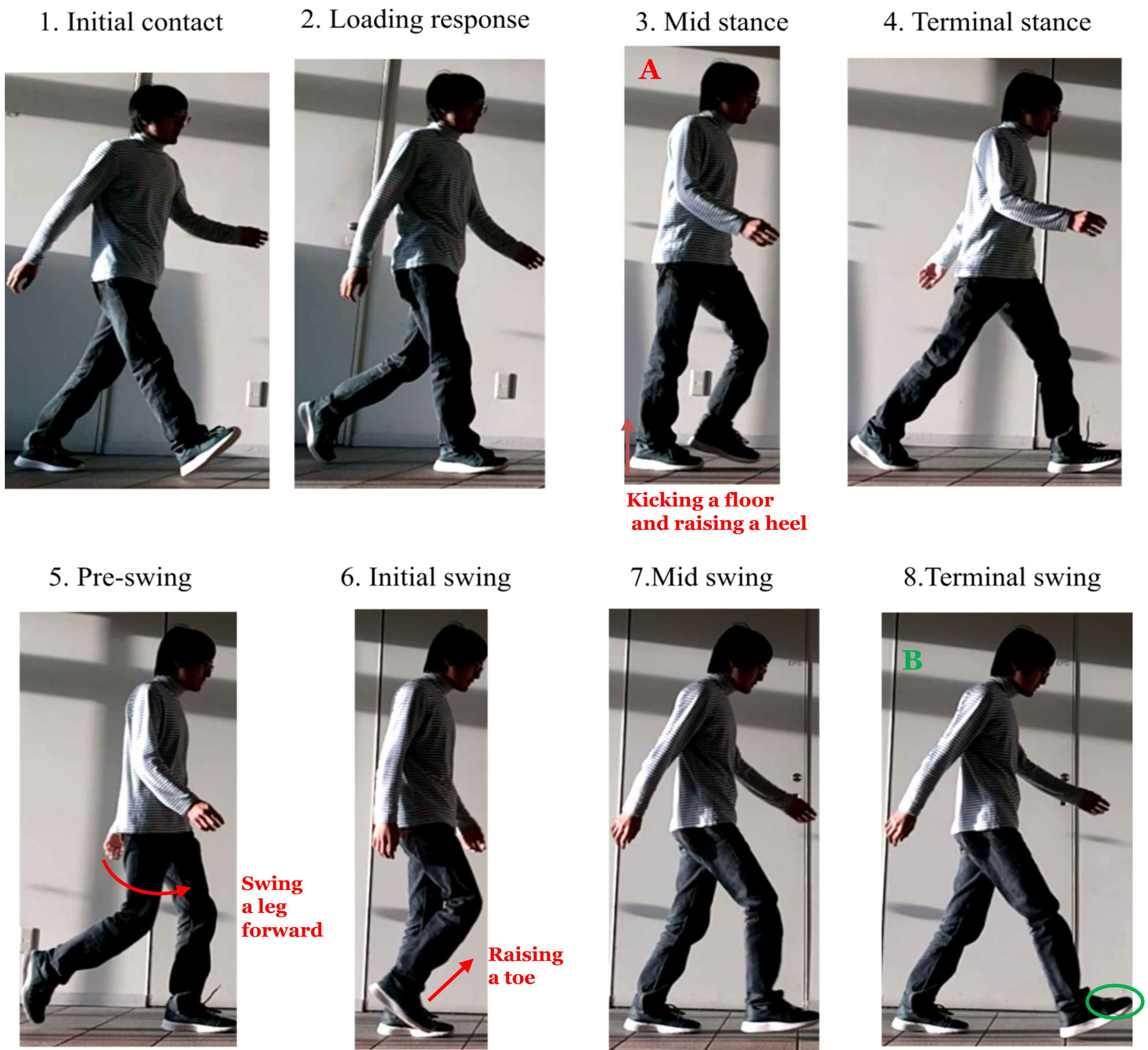
Short Biography

- Yoshitoshi Murata received his Dr. Engineering from Shizuoka University, Japan. From 1979 to 2006, he belonged to NTT and NTT DoCoMo. From 2006 to 2020, he was a professor of Iwate Prefectural University. He retired from Iwate Prefectural University end of March, 2020. He is a Professor Emeritus of Iwate Prefectural University.
- Prof. E. Yoshitoshi Murata is a Fellow of IARIA.
- His research interests are IoT in the medical and healthcare industry and the Factory.

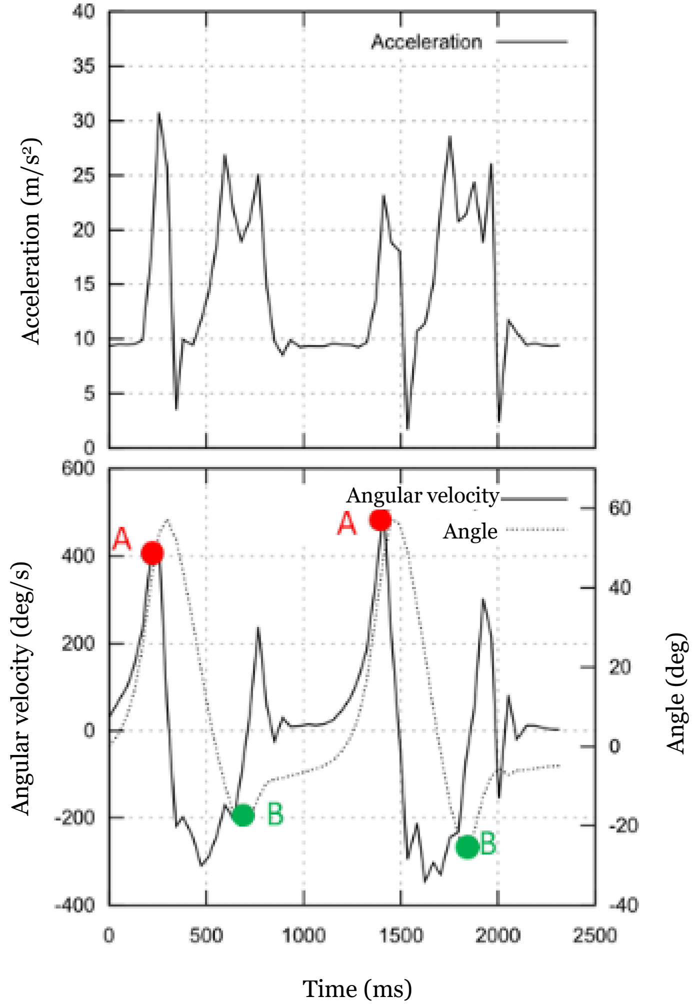
Background and purpose

- Elderly people and people with diseases such as hemiplegia often have a walking disability, because of their lower muscle power.
- The disability increases their risk of falling and suffering injuries.
- We are developing a heel-raising unit based on a spring to compensate for low muscle power.
- The structure of previous one was simple structure, but it lacked a mechanism to release the spring at the optimal timing.
- In this conference, an evolved heel-raising unit of which spring-release timing is improved is proposed.

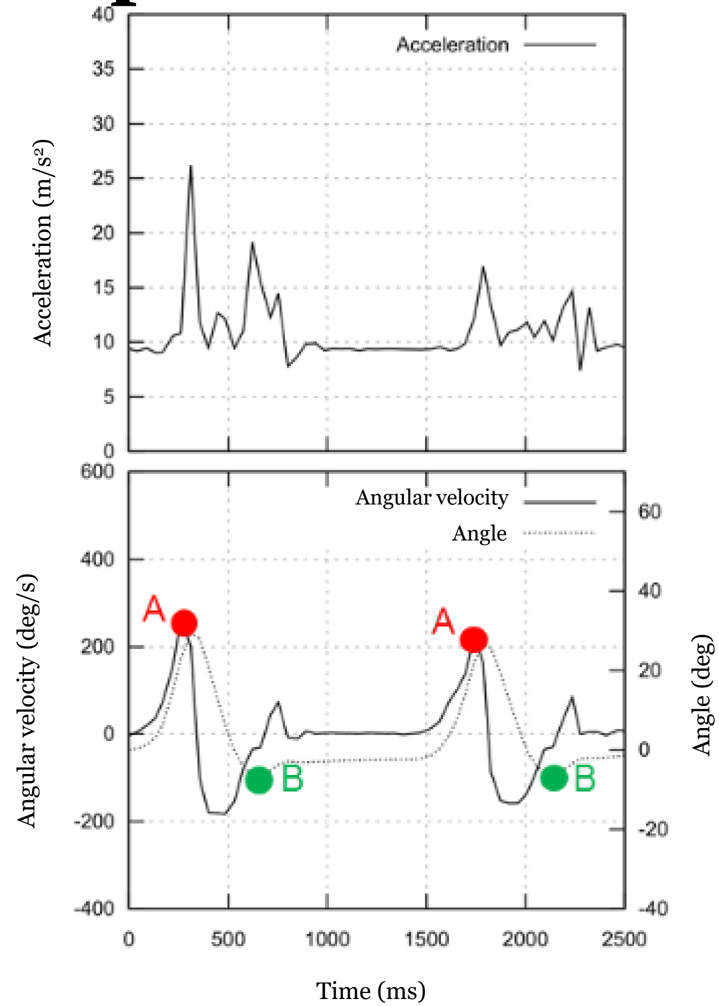
Normal walking gait cycle (right foot)



Gait differences between hemiplegia patients and healthy people



[Measured data for a hemiplegia patient]



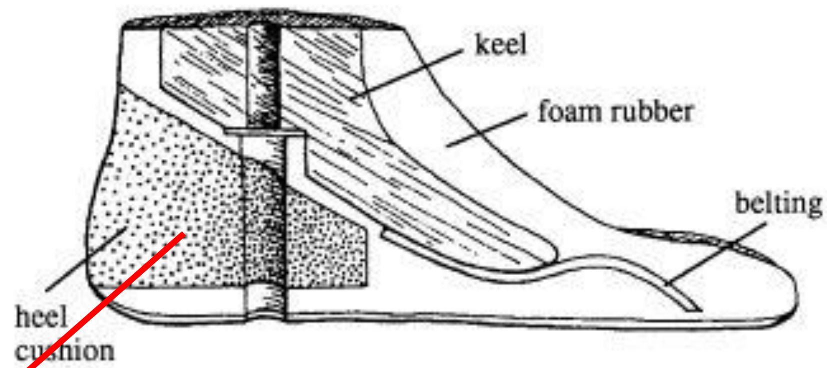
[Measured data for a hemiplegia patient]

* A and B correspond to A and B steps on the previous slide.

Basic idea of the gait assist shoes

The energy storage and return (ESAR) foot
: Vari-Flex, Össur, Iceland

The Solid-Ankle Cushion Heel (SACH) foot

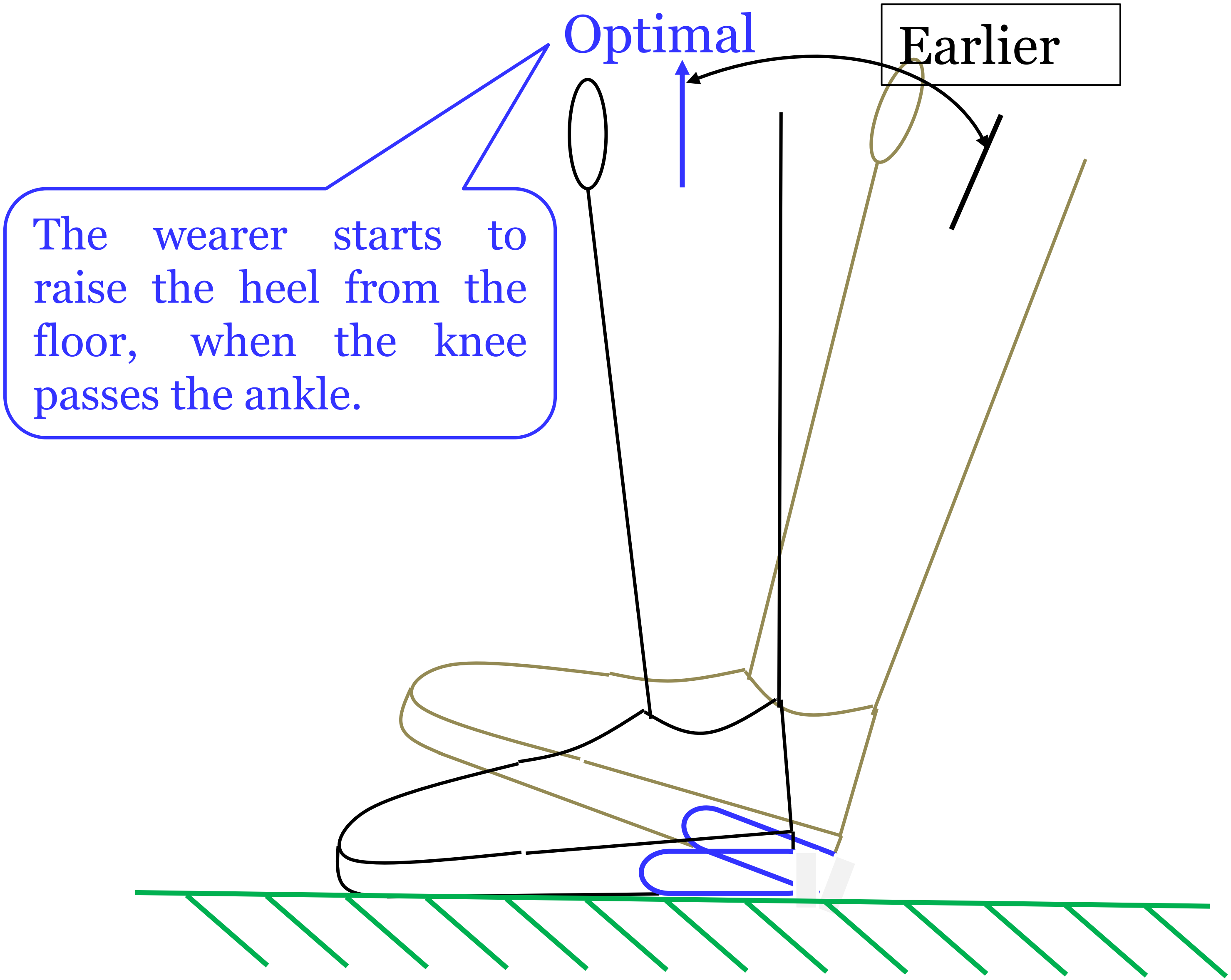


These parts absorb shock when the heel of the shoe contacts the floor, and thus assist in raising the heel.

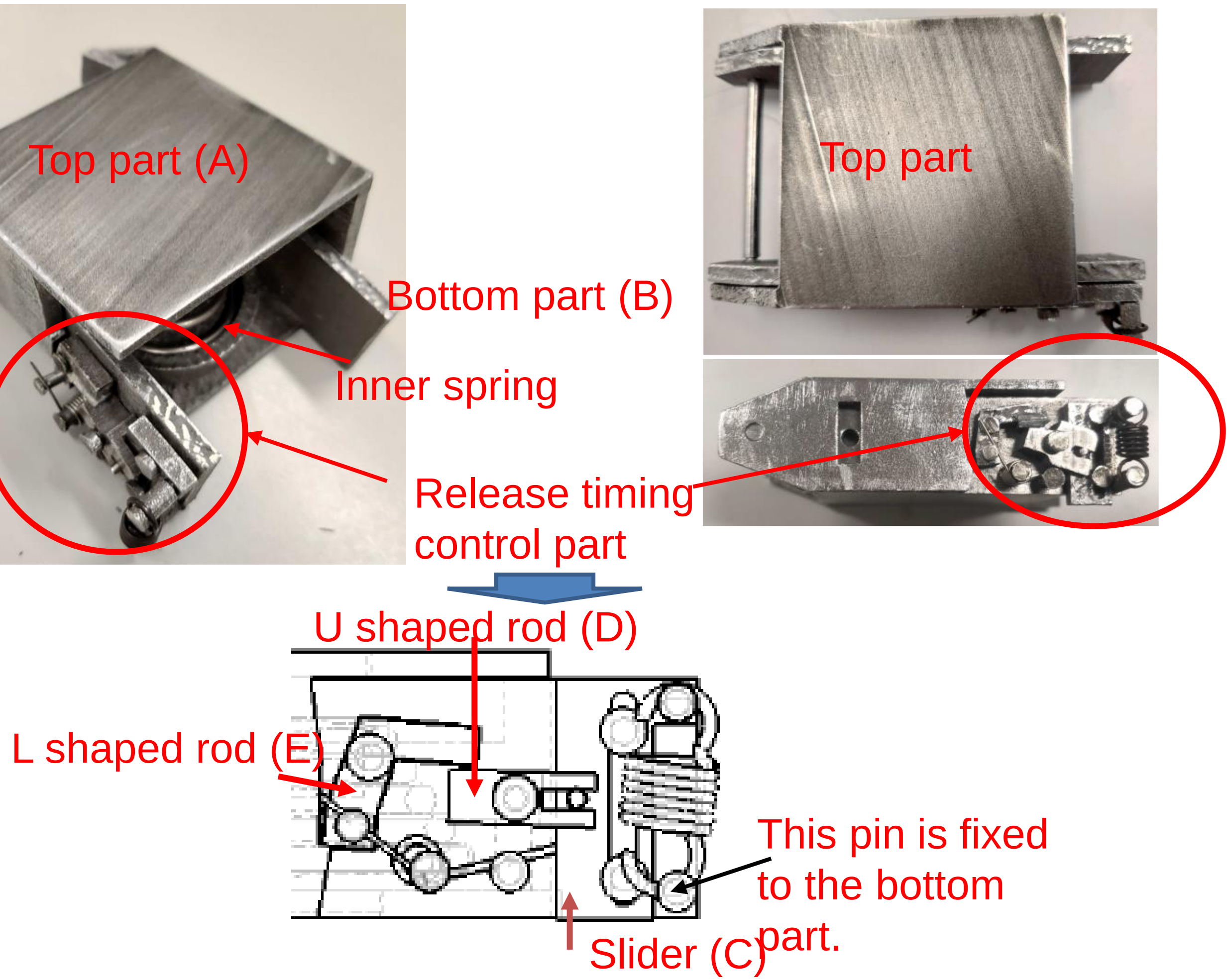
Prototype of the gait assist shoes with the simple heel-raising unit

Simple heel-raising unit
(Weight = 37 g)

Spring-release timing

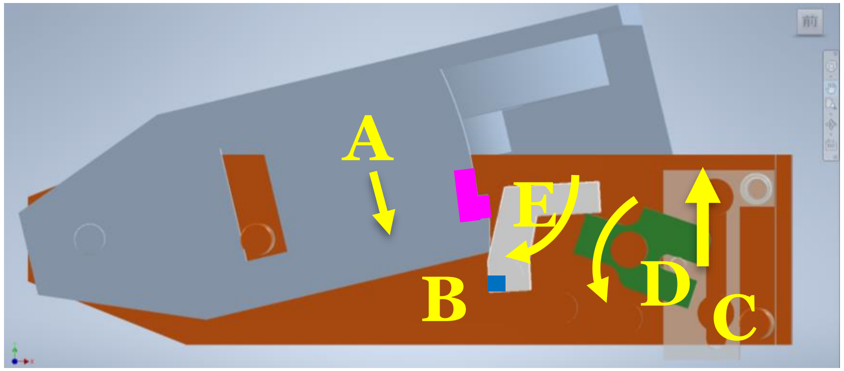


Evolved heel-raising unit

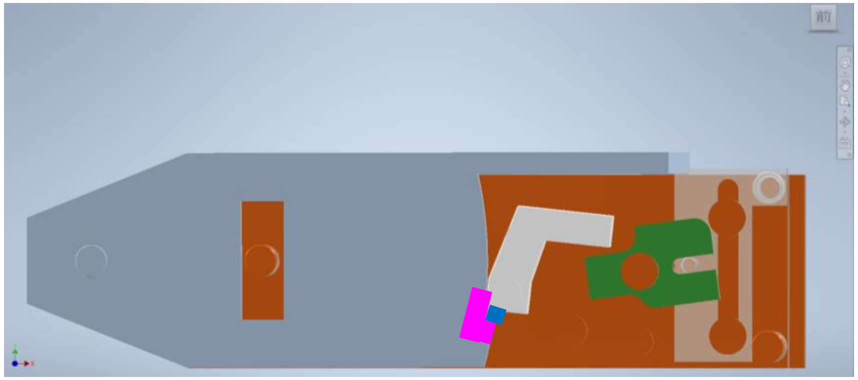


This model is fabricated with a metal 3D printer.
Its weight is 210 g, and its material is titanium.

Configuration for locking the inner spring



Released state

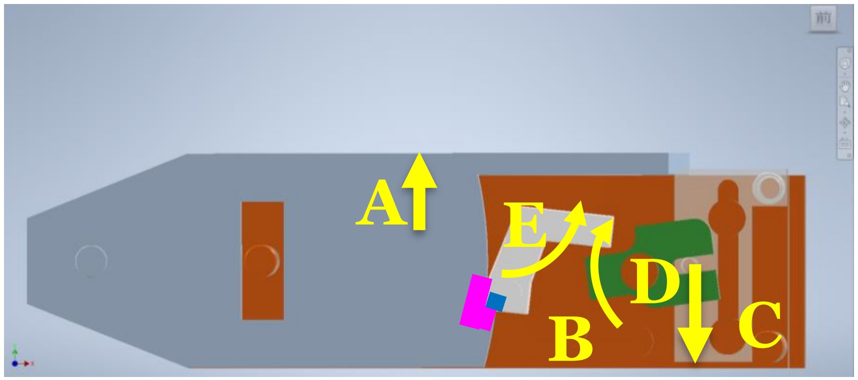


Latched state

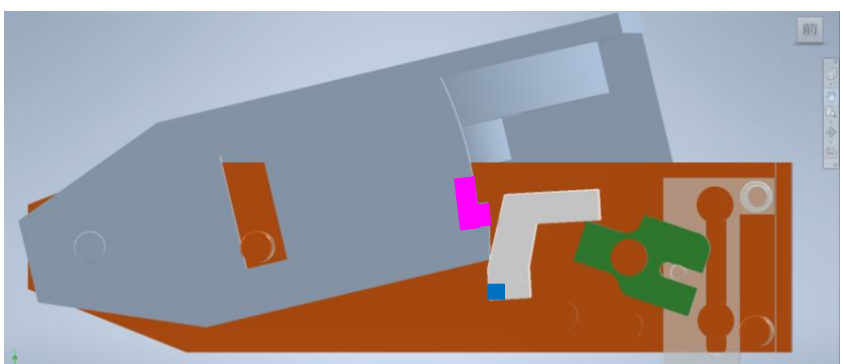
When the wearer touches the heel to the floor;

- the top part A goes down,
- the part C slides up,
- the part D rotates counterclockwise, and the part E rotates clockwise,
- the corner of part E latches with a notch in the top part A.

Configuration for releasing the inner spring



Latched state



Released state

When the wearer raises the heel from the floor;

- the part C slides down,
- the part D rotates clockwise, and the part E rotates counterclockwise.
- the corner of part E releases from the notch,
- the top part A raises the heel.

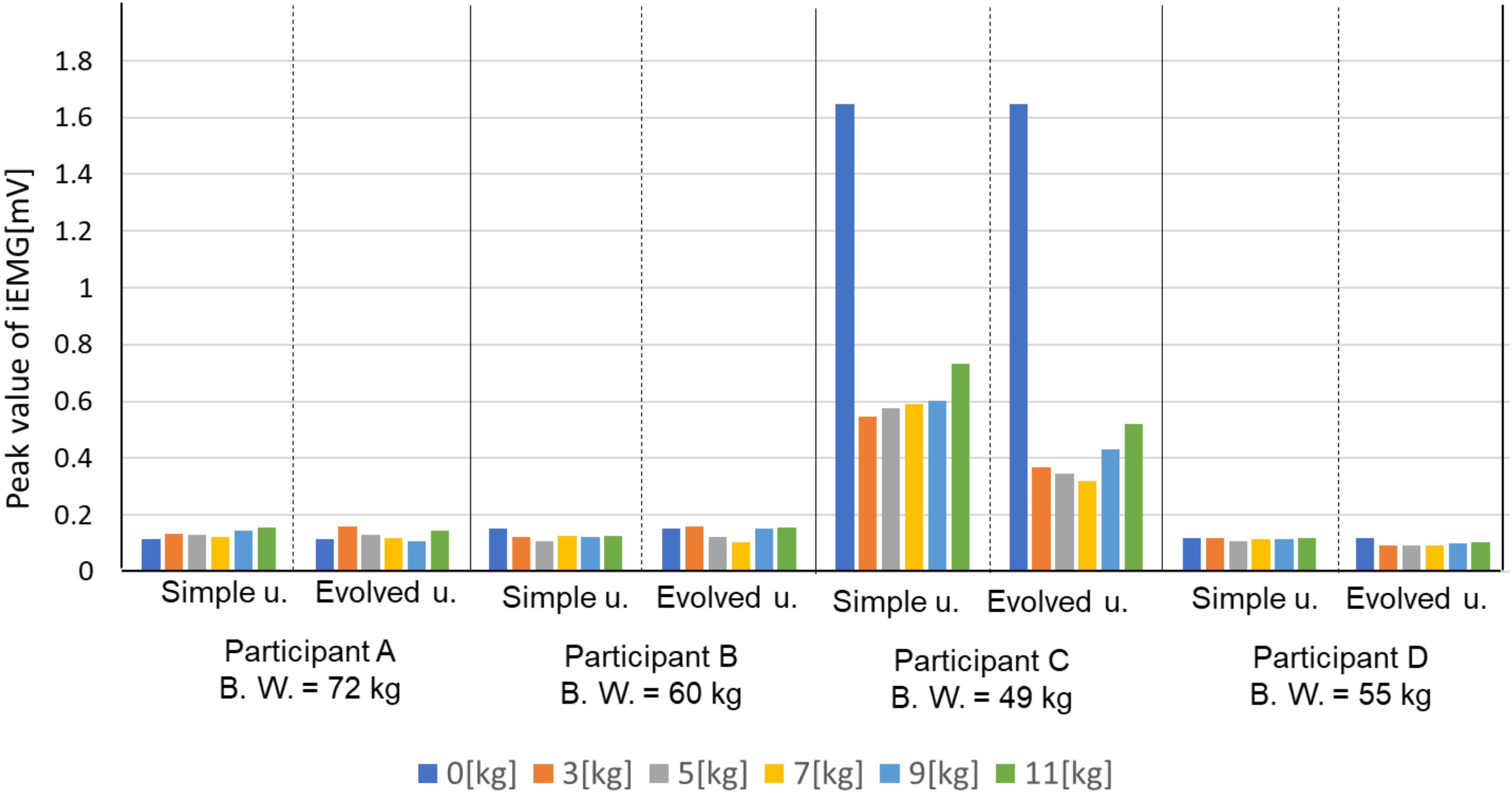
Evaluation measurement

(a) Shoes: Spring released state

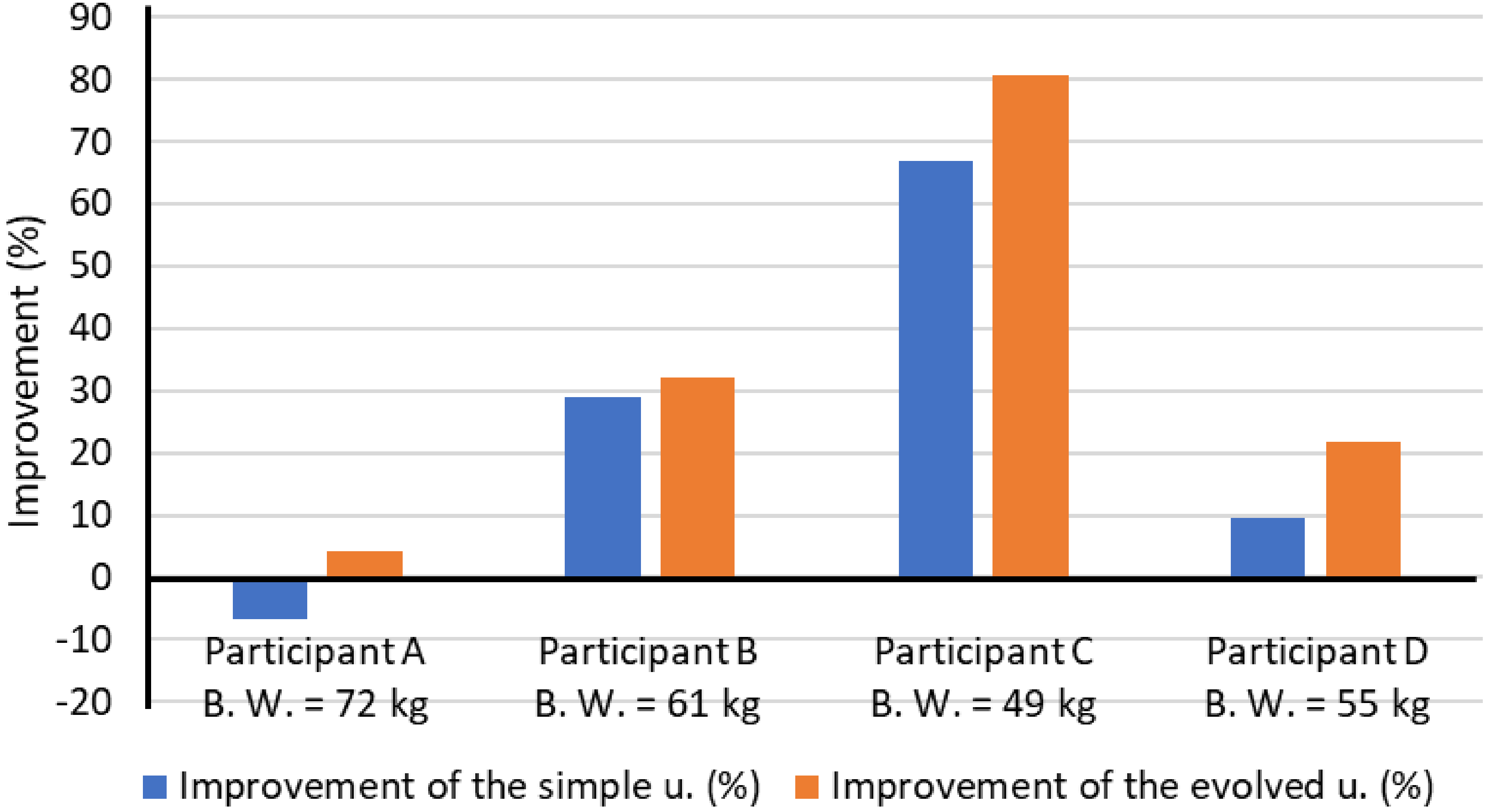
(b) Shoes: Spring compressed state

(c) Measurement space

Measured iEMG vs. spring stiffness for each participant



Improvement rate (IR) due to heel-raising unit

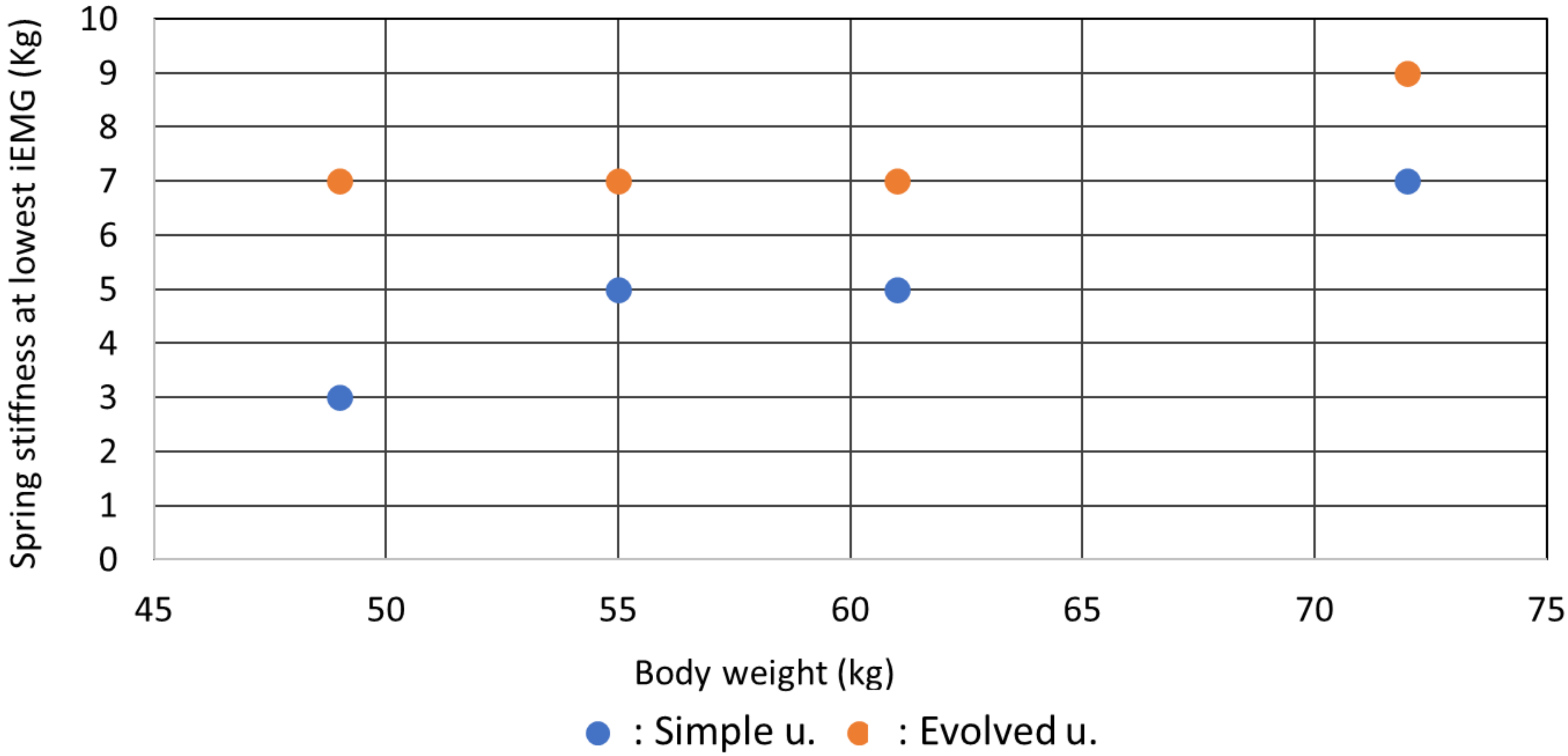


$$IR = 100 * (B-A)/B$$

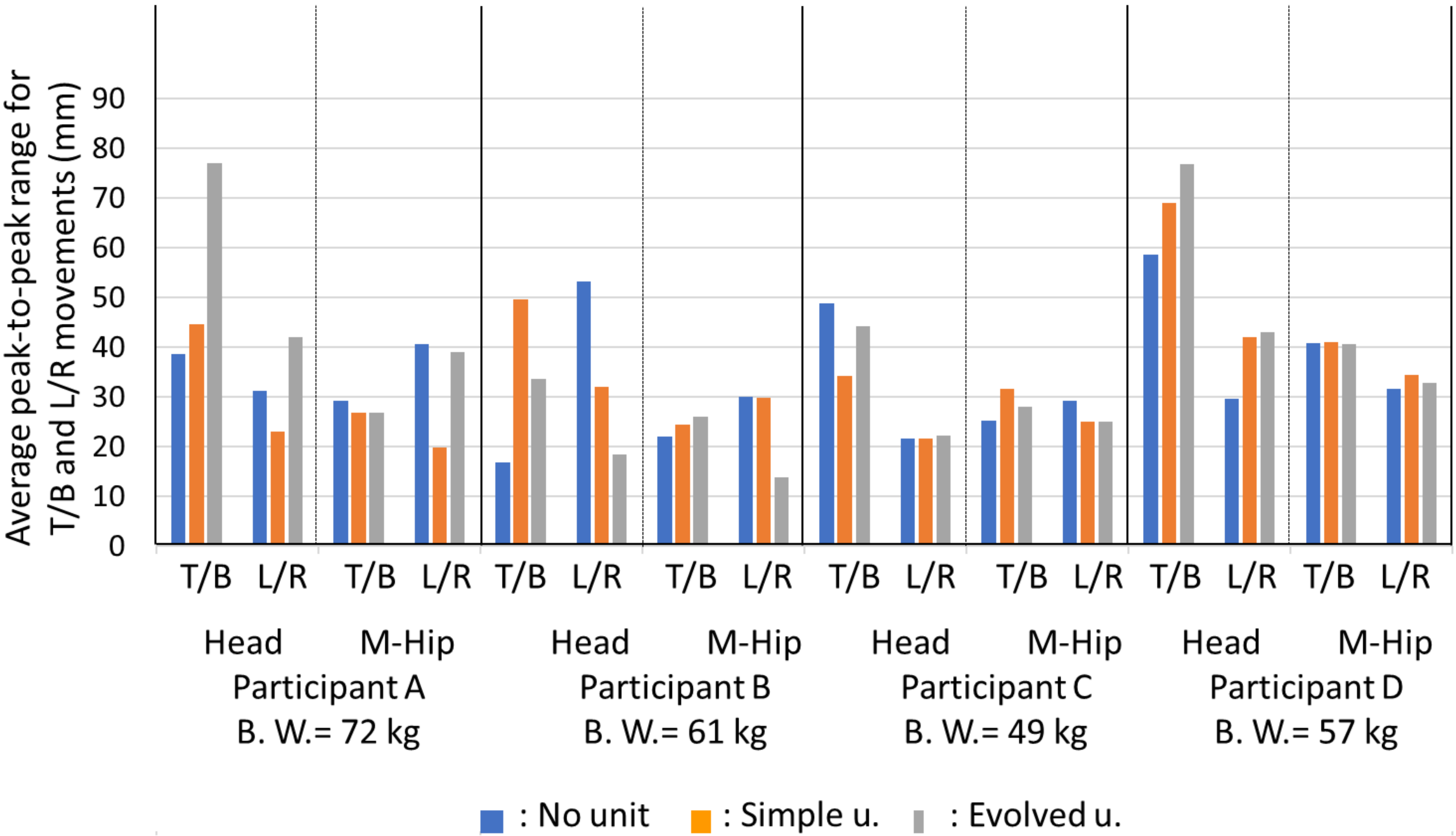
A: iEMG at most effective spring stiffness;

B: iEMG without heel-raising unit.

Spring power at lowest iEMG vs. participant body weight



Average peak-to-peak range for T/B and L/R motion over two steps [mm]



Conclusion

- We developed an evolved heel-raising unit, in which a spring in the unit is released when the foot shifts from the whole shoe contacting the floor to the heel rising.
- Experimental results with the evolved unit demonstrated that its assistance effect was notably better than that of our previous unit.
- The evolved unit had little effect on the walking posture as much as the previous one had.

Future works

- This experiment included a low number of participants who were all healthy students. We will thus need to measure data from many elderly people to correctly evaluate the evolved unit's assistance effect.
- Another problem is that the prototype model in these experiments was heavy and sometimes broke or did not work well, since the model was fabricated with a metal 3D printer.
- A consumer model will need to be lighter and more reliable, and to have a lower cost.