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

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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 $\beta$, verticalization angle $\alpha$ and leg load force $F_{\text{Load}}$ also increased. To the authors' best knowledge, this study is the first of its kind to be performed with an ICU patient.

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

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

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

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

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
• Normalized step length
• Median and 95% confidence interval (CI) of 30-50 steps

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
[4] Cometa of, Italy, EMS and motion tools software V.7.0

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