

Computer-Aided Arm Rehabilitation

Using the Pablo®Plus System

Maik Hartwig MSc NR, OT
Head of clinical application
tyromotion GmbH
Graz, Austria
maik.hartwig@tyromotion.com

I. INTRODUCTION

Neurological damage caused by a stroke, for example, often entails a paresis of the arm which is so severe in most cases that the affected limb is not functional any more. The initially flaccid stage is followed by an increase in tone accompanied by synergistic bending movements in the glenohumeral joint and the cubital joint, while the hand remains paralysed. The rehabilitation of these patients proves to be a process that is as difficult as it is demanding, and the prognosis regarding the restoration of motor skills is quite infaust as well [1].

II. BACKGROUND

Research in the field of motor learning is concerned with factors that have an influence on the acquisition of motor skills. By learning, we understand a relatively long-lasting change in behaviour which is independent of influences such as tiredness, concentration on the directly observed performance [2]. The objective of every training process is a relatively long-lasting change of the quality of a movement. Patients with neurological deficits should be able to move their affected upper limbs or to manipulate objects not only while in therapy, but also when they are at home later, in unfamiliar surroundings, and without the assistance or instructions of a therapist. Motor research has identified important influence variables for the learning process, which also have implications for the rehabilitation of patients suffering from neurological damage. These are, among others, the learner's focus of attention, which is induced by means of instructions or feedback [3][4], and self-controlled practising, where the learner can control certain aspects of the training conditions on his/her own [5][6]. Furthermore the repetitive practicing of selective movements [7] [8], the targeted use of biofeedback [9], arm-robot therapy including bilateral training [10] proved to be helpful interventions for the reacquisition of motor skills of the upper limbs.

III. METHODS

Based on these findings, the Pablo®Plus system for patients with subacute and chronic arm paralysis was developed. The therapeutic device consists of a handle with integrated strength and movement sensors (Fig. 1), the Pablo®Plus Multiboard

(Fig.2 and 3) and the Pablo®Plus Multiball (Fig.4 and 5), each of which is connected to a PC via a USB interface. The computer-aided therapy system enables the targeted reacquisition of motor skills of the entire affected upper limb. Numerous possible exercises on the basis of the latest neuroscience findings have been integrated in this system. Diverse therapy variations in the field of motor learning combined with a high "fun factor" ensure fast and visible therapeutic success. Individually adjustable starting positions and variable handles enable the desired measurements and the targeted training of the respective groups of joints and muscles. Independently of the patient's current muscle tone conditions in the upper limb, he/she reacquires hand function, strength dosage and muscle tone control as well as single- and multi-joint and movements. It is of great therapeutic importance that every movement to be practised and every strength variable can be specified so that the patient practices only the movement sequences or strength dosages that are actually relevant for him/her, and furthermore the training can be started even with a pathological arm or hand position. Each of the individual Pablo®Plus units is "tailored" to the training of patients with a wide variety of motor deficits of the upper limbs. The handle enables the practising of motor gripping skills and grip strength for hands and fingers and of active finger extension as well as the practising of all known precision grips. The practising of arm and shoulder movements can also be done with the aid of the handle, which can be attached with a wrist strap when there is no sufficient hand function.

The Pablo®Plus Multiboard is used for the repetitive training of individual and several joints with distal or proximal insertion. Depending on the starting position selected, exercises for the glenohumeral joint, the cubital joint and the wrist can be done in all physiological directions of movement. The rounded pad of the Pablo®Plus Multiboard and the integrated handlebar promote the correct performing of the movements. Owing to the shape of the Pablo®Plus Multiboard and the adjustable handles, it can be brought in position and consequently be used for the training of paralysed as well as hypertonic/spastic upper limbs. When the patient can still use his/her hand, he/she manipulates the Pablo®Plus Multiboard by holding the handles or the handlebar.

The Pablo®Plus Multiball is used for the distal functional training of upper limbs. The patient does exercises for pronation and supination as well as dorsal extension and palmar flexion using a functional ball. The optional fixing of the affected hand by means of a Velcro tape, the Pablo®Plus Multiball and the board provide applications that can be used even in an early rehabilitation phase. The centrepiece of the system, however, is the therapeutically adapted software of the Pablo®Plus System. The motor learning process and the reacquisition of an active arm-hand function are ultimately accelerated by means of the specific design of the wide variety of one- and two-dimensional therapeutic games. Each of the therapeutic modules offers 10 different shaping variations, audible and visual feedback, options such as mirroring, adjustable direction of movement and display and repetition settings. For the respective games, you define in advance whether the patient is to work in the strength or the movement mode, and specify the movements to be carried out or the respective strength to be applied. In this way, the patient learns how to use his/her upper limb in a targeted and repetitive manner, and the game can only be played with the movement or strength that was specified before.

However, the Pablo®Plus System offers much more than just therapeutic options. It also enables the user to carry out assessments in the field of bodily functions and structures as well as the level of activity according to ICF. With this system, the therapist can make a diagnosis and measure the hand and finger strength with all types of grips and precision grips and measure the active movement scope of the respective joints of the upper limb. In a documentation system, Pablo® records all individual results of the report in an electronic patient record, which is created by the therapist at the beginning of therapy. All new findings are stored as well and merged automatically into a therapy and progress report by the system in the background. Additionally every therapy that has been completed is documented with regard to intensity and quality, and the therapist can monitor progress and reassess the situation at any time. Notes and first-hand comments can also be saved in the documentation system.

IV. CONCLUSION

Pablo®Plus combines evidence from neuroscience, practical experience of therapists and modern-day requirements regarding a high-quality therapy design, but also fun and motivational factors to form an innovative therapy system. The fact that it is highly practicable and requires little space makes it extremely interesting for in-patient and especially out-patient treatment as well. Evaluations of this computer-aided arm rehabilitation device are being carried out in several occupational therapy practices and neurological clinics in Germany at present. Efficiency studies are planned for this year at the Neurological Clinic Bad Neustadt and the Centre for Ambulatory Rehabilitation (ZAR) Berlin.

V. FIGURES



Fig.1: Handle with strap and extension band



Fig.2: Pablo®Plus Multiball



Fig.3: Pablo®Plus Multiball



Fig.4: Pablo®Plus Multiball



Fig.5: Pablo®Plus Multiball

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