PRODUCT PROFILE

Fun and evidence - computer-based arm rehabilitation with the Pablo®Plus System

Maik Hartwig

Computer-based therapy has become an important sector in motor rehabilitation. This kind of intervention offers neurologically damaged patients a new and promising way of self-dependently integrating their severely affected upper limbs into the daily routine.

In the arm and hand rehabilitation sector, devices with unilateral and bilateral approach prevailed for acute patients[1, 9, 20], and one-dimensional and passive exoskeleton systems [11, 12, 15] prevailed so far for chronic patients. A systematic review [7] with eight included studies came to the conclusion that robotic-based therapies of the proximal upper limps improves the motor control of the paretic shoulder and the elbow of sub-acute and chronic patients much better on the short and long term than conventional therapies. Especially the distal training of both arms seems to have a positive effect on the improvement of functions [7, 9]. Besides the improvement of motor functions during the robotic therapy, the muscular strength improved more than in comparison to control groups. However, the transfer of acquired skills into everyday-life could not be significantly improved by the application of robots compared to conventional therapies. With the AMADEO hand and finger trainer by tyromotion, a very effective computer-based therapy device has been developed, and its efficiency has been tested and proven in several studies [3, 8, 17]. For the rehabilitation of the upper limbs, tyromotion cooperated with experienced ergotherapy specialists to develop the Pablo©Plus System. With this computer-based therapy device, the inventors created an optimal symbiosis of innovative technology and various targeted variations of therapy, finding and documentation.

What are the drivers of Pablo©Plus?

Neuroscientific, technically empirical and also economic considerations were taken into account for the development of Pablo©Plus. The outcome was a multiple treatment system combining the contents from modern evidence-based methods with motivational aspects ("fun factor") including ICF-oriented assessment and documentation functions. Pablo©Plus offers established therapeutic intervention options on functional and activity level, and is perfectly suited for the clinical treatment as well as for the ambulant and home treatment of adults and children with neurologically and orthopedically-related motor impairments. The combination of many targeted exercises and therapy sequences with assessment and documentation functions in one single therapy device makes the Pablo©Plus System economically viable as well. In the meantime, the computer-based therapy device is not only used for arm rehabilitation but also for the treatment of the lower limbs as well as for post control and balance.

Which modern therapy methods are included in Pablo©Plus?

The treatment system is primarily based on the principles of motor learning which is also used for isolated sensomotor exercises and task-oriented exercise therapies. The learning process in this context is defined as the reacquisition of motor skills after central lesions [16]. Pablo©Plus can be integrated in each of the three phases of the motor learning process according to Fitts and Posner [6].

Depending on the learning phase, it also includes intrinsic and extrinsic intervention alternatives to be introduced (16). The focus of the attention on the target of motion (external focus) plays major role in every phase. The reason is the evidence that motor activities are learnt more easily if an external focus is applied [24]. Contents of the psychological learning theory [19] such as positive reinforcement of successful motion sequences are also taken into account. A central issue of Pablo©Plus is the versatile option of actively and repetitively exercising the activities to be learnt, or of the motion (of single and multiple joints) knowing that repetitive exercise stimulates the functional recovery in a special way [2]. For example, in robot-based therapies, two to seven times more motor actions are achieved as in conventional therapies [14]. Stereotype repetitions alone, however, do not result in the (re-) learning of motions in the upper limbs. For cortical reorganisation, pure repetition is not the only factor. Therefore, therapeutic interventions should not only be repetitive but also active, intensive and task-specific [13, 18]. The duration of exercises and the duration of breaks is also very important [21] and can be indicatively controlled by entering in the system of Pablo©Plus. It is possible to work with the technique of shaping (gradual increase of the level of difficulty depending on the motional success) in every single therapy module of Pablo©Plus, and the level of difficulty can be precisely adjusted to the individual strength limit of the patient [23].

Furthermore, the device incorporates core elements of modern therapy concepts such as isolated sensomotor [4, 5], bilateral [22] and task-oriented exercises (individual motions are provoked by means of the task on the desktop). The finding that the CNS plans activities in a target-oriented way, and that different muscles are activated to accomplish functional requirements for different context conditions, was also taken into account when developing the therapy module of Pablo©Plus.

How is Pablo©Plus designed? How is Pablo©Plus used for findings, documentation and therapy?

The therapy device consists of a handle with integrated strength and motion sensors including wrist straps, Multiboard and Multiball which are connected with the PC via a USB interface. Each single Pablo©Plus element is "tailored" to the training of different motor deficits in particular of the upper limbs. However, the system offers more than just therapy modules.

Assessment, findings and documentation

Pablo©Plus includes assessments on the level of bodily functions and activities for the strength measurement of hand functions and for the measurement of the active extent of motion of the upper limbs (table 1). Measurements can also be made on the basis of a pathologic initial position. It is not mandatory for the patient to bring his affected limbs to "zero position" first.

In the documentation system, Pablo©Plus stores every single result with regard to findings and the course of therapy in an electronic patient file which is created at the beginning of the therapy by the therapist. The system automatically stores and combines each new finding in a therapy and final report with progression diagram including all data. The report is displayed in the background. Furthermore, each therapy made is documented in Pablo©Plus with regard to intensity and quality. Thus, the therapist can permanently control and reflect progression. Observations and own comments of the therapist can also be entered in the documentation system. Thus, therapies can be accessed and reproduced at any time. Individual details such as precise duration statistics, the kind of therapy game including results, etc. are also automatically stored by the system.

- **Handle**

Due to its integrated motion and strength sensors, the PABLO®Handle allows for the training of all hand and finger functions described in the examination report as well as for the motion of the upper limbs on the basis of the different initial positions of the patient. Even if arms or hands are in pathologic position, the handle can be adjusted, and the patient can be activated in the motor learning process on the basis of this position. An additional "balance pad" is available for the therapy in upright position which creates a dynamic support surface, thus shaping balance and postural control.

- **Multiboard**

The PABLO®Multiboard is used for repetitive exercises of one or more joints in distal or proximal approaches. It is used for bilateral exercises, and also if only the affected upper limb is trained. For this purpose, the handle of the PABLO® system is inserted in the Multiboard. Here again, the therapist stores the motions for the exercise - optionally for one or several joints (table 2) - and the patient implements the stored motions in the motor learning process. Compensation strategies, however, won't result in the implementation of a successful game; the patient learns how to use correct motion patterns and how to avoid compensation. This extremely versatile device is designed so that also severely affected patients can be treated. The shape of the Multiboard with its adaptable handles, supporting surfaces for forearms and the ball-shaped supporting surface below the board allow for the positioning and thus the training of plegic and paretic upper limbs as well as of hyperton/spastic upper limbs. Depending on the selected initial position, shoulder joint, elbow and wrist can be trained in any physiologic direction of motion. The rounded supporting surface for the forearms and the integrated handle support the correct execution of the motions without fixating the patient. Thus, the hypoton/slack limb can be positioned on the curved forearm support and the front handle (fig. 1a). Although affected arm and hand are secured, they must actively participate. In case of spastic patients, for example, with internally rotated shoulder joint, the hand is placed on the outer handle in order to accomplish the activation in an externally rotated / supine joint position (fig. 1b). The therapist must set-up the Multiboard depending on the motor deficits of the patient according to the findings. The complete device can be rotated, and can then be manipulated by grabbing the handles or the brackets (fig. 1c). Thus, not only the software shapes but also the device. The good and easy handling of the Multiboard allows for a versatile and early application of this functional form of therapy (e.g. in upright position and at the edge of the bed for persons who are only little mobilized). But also for "advanced" patients, the Multiboard is very demanding. Of course, it is still up to the therapist's creativity and professionalism to fully exploit the Multiboard with all its functionalities.

- **Multiball**

The PABLO®PLUS Multiball is used for the distal functional training of upper limbs. The "functional ball" was primarily designed for the training of pro and supination as well as for dorsal extensions and palmar flexions, irrespective of the prevailing tonus conditions. The Multiball can already be used in early rehabilitation phases due to its option of securing the affected hand by means of a Velcro strip. Furthermore, the hand rests on the ball with relatively stretched fingers, the thumb is in a "guiding groove" in a slightly abducted and stretched initial position. The patient collective as described for the Multiboard is also used for the therapy with the Multiball. If the initial position of the affected limbs and/or the patient is changed, it is possible to train even more motion components with the Multiball, e.g. external rotation of the shoulder joint with extended elbow while stabilizing the wrist, supporting activities of the arm in upright position with simultaneous active motion of the affected hand, or even working while standing (fig. 1d) and at the edge of the bed for little mobilized patients.

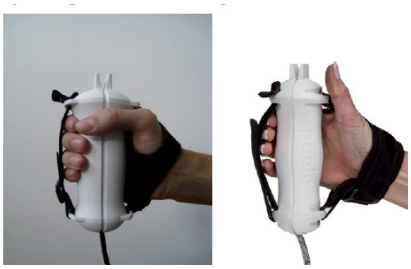
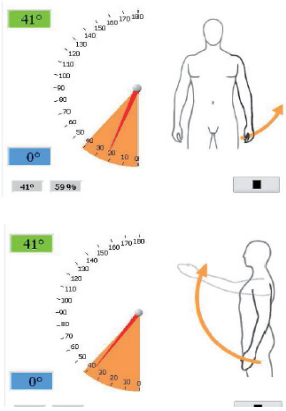
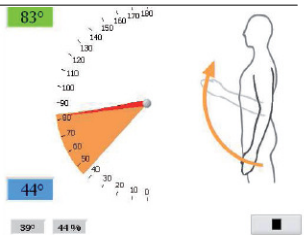
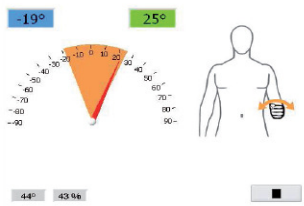
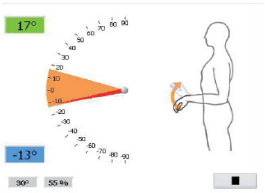
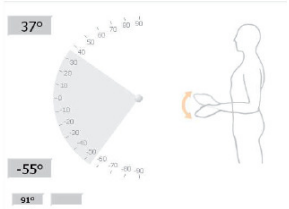
Strength measurement (isometric) of grabbing types and precision handles	Measurement of the active range of motion of shoulder/arm/hand
Cylinder grip and hand (finger) extension	Shoulder; abduction/flexion
	
Forceps grip	Elbow: flexion/extension
	
Lateral grip	Forearm: pronation/supination
	
Inter-digital grip	Wrist: flexion/extension
	
Three-finger grip	Wrist: ulnar flexion/radial flexion
	
Optional free measurement	Optional free measurement

Table 1: Assessment overview

Thus, therapies can be accessed and reproduced at any time. Individual details such as precise duration statistics, the kind of therapy game including results, etc. are also automatically stored by the system. For each new treatment unit, Pablo©Plus will accept the settings of the previous unit thus allowing for a continuous treatment process. The final report can be individually processed, stored and/or printed as an option.

Therapy

The "core" of the system is the therapeutically adjusted software of the Pablo©Plus System. The motor learning process and the reacquisition of active arm and hand functions is promoted by the well-directed design of the different therapy games. Our brain does not primarily train our muscles, but our muscles are used as tools in order to achieve economic motion sequences [10]. Therefore, motor learning should not be targeted on strengthening our muscles but on the training of functional motion sequences.

Presently, five one-dimensional therapy games are available for the Pablo©Handle (table 2), and three two-dimensional therapy games are available for Pablo©Multiboard and Multiball (table 3). Each of the therapy modules offers ten different levels with different shaping variations, acoustic and visual feedback (individually adjustable), options such as mirroring, mirror-reversing, adjustable motion and display direction (e.g. for object-related and/or visual neglect) as well as various repetition settings. Thus, cognitive tasks such as the performance of attention, concentration or spatial orientation can be trained in addition to motor deficits.

It is of great therapeutic relevance that, depending on the requirements, the therapist can store in advance whether the patient should play the game with controlled strength/physical strength/tonus control (strength mode), or by motion learning (motion mode). Furthermore, the therapist can select the type of motion or grip or with how much strength the exercises are to be accomplished.

Therapy module	Content	Exercise	Shaping
Applehunter 	Falling apples must be caught with a basket: active repetition of a coordinated motion sequence, or application of a strength value to a selected hand function	Motion control, strength, strength control, tonus control, goal-oriented motor, coordination, attention, balance and postural control	Number and speed of falling apples, size of the basket, mirroring
Balloon 	Manoeuvring a balloon through a course and past obstacles: dynamic motion sequence, and/or the application of a strength value over a longer period of time	Motion control, motion coordination, strength control, permanent contraction, concentration, balance and postural control	Number of obstacles, flying speed, width and height of air lane, mirroring
Shooting cans 	Cans move past a fixed reticule on the screen. Pulling the trigger at the right time will shoot the cans: timely activation of strength and/or motion impulses	Triggering of motion, concentration, precise and quick application of strength, coordination, reaction, balance and postural control	Speed and size of the cans, mirroring
Firefighters 	Flaring flames must be extinguished with a water jet as precisely as possible: achieving and maintaining the required strength and/or motion level	Strength control, strength rationing, coordination, goal-oriented motor, permanent contraction, attention, balance and postural control	Number of fires, duration of extinguishing the fires, width of the water jet, mirroring
Recycle 	Grabbing different pieces of waste with a gripper and depositing them in the corresponding container: achieving and maintaining the required strength and/or motion level	Strength control, strength rationing, coordination, goal-oriented motor, permanent contraction, attention, balance and postural control	Speed, number of pieces of waste, mirroring

Table 2: One-dimensional therapy games (Handle/Multiboard/Multiball)

Therapy module	Content	Exercise	Shaping
Farm 	A chicken must be controlled while it is picking worms from the ground: achieving active and efficient motions without compensation	Goal-oriented repetitive motions, complex motions with everyday-relevance, learning how to correctly control motions, prevention of compensation during the learning process, tonus control and tonus normalisation, training of spatial orientation and of reactions	Speed, number of worms, time target, mirroring
Labyrinth 	A ball must be guided through a labyrinth with obstacles: achieving active and efficient motions without compensation	Goal-oriented repetitive motions, complex motions with everyday-relevance, learning how to correctly control motions, prevention of compensation during the learning process, tonus control and tonus normalisation, training of spatial orientation and of reactions	Number and complexity of obstacles, speed, time, mirroring
Set the table 	Correct allocation of dishes to place mats on the table (as if the person itself is standing in front of the table): achieving active and efficient motions without compensation	Goal-oriented repetitive motions, complex motions with everyday-relevance, prevention of compensation during the learning process, training of spatial orientation and of cognition	Number of dishes and place mats, spatial changes, mirror-inversion, speed, time

Table 3: Two-dimensional games (Multiboard/Multiball): motion training for one and several joints

Pablo©Plus accepts the settings, and the selected game can only be played on the basis of these preselected settings. Thus, the patient will learn to use his upper limbs in a targeted and repetitive way by means of automated recall because he is finally oriented on the external focus (course of the game on the monitor). As soon as the patient (typically) compensates its motions, implements the required inputs incorrectly or does not implement them at all, the course of the game cannot be implemented anymore, the system does not react to the "incorrect" motions. Among others, this aspect distinguishes the Pablo©Plus System significantly from conventional games where strength or motion parameters cannot be adjusted to the deficits and resources of each individual patient in any way.

Pablo©Plus – one for all?

This computer-based therapy device opens up new perspectives and variants in motor rehabilitation on functional and activity level. However, despite various training alternatives, it is indispensable to transfer practiced motions or functional components into everyday activities together with the patient. No therapy device, however "complex" it might be, won't ever completely replace the exercises with regard to real everyday activities accomplished by patient and therapist together.

Pablo©Plus offers promising intensifications on the field of the relatively new computer-based and robot-assisted arm rehabilitation. The system integrates requirements on modern therapies which do not only include evidence-based practice but also interfaces such as documentation, the illustration of the course, reporting and also fun and a high degree of motivation. With the current boom of robot-based methods, especially therapists involved in ambulant care (e.g. occupational therapy, home visits) may well ask about financing, mobile and simple handling, space requirements, application compliance and versatility. Tyromotion Austria specialists meet all of these issues with their Pablo©Plus System, always bearing in mind that Pablo©Plus as well as the computer-based arm therapy would need even more intensive evidence of efficacy in order to become part of the modern evidence-based therapy. Several ergo-therapeutic offices, the ambulant rehabilitation centre ZAR Berlin, the neurological hospital in Bad Neustadt/Saale and the Medical University of Innsbruck are presently carrying out or planning studies on the efficacy.

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Credit

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Correspondence address

Maik Hartwig
tyromotion GmbH
Bahnhofgürtel 59
A-8020 Graz
m.hartwig@tyromotion.com