Testing robot-based assist-as-needed therapy for improving active participation of a patient during early neurorehabilitation: a case study

Kim K. Peper[1], Dinmukhamed Zardykhan[1], Marion Egger[3], Martina Steinböck[3], Friedemann Müller[3], Xavier Hildenbrand[2], Alexander Koenig[2], Elisabeth R. Jensen[1] and Sami Haddadin[1]

[1] Technical University of Munich, Munich Institute of Robotics and Machine Intelligence, [2]Reactive Robotics GmbH, [3]Schön Klinik Bad Aibling

ABSTRACT

An intensive care unit (ICU) patient received assist-as-needed (AAN) robot-based mobilization therapy with VEMOTION (fig. 1). Surface electromyography (sEMG) of the M. rectus femoris (RF) and M. biceps femoris (BF) were measured and analyzed. Active participation increased over the course of three weeks. The patient's tolerated hip range of motion β, verticalization angle α and leg load force F_{Load} also increased. To the authors' best knowledge, this study is the first of its kind to be performed with an ICU patient.

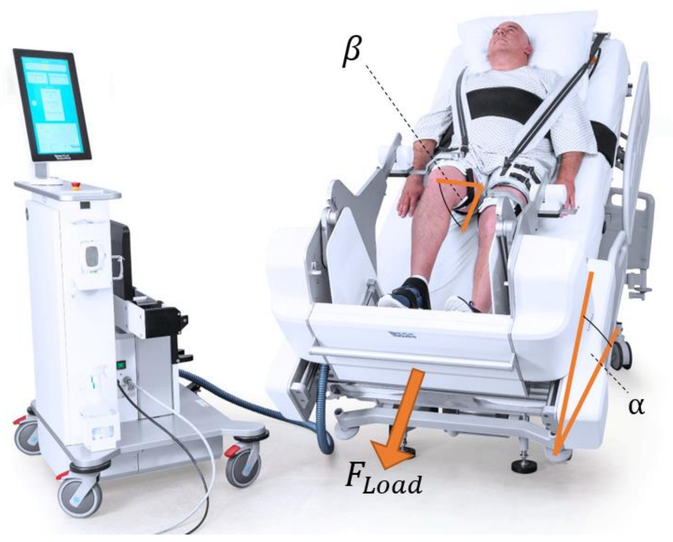

Fig. 1: VEMOTION therapy system and relevant settings: Verticalization angle, α, hip range of motion, β, and applied force by the patient, F_{Load}.

INTRODUCTION

- Very Early Mobilization (VEM) decreases complications from prolonged bedrest [1].
- Mobilization alone is not enough for effective rehabilitation and voluntary movement is important for motor learning [2].
- AAN function was developed [3] and integrated into VEMOTION (fig. 1) to encourage active participation.
- AAN control scheme provides only the required amount of support for the patient through velocity shaping.

Goal

Observe the ability of a patient in the ICU to actively participate during VEMOTION-based AAN therapy.

METHODS

Participant

ICU patient, F, 69 y.o., critical illness polyneuropathy

Experimental Protocol

- Six AAN therapies over the course of three weeks
- sEMG (Cometa, 2kHz) of RF and BF of the right leg during two therapies (first and third week)
- **VEMOTION settings** (fig. 1) manually adjusted for each therapy

sEMG data analysis

- Manually synced with VEMOTION data using accelerometer data
- Full-wave rectification and root mean square (RMS) with a 200ms window
- Nomalized step length
- Median and 95% confidence interval (CI) of 30-50 steps

RESULTS

Changes of **VEMOTION settings** (fig. 2) from week 1 to week 3:

- Full hip extension (0° vs 3°)
- Higher upright position (+15°)
- Higher weight bearing (+18kg)
- Longer therapy time (+5min)

Changes of **sEMG** (fig. 3) from week 1 to week 3:

- Increased median peak and CI
- Highest change observed in leg extension
- Activation of both biarticular muscles, RF and BF, during leg flexion and extension

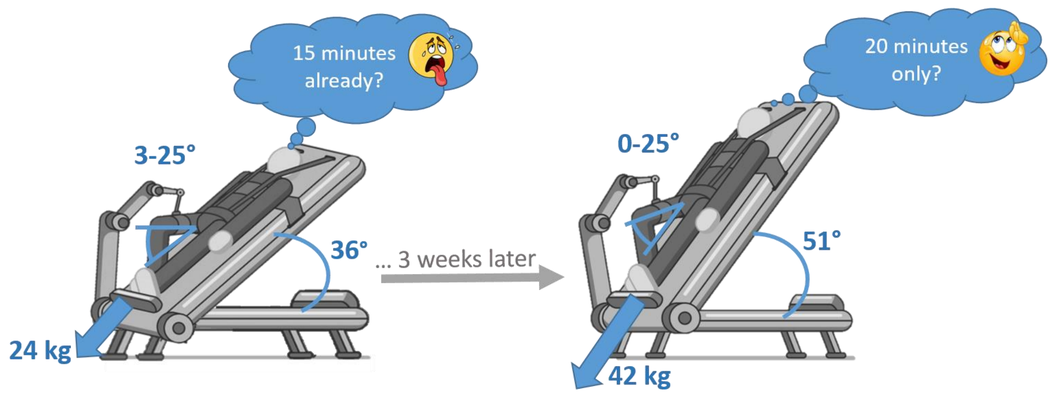

Fig. 2: Change of verticalization angle, hip range of motion, applied force by the patient and patient endurance over the course of three weeks

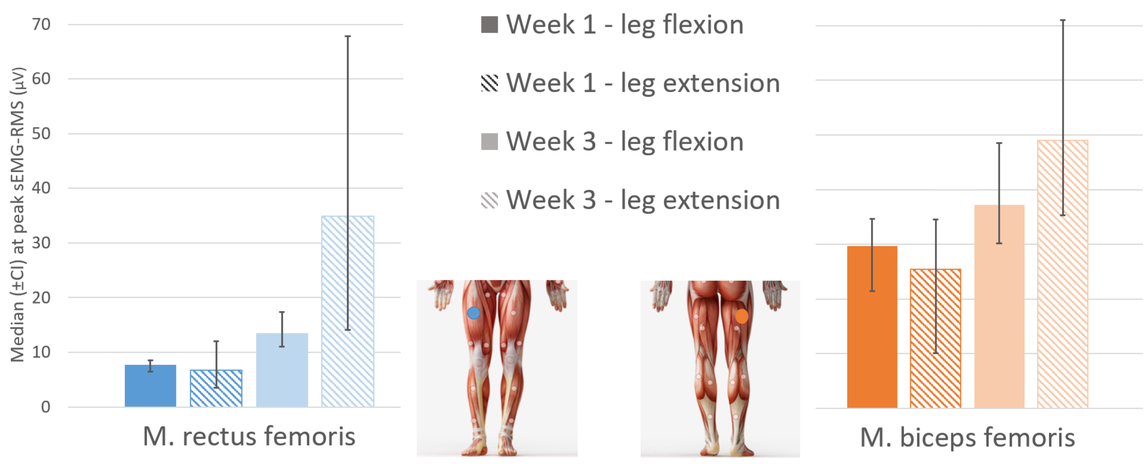

Fig. 3: Median and CI at peak RMS during leg flexion and extension at week one vs week 3. Leg images adapted from [4].

DISCUSSION & CONCLUSION

- Active participation of the patient increased.
- Both the hip and knee joint are actively flexed and extended using biarticular muscles.
- The current results should be compared with a larger number of subjects and other conventional, non-robotic ICU mobilisation therapies [6].

REFERENCES

[1] G. K. Alaparthi et al., "Effectiveness, safety, and barriers to early mobilization in the intensive care unit," Critical Care R. and Practice, 2020.
[2] R. Van denBrand et al., "Restoring voluntary control of locomotion after paralyzing spinal cord injury," science, 2012.
[3] E. Shahriari et al., "Energy-based adaptive control and learning for patient aware rehabilitation," IROS, 2019.
[4] Cometa srl, Italy, EMG and motion tools software V.7.0
[5] F. Taut, "Elektromyographische evaluierung des kipptisch-stepper-systems-erigo an gesunden und chronisch rückenmarksverletzten patienten," Dissertation, 2009.

CONTACT

ACKNOWLEDGMENT

This work was supported by the German Federal Ministry of Education and Research as part of the projects MobIPaR (grant no. 16SV7987) and AI.D (grant no. 16ME0539K)

SPONSORED BY THE Federal Ministry of Education and Research