KEMENTERIAN PENGAJIAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

POLITEKNIK MALAYSIA
TUANKU SYED SIRAJUDDIN

National Conference on TVET for Undergraduate Students

e-Proceedings NCTS 2022

NATIONAL CONFERENCE ON TVET FOR UNDERGRADUATE STUDENTS

E-PROSIDING NATIONAL CONFERENCE ON TVET UNDERGRADUATE STUDENTS 2022

This book contains information submitted by the author based on his knowledge, experience and expertise in the field of teaching cost accounting. In addition, this book also contains some information obtained from other parties whose original source is stated through reference.

However, since this book only covers topics related to element costs then readers are encouraged to refer to the contents of other related books to gain a detailed understanding in cost accounting.

Published by:
Politeknik Tuanku Syed Sirajudddin (PTSS)
Pauh Putra, 02600 Arau, Perlis
Tel No. : 04-988 6200
Fax No. : 04-988 6300
www.ptss.edu.my

e ISBN 978-967-2258-97-1
9 7 8 9 6 7 2 2 5 8 9 7 1
e-Proceedings NCTS 2022

Development of Finger Therapy Device by Using Flex Sensor with Vibration Motor

Ahmad Syafiq Shaari[1], Dr Sabariah Bohanudin [2]
Electrical Engineering Department (Medical Electronic),
Politeknik Sultan Salahuddin Abdul Aziz Shah, 40150 Shah Alam, Malaysia
[2] bsabariah@psa.edu.my
[1] ariff0302@gmail.com

ABSTRACT

Exercise and massage are two of the best activities for recovering from and improving a healthy lifestyle to avoid various health issues, especially stroke. When there is no direction on recovery training, exercise will be boring, as will the stress of manually recording training data and the lack of multitasking devices on the market, which can lead to increased stroke rates. In order to overcome the problem, a massage and rehabilitation device that can analyse the ability of fingers was designed and constructed. It is able to improve exercise motivation by automatically saving data activities for better diagnosis. The device uses a flex sensor, vibration motor, and elastic material that is attached to a Bluetooth module for recording exercise data remotely. The analysis is done by calculating the perfect grip angle through a flex sensor when completing the grip, which is automatically recorded by the application after receiving data via Bluetooth. The device also uses a flat vibration motor and elastic material as vibration and pressure in the glove to include the process of recovery. When directed at the gloves, the pressure and vibration can promote finger strength and blood flow in the fingers more effectively. The combination of recording data of finger grip capability with vibration and pressure has the potential to be a necessary medical or rehabilitation requirement in order to deal with the rising rate of strokes and maintain a healthy lifestyle.

Keywords: Finger recovery, flex sensor, rehabilitation.

1. INTRODUCTION

According to the Centers for Disease Control and Prevention (CDC), someone in the United States has a stroke every 40 seconds, and every year, more than 795,000 people in the United States have a stroke and approximately two-thirds of these individuals survive and require rehabilitation (*Stroke Facts | Cdc.Gov*, 2021). Therefore, the goal of rehabilitation is to help patients with physical or cognitive disabilities regain as much functional ability as possible. There is a strong consensus among rehabilitation experts that the most important element in any rehabilitation programme is carefully directed, and repetitive practice (Bütefisch et al., 1995). Overall, repetition and regularity are the best ways to ensure the success of any treatment programme because they are able to promote neuroplasticity, which is the capability for the mind to form or repair connections that grow out of consistency.

A study in the Journal of Strength and Conditioning Research concluded that grip strength is a predictor of muscular endurance and overall strength (Prasitsiriphon & Pothisiri, 2018). Other studies have found that a stronger grip correlates with a lower risk of heart attack and stroke (Prasitsiriphon & Pothisiri, 2018). Without missing the fact, changes in lifestyle and the rising cost of living are now able to contribute to stress factors that are known to cause the heart to work harder, increase blood pressure, blood sugar and fat levels (Galimanis et al., 2009). These factors can raise the chance of blood clotting and spreading to the heart or brain, resulting in a heart attack or stroke (Galimanis et al., 2009). This shows that it is important to maintain health, such as through exercise, because treating the effects of stroke is as important as preventing the cause of stroke.

Now, the development of technological advances in treatment and training is able to provide an injection of motivation. Motivation in the context of work can be defined as the level of readiness of an individual to perform and sustain efforts toward achieving a goal (Colombo et al., 2007). Work motivation is an internal process by which an individual receives certain stimuli from the environment. In the process of rehabilitation and exercise, motivation is recognised as an important factor and is often used as a determinant of recovery outcomes (Colombo et al., 2007). As a result, efforts to make better use of available technological facilities must be done through focusing and combining on treatment, training, and cost reductions in order to bring about change and better preparation for the rising number of stroke victims.

2. METHODOLOGY

In this section, a description and explanation of the methods used in developing this project are provided. In addition, the project design, block diagram, and flow chart of operation are provided to ensure an explanation of the development process and an overview of this project.

2.1. BLOCK DIAGRAM

The block diagram is an overview of this project's use and arrangement of components. Based on Figure 1, the block diagram is very important to reduce errors in the development process. So, below is the block diagram for this project.

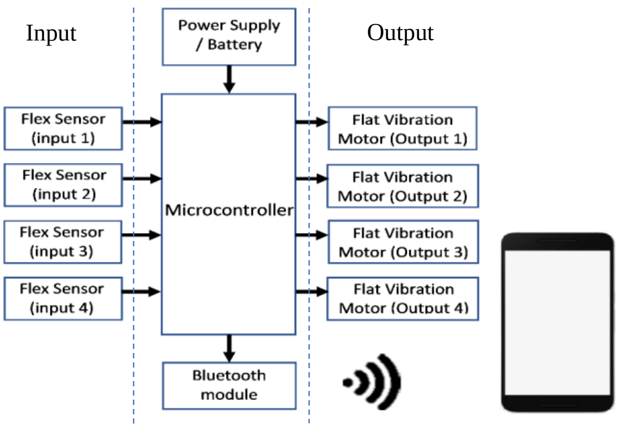

Figure 1, show the functional block diagram of hardware circuit

Based on figure 1, a total of four bending sensors are used as sensor inputs in identifying the grip angle before being processed by the microcontroller. After receiving the input, the microcontroller will give a pre -programmed command to the output, which is a flat vibration motor that works to enhance the finger recovery process. Each activity that occurs will be sent by a Bluetooth sensor to the device to increase motivation and facilitate the storage of data as well as details for diagnosis. This data is stored directly on the storage device in order to see the difference in grip angle change for each finger and enable for additional therapy if necessary.

2.2. PRODUCT DESIGN

To ensure that the project succeeds in achieving its objectives, project design needs to be developed to ensure the selection of components and the way the function runs smoothly. Based on Figure 2, the design of the project is shown with labels to facilitate understanding of the position of the component and facilitate the development of the project.

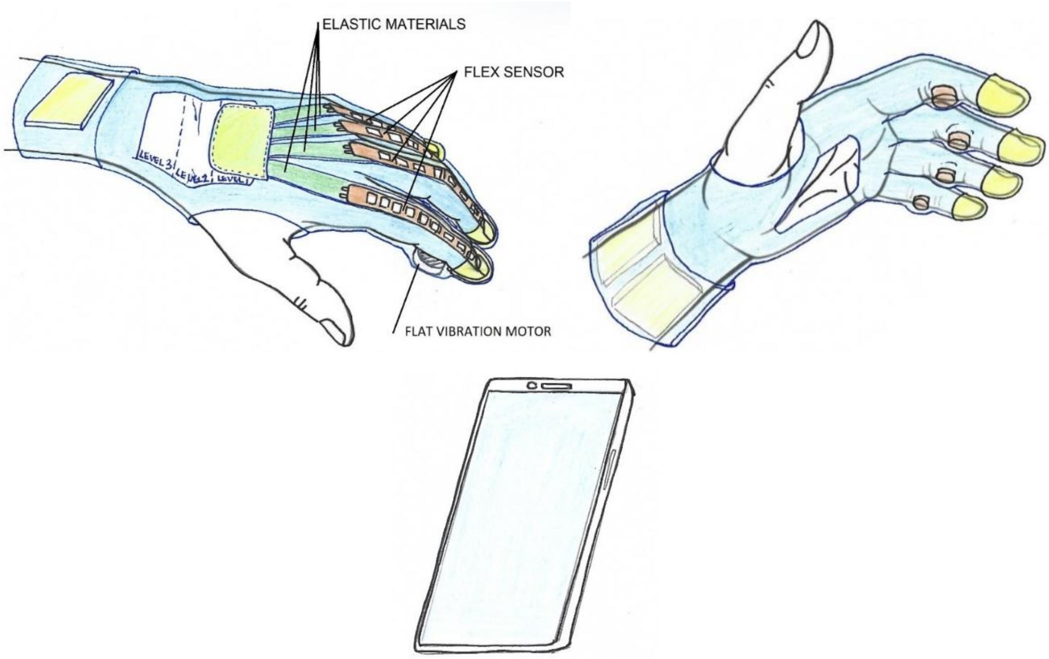

Figure 2. Design of project

This project works by using four flex sensors that shows on Figure 2, where to monitor the angle of grip for each of the four fingers that it supports. The setting of the programmed angle plays a role in analysing the ability of each finger, which will further facilitate the monitoring of the physiotherapist to know the level of each finger. Physiotherapy will decide if another treatment is needed. The data from each finger will be saved automatically on another device. The data is stored using a Bluetooth module that connects to a monitoring device (smartphone). This digital data storage can help to decrease the risk of manipulated data from patients who are losing interest in rehabilitation.

When getting an angle less than required, a flat vibration motor is used to give vibration as therapy to the fingers. The given vibration function only occurs when the set angle is not reached because it can be counted as having no strength or suffering from lack of oxygen in the muscle. This vibration was inspired by the use of muscle therapy (muscle gun), in that it will increase blood flow while suitable for treating tight muscles, adhesions, and minimising muscle soreness and tension (Imtiyaz et al., 2014).

Last but not least, elastic material is used to provide the training necessary to improve the grip strength and also as a measure of stiffness when performing the therapy (Daher, 2013) (Jaber et al., 2012). This material's elastic is manually adjusted according to the user's preferences. Training with this elastic material allows for a stronger development in grip strength, which is highly recommended when a study shows that grip strength is linked to health and correlates with a lower risk of heart attack and stroke (Prasitsiriphon & Pothisiri, 2018).

2.3. FLOW CHART OF OPERATION

This flow chart will describe about the expected operations that will be performed in this project. Based on Figure 3, this explanation can give a better picture of the use and simplify the setup process.

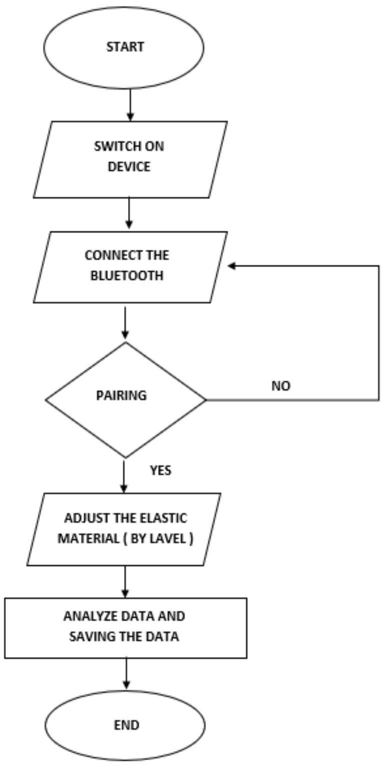

Figure 3. Show the Flow Chart of Operation

Based on the figure 3, the operation of the project begins with the wearing of gloves and is followed by the process of connecting gloves and data storage devices. The connection between these devices is made using Bluetooth. After that, it requires the user to adjust the force level built into the glove to differentiate between the recovery and training process by changing the force level. Every movement in completing one grip requires effort and strength. More and more efforts are made to further increase the strength and recovery process required.

3. RESULT AND FINDING

In this chapter, the final results of the project are shown along with the analysis of this project, which is clarified. In ensuring that the final result of this project achieves the objective, two analyses of the project are done and clarified to support the achievement of the objective of this final project. In addition, to ensure the effectiveness of the project, analyses for bending sensors and forces for elasticity have been developed to ensure that their functions are achieved and impacted.

3.1. ANALYSIS PROJECT

To ensure the effectiveness of the project in achieving the objective, analysis of the functions of the project must be done as proof that the end result of the project can be used in improving treatment and diagnosis for stroke patients. The analysis is done on two main functions of this project, namely the force of elastic material and the angle of the flex sensor, to give a picture of the success of this project. Therefore, the analysis proves that the function in this project works well.

3.2. ANALYSIS OF ELASTIC MATERIAL FORCES

In this section, the analysis was done by applying Hooke's law equation to determine the force, which is related to the use of elastic material for this project. The use of the elastic potential energy formula is also explained to support the calculation of force for the production of force from elastic material. In this analysis, elastic force is measured to support the function of weight training in order to strengthen muscles. This elastic material is placed on the finger and pulled to attach at the back of the hand, which will affect the force on the finger. Based on Figure 4, the length of elastic material must be taken to complete the requirement of formula Hooke's law, which is a constant length.

Figure 4, shows the process of measure the original length

Based on Figure 5, Hooke's law requires a new length to be multiplied by a constant value to obtain the value of elastic force. After calculating the original reading, the reading after fully gripping is also taken into account to see the change in the elastic material. The elastic nature of the material provides the appropriate traction placed on the finger to increase the strength of the finger at a pressure value that is not too high. The use of elastic material also allows full grip to be done without any interruption.

Figure 5, shows the process of measure the new length

Based on Figure 6, Hooke's law, which is used in this analysis, is to measure the force exerted by the elastic material on the object attached to it with the help of the following equation: F = kx. Where "k" is the elastic constant and measures how stiff and strong the elastic is, and "x" is the distance the elastic is stretched or compressed away from its equilibrium or rest position.

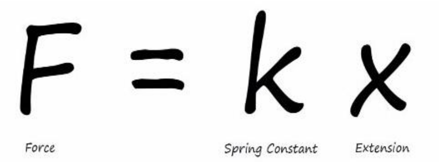

Figure 6, Hooke’s law equation for flexible object

Based on Table 1, this analysis takes the initial value of the length of the elastic material and its new value during stretching to obtain the resultant force values. There are two levels provided in this project to allow the change of force according to the user's ability. The value readings for levels one and two show an increase as the stretching increases by 1 cm, which gives a rate of increase to the force value. The increase in the value of the force on this finger proves that the energy to complete the grip requires an excess of energy when there is a value of force produced by the elastic material. In Table 1, the value of potential energy is also stated to support the change in the use of elastic material from level 1 to 2 with increasing values.

Table 1, shows a change in length of the elastic material

	LEVEL 1				LEVEL 2			
	k	x	f	W	k	x	f	W
Finger 1	12cm	13cm	0.0156N	0.00203J	13.5cm	14.5cm	0.0196N	0.00284J
Finger 2	14cm	15cm	0.0210N	0.00315J	15.5cm	16.5cm	0.0256N	0.00422J
Finger 3	13cm	14cm	0.0182N	0.00254J	14.5cm	15.5cm	0.0225N	0.00348J
Finger 4	11cm	12cm	0.0132N	0.00158J	11.5cm	12.5cm	0.0144N	0.00180J

k constant, x displacement, f force (N), W elastic potential energy (J)

Based on Table 1, each finger has a different original length value, causing the force value for each finger to have a different reading. This original length difference occurs according to the strength capacity of each of those fingers. For example, the value of the force for the little finger is 0.0132N, while the value of the force for the index finger is 0.0156N, for which the difference in original length and strength between the fingers is different.

In addition, the calculation of elastic potential energy is also done to support the proof of the use of elastic material to provide force on the grip. The elastic potential energy is the stored energy of an elastic or stretchable object like a spring or rubber band to move or stretch. The formula for the elastic potential energy is W = Fx, which is W = elastic potential energy (J), F = force (N), and x = displacement (m). With the known value of F, connect the formula of force (F = kx) with the elastic potential energy (W = Fx). Then, the elastic potential energy can be calculated with the equation ($W = kx^2$).

Therefore, the force value resulting from this elastic material provides additional pressure to complete the grip, which indirectly allows the encouragement of increased muscle strength in a faster period. The stated elastic potential energy also brings the same evidence as the value of force, which is, the greater the value of force or potential energy, the greater the amount of energy required to complete the grip. So, the use of force or excess load on exercise allows the muscles involved to work harder and is able to promote increased strength and better blood flow.

The methods and ideas of force used in this project exercise have been taken and refer to existing studies on strengthening programmes in an effort to reduce the amount of knee flexion while walking for children with cerebral palsy, which is weaker in the quadriceps and hamstring muscle groups than controls (Damiano et al., 1995). As a result of this reference studies, quadriceps strength increased significantly and it was recommended to do resistance exercise, which can be a useful adjunct in the treatment of cerebral palsy (Damiano et al., 1995).

3.3. ANALYSIS ANGLE OF FLEX SENSOR

In this section, the second analysis is performed for the flex sensor used in this project. The flex sensor that is used in this project to identify the angle of the finger when it has a reflex on the resulting resistance input if the sensor is bent. In this analysis, the Arduino IDE platform and Angulus apps are used in determining the value for the finger angle with the resistance value read that show on Figure 7. Each angle is measured to obtain data readings of each finger for a better diagnosis. By that, the greater the angle of the curve, the greater the resistance value.

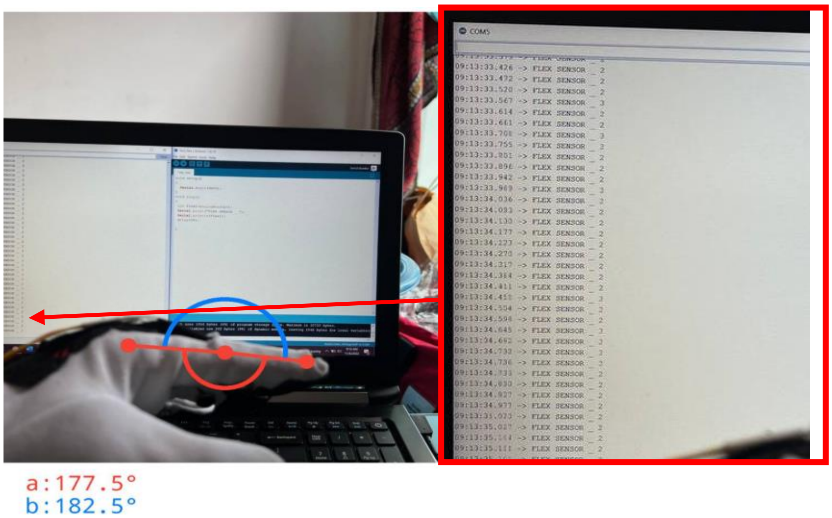

Figure 7, shows the straight condition

Based on Figure 7, the Arduino IDE is used to display the input results on a serial monitor for the resulting resistance value. The resulting resistance value in the straight finger condition indicates a value of less than 10 due to the low resistance rate. After getting the resistance reading, the angle on the finger is calculated using Angulus apps to ensure that the angle of the finger is in a straight state. Angular readings using Angulus are performed by setting the angle point on the finger joint and ensuring the value reaches 180°. Therefore, if the input value is at an average of 30 and below, the finger state is in the straight state.

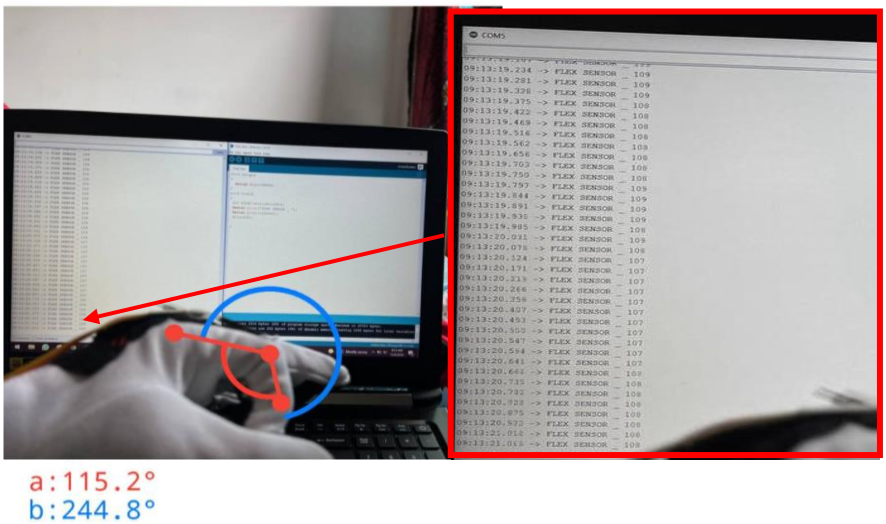

Figure 8, shows the curve condition

Based on Figure 8, the finger is bent more than 90 ° as a sign that the grip has reached the desired angle. At this angle, the value readings recorded on the Arduino IDE show a sharp increase to 100–170 when the finger angle exceeds 90 ° and above. Finger angle recording using Angulus apps displays 115 ° with a resistance value of 108. With the increase in the resistance value along with the increase in the finger angle value, analysis can be performed to identify the finger angle using a flex sensor.

Table 2, Data of flex sensor reflections when bent

Finger Angle	Flex Sensor (Bend)
Straight	0-29
Half Bend	30-99
Full Bend	100-170

Based on Table 2, the change in the resistance value of the flex sensor in this project is influenced by the angle of the finger during the grip, which allows identifying the ability of the finger to complete the grip. In order to get the flex sensor value of resistance, it is necessary to connect the sensor with a fixed value of resistance to create a voltage divider. Therefore, in Table 2, three angles are determined in this project to determine the abilities of each finger. If the full bend condition is achieved, the score for the finger will increase as a sign of complete grip. This increased resistance value occurs when the conductive layer is stretched when the sensor is bent, resulting in a smaller cross section and effecting the higher resistance.

4. CONCLUSION

In conclusion, exercise and massage are important aspects of improving a stroke patient's healthy lifestyle and recovery process. The need to improve rehabilitation efforts for stroke patients needs to be enhanced as the rate of increase in stroke patients increases and the problem of diagnosis and motivation in patients who are able to affect the treatment process needs to be addressed. Therefore, a combination of massage devices and rehabilitation gloves is used in this project to bring the function of massage and diagnosis devices together to better monitor and treat the treatment process. The use of components in this project allows for the recommended treatment of stage 4 stroke patients by referring to the Brunnstrom approach. Methods of improving existing products on the market allow the use of components, can be combined into one device that allows more effective treatment. The three main components, flex sensor, flat vibration motor, and elastic material, in this project are able to provide encouragement to treatment by helping blood flow and participation in load treatment methods to make the process of building muscle strength more comprehensive and faster. Thus, the combination of finger grip ability recording data with vibration and stress has the potential to be a medical or rehabilitative necessity needed to address increased stroke rates and maintain a healthy lifestyle.

REFERENCE

Bütefisch, C., Hummelsheim, H., Denzler, P., & Mauritz, K. H. (1995). Repetitive training of isolated movements improves the outcome of motor rehabilitation of the centrally paretic hand. *Journal of the Neurological Sciences*, *130*(1), 59–68. https://doi.org/10.1016/0022-510X(95)00003-K

Colombo, R., Pisano, F., Mazzone, A., Delconte, C., Micera, S., Carrozza, M. C., Dario, P., & Minuco, G. (2007). Design strategies to improve patient motivation during robot-aided rehabilitation. *Journal of NeuroEngineering and Rehabilitation*, *4*, 1–12. https://doi.org/10.1186/1743-0003-4-3

Daher, N. (2013). *Effects of elastic band orthosis (aider) on balance and gait in chronic stroke patients*. https://www.jptrs.org/journal/view.html?doi=10.14474/ptrs.2013.2.2.81

Damiano, D. L., Vaughan, C. L., & Abel, M. E. (1995). Muscle Respon Se T O Heavy Resistan Ce Exercise in Chi1 Dren With Spastic. *Developmental Medicine & Child Neurology*, *37*(3), 731–739.

Galimanis, A., Mono, M. L., Arnold, M., Nedeltchev, K., & Mattle, H. P. (2009). Lifestyle and stroke risk: A review. *Current Opinion in Neurology*, *22*(1), 60–68. https://doi.org/10.1097/WCO.0b013e32831fda0e

Imtiyaz, S., Veqar, Z., & Shareef, M. Y. (2014). To Compare the Effect of Vibration Therapy and Massage in Prevention of Delayed Onset Muscle Soreness (DOMS). *Journal of Clinical and Diagnostic Research*, *8*(1), 133–136. https://doi.org/10.7860/jcdr/2014/7294.3971

Jaber, R., Hewson, D. J., & Duchêne, J. (2012). Design and validation of the Grip-ball for measurement of hand grip strength. *Medical Engineering and Physics*, *34*(9), 1356–1361. https://doi.org/10.1016/j.medengphy.2012.07.001

Prasitsiriphon, O., & Pothisiri, W. (2018). Associations of Grip Strength and Change in Grip Strength With All-Cause and Cardiovascular Mortality in a European Older Population. *Clinical Medicine Insights: Cardiology*, *12*, 117954681877189. https://doi.org/10.1177/1179546818771894

Stroke Facts | *cdc.gov*. (2021). https://www.cdc.gov/stroke/facts.htm