Functional ergonomic and neuro-muscular Assessment of TWIN-Acta exoskeleton in healthy subjects (FEAT) and persons post-stroke (FEAT-Stroke)

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The basis of these funded projects by Eurobench was **TWIN-Acta**, a control suite for lower limb exoskeleton, designed and developed with a user centered approach for training persons post-stroke.

- TWIN is a powered lower limb exoskeleton developed for persons affected by Spinal Cord Injury [1] (Fig. 1), who do not have any residual motor function, and therefore is primarily based on an assistive approach;
- Fondazione Don Carlo Gnocchi (FDG) and Istituto Italiano di Tecnologia (IIT) have designed and developed **TWIN-Acta,** a control suite which enables the TWIN exoskeleton to provide a tailored support depending on the patient's residual skills to boost his/her recovery.

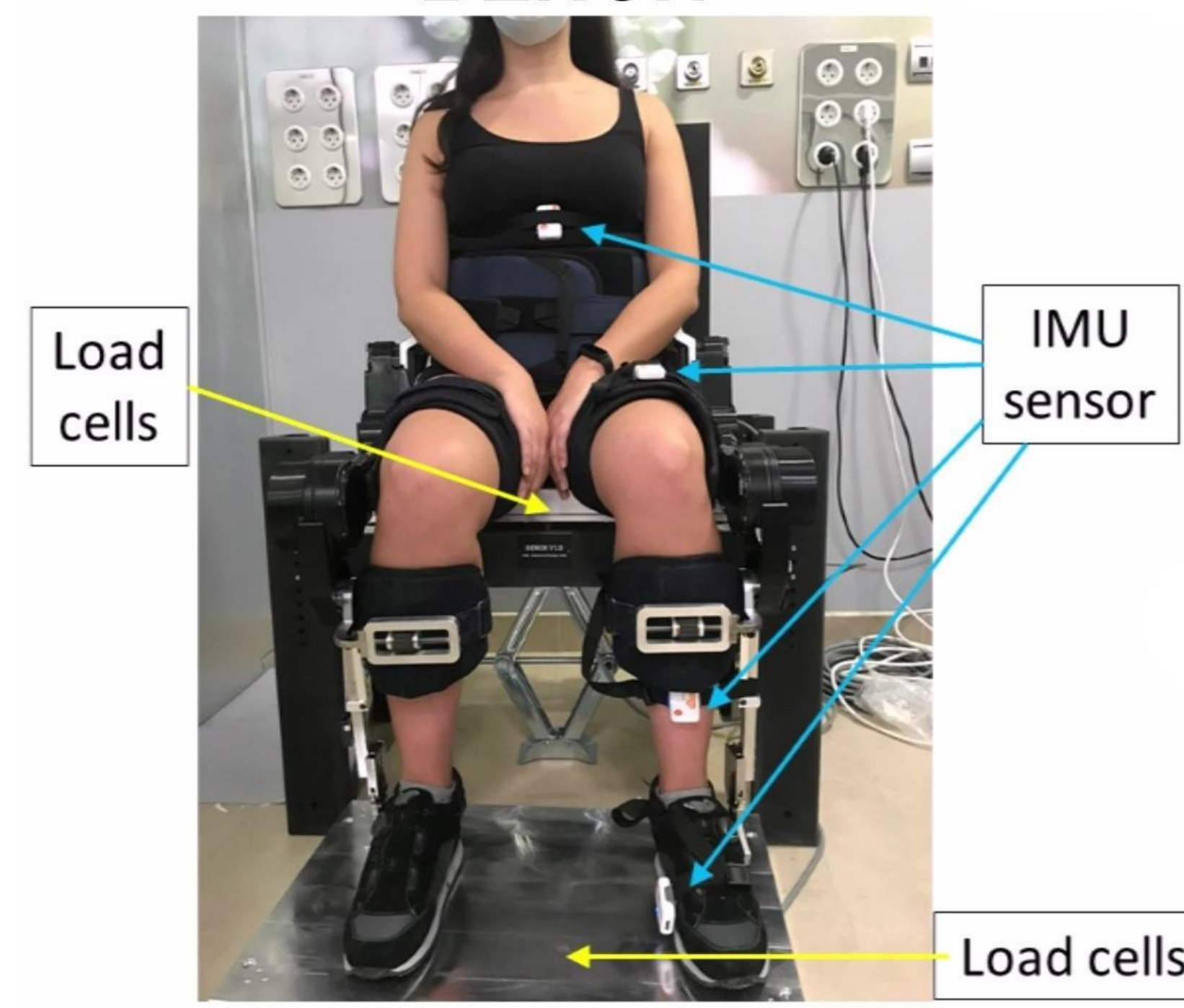Fig. 1 The TWIN exoskeleton developed at the IIT-INAIL Rehab Technologies Lab.

The goal of **FEAT** project was to perform a set of experiments on healthy subjects to evaluate the functional performances, ergonomics and human factors of TWIN exoskeleton operated by TWIN-Acta.

STEP-BY-STEP

PEPATO

EXPERIENCE

BENCH

Load cells

IMU sensor

Load cells

Fig. 2 Eurobech scenarios tested during the FEAT time frame

At the Hospital Los Madronos (Madrid, FEAT project) five healthy subjects performed the following scenarios while wearing the TWIN exoskeleton operated by TWIN-Acta (Fig. 2):
- STEP-by-STEP, EXPERIENCE, BENCH and PEPATO [2].

At the FDG facility (IRCCS Santa Maria Nascente, Milan, FEATStroke project) three persons post-stroke performed the following scenarios while wearing the TWIN exoskeleton operated by TWIN-Acta:
- PEPATO and modified protocols of EXPERIENCE and BENCH.

Stroke

Hemiparesis

Gait rehabilitation

Exoskeleton operated by TWIN-Acta

RESULTS IN PERSONS POST-STROKE

Persons post-stroke have an altered activation pattern of muscle synergies during gait [3], therefore rehabilitation aims at recovering physiological muscle activations. From this point of view, an important finding was the high similarity found between the gait muscle synergies of patients while wearing the exoskeleton with respect to the normative reference of walking without the device (Fig. 3). This result supports the use of TWIN-Acta in gait rehabilitation after stroke to recover a more physiological gait pattern.

RESULTS ON HEALTHY SUBJECTS

- TWIN-Acta succeeded in performing all considered tests;
- The ergonomics and functionality of TWIN-Acta have been found suitable for its use on neurologic patients in clinical studies;
- A strong degree of similarity has been found between the motor pools shown while walking with the exoskeleton with respect to the normative reference obtained without the device.

In conclusion, FEAT findings suggest that the TWIN exoskeleton operated by TWIN-Acta can be used as a rehabilitation device to enhance the recovery of the physiological motor control in persons with residual ability.

Reference modules are obtained for "speed2kmh"

module #1   IN: pattern similarity = 0.84
module #2   IN: pattern similarity = 0.79
module #3   IN: pattern similarity = 0.28
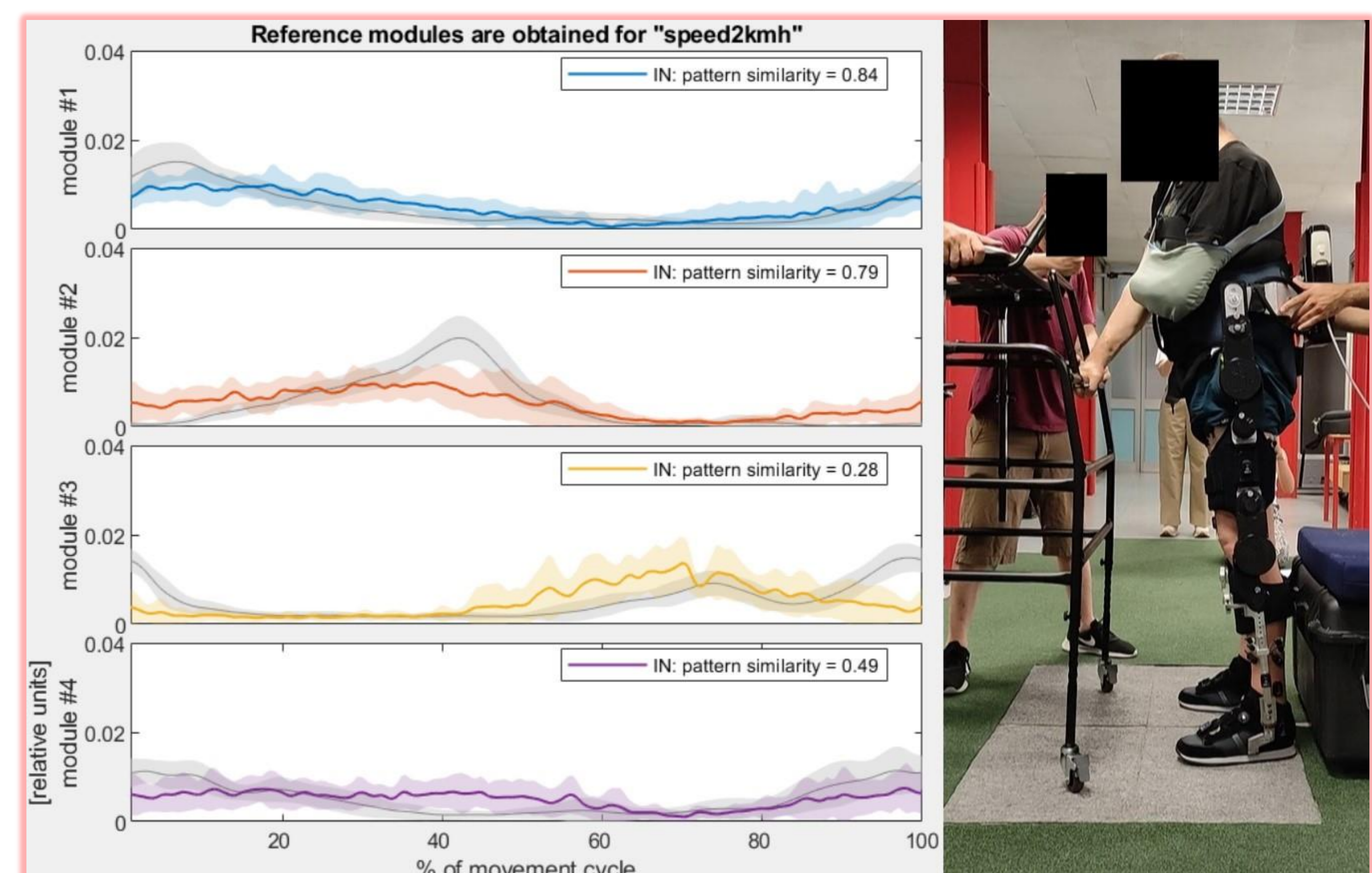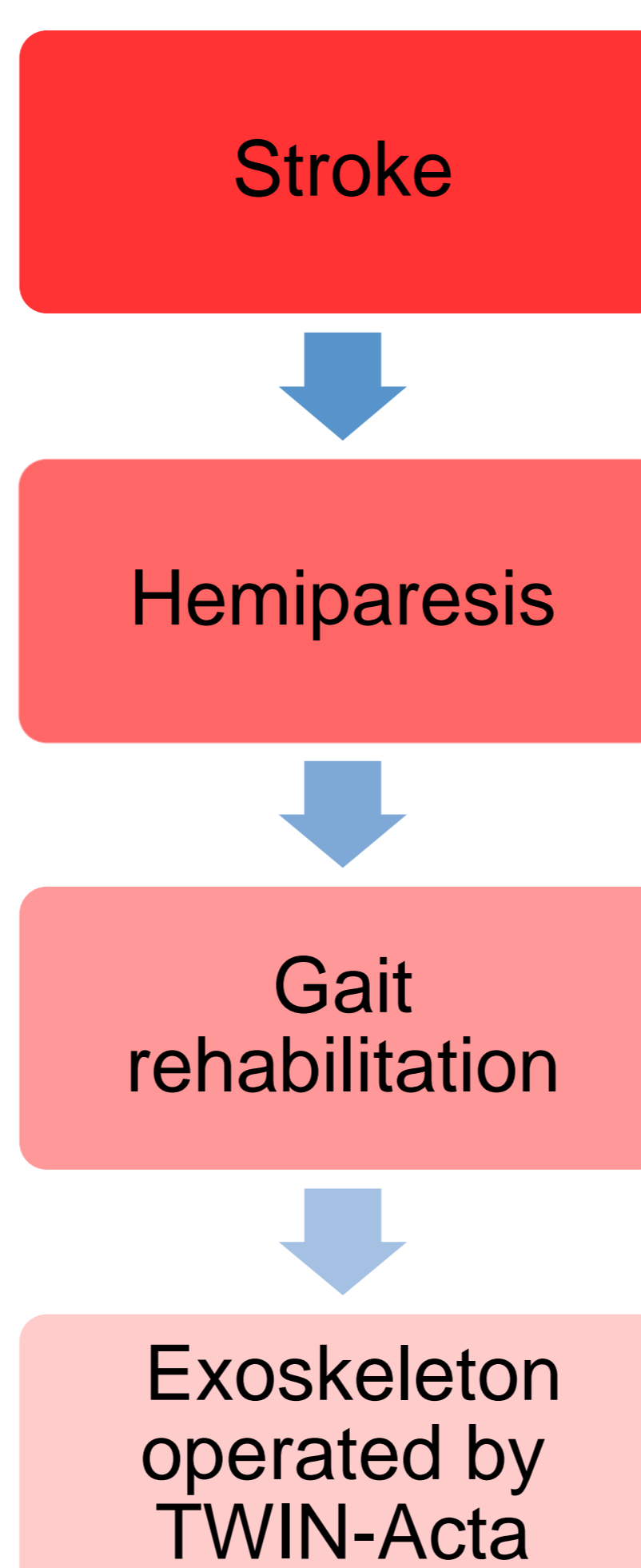module #4   IN: pattern similarity = 0.49

% of movement cycle

Fig. 3 Muscle synergies extracted by PEPATO tools in a person post-stroke while walking wearing the exoskeleton operated by TWIN-Acta (normative data in grey color).

REFERENCES

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[2] Lencioni T, et al. *SIAMOC Conference.* Bari, 5-8 October 2022.
[3] Clark DJ, et al. *J. Neurophysiol* 2010; 103(2): 844–857.