

Armeo[®] Therapy Concept



**Helping Patients to Grasp the Initiative and
Reach Towards Recovery**

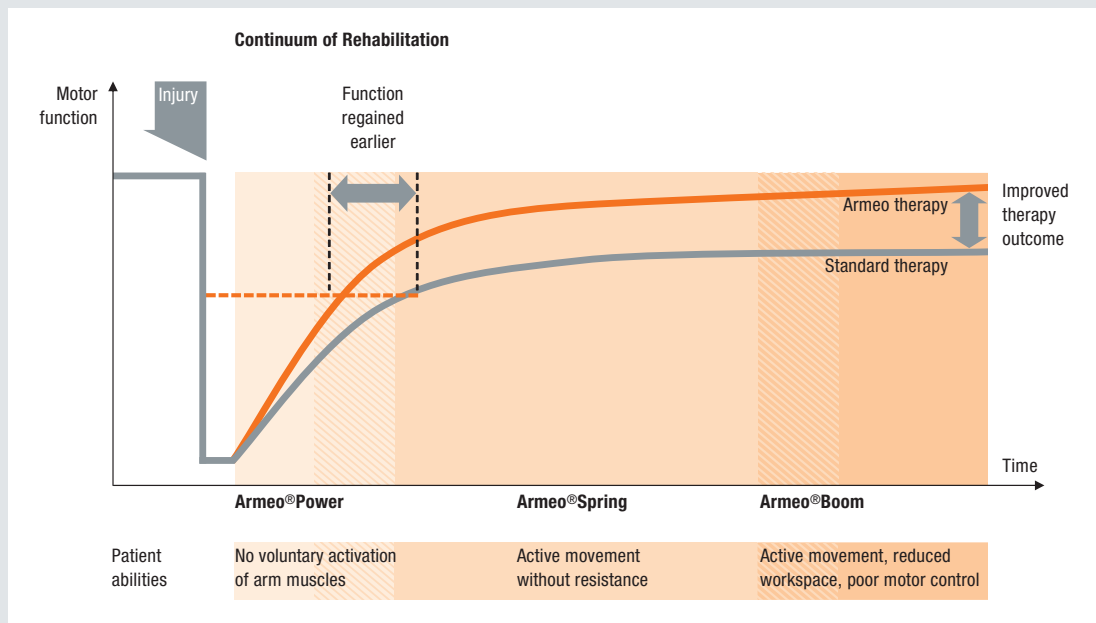
The Armeo® Therapy Concept

This is a sustainable and powerful therapy concept for individuals who have suffered strokes, traumatic brain injuries or neurological disorders resulting in hand and arm impairment.

Despite the patient's disorder, research suggests that the neural plasticity of the brain is retained and new connections can be made through intensive, repetitive, task-oriented movements. These exercises assist the gradual reorganization of the brain, which subsequently allows the restoration of movement and functionality to the affected parts.

Clinical trials also indicate that therapies are more effective if the patient initiates the exercise and remains motivated through the often lengthy rehabilitation process, a recovery period in which one-to-one therapist attention may not be economically viable.

Using this clinical evidence as a basis, the Armeo Therapy Concept has been developed. It comprises three features and a modular line of three Armeo products, all driven from a single software platform. The result is a comprehensive therapy concept which addresses different patient and therapeutic needs across the whole "Continuum of Rehabilitation", from the beginning of the rehabilitation process through to home therapy.



The Armeo Therapy Concept improves the efficiency of therapy treatments because the exercises are self-initiated, self-directed, functional and intense. Even severely impaired patients can practice independently, without the constant presence of a therapist, allowing patients to exploit their full potential for recovery.

The Augmented Performance Feedback provided by the shared software platform, encourages and motivates patients to achieve a higher number of repetitions, and this leads to better, faster results and improved long-term outcomes.

The software also provides automatic, ongoing assessment of motor functions and patients can readily track their progress, helping them to grasp the initiative and reach towards recovery.

Three innovative products, three key features

The rehabilitation, from immediate post-injury to long-term recovery, referred to here as the "Continuum of Rehabilitation", requires a range of therapies to address the changing needs of the recovering patient. The Armeo Therapy Concept includes three distinct products, Armeo®Power, Armeo®Spring and Armeo®Boom, each designed for a particular stage in the recovery process. However, the backbone of the Armeo Therapy Concept is the combination of three key features:

Arm Weight Support **Augmented Performance Feedback** **Assessments Tools**

Together, these features enable the patient to achieve a higher intensity of self-directed movement exercises, while remaining continuously motivated and capable of assessing and tracking the progress towards recovery.

The whole Armeo Therapy Concept is governed by the Armeo software which is the basis of a shared user management system and database, providing therapy plans, assessment modalities, exercises and games across all three Armeo products.



1. Arm Weight Support

By providing support for the affected arm and hand, the Armeo Therapy Concept allows patients to reacquire and improve motor control. The support counteracts the effects of gravity and helps to:

- reveal any remaining motor functions
- facilitate self-initiated and intensive repetitive movements
- increase movements within a 3D workspace



2. Augmented Performance Feedback

Utilizing a wide range of self-initiated, functional and motivational exercises and games, which simulate regular activities of daily living, the shared software gives the patient Augmented Performance Feedback through:

- repeated tasks which are motivating and rewarding
- functional exercises with immediate performance feedback
- adjustable difficulty levels according to the patients' needs and progress
- adjustable workspace according to the patients' changing abilities



3. Assessment Tools

Included in the Armeo software, these tools allow accurate monitoring of the patient's recovery progress through:

- an integrated database for the management of individual therapy plans
- documentation of progress as a basis for clinical decisions
- precise assessments of the individual patient's ability to move.

The Armeo® Therapy Concept

Armeo®Power

Robotic arm exoskeleton



Armeo®Spring

Exoskeleton with integrated spring mechanism



Armeo®Spring Pediatric

ArmeoSpring specifically designed for children



Armeo®Boom

Overhead sling suspension system



Armeo® Software

Augmented Performance Feedback, Assessment and Reporting Tools for every Armeo product.

The Armeo Therapy Concept includes four distinct products, the ArmeoPower, the ArmeoSpring / ArmeoSpring Pediatric and the ArmeoBoom, each designed for a particular stage in the recovery process. Patients, who have no voluntary activation of the arm muscles yet, can begin their therapy using the ArmeoPower. Once they begin to regain active movement of the arm and hand, they can start training with the ArmeoSpring. Finally, the patients can use the ArmeoBoom to further increase active arm movements and improve motor control. The ArmeoSpring Pediatric was specifically designed to meet the needs of children.

		Armeo®Power	Armeo®Spring Armeo®Spring Pediatric	Armeo®Boom
Software Features	Augmented Performance Feedback	•	•	•
	Grasp and release exercises	•	•	
	Assist-as-needed support	•		
Arm Weight Support	Arm Weight Support	•	•	•
	Exoskeleton for movement guidance	•	•	
	Active arm support	•		
Assessment Tools	A-MOVE	•	•	•
	A-GOAL	•	•	•
	A-ROM	•	•	
	A-FORCE	•		
Therapeutic Goals	Increase active range of motion	•	•	•
	Increase strength and endurance	•	•	•
	Facilitate self-initiated movement	•	•	•
	Increase selective control	•	•	
	Mobilize patients	•		

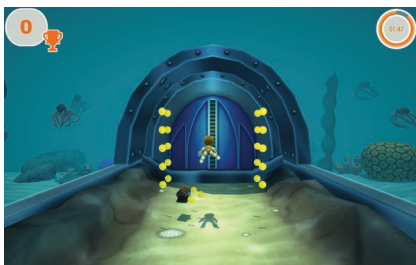
"I can't over-emphasize how important it is that the effort in the Armeo therapy is self-initiated. In hands-on therapy, the initiation often comes from the therapist. With Armeo therapy, it's coming from the patient's own brain."

Louise Rutz-LaPitz
Director of Therapy and Training, Rheinburg-Klinik, Switzerland

Armeo[®] Software

The Armeo software is the core of all Armeo devices. It helps to motivate the patients and increases efficiency of the therapist's work. It consists of:

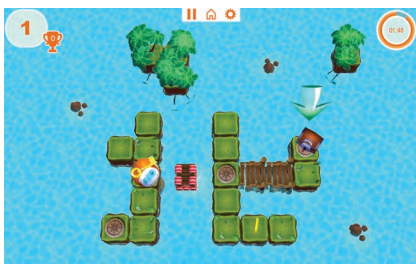
- Augmented Performance Feedback
- Fast and user-friendly workflows
- Assessment and Reporting Tools



Diving: Explore the whole 3D workspace in order to collect coins in an undersea world. This exercise trains range of motion and movement coordination.



Supermarket: Buy items from a shopping list to train range of motion in 3D, movement coordination as well as grasping and cognitive functions.



Treasure Island: Train movement coordination by guiding the key over bridges to unlock treasures.

Augmented Performance Feedback

The Augmented Performance Feedback increases the patient's active effort with motivating game-like exercises. The large library of exercises has been developed together with leading hospitals and clinics specifically for neurological patients.

Goal-oriented movements in motivating game-like environments:

- Immediate motivation and performance reward.
- Long term motivation due to increasingly challenging and diverse game levels.

Covers therapeutic goals for all patients from severe to moderately affected:

- Train range of motion, movement coordination, grasping function as well as strength, endurance and cognitive functions.
- 1D exercises with single-joint movements for severely affected patients.
- 2D and 3D exercises with complex movements for moderately affected patients.

Exercises can be easily adapted to each patient's needs:

- Difficulty (motor abilities)
- Visual details (cognitive abilities)

Fast and user-friendly workflows

- The same user interface and workflows are used in all Armeo devices to save time on staff and patient training.
- Intuitive and easy to use workflows maximize the effective therapy time.

Assessment and Reporting Tools

The Armeo software enables easy progress tracking with integrated assessments:

- A-MOVE: Measures patient's active range of motion in a 3D workspace.
- A-ROM: Measures active and passive range of motion in all degrees of freedom.
- A-GOAL: Measures precision of movements.
- A-FORCE: Measures the isometric force generated in a static position.

The Reporting Tools allow accurate monitoring of the patient's recovery progress through:

- Integrated database for the management of individual therapy plans.
- Documentation of progress as a basis for clinical decisions.

Armeo[®]Power



Stroke patient C. Ricca with the ArmeoPower.

The ArmeoPower is the world's first commercially available rehabilitation exoskeleton that allows early rehabilitation of motor abilities and provides intelligent arm support in a large 3D workspace. As a part of the sustainable Armeo Therapy Concept, the ArmeoPower is designed for individuals who have suffered strokes, traumatic brain injuries or other neurological disorders resulting in hand and arm impairment. The ArmeoPower is based on the ARMin technology developed at ETH Zurich and University Hospital Balgrist under the supervision of Prof. R. Riener.

Early Rehabilitation Therapy

The ArmeoPower has been specifically designed for arm and hand therapy in an early stage of rehabilitation. The device enables even patients with severe movement impairments to perform exercises with a high number of repetitions, which is paramount for relearning motor function.

Improved Therapy Efficiency

The ArmeoPower allows the therapist to focus on the patient and the actual therapy by reducing the therapist's physical effort. This liberation allows for a more efficient use of staff resources. Therapists are enabled to make better use of their clinical know-how and expertise leading to optimized patient care.

Extensive 3D Workspace

The robotic exoskeleton with six actuated degrees of freedom allows training in an extensive 3D workspace. This enables patients to practice the movements important for their therapy progress and daily life.

Augmented Performance Feedback

An extensive library of motivating, game-like exercises has been designed to train activities of daily living. Immediate performance feedback helps patients to improve their motor abilities, leading to more independence in daily routine and therefore better quality of life.

Assist-as-Needed Support

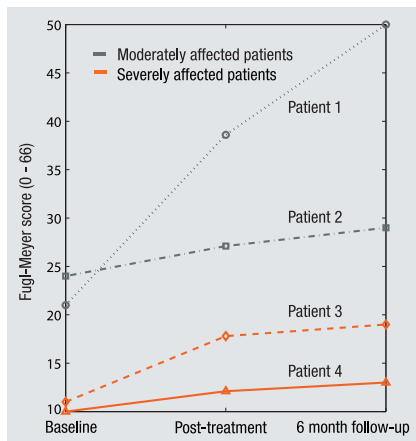
The ArmeoPower recognizes when the patient is not able to carry out a movement and assists the patient's arm as much as needed to successfully reach the goal of the exercise. It adapts the arm support to the individual needs and changing abilities of each patient – from full movement guidance for patients with very little activity to no support at all for more advanced patients. This assist-as-needed arm support enables and motivates patients to participate actively in their training, which effectively supports motor relearning.



Balloons: Train range of motion in the frontal plane by puncturing balloons and avoiding bombs.

"With the ArmeoPower we are able to train severely affected patients with an intensity that was not possible before."

Dr. med. Verena Klamroth-Marganska
Institute of Robotics and Intelligent Systems, ETH Zurich, Switzerland



Fugl-Meyer score of four chronic stroke patients at baseline, after 8 weeks of therapy and at 6 months follow-up in a pilot trial with the research prototype of the ArmeoPower (ARMin robot). Figure adapted from Staubli et al. 2009.



Assessment Tools

The ArmeoPower precisely records how patients perform and how much support they need during their therapy sessions. Standardized Assessment Tools evaluate the sensors and motors of the device to investigate specific function. The results can be used to analyze and document the patient's state and therapy progress.

The Armeo software supplies accurate assessments through the options A-MOVE, A-GOAL, A-ROM and A-FORCE (please refer to page 5).

Scientific Results

The development of the ArmeoPower has been performed in close collaboration with research partners. Pilot trials with the research prototypes of the ArmeoPower (ARMin robot) have demonstrated in a number of single cases that therapy of severely and moderately affected stroke patients with the device is safe and effective. Patients improved during therapy and sustained their functional gains. Furthermore, a multicenter trial has shown that robotic training with the ArmeoPower reduces motor impairment faster and more effectively than conventional therapy after stroke (Klamroth-Marganska et al. 2014).

Clinical benefits

- Early rehabilitation with highly repetitive training for severely affected patients.
- Improved therapy efficiency and patient care.
- An extensive 3D workspace.
- Augmented Performance Feedback with motivating exercises to train activities of daily living.
- Assist-as-needed support provided by the robotic arm exoskeleton that automatically adapts to the patients' capabilities.
- Objective analysis and documentation of the patient's progress.

"The training with the device is fun and makes me go to my limits. Today, I can already use my arm again and accomplish things I couldn't do before."

R. Bolliger
Patient, Switzerland

Armeo® Spring

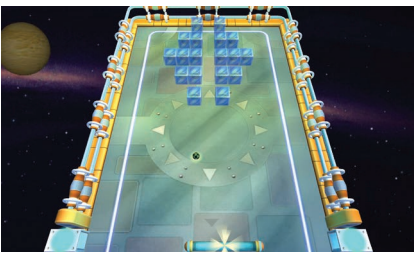


The ArmeoSpring is specifically suited for patients who are beginning to regain active movement of the arm and hand, and has already proved to be successful in many clinics worldwide. Often becoming the preferred therapy choice of recovering patients, it is based on research and development conducted under Prof. D. Reinkensmeyer at the University of California, Irvine (UCI) and at the Rehabilitation Institute of Chicago (RIC).

Mounted on a trolley for quick and easy positioning, the ArmeoSpring offers various self-initiated repetitive therapies to increase the patient's range of motion and selective control. The self-directed exercises motivate the patient to exert intense levels of both concentration and coordination.

Arm Weight Support

The ergonomic and adjustable arm support is an exoskeleton with integrated springs. It embraces the whole arm, from shoulder to hand, and counterbalances the weight of the patient's arm, enhancing any residual function and neuromuscular control, and assisting active movement across a large 3D workspace.



Brick Breaker: Train 1D range of motion in different joints.

Augmented Performance Feedback

The Armeo software contains an extensive library of game-like movement exercises supported by a virtual-reality training environment that is both motivating and informative, clearly displaying the functional task along with immediate performance feedback. The motivating and self-initiated exercises include proximal and distal components, specifically related to:

- grasp and release
- pro- / supination
- wrist flexion / extension
- reach and retrieval function

The equipment detects even trace amounts of movement and function and facilitates intensive reach and grasp exercises at an early stage of therapy.

Assessment Tools

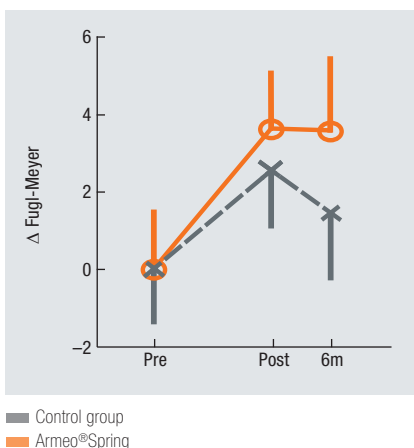
Besides functional exercises, the system contains exercises specifically designed to assess the motor ability and coordination of patients. Built-in sensors record the active arm movement at each joint during all therapy sessions and the performance data is stored in the computer, where it can be used to assess and document the patient's progress, to determine the next appropriate challenge and to promote the optimum therapy and best possible outcomes.

The Armeo software supplies accurate assessments through the options A-MOVE, A-GOAL and A-ROM (please refer to page 5).

Scientific results

Clinical evaluation of therapy utilizing ArmeoSpring was conducted at the Rehabilitation Institute of Chicago. The randomized controlled trial compared Armeo therapy to conventional, self-directed therapy in 28 moderately to severely impaired chronic stroke patients and the following findings were reported (Housman et al., 2009):

- Better long term outcomes
- Significantly better outcome in motor ability (FuglMeyer) at 6 months follow up
- Increased motivation
- Patients were clearly in favor of Armeo therapy compared to conventional, self-directed therapy. It was described as "more beneficial" and "less boring" than conventional table-top therapy



Clinical benefits

- Reveals any remaining motor function
- Even moderately to severely impaired patients can practice independently and benefit from highly intensive, repetitive, self-initiated movement therapy
- The workspace is adjustable to the patients' capabilities
- Patients with only trace motor function can integrate their remaining function into the intensive, engaging, functional exercises
- Optimum integration of arm, hand and wrist brings the whole movement chain into the therapy
- As a universal platform, the ArmeoSpring provides an interface to hand modules for patients with lower or higher functionality



ArmeoSpring with the ManovoSpring hand module.

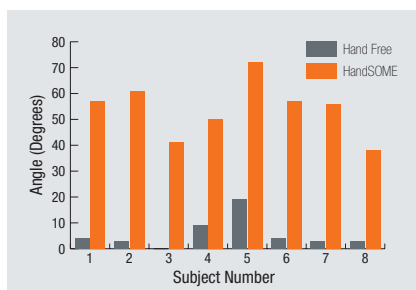
Manovo®Spring Hand Module

The ManovoSpring was specifically designed for the training of grasping and releasing movements in patients with neurological disorders. The adjustable spring mechanism of the ManovoSpring was developed to counteract the high tone of the flexor muscles and the weakness of the extensor muscles. In each stage of hand opening it brings in a physiologic amount of force needed to open the hand while coupling finger and thumb movements. Thereby, also patients who show only limited active movement in their fingers can participate in intense, repetitive movement exercises.

The advantages of the ArmeoSpring therapy with the ManovoSpring are:

- Easy installation and swapping between left and right hand use.
- Simultaneous therapy of the complete movement chain from the shoulder to the fingers.
- Adjustable support for opening of the hand with a physiological coupling of finger and thumb movements.
- Captures the patient's active hand movements and facilitates reach and retrieval training with the Augmented Performance Feedback.

In pilot trials with the research prototypes of the ManovoSpring (HandSOME device) stroke patients showed a large increase in range of motion in opening and closing of the hand (see graph) as well as an increased ability for functional grasping of objects (Brokaw et al. 2011).



Increased Range of Motion of the fingers with the prototype of the ManovoSpring (HandSOME). Figure by Brokaw et al. 2011.

Armeo®Spring Pediatric



Stroke patient with the ArmeoSpring Pediatric.

The ArmeoSpring Pediatric is specifically designed for and adapted to the needs of children with movement impairments in their arms and hands resulting from neurological conditions.

- The Augmented Performance Feedback motivates the patient with intensive and functional movement exercises.
- The Assessment Tools allow an easy documentation and precise assessment of the therapy process.
- The Arm Weight Support helps to reveal any remaining motor functions and increases movements within a 3D workspace.
- The length of the orthosis and the amount of Arm Weight Support can be adjusted to children in the age group of about 4 – 12 years.
- All the benefits and features of the adult version are included.

Armeo[®] Boom



Stroke patient during training with the ArmeoBoom at home.

The ArmeoBoom is a product specifically designed for out-patient clinics and home settings. In these environments, it offers an optimal therapy solution for patients with mild to moderate movement impairments.

Like the other products in the Armeo Therapy Concept, the ArmeoBoom combines self-directed movement exercises with Augmented Performance Feedback and Assessment Tools driven by the Armeo software.

The product is based on research and development activities led under Prof. H. van der Kooij and Dr. A. Stienen at the University of Twente and Roessingh Research and Development in Enschede, the Netherlands.

Arm Weight Support

The ArmeoBoom has an overhead sling suspension system with low inertia to provide an adjustable amount of arm weight support and allow patients to perform self-directed, free movement exercises of the impaired arm in a large 3D workspace.

The system is lightweight and compact, easy to transport and to stow away, and quick and simple to set up.

Assessment Tools

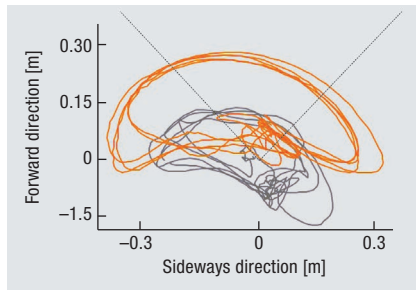
The integrated Armeo software supplies accurate assessments through the options A-MOVE and A-GOAL (please refer to page 5).

Augmented Performance Feedback

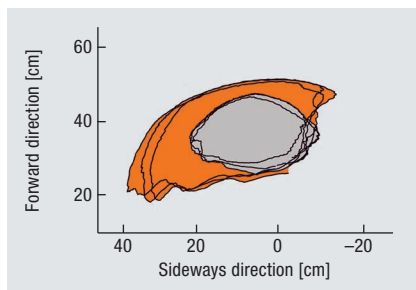
Once adjusted, the ArmeoBoom can be operated easily by the patient and the Armeo software contains the same extensive library of game-like exercises utilized by the other products in the Armeo Therapy Concept. For the ArmeoBoom, the reach and retrieval exercises have an adjustable workspace and the patient can select horizontal or frontal movement planes or 3D movements.



Fishing: Catch the moving fish to train range of motion in the frontal plane as well as movement coordination.



■ Without weight compensation
 ■ With weight compensation



■ Before training
 ■ After training

Active range of motion before and after
 9 hours of training (6 weeks, 3 times 30 minutes)
 using the ArmeoBoom prototype. Stroke patient example,
 modified from Stienen, A. H. (2009)

Scientific results

Arm Weight Support facilitates active arm movement without impairing motor control or changing coordination patterns. It may therefore be a valuable way of increasing the intensity of training for mildly to moderately impaired patients. (Prange et al., 2009)

Clinical benefits

Clinical evaluation of self-directed movement therapy in a group of chronic stroke patients, utilizing the ArmeoBoom with its overhead sling-based arm weight support, resulted in:

- significant improvement of the active range of motion (Stienen A. H., 2009)
- improved motor ability (Prange et al., 2009)

"I am convinced that a real limitation in rehabilitation could be overcome if we could encourage the active participation of the patients, and extend it over a prolonged rehabilitation period."

Prof. Dr. J.S. Rietman
 Scientific Director Roessingh Research and Development, Enschede

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