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# Designing and constructing fingers' empowering device with strengthen changing capability for MS patients

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## ABSTRACT

*Multiple sclerosis (MS) is a chronic disease of the central nervous system (CNS) and is considered as one of the most important reasons of nervous disability in the young adults around the world (1). The complexity of this disease is to determining the appropriate treatment by two pharmacological and rehabilitation approaches. The later one is divided into two psychotherapy and symptomatic therapy sections. The exercise and physiotherapy are the best solutions to help prevent the reduction of ability (2).With regard to this matter that the endurance trainings are useful for the Parkinson and Multiple Sclerosis patients (3), the present research aims to do some fingers movements for griping the things. So, at first, a device is designed for strengthening the flexor and extensor muscles of the fingers. Then, this device is made by studying the appropriate materials for its production. This device can be used for empowering the fingers from the lowest to highest level. It can gradually increase the power of the extensor and flexor muscles of the fingers. With regard to this matter, this device is more economical than the other devices and the exercise and physiotherapy devices, since it can be used instead of using two separate devices for empowering the extensor and flexor muscles in different strengths of that.*
*Key words: MS, design, strength*

**Introduction**

The Multiple Sclerosis is an autoimmune disease that affects the brain and spinal cord (central nervous system (CNS)) and even at the early stages of disease, it destroys myelin around nerves and nervous system axons (1). This disease occurs more in the women between the ages of 20 to 40 (4). In MS disease, the immune system assails the brain and spinal cord which are two components of important components of central nervous system and disables them and reduces the balance and ultimately, it causes the movement disability and cognitive deficiency (1).

There is no absolute reason opinion about the main reasons of the immune system for destroying the nervous system in the MS patients. Some scientist believe that a combination of genetic and environmental factors such as the shortage of vitamin D, fatness, smoking, ultraviolet B (UVB), and virus infection can cause this disease (5). The non- deterministic treatment of MS disease is divided into three sections of treatment of resonance, decelerating the disease development by corrective therapy and the treatment of symptoms. Accordingly, the development of disease can be reduced by the care (6).

The weakness and limitation in movement is one of radical problems of these patients that, on one side, it is due to involvement of movement sections of brain and spinal cord and on the other side, the less movement of these patients. According to the researches and scientific evidence, the empowering activity can be useful for the MS patients (3). Furthermore, the physiotherapy has been proposed as a component of a general approach to control MS symptoms such as the fatigue. Indeed, the physiotherapy is useful due to its new viewpoints in the domain of rehabilitation. On the other hand, the continuous self- treatment by the cooperation with physiotherapist is the basis of success in treatment by physiotherapy (2).

The plastic circles are the most popular device for strengthening the hand fingers that are supplied in three colors and three different powers in the market. These circles are only used for empowering the flexor muscles of the fingers. However, the weakeest of them is so strong and tight that even the health women with natural power cannot force that and with regard to this matter that the present research is about the empowerment of MS patients' fingers and this device is not appropriate for the natural patients. However, if it is assumed an individual can work with this device and s/he should increase his/her power in order to force that; with regard to this matter that the number of mitochondria and muscles diameter are increased at the time of endurance trainings, the power of circle should be increased. Therefore the second and third circles should be provided (it means to add an extra expenditure to the overbid costs of treatment of this disease) and again, at that time, since the individual does not enough strength, s/he should exercise further to gain the optimal power and this would not be good for a patient who has lost his/ her mentality. The present research aimed to design and construct the fingers empowering device with strength change capability for the MS patients.

## Procedure of design and construction

### Measurement of fingers

Ten individuals were randomly selected. Then, the size of their every finger was measured by using the calipers and collected in a table. The device accuracy was 0.1 cm (table 1).

**Table 1: fingers' size (cm)**

| | First finger (small finger) | Second finger (ring finger) | Third finger (middle finger) | Fourth finger (forefinger) | Fifth finger (thumb finger) |
|---|---|---|---|---|---|
| First member | 5.1 | 6.3 | 7.1 | 6.5 | 5 |
| Second member | 5.2 | 6.1 | 7 | 6.2 | 5.1 |
| Third member | 5 | 6.2 | 6.9 | 6.2 | 5.6 |
| Fourth member | 5.5 | 6.7 | 7.4 | 6.6 | 5.3 |
| Fifth member | 5.8 | 6.7 | 7.3 | 6.7 | 5.6 |
| Sixth member | 5.1 | 6.4 | 6.9 | 6.2 | 5.5 |
| Seventh member | 5.9 | 7.6 | 8.1 | 7.5 | 5.6 |
| Eighth member | 6.8 | 7.8 | 8.6 | 7.7 | 5.6 |
| Ninth member | 5.6 | 6.8 | 7.2 | 7 | 5.2 |
| Tenth member | 5.5 | 6.8 | 7.6 | 7.2 | 5.3 |

### Measurement of Fingers' angles

For Measurement the angles between the fingers, a plastic and mobile piece was placed on the conveyor and the subjects were asked to start from the point zero and open their fingers by pushing the piece. After taking the hand, the angle on which the piece has been fixed was recorded as the angle between that finger and the adjacent finger (table 2).

**Table 2: angle between hand fingers**

| | Angle between small finger and ring finger | Angle between ring finger and middle finger | Angle between middle finger and forefinger | Angle between forefinger and thumb finger |
|---|---|---|---|---|
| First member | 32 | 44 | 39 | 74 |
| Second member | 34 | 32 | 36 | 74 |
| Third member | 36 | 25 | 31 | 84 |
| Fourth member | 34 | 32 | 34 | 59 |
| Fifth member | 42 | 44 | 51 | 87 |
| Sixth member | 41 | 33 | 31 | 73 |
| Seventh member | 36 | 39 | 51 | 83 |
| Eighth member | 38 | 52 | 42 | 73 |
| Ninth member | 36 | 36 | 31 | 84 |
| Tenth member | 37 | 42 | 37 | 69 |

MS patients' fingers' strength

In third stage of project, the Handgrip Strength Test is used for measuring the strength of MS patients' hands in two states of open and closed fingers. With regard to this matter that the scale of muscular force is kilogram, the number observed on the scale should be recorded (table 3).

**Table 3: fingers' strength (kg)**

| MS patients' strength in closing the right hand | small finger | ring finger | middle finger | forefinger | thumb finger |
|---|---|---|---|---|---|
| First test | 0.860 | 0.615 | 0.780 | 0.660 | 0.714 |
| Second test | 0.865 | 0.630 | 0.750 | 0.670 | 0.700 |
| Third test | 0.853 | 0.595 | 0.765 | 0.653 | 0.720 |
| Fourth test | 0.860 | 0.605 | 0.769 | 0.660 | 0.715 |
| Fifth test | 0.862 | 0.620 | 0.770 | 0.672 | 0.712 |
| Table of MS patients' strength in closing the left hand fingers (kg) | | | | | |
| First test | 1 | 1.31 | 1.205 | 1.275 | 1.140 |
| Second test | 1.993 | 1.25 | 1.203 | 1.273 | 1.137 |
| Third test | 0.995 | 1.33 | 1.206 | 1.270 | 1.135 |
| Fourth test | 0.990 | 1.30 | 1.200 | 1.278 | 1.141 |
| Fifth test | 1.01 | 1.32 | 1.205 | 1.271 | 1.132 |
| Table of MS patients' strength in opening the right hand fingers | | | | | |
| First test | 0.295 | 0.125 | 0.185 | 0.365 | 0.350 |
| Second test | 0.287 | 0.120 | 0.180 | 0.363 | 0.354 |
| Third test | 0.303 | 0.128 | 0.180 | 0.360 | 0.347 |
| Fourth test | 0.290 | 0.130 | 0.190 | 0.367 | 0.345 |
| Fifth test | 0.293 | 0.122 | 0.182 | 0.370 | 0.352 |
| Strength of opening the left hand fingers | | | | | |
| First test | 0.365 | 0.265 | 0.235 | 0.300 | 0.315 |
| Second test | 0.360 | 0.263 | 0.231 | 0.294 | 0.313 |
| Third test | 0.367 | 0.268 | 0.233 | 0.303 | 0.318 |
| Fourth test | 0.363 | 0.262 | 0.238 | 0.305 | 0.310 |
| Fifth test | 0.370 | 0.267 | 0.236 | 0.298 | 0.319 |

For analyzing the data, since the fingers' size is restricted to a limited interval, the mean can be used as a tool for the descriptive statistic calculation and the variance and standard deviation can be used as the distribution statistics. The relations of mean, variance and standard deviation used in the calculations are respectively represented as following:

$$\bar{x} = \frac{\sum x_i}{n} \quad (1)$$

$$s^2 = \frac{\sum (x_i)^2}{n} - \bar{x}^2 \quad (2)$$

$$s^2 = \frac{\sum (x_i)^2 - \frac{(\sum x_i)^2}{n}}{n} \quad (3)$$

$$s^2 = \frac{\sum (x_i - \bar{x})^2}{n} \quad (4)$$

$$sd = \sqrt{s^2} \quad (5)$$

Where; $x_i$ is the obtained data and n is the number of data.

Drawing the device map

The device design was done with regard to the following properties:

1- Having appropriate ergonomic design

2- Active empowerment of agonist and antagonist muscles pairs

3- Strength change capability

The final design was represented as following:

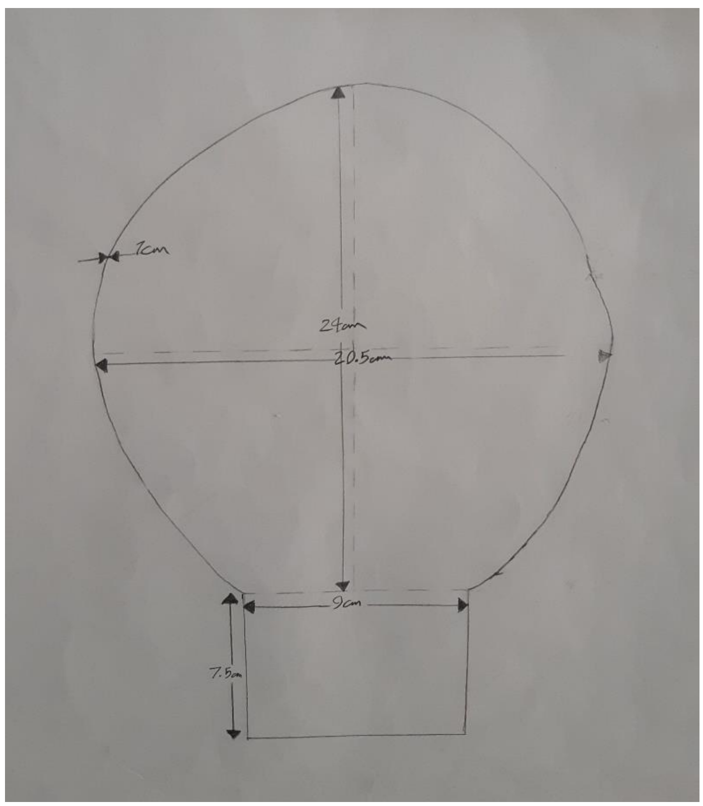


**Figure 1: final and reformed design of hand fingers empowering device**

### Determination of material

The factors of portability, strength and cheapness were regarded for determining the device material. It was revealed that the material known as white Teflon in the market is nearly like the plastic and has almost a higher resistance. Then, it was selected as the underlying sheet of this design.

### Device construction

For construction of device, at first, the design was drawn on the white Teflon and then it was cut by using the chain saw upright on the frame design as it is observed in the figure.

**Figure 2- cutting the design by chain saw upright on white Teflon**

Then, the cutting and chiseling delicacy of touch was done by the milling machine and a regular and clean design was resulted. By making a hole on the neighborhood, we create the adaptor bed for opening the fingers. Next, with regard to the mean of obtained angles in the research, some holes were created by the drill for the adaptor bed to change the distance of spring Δx and the place of fingers location. The size of every adaptor bolt was regarded 5.5 cm and a wing nut was devised for every bolt to facilitate the adaptor change. Accordingly, the frame of device design was prepared.

### Spring selection

To do so, with regard to the considered adaptor (5.5 cm), the rigidity of spring should be designed in such a way that it has the weakest force, but it should not be so weak that could not improve the fingers' strength. With regard to the fingers' force, this interval is about 200 gr to 2 kg which is a large interval. It should be attended that the fingers' length are important along the adaptor length. The small and thumb fingers have the lowest length and with regard to this matter that there is no considerable in their length, the sizes of small finger are used in the research. In the case of lowest amount of spring rigidity, 0.2 kg/ cm sounds to be an appropriate size to bring 0.2 kg, i.e. 200 gr power in the fingers by 1 cm movement. Then, the intended spring was tested to obtain k of spring. For doing so, the following relation was used.

$$k = \frac{F}{\Delta x} \tag{6}$$

Where; Δx is obtained by the following relation:

$$\Delta x = x_1 - x_2 \tag{7}$$

Where; F, K $\Delta x$, $X_1$ and $X_2$ respectively are: spring force, fixed rigidity coefficient of spring, difference between two states of spring relaxation and extension, spring relaxation and spring extension.

And in the case of small finger:

(Mean of small finger's size) X= 5.55cm

(Reglage size) $\Delta x$ = 5.5cm

(Total length of spring extension) $\Delta x$ + X = 11.05

For calculating the maximum force brought in the small finger, the small finger length is added to the reglage size, since when the finger is completely bent, a length equal to the finger and reglage size is created.

Therefore, with regard to the relation 4-6, k mean, reglage amount and finger size, we have:

$$F = 0.25 \times 11.05 = 2.76\ kg$$

In the case of other fingers:

$$ring\ finger\ F = 0.25 \times (5.5 + 6.74) = 3.06\ \ kg$$
$$middle\ finger\ F = 0.25 \times (5.5 + 7.51) = 3.25\ \ kg$$
$$forefinger\ F = 0.25 \times (5.5 + 6.78) = 3.07\ \ kg$$
$$thumb\ finger\ F = 0.25 \times (5.5 + 5.38) = 2.72\ \ kg$$

So, the lowest fore brought in the finger, when the finger moves 1 mm, would be 0.25 kg. It means that with regard to the relation 4-6: $F = 0.25 \times 1 = 0.25$ and its maximum amount in the case of different fingers, i.e. small, ring, middle, forefinger and thumb finger respectively is 2.76, 3.06, 3.25, 3.07, 2.72 kg.

At the end, for the removal of sharp points of the adaptor bolts, an elastic band was devised around them. For improving the condition of hand and prevention of any damage to the forearm, the part on which the wrist and forearm are placed in the device is located upper and the middle part is located lower so that the hand is placed with a few angle on the device and is fixed on the device by a bond. Finally, the circles in which the fingers are located are cut and located in the device.

**Conclusion**

The Multiple Sclerosis is a disease with force impoverishment and the patient facilitates this impoverishment due to the reasons such as fear. Therefore, some devices are required to pave the way for the patient to exercise with lowest risk and without fear and to reduce the speed of impoverishment (2).

The hands and feet are the most important body members respectively for griping the things and walking. The present research aimed at the empowerment of the hands for gripping the things. As it was mentioned, this device creates the lowest risk for the patients by being bound to the hands and its appropriate design for the fingers location and encourages the patients to do exercise by reducing their fear of disease.

When putting the hand in the device, when the adaptor is at the lowest level, the force brought in every finger is equal to zero. The more the fingers bend, the more force is applied to the fingers according to the formula 4-6. Then, by increasing the adaptor, the applied force increases due to the increase of $\Delta x$. On one side, when the adaptor are located up we would have the early applied force, when the hand has a relaxed state without bending the fingers. It is due to the difference between the size of relaxed and extended spring. With regard to the size of adaptor (5.5 cm) and fixed coefficient of spring rigidity (0.25), the early force brought in the hands would be 1.375.

$$F = k\Delta x = 0.25 \times 5.5 = 1.375$$

The other advantage of this devices is changing the strength in the case of both the exercise and muscles that involves both the flexor and extensor muscles of the fingers and ultimately, the extra expenditures of the disease are economized. In addition, the strength of fingers can be improved to the higher level and their force can be considerably increased.

Because, in this disease, the physicians estimate the hand strength relatively by taking that and with regard to the existence of religious restrictions for some patients, it is possible to measure the force medically by adding an ergometer to this device. used this device as a dynamometer hereafter.

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