Experimental Research upon a Pneumatic Equipment for Wrist Recovery

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Abstract
The equipment under experimental research is an equipment intended for recovering the wrist, which is driven by means of a linear pneumatic muscle. The palm is supported and moved with a device based on the „Fin Ray Effect" concept. This device has the advantage of simultaneously mobilizing wrist and knuckles. In this paper, the experiment results for the area of the wrist will be presented.

Keywords
recovery equipment, pneumatic muscle, wrist

1. Articular Movement Techniques

In paper [1] a classification of the articular movement techniques is presented. These techniques are used in order to avoid joint blocking, to improve coordination, to avoid muscular hypotrophy. In the case of this classification, passive techniques are presented as belonging to dynamic techniques.

According to paper [1], the actual passive technique is a movement made by the kinesiotherapist with his hands or with the help of some devices, within the limits of the physiological movement, with a certain speed, a certain rhythm, repeated a number of times. In the case of this technique, the patient does not make effort to achieve the movement, the effort being made by the kinesiotherapist or by the recovery equipment.

The recovery movement must be made according to the right trajectory, for the patient to correctly acquire the sensations of muscle contraction and relaxation, preventing muscle retractions which lead to joint blockage.

With a view to preventing joint blockage, passive kinesiotherapy is recommended, even in patients with irreversible lesions [2].

Another technique presented in paper [1] is the auto-passive technique. This technique, in its turn, belongs to the category of passive techniques. In this case, the patient uses a healthy member, in order to move a segment of a deficient member, or even the deficient member. This technique can only be applied after the kinesiotherapist has instructed the patient, and makes sure (s)he has correctly understood the movements.

The wrist can achieve several movements. In this paper, we are interested in hand flexion and extension. The maximal values of flexion and extension can be found in paper [3].

It should be specified that the maximal values vary from individual to individual. In the case of people with hyperextension, the maximal value of the extension is exceeded.

In figure 1, the maximal value of hand flexion is shown, the wrist rotation being of 80°.

The maximal value of hand extension can be seen in figure 2, the maximal rotation having 70°.

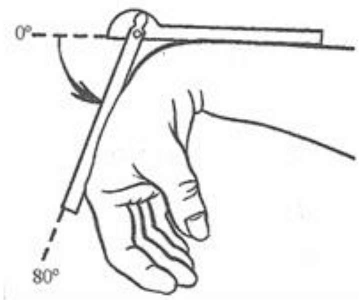


Fig. 1. Hand flexion

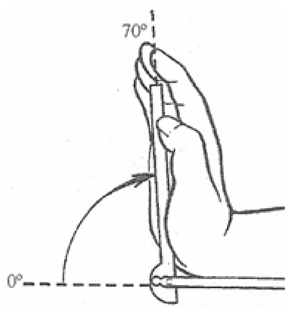


Fig. 2. Hand extension

Considering the above, the wrist recovery equipment was designed so as not to exceed the maximal values of flexion and extension.

2. Wrist Recovery Equipment

The recovery systems can be electrically, pneumatically or hydraulicaly driven. The most common drive systems for recovery equipments are electric motors.

In terms of mobility, the types of equipment for hand recovery can be portable and fixed. In the following images, I will present a few types of equipment, either marketed or only in the research stage.

In figure 3, there is a portable equipment used for wrist recovery, [4]. This equipment ensures a rotation ranging between 0° and 90° both for flexion and for extension.

Fig. 3. W2 Wrist CPM

In figure 4, there is a fixed equipment intended for wrist and knuckle recovery [5].

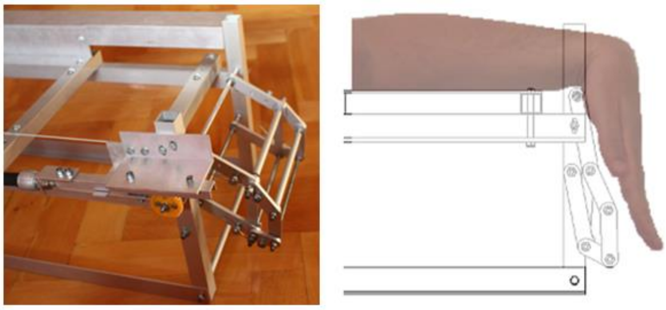
Fig. 4. Maestra

As regards this equipment, the extension is made between 0° - 50°, and the flexion between 0° - 90°.

The types of recovery equipment with pneumatic drive are currently under research. In paper [6], an equipment driven with linear pneumatic muscles is presented. This equipment is shown in figure 5.

Fig. 5. Wrist recovery equipment

The studied recovery equipment falls under the group of equipment with pneumatic drive. In figure 6, there is shown the recovery equipment driven by means of a linear pneumatic muscle.



a b
Fig. 6. Hand recovery equipment
a – Recovery equipment, b – Arm placement on the equipment

The equipment operates as follows:

- the arm is placed on the equipment as in figure 6b. In this position, the pneumatic muscle is relaxed, the pressure inside it is zero, and the palm flexion is maximal.
- pressure is introduced in the pneumatic muscle. Once with the rise in pressure, the pneumatic muscle shortens its length and pulls the rack. This action results in the rotation of the pinion and in the lift of the support on which the palm rests (see figure 6a). Depending on the pressure within the system, the palm lifts more or less.

3. Experimental Determination of the Flexion and Extension Angles Made by the Device

With a view to determining the angular shift of the palm support, the pressure within the system continuously varies. As for the conducted experiment, the pressure increases from 0 to 6 bar, then it continuously decreases from 6 to 0 bar. The rotation of the palm support was measured with a digital protractor. In figure 7, there is shown one of the measurements achieved for determining the value of the angle made by the palm in relation to the forearm

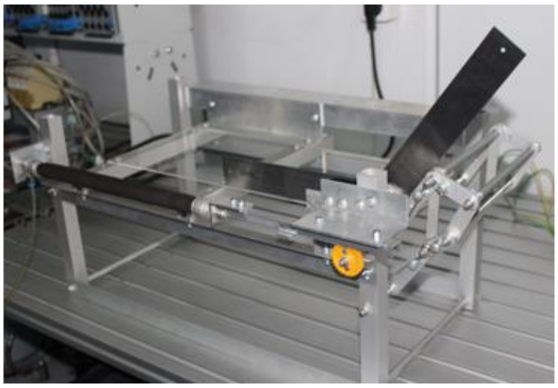


Fig. 7. Forearm – palm angle measurement

The measured values are shown in Table 1.

Table 1 – Rotation of palm support

Pressure [bar]	0	1	2	3	4	5	6
Angle [°]	-76.2	-64.7	-49.8	-25.0	7.1	35.0	61.8
Pressure [bar]	6	5	4	3	2	1	0
Angle [°]	61.8	57.2	45.7	21.3	-18	-49	-67

The values in Table 1 help to obtaining the diagram in Figure 8. The obtained experimental results highlighted deviations in the values of the limit angles in relation to the ones theoretically obtained. Thus, in the case of the maximal flexion, the deviation is of approximately 4° at the beginning of the muscle contraction, and reaches 13° because of the muscle hysteresis. In the case of the maximal extension the deviation is of approximately 8°.

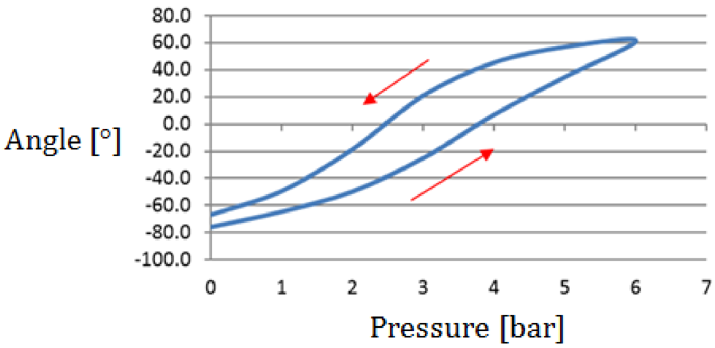


Fig. 8. Angle – pressure curve

Considering the above, the diagram in Figure 8 will be used for adjusting the equipment. For instance, if we set the equipment in the position of 0°, the pressure must be increased to 3.8 bar. This value is obtained from the intersection of the muscle contraction curve with the horizontal axis (0°). For a point on the muscle contraction curve, a single value corresponding both to the angle and to the pressure will be found. In this way, for any angle of the palm support included in the active area of the equipment, a unique value of the pressure will be determined. Various programs for the movement of the AB support can be thereby achieved.

4. Conclusions

Given the results obtained from the measurements, it can be deduced that the equipment may be used for the intended purpose, which is wrist recovery. The equipment achieves the palm movement on its functional area, having problems only on the area of the maximal mobility.

The deviations of the equipment from the theoretical positions can be explained through the deviations occurring during assemblage, and through the varied elastic constants of the torsion springs contained in the palm-supporting device.

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Received in June 2017