Force Sensitive Resistor Feedback with Assistive Walker Device

Hazem Ali Jasim [1, a)]

[1] *Department of Biomedical Engineering, College of Engineering, Al-Nahrain University, Baghdad, Iraq*
Author Emails
a) st.hazim.a.jasim@ced.nahrainuniv.edu.iq

Hassanain Ali Lafta [1, b)]

[1] *Department of Biomedical Engineering, College of Engineering, Al-Nahrain University, Baghdad, Iraq*
Author Emails
b) hassanain.a.lafta@ced.nahrainuniv.edu.iq

ABSTRACT

Fear of falling might cause older people to limit their involvement in activities. When the user begins to utilize the walker, a force from the walker's handle is applied. Force feedback is a significant component for many of these walkers, providing the user and physician with valuable information that leads to an improved quality of life for the subject. A force-sensitive resistor (FSR) was used for this function in the recommended system. Depending on how much pressure is put on the sensing area, this FSR's resistance changes. FSR was attached to a resistor, and interfaced with the Atmega328p microcontroller to connect it to a microcontroller. The quantifiable data generated by the force sensor enables to determine pressure ranges (light touch, light squeeze, medium squeeze, strong squeeze). These readings were illustrated in the form of a graph for two groups, the first, Group A, which includes six young adults; and the second, Group B, which includes six elderly participants. The FSR was calibrated to acquire precise force values applied to the exposed surface. The final relationships established between the applied force and the voltage, resistance, and conductance values of FSR sensor.

Keywords: Embedded Microcontroller, FSR, Multisensors, Smart Walker.

INTRODUCTION

The human hand is quite amazing. It not only makes it possible for everyone to throw, grab, climb, and pick things up, but it may also be a sign [1] of good health. Estimating the force a person can generate with their understanding by measuring their hand-grip strength. The fall assessment tools usually involve a screening to measure general health with balance and walking, with the objective of improving safety and lowering the risk of falls. When the user begins to utilize the walker, a force from the walker's handle is applied [2]. Force feedback is a significant component for many of these walkers, providing the user and doctor with valuable information that leads to an improved quality of life for the subject. Medical devices using force feedback enable designers to produce novel items that set them apart from the competition [3]. One of the most important elements of a medical device is the feedback it provides to the person using the tool, whether it is a primary care physician or patient. A tiny, thin tactile force sensor was fitted on the walker's chassis to provide simple, easy-to-access data. Using hand-grip strength to assess how much power a person can generate with their comprehension abilities. The microcontroller communicates with the force sensor [4] to interpret the applied force for processing. Changes in force might indicate a neuromuscular condition or injury. The quantifiable data generated by the force sensor enables the user or a doctor to study and determine pressure ranges (light touch, light squeeze, medium squeeze, strong squeeze).

SUBJECTS

This study was conducted on twelve subjects volunteered (ten males and two females) who gave their written informed consents according to the approval obtained from the Research Ethics Committee of the Biomedical Engineering Department at Al-Nahrain University. The participants were divided according to their age into two groups. The first group, Group (A), included six young volunteers with a mean age of 29+2.34 years, a mean height of 171.33+7.94 cm, and a mean weight of 78.66+16.68 kg. On the other hand, the second group, Group (B), included six elderly volunteers with a mean age of 61+3.27 years, a mean height of 175+7.98 cm, and a mean weight of 84+17.24 kg. As demonstrated in Table 1, the body mass index (BMI) and the type of impairment for all volunteers was determined. None of the participants had cognitive impairment and were able to comprehend and respond to the questionnaire.

METHOD

An aluminium rollator walker provides stable support to the user as they walk properly [5]. It was devised for those with restricted mobility who need constant support and help moving. In order to preserve posture, increase walking comfort, and reduce the risk of falling, it was also suggested for the elderly. The use of a walker helps people who have trouble moving around and leaning into an upright position resume their normal activities. It enhances safety, support, and stability when moving. It has adjustable arms and grip handlebars that may be changed from 31 to 35 inches for a custom fit. The walker contains casters, which are smooth-rolling 5 inch wheels that allow it to be used indoors, around the home, and outside. The walker offers good stability and can support the user's weight whether they're standing or walking, because it has a wide support platform. Despite the sensors' recognition of obstructions, the wheel is prone to falling or imbalance, and the user is prone to tripping or tumbling. The walker's legs might even be caught in a ditch. Alternatively, the user may reach unstable terrain via an exterior path and a probable crash. Carrying the walker around an interior mat may cause it to stutter or become stuck. Low obstacle detectors on the walker are useless in these conditions. In order to resolve these concerns, another front wheel has been fitted in a method that does not compromise the walker's stability, as shown in FIGURE1. A variable resistance (potentiometer) was connected to the wheel. When the walker begins to move, and there is a hole or the ground is cracked, the value of the variable resistance changes, and

thus the current changes, and it sends an instruction to the microcontroller to notify the user. a force sensor may be thought of as a variable resistor with surface pressure-dependent terminal resistance. The terminal resistance will be lower at higher pressures and greater at lower pressures. The force sensor effectively transforms pressure into an inverted resistance value. For the convenience of usage, this resistance parameter was changed to a voltage parameter. A voltage divider circuit was used as a consequence.

Table 1 : Demographic Information of Volunteers.

Subjects	Gender	Age (Year)	Height (cm)	Weight (kg)	BMI $(\frac{kg}{m^2})$	Impairment Type
Group A (Adult Volunteers)						
Case 1	Male	27	172	88	29.7	No Imp.
Case 2	Male	27	177	91	29	No Imp.
Case 3	Male	29	172	72	24.3	Visual
Case 4	Male	28	178	70	22.1	No Imp.
Case 5	Male	33	173	98	32.7	No Imp.
Case 6	Female	27	156	53	21.8	No Imp.
Group B (Elder Volunteers)						
Case 7	Male	63	179	98	30.6	Physical
Case 8	Male	56	182	103	31.1	Physical
Case 9	Male	61	180	92	28.4	Physical
Case 10	Male	65	175	67	21.9	Visual
Case 11	Male	60	173	85	28.4	Physical
Case 12	Female	58	160	60	23.4	Visual

FIGURE1 : Modifying the Walker by Adding the Front Wheel and Potentiometer.

As depicted in FIGURE2, there will be two resistances in this resistive network. The first is constant resistance (R1), whereas the second is variable resistance (R2) (RV1). Vo is the output voltage and the voltage at the midpoint of the voltage divider circuit. The voltage across the variable resistance is also known as Vo (RV1). As a result, changing the resistance value of RV1 alters the output voltage Vo. With a voltage divider circuit, a change in resistance will result in a change in voltage.

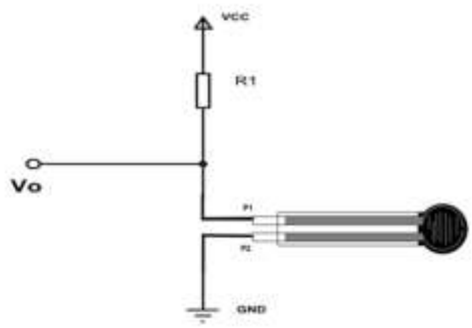

FIGURE2 : The Circuit of Force Sensor With Voltage Divider [6].

Here, R1 is a constant resistance, and the force sensor acts as a variable R. Vo is the output voltage and also the voltage across the force sensor.

Here,

Vo = VCC (Rx/ (R1+Rx)).

Rx : force sensor resistance. The terminal resistance will be quite high if no pressure is applied to the force sensor. This resistance is also present in the voltage divider circuit. Thus, across the sensor, the whole voltage VCC is measured. As a result, Vo will be high since the sensor's voltage is high. The terminal resistance of the sensor is significantly reduced when pressure is applied to its surface. The voltage drop across the sensor in the voltage divider circuit likewise reduces as a result of this reduction. So, Vo also perishes. The Vo continues to decline when pressure is raised. A Force Sensor Resistive (FSR) was attached to a resistor, and interfaced with the Atmega328p microcontroller [7] to connect it to a microcontroller. FIGURE3 and FIGURE4 demonstrate this interface and component placement with the circuit schematic. The microcontroller has an analog input function. The voltage (between 0V and Vcc) is converted into the ADC value, which is an integer value (between 0 and 1023), using the analog input pin.

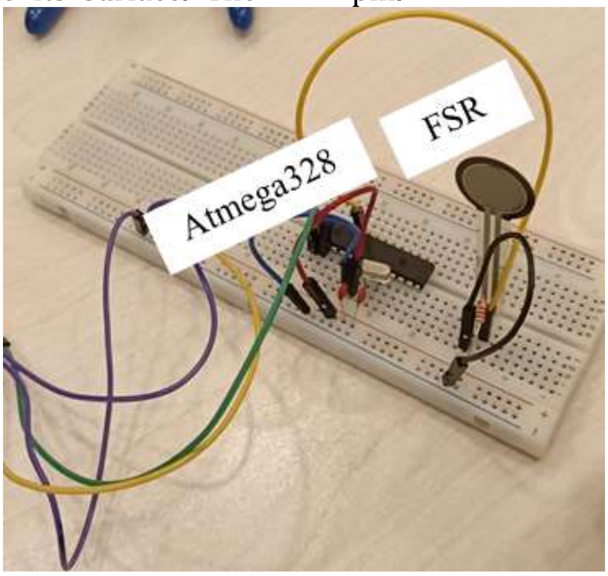

FIGURE3 : Interfacing Force Sensor Resistive(FSR) with Microcontroller.

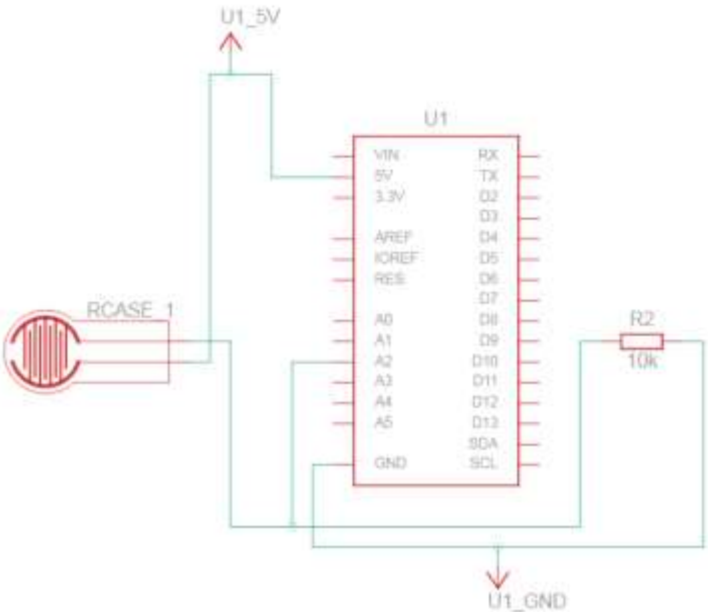

FIGURE4 : Circuit Diagram of Force Sensor Resistive

RESULTS AND DISCUSSION

A force sensor was attached to a fixed resistor in order to acquire measurements. Because its resistance changes when force is applied, the force sensor serves as a variable resistor. As a result, it was used a voltage divider setup. Every force-sensing resistor has two pins, one directly linked to VCC and the other connected to the GND. This location was directly coupled to an analog input of the microcontroller, which was utilized to measure this sensing resistor. For all volunteered individuals, readings were shown in the Table1 below in the form of ADC values taken from the FSR while touching it with varied pressure. The sensor readings were compared to set values to estimate the amount of pressure on the sensor.

Table 2: Pressure Scales Assessments.

Subjects	Sensor Readings g/mm^2	Pressure Scale
Case 1	857	Big Squeeze
Case 2	873	Big Squeeze
Case 3	833	Big Squeeze
Case 4	822	Big Squeeze
Case 5	909	Big Squeeze
Case 6	616	Medium Squeeze
Case 7	784	Medium Squeeze
Case 8	809	Big Squeeze
Case 9	795	Medium Squeeze
Case 10	763	Medium Squeeze
Case 11	774	Medium Squeeze
Case 12	761	Medium Squeeze

These readings were illustrated in the form of a graph for two groups, as illustrated in FIGURE5 and FIGURE6; the first, Group A, which includes six young adults; and the second, Group B, which includes six elderly participants, as well as the relationship of these assessments to the body mass index for each volunteer who participated in the research.

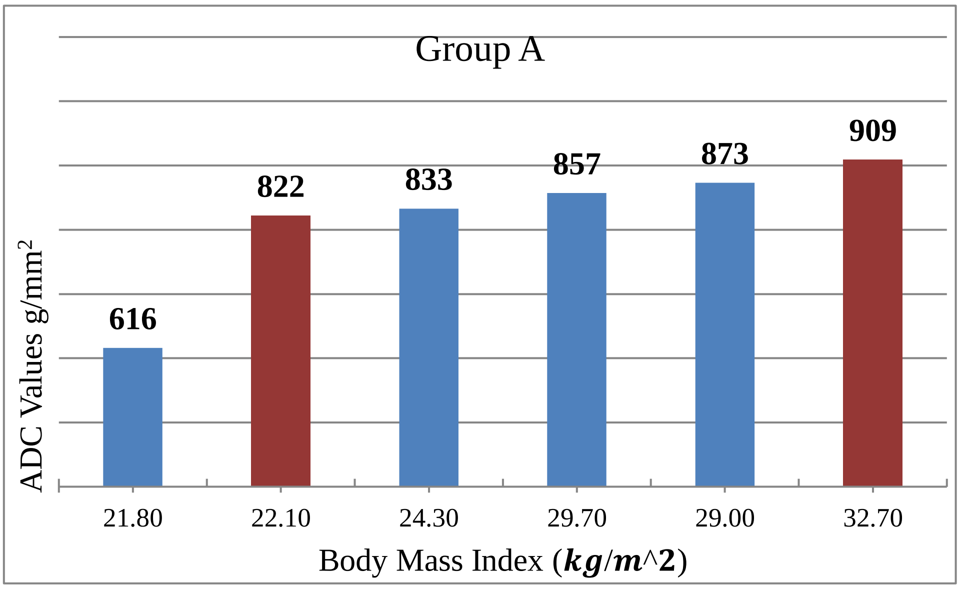

FIGURE6 : FSR Values Relating to BMI for Group A.

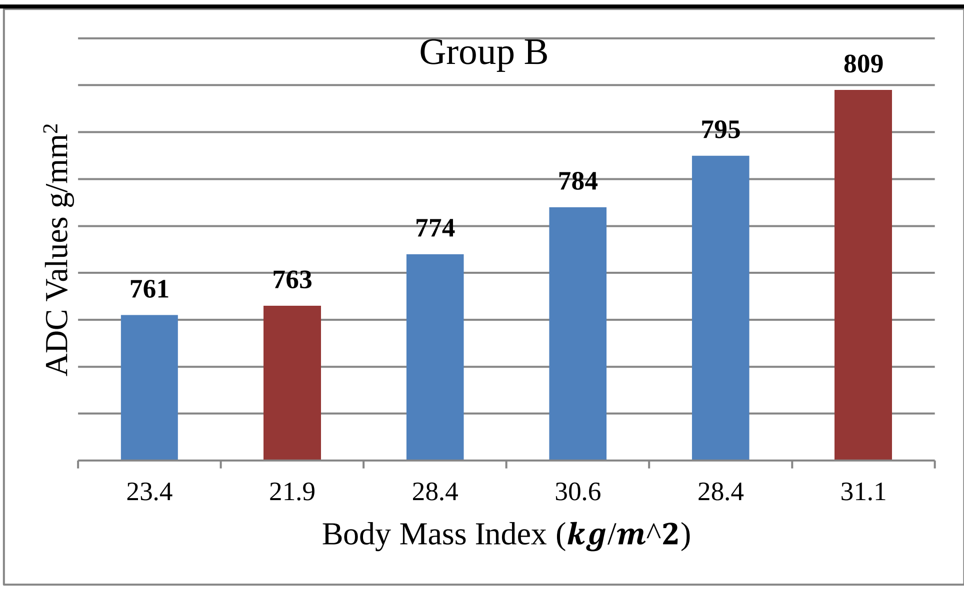

FIGURE7: FSR Values Relating to BMI for Group B.

Using the ADC values obtained from the FSR, the voltage reading, resistance, conductance, and force in newtons were calculated as well, according to the touch as listed in Table3. Voltage readings were printed on the serial monitor in millivolts. These readings were changed proportionately as the force applied was modified to the sensor.

Table 3: Values of FSR Sensor.

Subjects	Voltage (V)	FSR Res. (KΩ)	Conductance (ms)	Force (N)
Case 1	4.188	1.938	0.515	6
Case 2	4.266	1.72	0.581	7
Case 3	4.071	2.281	0.438	5
Case 4	4.017	2.447	0.408	5
Case 5	4.442	1.256	0.796	9
Case 6	3.01	6.611	0.151	1
Case 7	3.831	3.051	0.327	4
Case 8	3.954	2.645	0.378	4
Case 9	3.885	2.87	0.348	4
Case 10	3.729	3.408	0.293	3
Case 11	3.782	3.22	0.31	3
Case 12	3.719	3.444	0.29	3

The FSR was calibrated to acquire precise force values applied to the exposed surface. The final relationships established between the applied force and the voltage, resistance, and conductance values of FSR sensor are shown in FIGURES 8, 9, and 10.

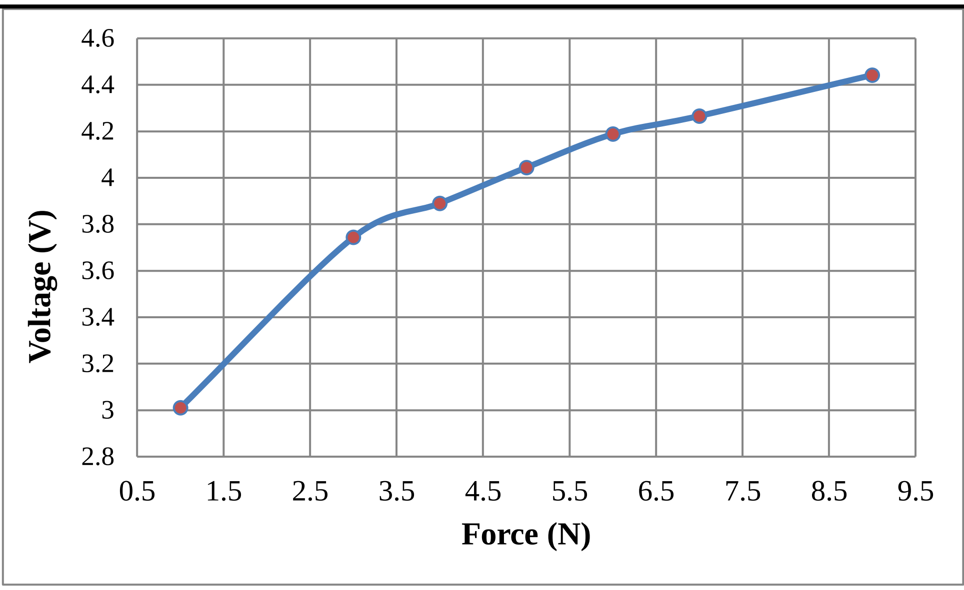

FIGURE8: Experimental Force-Voltage Curve.

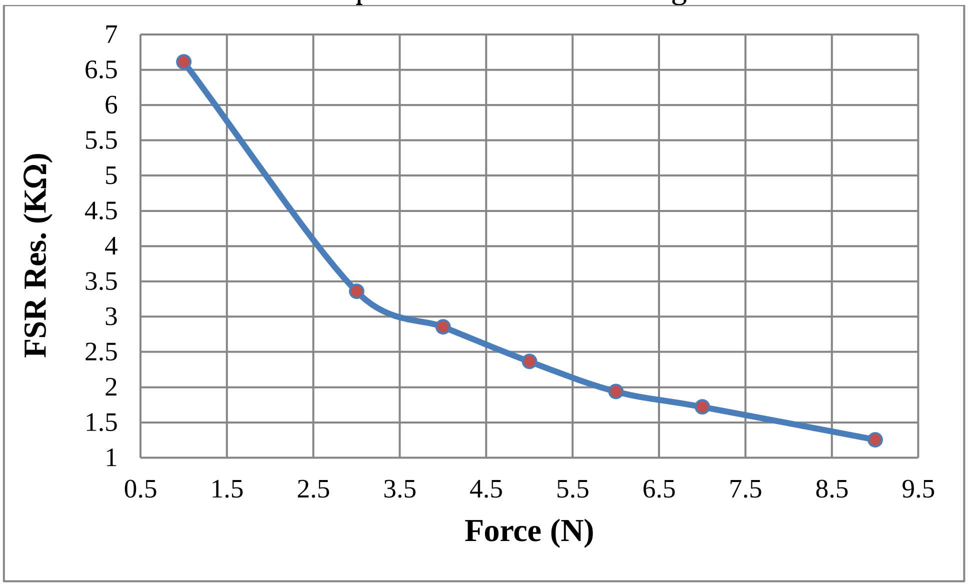

FIGURE9: Experimental Force-Resistance Curve.

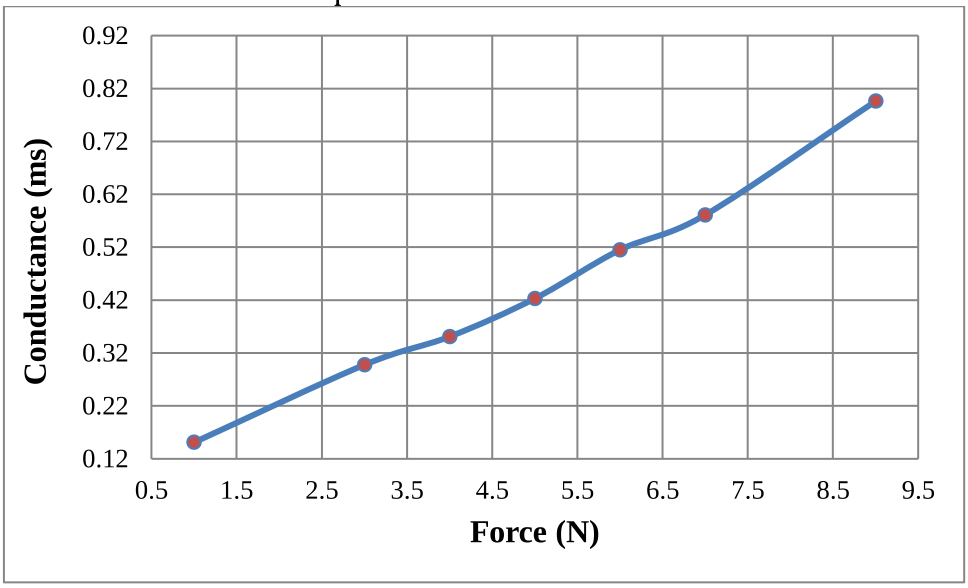

FIGURE10: Experimental Force-Conductance Curve

As illustrated in FIGURE11, the sensor has a large resistance in the range of several Mega ohms (MΩ), but when a force is applied, the resistance reduces significantly to the scale of Kilo-ohms (KΩ). When conductance (the inverse of resistance) is evaluated, the relationship between conductance and the sensor's defined force range is linear.

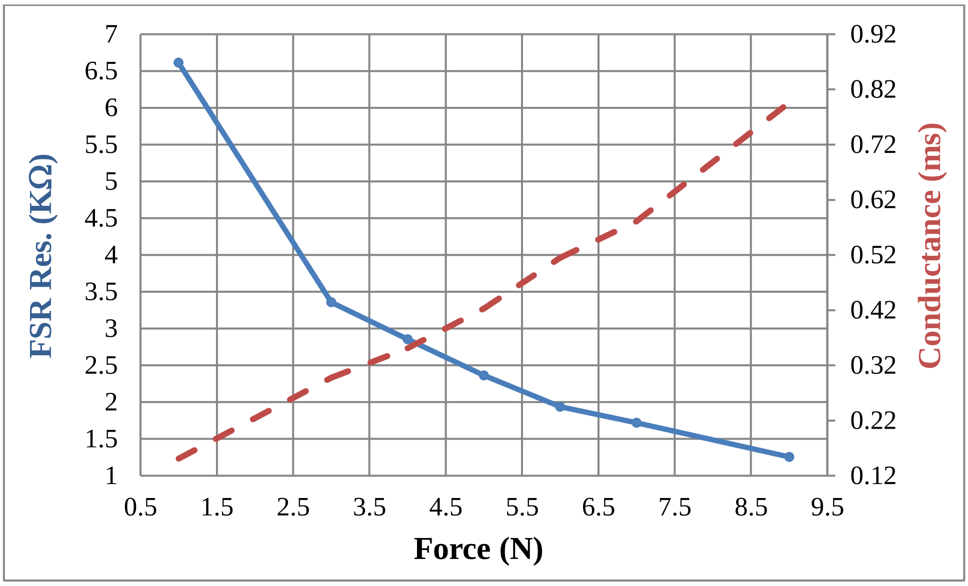

FIGURE11: Experimentally Measured Resistance vs Conductance vs Force for FSR.

CONCLUSION

An assisted walker should give assistance and safety when needed, and it should be a simple item to use. These assistive walkers should offer a variety of alternatives, whether mechanical, structural, or electronic, to provide physiotherapists with additional options for working with their patients and achieving higher quality and optimal rehabilitation results. Furthermore, when moving forward, the walker avoids obstacles. Such a concern must be addressed in terms of safety. This study showed that various types of sensors would achieve better precision in identifying impediments. The walker's overall performance is impacted by the sensor's precision and consistency, the type of user intervention utilized (such as acoustic or sound), the acceptability and efficiency of the user intervention, and the walker's reduced latency. The force sensor's measurable data allows the user or a clinician to examine and estimate pressure ranges (light touch, light squeeze, medium squeeze, strong squeeze). For many of these walkers, force feedback is an important component. Thus, the suggested walker not just supports and assist but also covers the scope of elderly care.

REFERENCES

[1]. Nikonovas, A., Harrison, A. J. L., Hoult, S., & Sammut, D. (2004). The application of force-sensing resistor sensors for measuring forces developed by the human hand. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, 218(2), 121-126.

[2]. Frizera, A., Ceres, R., Pons, J. L., Abellanas, A., & Raya, R. (2008, April). The smart walkers as geriatric assistive device. the simbiosis purpose. In Proceedings of the 6th International Conference of the International Society for Gerontechnology (Vol. 7, pp. 1-6).

[3]. Overtoom, E. M., Horeman, T., Jansen, F. W., Dankelman, J., & Schreuder, H. W. (2019). Haptic feedback, force feedback, and force-sensing in simulation training for laparoscopy: A systematic overview.

Journal of surgical education, 76(1), 242-261.

[4]. Sundar A, Deshmukh MK, Pilani B, Goa B, Das C, Deshmukh MK. Novel Applications of Force Sensing Resistors in Healthcare Technologies Wind Resource Assessment View project Chinmay Das BITS Pilani, K Birla Goa Novel Applications of Force Sensing Resistors in Healthcare Technologies. 2015; Available from:https://www.researchgate.net/publication/280655620

[5]. ZCPDP, (2019, September 19). ZCPDP Ultra lightweight folding rollator,Zimmer frame with wheels, walking frame with seat, non-slip,suitable for the elderly disabled Retrieved from https:// www.amazon.co.uk/ZCPDP-Lightweight-Rollator-Non-Slip-Suitable/dp/B07Y3B2566?ref_=d6k_applink_bb_marketplace.

[6]. Sadun, A. S., Jalani, J., & Sukor, J. A. (2016, July). Force Sensing Resistor (FSR): a brief overview and the low-cost sensor for active compliance control. In First International Workshop on Pattern Recognition (Vol. 10011, pp. 222-226). SPIE.

[7]. Nasir, S. Z. (2017, August 4). Introduction to atmega328 - the engineering projects. Google. Retrieved from https://www.google.com/amp/s/www.theengineeringprojects.com/2017/08/introduction-to-atmega328.html/%3famp=1.