Modern Hand- and Arm Rehabilitation

THE TYROSOLUTION CONCEPT

A rapid development has occurred in recent years particularly for the treatment of upper extremities in the area of robotic- and computer-assisted therapy as well as virtual reality therapy. This applies to research and also, in the meantime, to broadly dispersed offers for various arm rehabilitation therapy devices. Computer- and robotic-assisted forms of therapy have proven to be an important component for optimising the rehabilitation of upper extremities. The »**TYROSOLUTION** concept« offers a solution from one source that fulfils the various requirements in this area. The therapy systems by **TYROMOTION** GmbH with headquarters in Graz, wAustria are extremely versatile, sophisticated and compatible but also quite affordable.

Systematic investigations in recent years have revealed that »traditional« physiotherapeutic and ergotherapeutic treatment approaches are in no way superior to computer- and robotic-assisted arm- and hand rehabilitation [7, 10, 14, 16, 21, 22, 24]. In fact, device-assisted therapy incorporates and integrates many elements that have proven to be significant and effective in clinical studies for traditional physiotherapy and ergotherapy practices; i.e. it is an evidence-based approach [17, 21, 28]. The treatment includes

- Repetition (high number of repetitions) [2, 31]
- »Forced use« of the affected extremity [27, 32]
- Use of visual- or acoustic »cues« [29]
- External instead of internal focus of attention [4, 33, 34]
- »Shaping« (successively increasing difficulty) [32]
- Exercising up to the determined performance limit of the patient (high intensity) [3, 15]
- High-frequency exercise [3]
- Feedback (acoustic, visual, tactile, somatosensory)
- Context-relevance-computer-assisted systems with integrated »virtual reality« compensate for the lack of relevance to everyday situations
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In addition to these undisputed and promising core items of motor learning, modern computer-assisted therapy also provides significant advantages over conventional therapy approaches:

- Automated assessment, documentation and follow-up monitoring
- High motivation and the "fun factor" due to »serious gaming« [6, 20]
- Cost reduction due to group and circuit training
- Cost reduction due to self-controlled training

FROM TYROMOTION TO TYROSOLUTION

TYROMOTION GmbH with headquarters in Graz, Austria was founded in 2007 by the graduate engineer David Ram and Dr. Alexander Kollreider as a spin-off company from the Graz University of Technology. In the meantime, the company has expanded internationally and employs a large team of therapists, medical professionals and IT specialists. Practical implementation has become the core emphasis of conceptual development, which D. Sackett has described as evidence ([24], p. box). This means that the latest research results, technical expertise and decades of clinical therapeutic experience are interlinked in order to optimally support the rehabilitation process. The result – **TYROSOLUTION** – is a system comprised of four different and mutually complementary computer-, robotic- and virtual reality-assisted therapy devices called **AMADEO®**, **DIEGO®**, **PABLO®** and **TYMO®**.
An additional comprehensive and adaptable work place, the »**TYROSTATION®**« was developed for the latter two devices. Together but also individually, the systems provide holistic rehabilitation for the upper extremities for patient groups with various conditions such as spasticity, hypertension, bio-mechanical and musculoskeletal deficits. **TYROSOLUTION** is also exceptionally well-suited for the treatment of associated problems such as restrictions of postural control, balance and cognition. The team placed great

> *»Evidence-based rehabilitation is defined as the conscious, explicit and well-deliberated usage of the best available information for making decisions related to the care of an individual patient. For clinical practice this means the integration of individual clinical expertise with the best available external evidence from systematic research. Professional therapists use clinical expertise and the best available external evidence since neither of these factors is sufficient by itself«*
> *(D. Sackett).*

Fig.: Group therapy with **TYROSOLUTION** in small spaces

emphasis on a broad spectrum of treatment options during the development phase to ensure a targeted usage of resources while at the same time providing the highest possible results quality for rehabilitation.

The four named devices are exceptionally well-suited for group therapy in small spaces (cf. Fig.). Due to high mobility and practicability, the systems can perform all usage options from individual bedside treatments to treatments during house calls. In addition to being useful for inpatient rehabilitation, especially **PABLO®** and **TYMO®** constitute foundational pillars for outpatient- and home treatments as well as for self-training. A contributing factor is the user-friendly, lucid, fast and simple handling.

UNIQUE SOFTWARE OPTIONS

What does the **TYROSOLUTION** concept offer specifically for professional users?
The systems are built on three foundational pillars:

- Objective, reliable, valid and practical assessments or results based on ICF
- Comprehensive variants for interactive motor- and cognitive therapy but also for maintaining the patient's condition as well as mobility-enhancing treatment options
- Professional documentation and report preparation for performed assessments and therapies with minimal expenditure (e.g. automatically created final report with process charts)

The therapeutically coordinated software Tyros® makes this possible; it incorporates all core items for optimally (re) learning motor skills. Depending on the determined goal, the software can switch between previously determined superior control modes (strength or muscle tone control or mobility mode). Bio-feedback variations in real time (acoustic, tactile, visual), external focus, the option for numerous active and, if necessary, passive repetitions and intensive shaping play an important role in the different often playfully designed therapy modules.

All of these functions are complemented in the **TYROSOLUTION** concept by even more evidence-based therapy options. One- and multi-dimensional therapy modules provide training options for single- or multi-jointed training movements and activities or even task-oriented interventions. Depending on requirements, the attending professional can determine beforehand in the therapy module whether the patient is to perform the game with strength dosage, strength, tone- or spasticity control or active or assistive movements. It can also be configured which movements or grip types are to be used or how much strength or strength control is applied during training. The software interprets the entries of the attending professional so that the selected therapy module can only be performed according to the desired goal-oriented settings. The patient learns to repetitively use the upper extremity including hand and fingers in a targeted manner according to the automatic prompts. As soon as the patient compensates or fails to comply with the required entries, the game progress stops, and the system no longer responds to the »wrong« movements. The motor learning process can occur in a targeted manner while integrating the learning technique »knowledge of results«, which is very important for the patient's rehabilitation. Among other things, the above-mentioned aspects substantially distinguish the **TYROSOLUTION** concept from traditional devices, which do not provide adjustment settings for strength- or movement parameters to compensate for the patient's respective deficits and resources.

Other absolutely unique software options make it possible to perform an evidence-based training for cognitive deficits in connection with concurrent motor training. Therapeutic treatment for cognitive problems such as attention-, memory- and orientation disorders and speech deficiencies such as Broca's aphasia as well as exploration training for visual neglect (based on optokinetic stimulation) or the treatment of deficits caused by alexia and acalculia are also possible. As a novelty, the current software also incorporates comprehensive treatment components for brain capacity training according to Verena Schweizer.

A uniform concept-oriented design was selected for all devices especially for documentation, process illustration, reporting and therapy games. The assessments for the respective device are based on ICF and located in the automatically created final report with process charts e.g. for all hand functions, active joint mobility of the upper extremity, strength dosage, active balance, weight compensation for position changes, finger- and hand strength and the results of the proven neutral zero method. Of course, the results- and report options also provide space for customised comments; each documentation or report can also be adjusted to the administrative concerns of the respective clinic or individual practice. Processing, the export as a PDF- or text document as well as adaptation to possible interfaces is also easily possible.

HARDWARE

Yet, what would be the use of all these functions without precisely coordinated and versatile hardware? The **TYROSOLUTION** concept provides diverse practice- and patient-oriented options. Depending on the functional operating principle, the individual therapy systems incorporate various additional components such as Multiboard, Multiball and the belts for the **PABLO®** system, multiple configurations for the »hand unit« of **AMADEO®**, the dynamic rolling mechanism for **TYMO®** and finally the flexibly usable hand- and arm loops for **DIEGO®**. The operator can arbitrarily choose between a proximal- and distal approach for motor training; however, the **TYROSOLUTION** concept prioritises the significantly more effective distal approach.

The consistently attractive design of the devices should also be mentioned for which **TYROMOTION** GmbH received the Design Management Europe Award 2012.

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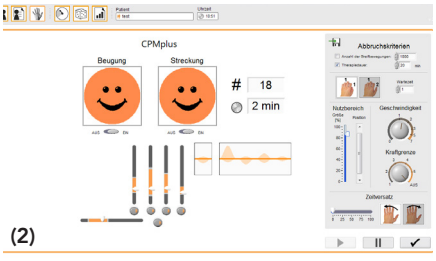
AMADEO® (ROBOTIC- AND COMPUTER-ASSISTED HAND- AND ARM REHABILITATION)

The robotic-assisted hand- and finger trainer **AMADEO®** provides targeted training for hand and fingers including exact assessments of finger- and hand strength and active finger mobility. The patented mechanism simulates the natural gripping movement of the hand. After fastening the finger supports to the finger tips and thumb, bending and stretching movements can be performed with the fingers either (1) individually in a consecutive and alternating manner or all at once in a passive, assistive (2) or active/ interactive manner (3) . The device always provides the exact supportive intensity, which requires the patient to work up to determined individual performance limit. Various therapy modifications with shaping, intensive repetitions, external focus, task-oriented training of hand- and finger strength, muscle tone control and selective movements are integrated. The passive mode primarily provides spasticity reduction. Visual, acoustic and tactile bio-feedback in real time is included within the treatment- and assessment modules. The system ensures a high motivation factor due to therapy games and also provides targeted exercise in »abstract modules« as well as proprioception training. Depending on the configured goal, the strength- and movement mode can be arbitrarily selected. The system has 10 difficulty settings and many other shaping variants as well as training programmes for cognitive- or attention deficits with active finger usage.

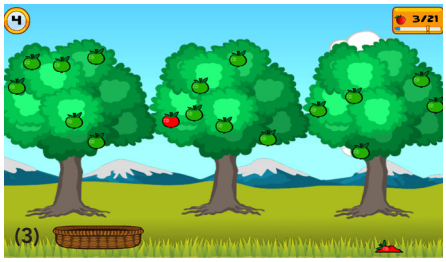
The **AMADEO®** system is rounded off with additional manual configuration options for the »hand unit«, which allows an outer rotation of the shoulder joint up to 90°, variable dorsal extension for the wrist and abduction or adduction of the fingers as well as treatment in a seated or standing position.

MODE	OPTIONS
Passive therapy (CPM = continuous passive motion)	Passive mobilisation for the optimisation of musculoskeletal conditions and for spasticity reduction
CPM+ (continuous passive motion plus)	Passive finger training with feedback for proportionately active movement requirement including external focus; among other things, ideal for distal tone regulation and -control
Assistive therapy:	Patient works actively with all or individually selected fingers in flexion or extension. Further movement is taken over by **AMADEO®** if the activity is not performed, includes bio-feedback in real time and external focus.
Active therapy/Single movement:	Targeted repetitive movement of an individual finger; strength or mobility range can be trained with various shaping variants, includes visual and acoustic feedback as well as deactivation of the visual display for proprioception training.
Active therapy: Memory:	Increasingly longer finger sequences are displayed, which the patient must memorise and copy. Among other things, the system trains cognitive performance and shaping by omitting the visual display.
Interactive therapy: Therapy games:	Active functional therapy with external focus and prompts for automatic movements in various difficulty settings; training of hand-eye coordination; adjustable movement- and display direction (neglect syndrome)


(1)



(2)



(3)

PABLO® (COMPUTER-ASSISTED REHABILITATION OF SHOULDER, ARM AND HAND)

PABLO® Plus is an extremely flexible computer-assisted therapy system for treating the entire upper and, in part, lower extremities. The basic device consists of a sensor grip including hand loop, which contains strength- and movement sensors; it can be connected to a PC via a USB interface. The **PABLO®** sensor grip (1) makes it possible to perform and measure the resulting forces of various grip patterns of the human hand such as stretching and bending as well as cylinder- and pinch grip movements. The device measures the mobility range of the arm via built-in position sensors. Additionally, Multiboard, Multiball, a balance pad and belts for attaching the hand grip to the torso, arm or leg are also provided.

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The **PABLO®** Multiball (2) trains forearm pronation and supination as well as wrist extension and flexion. It offers targeted application options during early rehabilitation phases e.g. for limp hemiparesis of the arm.

The **PABLO®** Multiboard (3) provides repetitive training for single and multiple joints in a selectable distal or proximal approach and can be used unilaterally as well as bilaterally.

Due to the deficit-relevant design, Multiboard and Multiball can treat highly impacted patients with massive hypertension or spastic paresis. The hand grip with integrated sensors is simply inserted into the board or ball. The software offers many one- or two dimensional therapy modules, which are used to practice movements required in everyday activities. Additionally, the already described modules for cognitive training can be performed in direct combination with functional training. The assessments provided by **PABLO®** are exceptional. Rough grips (cylinder grip/hand strength), all precision grips, finger extensions, strength dosage but also the active mobility of the upper extremity joints can be measured in a short period of time and then documented automatically and displayed in process charts.

(1)

(2)

(3)

TYMO® (COMPUTER-ASSISTED REHABILITATION OF EXTREMITIES WITH BALANCE AND POSTURE CONTROL)

TYMO® is the thinnest therapy platform worldwide and much more than a conventional balance pad. It is an all-in-one package for treating arms, torso and lower extremities in various initial positions. The computer-assisted system offers any conceivable training variation for improving balance, posture control, active strength usage as well as support activities for the upper extremity (1).

TYMO® can be used unilaterally or bilaterally as well as statically or dynamically. Except for a few exceptions, the therapy modules are designed similar to the modules for the **PABLO®** system and, therefore, provide the same treatment options. **TYMO®** also offers static and dynamic measurements and therapies. Movement transitions, strength usage, position change, weight distribution and shifting, stability while standing, walking speed etc. can be easily measured. The **TYMO®** design makes it possible to perform therapy in the (wheel)chair, at the bedside, on the table for arm-supported activities (2) or while standing. The static support surface becomes dynamic (3) by simply attaching a one- or two-dimensional »rolling mechanism« under **TYMO®**. The high practicability and uncomplicated transport are additionally complemented by cable-free handling (Bluetooth interface) and a very long battery life of over 12 hours.

TYMO® and **PABLO®** have proven to be especially valuable in outpatient care.

TYMO® SUPPORT FUNCTION Suitable for therapy of upper extremities	• Depiction and control of active strength usage for the upper extremity • Performance of support activities, also for hemiplegia • Weight distribution for bi-manual support
TYMO® SITTING FUNCTION The patients sits either directly on **TYMO®** or places the feet on **TYMO®** while performing the following training.	• Functional free sitting • Symmetric weight distribution • Torso- and pelvic activities • Control of weight distribution for position change
TYMO® STANDING FUNCTION The patient performs the following training while standing.	• Standing leg phase • Improvement of active knee control • Weight distribution • Building up of muscle strength • Coordination of the lower extremity and red muscles (holding muscles)

(1)

(2)

(3)

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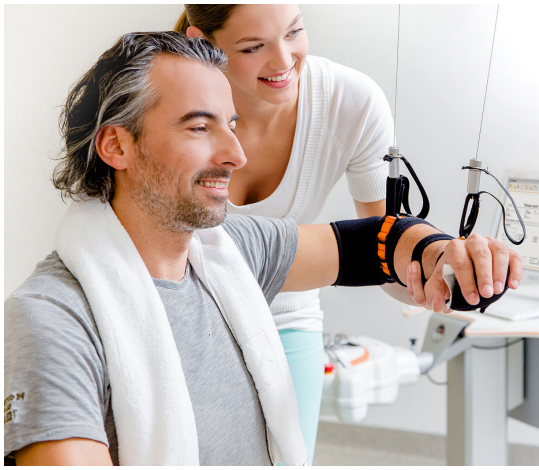
DIEGO® (ROBOTIC-, COMPUTER- AND VIRTUAL REALITY-ASSISTED REHABILITATION OF THE PROXIMAL UPPER EXTREMITY)



DIEGO® is the latest and possible the most exclusive **TYROSOLUTION** »highlight«; it is a robotic- and computer-assisted virtual reality system developed for treating one or both arms. **DIEGO®** provides realistic therapy in a virtual three-dimensional space. The two »arm ropes«, which ensure complete freedom of mobility for the upper extremity joints, provide sufficient space for qualitative training of the shoulder and arms without strenuous guidance (1). Patients can perform unilateral and bilateral exercises with virtual reality modules or with the integrated software from other **TYROSOLUTION** systems or simulate movements from everyday activities.

The virtual reality module for **DIEGO®** creates functionally relevant and realistic virtual scenarios such as hanging up laundry or swimming (2), which the patient can effectively use to transition back into everyday activities. These exercises ensure high motivation and concentration, which in turn promote the learning process.

Especially three-dimensional but also two-dimensional tracking, the creation of an ego-perspective, high multi-modality for feedback quantity and quality, real and consistent environments, a realistic interaction as well as instantaneous system responses ensure successful high-intensity learning experiences.

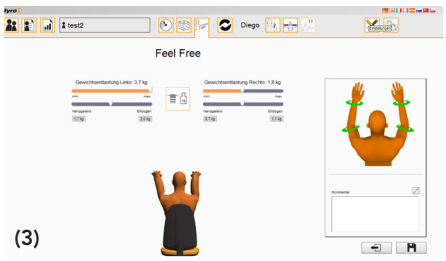
Of course, **DIEGO®** with its functionally coordinated design offers more than just virtual reality. The attending physician can measure the respective initial posture- or joint position at therapy begin. **DIEGO®** can also prescribe the movements that are to be learned. Individualised handling of arm- and hand loops provide active training options for the respective proximal or distal joints or the entire upper extremity. The complete natural mobility range of joints can be trained without an impeding outer restriction.

Intelligent weight easing (IGC) is an extremely useful core function of **DIEGO®**; it actively compensates for the gravity affecting the extremity. The weight of the arm can be smoothly decreased proximally and distally (3). Among other things, this creates optimal treatment conditions for deficits such as limp hemiparesis, hypertension/spasticity, restricted joint mobility or pain and subluxation problems. »Hands-off« therapy, possibly with assisted gravity compensation as an alteration of the physical environment, is provided, which also ensures effective motor learning.

In the area of ICF assessments, **DIEGO®** can measure the mobility range of the upper extremity joints (based on the neutral-zero method). These measurement values are then depicted as a process chart and documentation.


(1)

(2)



(3)

TYROSTATION® (ADAPTABLE WORK PLACE FOR PABLO® AND TYMO®)

The total concept is rounded off with the **TYROSTATION®**, an efficient, well-thought out »work place« for **TYMO®** and **PABLO®**. The height-adjustable therapy table includes a large work surface, an integrated multi-adaptable PC with the complete software and a training stool adjusted for **TYMO®**. **TYROSTATION®** is designed so that both systems including all accessory parts can be stored properly and accessibly.

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CONCLUSION

In the described constellation, the **TYROSOLUTION** concept is a one-of-a-kind treatment concept in the area of robotic-, computer- and virtual reality-assisted rehabilitation. In small spaces the system provides high results quality for holistic treatment options with an evidence-based background for various neurological and orthopaedic deficits. Important technical aspects and evaluation options have been achieved through cooperation with worldwide renowned universities, clinical institutes, rehabilitation centres and therapy practices. Meanwhile clinical studies have provided independent evidence for the systems **AMADEO®** and **PABLO®** [8, 18, 27, 28].

An overview of the advantages:

- Varied, targeted, evidence-based therapy modules
- Automated, assessment-, documentation- and reporting options
- High motivation factor due to appealing system design and therapy modules
- Concurrent treatment for associated problems
- Fast, user-friendly application
- Short treatment times
- High system mobility and practicability (application for outpatient care, house calls, individual training and inpatient care)

The systems form a cohesive unit due to the common software, but can also be used individually in versatile ways. Especially **PABLO®** and **TYMO®** constitute an important bridge between computer-assisted therapy for inpatient- and outpatient rehabilitation. The cost-benefit ratio for the individual systems and the total concept is more than convincing on account of the provided contents.

The operating premises of **TYROMOTION** in Schweinfurt (Germany) also include an integrated Tyromomentum therapy institute; the institute offers seminars, workshops and informational tours in state-of-the-art practice rooms for anyone who is interested. Upon consultation, demonstration events or workshops including patient treatments in clinics and practices performed by **TYROMOTION** experts are possible at any time.

| Maik Hartwig |

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