DEVICE FOR UPPER LIMB KINETHOTERAPY

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Abstract: In this paper a powered therapeutic devices providing for the rehabilitation of the upper limb after injury and illness is presented. The device guides the patient's limb through a series if desired exercises to rehabilitate multiple muscle groups. A comparative study of different devices is done. Based on the functions of upper limb, the structure of the proposed device is presented. Two applications are being emphasized: one for passive movements and the other one, for active movements.

1. KINETHOTERAPY – COMPONENT OF REHABILITATION

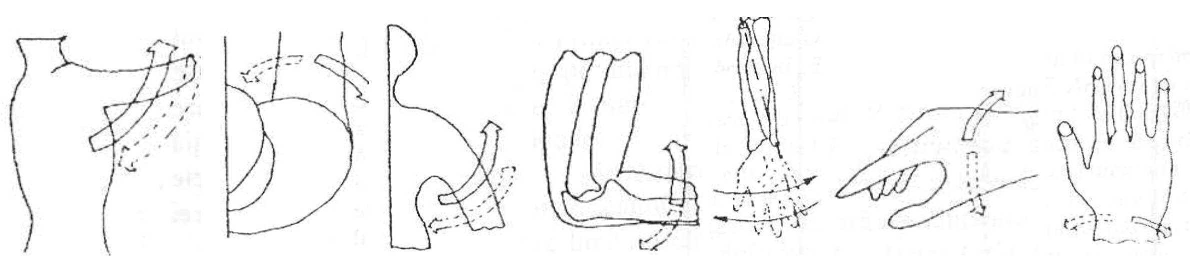
Kinetotherapy promotes motion as a basic element of rehabilitation treatment. Kinetotherapy aspects are varied, including: walking, running, gym, games, training – using specialized equipment, hidrokinethoterapy, [6], [8].

The passive mobilizations are those movements impozed to a patient's articulation by an exterior intervention, without its neuromuscular system to be involved. The active mobilizations or movements are the ensemble of exercises performed by the patient, voluntarly putting in function his/her neuromuscular system. Active movements may be assisted, free – without exterior restistance or active movements against a resisting force.

Kinetotherapy is an important part of *rehabilitation,* which is a complex medico-social assisting process that has as objective the reintregration of disabled in family and society. Its specific ways of action concern the achievement of optimal values for the morpho-functional capacity, psychical status, professional training, and social status. The other components of Rehabilitation Engineering are prosthetics, orthotics, mobility aids, walk assist devices, sensorial augmentation systems, [5].

2. COMPARATIVE STUDY OF SOME KINETHOTERAPY DEVICES FOR UPPER LIMB

The anatomic basic and specific movements of the hand positioning bio-system are the backward-forward arm's projection; the inner-outer arm's rotation; the arm's abduction-adduction and the forearm's flexion-extension (Fig.1 a, b, c, d)



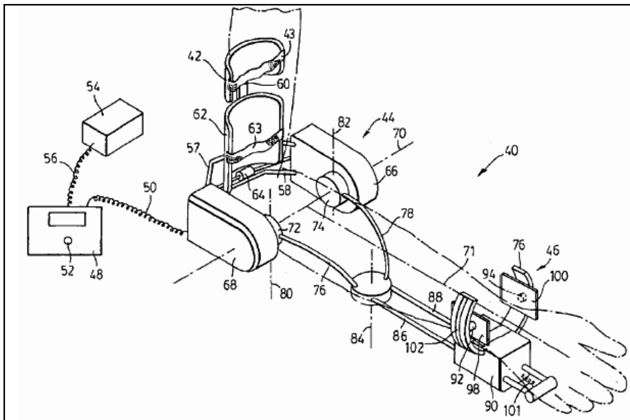
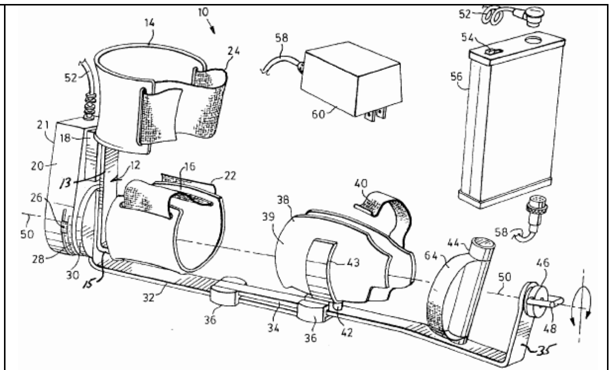
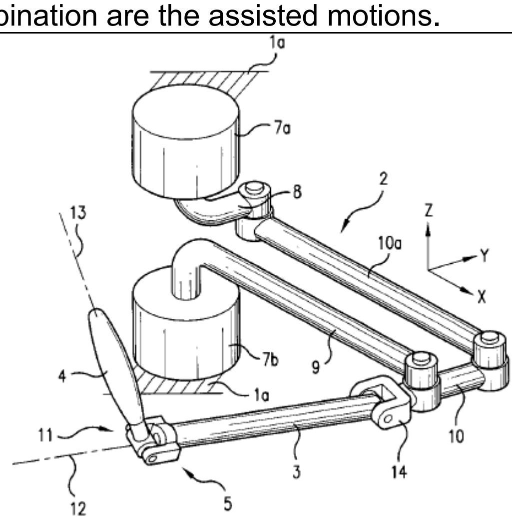
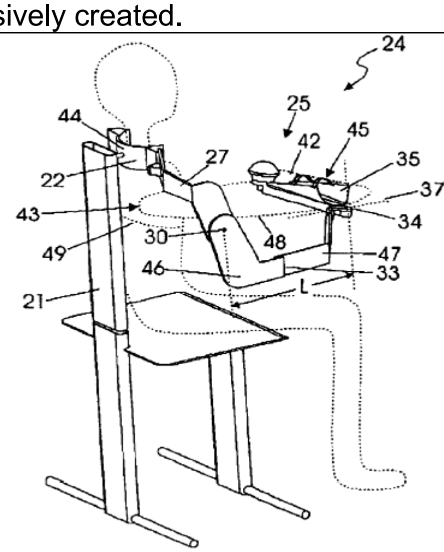
a b c d e f g

Fig. 1 The anatomical movements of the shoulder and elbow jointsl

forearm's pronation – supination, hand's abduction – adduction, hand's flexion – extension (Fig. 1 e, f, g). Prehension, that is gripping of different objects, like in a tweezer has the following basic anatomic movements: the thumb's flexion–extension and abduction–adduction and the 2-5 fingers flexion–extension and laterality movements [1].

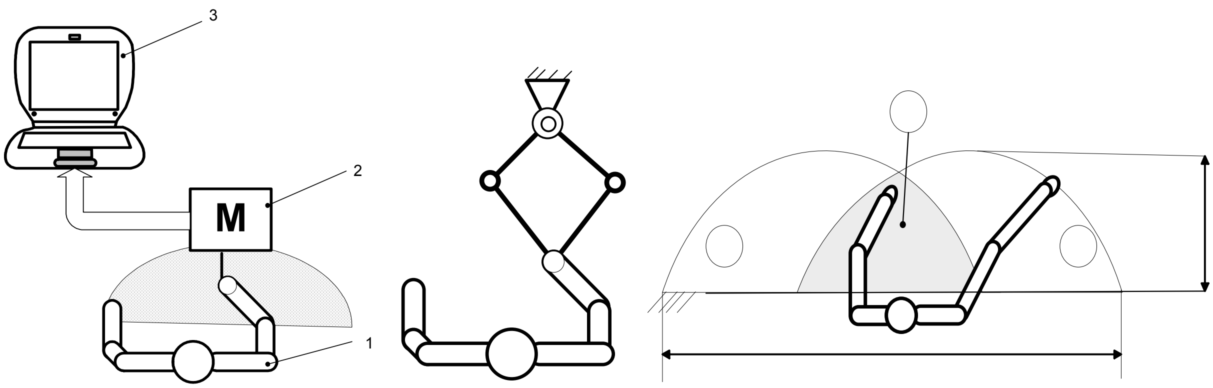
In table 1 some devices for kinetic treatment of the joints of the human upper limb are presented, according to [9].

Table 1 Devices for kinetic treatment of upper limb

	
The above figure relates to a therapeutic mobilisation and positioning device of joints having a control device that measures the force through the deformation of an elastic component. Elbow and wrist are the target joints and flexion-extension and pronation-supination are the assisted motions.	The continuous passive motion device includes an upper arm support suitably fixed to a drive actuator and a adjustable forearm support. Various cuffs are provided so a patient can secure the limb to the device; so pronation –supination is passively created.
	
The device is equipped with a controller for the sensing of the position of the handle at the end of an arm in the X and Y directions and in Z direction through a hinge which permits the arm to rotate upwardly. The joints of the device may be actuated to provide haptic feed-back.	In figure is a therapy and training device for the shoulder joint with a trunk base having two shoulders extensions on a rotational joint base. It has a modular structure and can produce passive motions of the shoulder and elbow.

3. THE DEVELOPED SYSTEM

The proposed device is designed to be used in passive and active upper limb's mobilization, aiming the reattainment of the shoulder articulations', elbow's and wrists' movement capacity and patient's motor skills.



a *b* *c*

Fig. 2 The structure of the studied system (a, b) and normal and maximal zones of convenient reach of upper limbs (c)

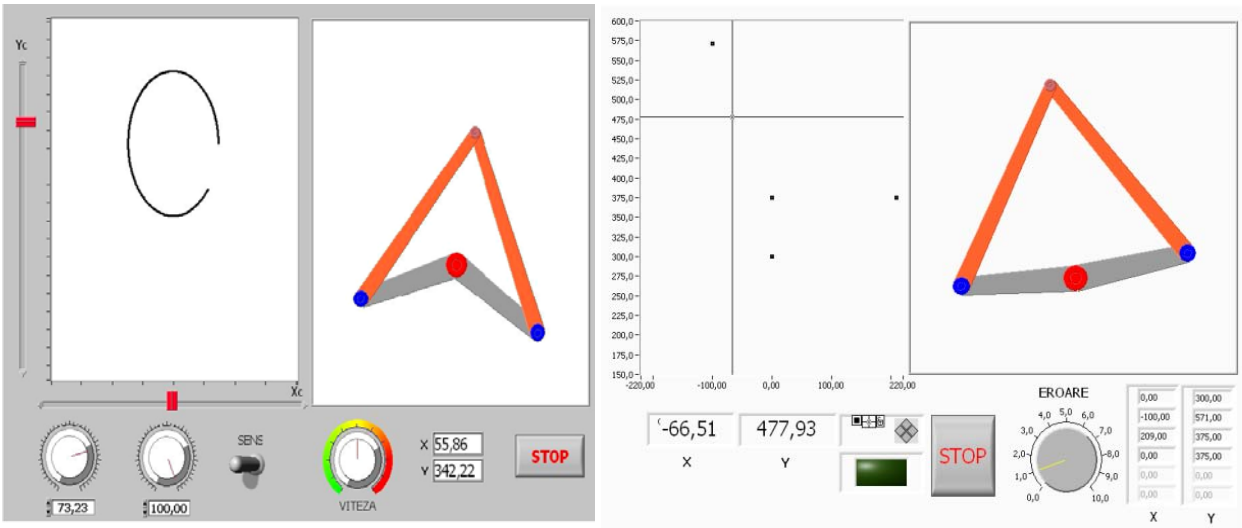
According to figure 2a, user 1, in the sitting position, has its upper limb linked with mechanical structure 2 (the hand is in direct contact with a handle). The upper limb is mobilized, actively or passively, in the marked plan. Mechanical structure 2 is connected to computer 3. The mechanical structure presented in figure 2b is consisting in using a pentalater mechanism, the driving joints being placed at the base. For insuring a light weight and a particular workspace's shape, we have chosen the particular case where the two driving joints are overlapped. A robotic system based on such a pentalater mechanism is described in [3].

The dimensional synthesis of the pentalater mechanism is based on its workspace, taking into account the so-called *zones of convenient reach (ZCR)* of upper limbs, for the sitting position (figure 2c).

The pentalater mechanism, which assures in-plane motion of the hand connected with the handle, will be placed at a height between the values of 650 mm and 1000 mm. This dimensions correspond to the ergonomical data concerning the height of the table desk, both for precision activities (800 mm – 1000 mm), as well as for effort activities (650 mm – 700 mm). Two applications were made using the *LabView* software. These can be performed with the developed device.

The user's interface for the first one (for passive motions) is presented in figure 3a. The robotic arm is programmed to move along an elliptical trajectory. Its form and dimensions could be modified, using the buttons 1. The position of the trajectory in the workspace also can be modified, using buttons 2. Hereby, the range of motions performed by the patient's limb is controlled, and the desired anatomical movements could be selected. The speed and the direction of motion is possible to be controlled.

The user interface for the second application is presented in figure 3b. The patient has to displace the pentalater mechanism's characteristic point in certain points, whose coordinates can be defined using table 1. This application is intended for active exercises. The proximity is marked by indicator 2. The positioning error is controlled with button 3.



a *b*

Fig. 3 The developed applications

CONCLUSIONS

The task of the kinethoterapy is the amelioration disabilities by performance’s improvement (forces, precision, and mobility of locomotor apparatus).In practice there is a particularly great need for rehabilitation with regard to movement constraints on the upper limb joints.

The most important principle of the proposed device is constructive simplicity; the device has an important role in maintaining the joint’s mobility; stimulating the circulatory regime, maintaining and developing muscular tonus, and developing motion’s control ability.

REFERENCES

[1]. Baciu, C., Aparatul locomotor - Anatomie funcțională, semiologie clinică, diagnostic diferențial, Editura Medicală, Bucureşti, 1981
[2]. Buhler, C., Robotics for rehabiliation–an European perspective, Robotica, vol. 16, 1998, pag. 487 – 490
[3] Hogan, N., ş.a., Interactive Robotic Therapist, U.S. Patent no. 5.466.213, 1994
[4] Kroemer, K., Ergonomics – How to design for ease and efficiency, Prentice Hall Englewood Cliffs, 1998.
[5] Mândru, D. ,Ingineria protezării şi reabilitării, Editura Casa Cărții de Ştiință, Cluj-Napoca, 2001.
[6] Mândru, D., Noveanu, S., Tătar, O., Studii privind particularitațile roboticii pentru reabilitare, Buletinul Stiintific al Universitatii de Nord Baia-Mare, seria C, vol. XVII, 2003, pag. 183 – 188.
[7] Mândru, D., Rusu, C., Noveanu, S., Research concerning the development of a robotic system for rehabilitation exercises, Mecatronica, nr. 2, ISSN 1583-7653, pag. 55 – 60, 2004.
[8] Plas, H.F., Kinetoterapie activă, Editura Polirom, Iaşi, 2001
[9] U.S. Patents no. 5.788.607, 5.951.499, 6.743.187, 6.781.569, 6.824.498.