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Designing a Flex Sensor-Based Posture Trainer

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Abstract: **There are several grave health hazards that can arise from poor posture. There are now two main categories of posture trainers on the market: electronic posture reminders and posture braces. Both of them struggle to develop appropriate posture. Flex sensors were utilized in this work as an option to evaluate posture specifically and generate effective posture training. This study aimed to develop a posture trainer that would assess and enhance sedentary posture. The researcher predicted that the posture trainer would lengthen the amount of time participants sat upright and reduce their average slouch score. The tool precisely measures the bend in the lower back using flex sensors and Arduino programming software (slouch value). At the start of the study, the subjects sat in a certain position to allow the researcher to assess a threshold of each subject's individual good and bad posture. For a week, the participants wore the gadget for 30 minutes every day. Their average slouch value and the number of minutes they spent in the "excellent posture threshold" were noted on day one. The device vibrated for the following five days to notify the participants to correct their posture and teach them to sit in the "good posture threshold" if they slouched into the "poor posture threshold." Data was again obtained on the last day and compared to the participant's initial day. Statistics showed that the researcher's findings were statistically significant and that their null hypothesis was wrong. After receiving vibration feedback, using the posture trainer increased the amount of time spent sitting upright and decreased the slouch value. The study also statistically investigates if the weight of posture trainer is affecting the posture of the user. Finally, the data collected from the posture trainer are used for classifying lower back pain from normal using a logistic regression. The model developed showed an accuracy of 0.9, precision of 0.83 and recall of 1.**

Keyword: Poor Posture, Lower back pain, Flex sensor, Logistic regression

I. INTRODUCTION

Poor posture affects many people all around the world, and its significance is rising as many people sit in a desk working at a computer for a growing number of hours every day. Poor posture not only displays a less confident, weaker appearance, but can also lead to a surplus of health risks, including back and neck pain, muscle fatigue, and breathing limitations (Brody, 2015). Currently, there are many different posture aids on the market, ranging from simple over- the-shoulder braces to expensive electronic devices. Although these aids are good reminders to keep good posture, they cannot successfully evaluate the wearer's natural spinal curves or measure the specific extent to which someone slouches. The purpose of this experiment is to design and create a device that will measure and improve someone's posture using flex sensors. The posture device will increase the amount of time the participants sit in a threshold of "good posture" and decrease their average measured slouch value.

Poor posture has many negative effects on the body. One of the most widespread issues people face today is back and neck pain, and poor posture plays a huge role as the cause. When people stay in one position for an extended period of time, their bodies are trained to adapt to that position, harming the body. Their muscles and tendons can fix to this stretched or compressed position and mold to it permanently. Bones and joints become stressed and often reshape, which can cause discomfort after time when standing up straight. If someone stays in a poor posture position for an extended period of time, their body adapts and struggles to fix this change if the person tries to improve their posture. A prevalent example of this is called "text neck," which is when someone is hunched over often with their neck looking down at something like a laptop screen, and over time they feel discomfort in their neck. The muscles in the person's neck and upper back have tightened, and that person struggles to return their neck in a comfortable, upright position (Brody, 2015).

Back and neck pain are only two of many harmful ways poor posture impacts the world today. Sitting and standing in a slumped position leads to muscle fatigue. When bodies are out of alignment, some muscles have to work harder than others, leading them to be overworked and tired. Improper posture can lead to breathing and digestion limitations. If one's body leans forward in a slouching position, their lung capacity can be reduced by up to 30%. This greatly reduces the amount of oxygen able to be carried to muscles and tissue around the body, which adds to muscle fatigue even more. When in a scrunched position, bodily organs in the abdomen are compressed, which impacts digestion and bowel function (Brody, 2015).

In any situation, posture is very important. Good posture portrays self-confidence, independence, and leadership. These are all necessary attributes, especially for situations like the workplace. Posture also greatly affects mood. A study was done at San Francisco University to build upon this theory. A professor had one group of students skip around campus with good posture all day, the other group was asked to walk with bad posture, slumped over. The results showed that the second group reported gloomier attitudes, whereas the first group reported feeling more vibrant and energized. This is a result of the behavior feedback phenomenon. This is the principle that going through certain motions can affect our emotions and our attitudes (Myers, 2014).

Good posture is especially important to today's youth. With the rise of heavy backpacks, it is imperative that children display good posture, considering the fact that they are still developing. If they walk around with poor posture all of their childhood, their bodies will form and grow in an altered way, making them more prone to osteoporosis and lifelong bad posture (Brody, 2015).

Many people think that standing and sitting up "straight" means having a flat back, but good posture actually involves 3 curves throughout the back. The first curve is called the cervical lordosis curve. This is the term for the curve in the neck, or cervical spine. This curve begins in a cavity at the back of the skull and extends to where the neck meets the beginning of the torso. It is a gentle curve inwards to the front of the body. The next curve is the thoracic kyphosis, which is the curve describing the arch of the mid back, or thoracic spine. It begins at the top of the shoulders and goes to the bottom of the ribcage. It curves outward away from the lungs. The last curve is the curve of the lower back; it is called lumbar lordosis. It begins at the base of the ribcage and travels through the base of the pelvis. It is seen curving inwards towards the body's organs. The natural combination of these three curves in the back creates the neutral spine. It is the best position for your spine to be completely supported (McGill, 2015).

II. LITERATURE REVIEW

A traditional way to improve posture has been to complete targeted exercises. Postural muscles are often worked on to improve posture. Postural muscles are the core stability muscles; they are found in your abdomen, pelvis, and back. Core muscles can become less efficient if someone has bad posture, and those muscles have to work harder to stabilize your body. The abdomen has four layers of muscles. The deepest layer is called transversus abdominis. It is the band around the lower stomach holding the torso together. The top layers of the muscles help the body to bend and twist ("Core muscles and…, 2018). Strengthening these muscles as well as the muscles around the shoulder blades, glutes, hamstrings, and neck help to improve posture (Gerstacker, 2015).

On the market today, there are three main types of posture correcting braces. The first is a cross-back elastic brace. It is easy to use, and it slips on over the shoulders and wraps around the upper back. The goal of the cross-back elastic brace is to support the shoulders to keep the chest in a good position with the thoracic curve present. Another variation is the molded upper back brace. It is similar to the cross-back brace, but it includes a stiff plastic or metal piece that sits vertical between the shoulder blades, giving firmer support. The third brace style on the market is the long-line back brace. It provides support from the base of the neck all the way down to the top of the hips. This brace is for consumers with serious low back pain and alignment issues. All three of these braces are supposed to train the back to consistently have good posture, but the problem with these braces is that, if worn too often, the muscles can start to rely on the brace for support. When the user stops using the brace, their body may fall easily back into a poor posture position without the added support (Anderson, 2019).

Another way to better posture is to use an electronic posture reminder. These reminders usually adhere to the skin on the upper back or clip to the front of someone’s shirt. They give gentle vibrations when they detect the user is in poor posture (Anderson, 2019). Two companies that have created the most widely used electronic posture reminders are Lumo Lift and Upright GO. Lumo Lift is worn on the chest near the collarbone. It uses accelerometers to detect changes in its positioned angle. It is not able to measure the curvature of the spine, only the lift in the chest. Upright GO attaches to the upper back with adhesives. It measures the positioning of the thoracic spine (Xia, 2018). These two devices let the user track their progress with an app.

Electronic posture reminders use the process of operant conditioning. Operant conditioning is a type of learning introduced by behavioral psychologist B.F. Skinner. It is the principle that behaviors followed with reinforcers will be strengthened, and they will diminish if followed by a punishment. Reinforcers can be positive or negative. Positive reinforcers are something desirable added to the situation; whereas, negative reinforcers are unwanted things removed from the situation. Punishments can also be positive or negative. Positive punishments are undesirable things introduced, and negative punishments are when something wanted is taken away. The purpose of operant conditioning is to either make a behavior reoccur or try to decrease its frequency (Meyers, 2014).

Electronic posture reminders use operant conditioning to try and decrease the amount of time someone spends in poor posture. They use positive punishment by adding an undesirable stimulus when the user is sitting with poor posture. This stimulus is often a vibration to alert the user to sit up with the proper spinal curves present. The use of the punishment is to train the person wearing the device to spend less time sitting slouched over. The basic formula consists of the user sitting in poor posture, getting a positive punishment to alert them, then the user should adapt over time by being trained to slouch less often.

To detect the actual curvature of a spine, flex sensors could be used in an electronic posture reminder instead of an accelerometer. Flex sensors are a thin strip, usually between one and five inches long. These sensors convert their bend radius into electrical resistance. The more they bend, the higher the resistance value. Flex sensors are made up of a combination of acetate, copper, and resistive material. These materials go into a heat shrinking tube to make up the main piece of the flex sensor. Flex sensors have many uses; they are used in robotics, virtual reality gloves, physical therapy devices, etc. (Jan, 2009).

For sensors, there are two main categories, analog and digital. Flex sensors are a type of analog sensor. Analog signals have an infinite number of possible signals within a range, they are continuous. Digital signals have a limited set of values; they give discrete data. Analog and digital signals can both be plotted on a graph, often represented by voltage changing over time. Time is on the x-axis, and voltage is on the y-axis. Analog graphs are smoother and continuous, whereas digital graphs are rough and not continuous (“Analog vs. Digital”).

Flex sensors have been used in posture and body position related devices before. One study used flex sensors to make a “smart garment.” In this garment, flex sensors were stitched on at different areas corresponding to joint positions like the wrist, elbow, and knee. The flex sensors were able to effectively monitor the angle at these joints (Abro, 2019). Another invention attaches to the back of a chair to detect posture. It uses contact sensors and flex sensors to detect posture, but the person must be sitting in that chair (Gokale, 2015). Another experiment was conducted that used flex sensors embedded into an elastic waistband wrap. The sensors were placed at 3 locations on the spine to determine which curve of the back can best be measured with flex sensors. The lumbar region, which is the lower back curve, was the curve most detectable with flex sensors (Xia, et al, 2018).

For flex sensors to do their job, they must be wired with a microcomputer, such as an Arduino. Arduino is a platform for building electronic projects. It encompasses physical, programmable circuit boards and software to run on a computer. Arduino lets users write and upload computer code to the physical board. Arduinos have many uses; they can be used with buttons, LEDs, motors, speakers, GPS, cameras, etc. They can be programmed with sensors to measure light, pressure, humidity, acceleration, temperature, etc. The Arduino boards contain pins, which is where wires can be connected to create circuits. The ground pin is used as a return path for the circuit, and the 5 volt or 3.3-volt pins supply power for the circuit to run. The analog pins read signals from analog sensors, such as a flex sensor. They convert the analog data into digital values. The digital pins are used for digital inputs and outputs, such as pushing a button or controlling a light. All boards have a reset button to restart the code on the Arduino board (“What is an Arduino?”).

Arduino boards come in many different models, so they can work in many different situations. The LilyPad Arduino is a collection of Arduinos designed by Leah Buechley. The LilyPads include electronic pieces designed specifically for e-textile projects. They have holes around their circumference that allow them to be sewn into clothing and other fabrics. They are circular and have a flat back to maximize comfort. Instead of requiring wires like other Arduinos, the LilyPad Arduinos require conductive thread to connect multiple pieces together. The conductive thread is often made with stainless steel fibers. LilyPads have been used to make articles of clothing light up, and they have even allowed electronic hands to move (LilyPad Basics: E-Sewing). These are just a few of the many great things LilyPad Arduinos have been able to do.

In order to function, all Arduinos need electricity, which is the flow of electric charge. Atoms are made up of protons, neutrons, and electrons; electrons are the charge carrier. The electrons on the outermost layer of the electron cloud, called valence electrons, are mainly where the electricity is generated. The valence electrons are pushed out of orbit by electrostatic force, moving from atom to atom, creating an electric current. Electrostatic force, or Coulomb’s law, states that charges of the same type repel, and that opposite charges attract. It also states that the amount of force atoms move with depend on how close together they are; the closer they are, the stronger their force (“What is Electricity?”)

In order for electricity to move, it needs a circuit to travel through. A circuit is a non- ending loop of conductive material that must be closed for electricity to flow. Insulating gaps can block the flow of electricity. Simple circuits can consist of a wire connected end to end.

However, circuits can be very complex, consisting of a mix of wires and many other components to control the flow of electricity. Circuits store energy in them, which is the ability of an object to do work on another object. The stored energy found in circuits is called electrical potential energy. The electrical potential energy is used to determine the electric potential of an electric field. The electrical potential energy and the electric potential build upon each other to help define how much energy, measured in volts, is stored in an electric field. Voltage is the difference in potential between 2 points in an electric field. It determines how much pushing force there is in an electric field. The energy in circuits must start somewhere, and batteries are commonly used as energy sources. Their negative end pushes the electric current through the circuit, converting chemical energy into electrical potential energy (“What is Electricity?”).

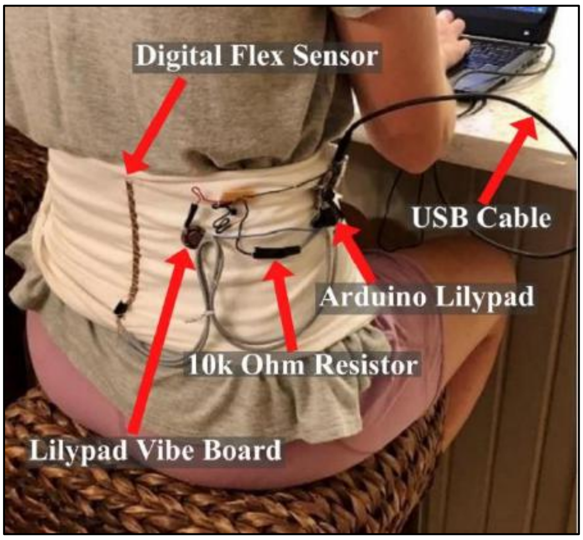
The purpose of this experiment is to create a device that will effectively measure and improve someone’s posture using flex sensors. The scientist hypothesizes that the posture device will affect the amount of time the participants sit in a threshold of “good posture” and each participants’ average slouch value. There are many different posture aids on the market right now, ranging from simple over-the-shoulder braces, to expensive electronic devices. Although these aids are good reminders to keep good posture, they cannot successfully evaluate the wearer’s natural spinal curves, which is an important aspect to maintaining good posture. This experiment will benefit those who suffer from bad posture. Poor posture is getting more widespread as more people sit in a desk working at a computer for hours on end every day. Poor posture not only displays a less confident, weaker appearance, but can also lead to a surplus of health risks, including back and neck pain, muscle fatigue, breathing limitations, and many other negative consequences (Brody, 2015).

III. THE PROTOTYPE

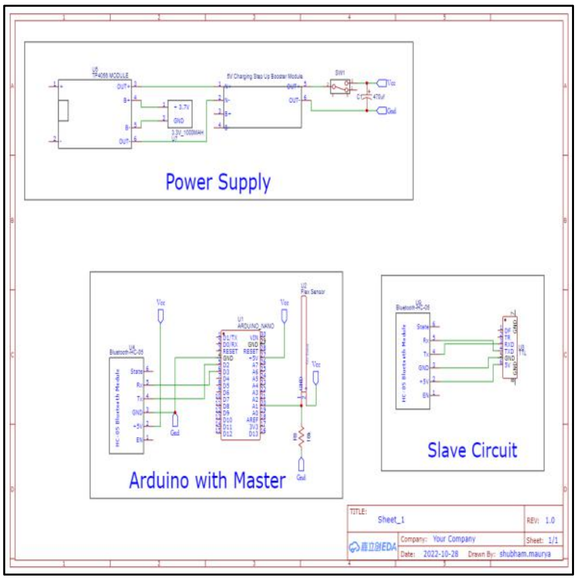
A. Experimental Design

1. Design and create a posture device to measure curvature when strapped around someone's lower back.
2. Using Arduino software, write a code that instructs an Arduino Lilypad to measure the curve in the spine using flex sensors and record values every 5 seconds for 30 minutes.
3. Write a second code that causes the device to calibrate to the initial bend in a participant's lower back and vibrates if the participant slouches past the initial threshold.

(a)



(b)



(c)

Figure 1: The (a) labelled diagram, (b) Author with the posture trainer and (c) Circuit diagram of the posture trainer

B. Procedure

1. Participants strap the posture device on around their lower back using the Velcro straps.
2. Connect posture device to a computer using a Micro-USB cable.
3. Tell participants to sit with a straight, flat back.
4. After 5 seconds, the posture device will calibrate to this position. The participants then sit as they normally would.
5. Upload the first code to the device. Participants sit wearing the posture device for 30 minutes.
6. Copy the slouch measurements recorded from the Arduino serial monitor into an excel sheet to find the average sensor value measuring slouch and the time spent sitting in the "good posture" threshold (this threshold is any value less than the initial sensor value from step 3-4 and represents an inward curve in the lower back).
7. For the next five days, repeat steps 1-4, but upload the second code to the device. Have participants wear posture trainer for 30 minutes each day.
8. This code will cause the device to vibrate if the participant slouches past the initial calibration value. Tell participants their goal is to have the device vibrate as little as possible while they are sitting.
9. On the seventh day, repeat steps 1-6. On this day, there is no vibration feedback, just a collection

of posture measurements to see how wearing the posture device with the vibration feedback has affected a participant's natural posture.

10. Repeat the procedure for each participant.
11. Compare minutes spent in the "good posture" threshold from the first day to the last, determine each participants' average slouch value before and after their trial, and perform proper statistical analysis.

C. Experimentation

The purpose of this experiment is to design and create a posture trainer that will effectively measure and improve someone's posture.

Research Hypothesis

Two research hypothesis are formulated for the study. The first is as follows:

Null Hypothesis: The posture trainer will not affect the participants' posture.

Alternate Hypothesis: The posture trainer will affect the participants' time sitting with good posture and their average slouch value.

Independent variable: Wearing the posture device with vibration feedback

Dependent variable: Minutes participants spent sitting in "good posture" threshold (inward curve in lower back); each participant's average measured slouch value.

Control: Data collected from minutes spent in "good posture" threshold and average slouch value from the participants' first day of using the posture device before their trial with vibration feedback.

The second hypothesis is as follows:

Null Hypothesis: The weight of the posture trainer will affect the participants' posture.

Alternate hypothesis: The weight of the posture trainer will not affect the participants' posture.

D. Results

The purpose of the experiment was to determine the effect of the posture trainer on the minutes each participant sat in the good posture threshold. The scientist compared the number of minutes that each participant sat in the good posture threshold before and after their trial wearing the posture trainer with vibration feedback.

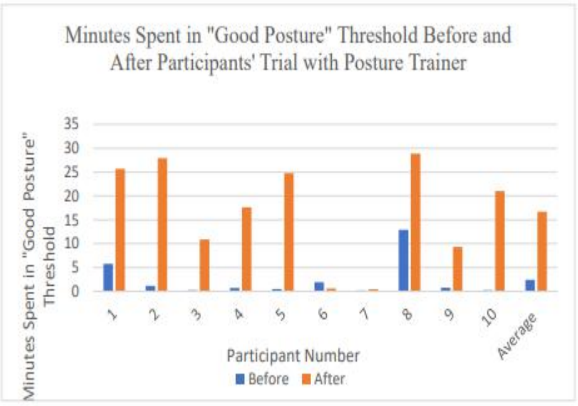


Figure 2: Bar graph showing the Good Posture threshold

From figure 2, it is observed that each participant sat with good posture for longer after their trial with the posture trainer except for participant 6. The average minutes of good posture for all of the participants combined increased after the trial compared to before the trial.

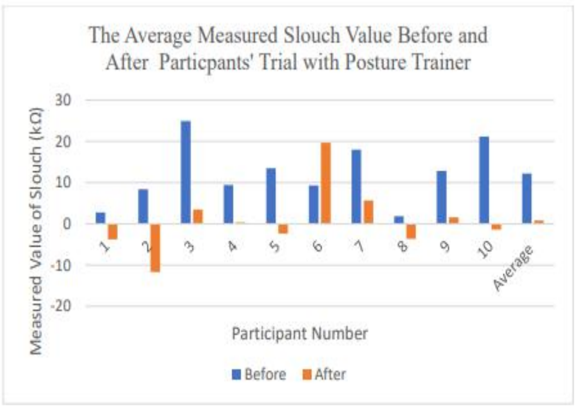


Figure 3: Bar graph showing the slouch value

The purpose of this experiment was to determine the effect of the posture trainer with vibration feedback on each participant's average measured slouch. The scientist compared the relationship of the average measured slouch before and after each participant's trial with the posture trainer. Positive values represent the participant sitting in the "bad posture" threshold, and negative values represent "good posture". From figure 3, it is observed that for each participant except participant 6, the average slouch value was lower after the trial with the posture trainer than before. The average slouch across all the participants was less after the trial with the posture trainer.

The purpose of the second hypothesis was to determine the weight of the posture trainer is having negligible effect on the posture of the participant. The time taken for the 10 participants in sitting in a position with and without posture trainer is noted and a one way analysis of variance is conducted.

E. Analysis

TABLE 1: STATISTICAL TABLE FOR SLOUCH VALUE

The Effect of Wearing the Posture Trainer on Participant's Average Measured Slouch Value		
Descriptive Information	***Before Trial***	***After Trial***
Mean	12.2	0.788
Median	11.2	-0.509
Range	23.1	31.4
Variance	55.9549	66.7178
Standard Deviation	7.4803	8.1682
Before vs. After: t(9): t=3.6934, p=0.002486, therefore reject null		

The purpose of this experiment was to test the effect of the scientist's posture trainer on each participants' measured value of slouch. Before wearing the posture device with vibration feedback, the mean slouch value was 12.2 kΩ. After the trial, the mean reduced to 0.788 kΩ. The median value decreased from 11.2 kΩ before to -0.509 kΩ after. The variance for the pre-trial was 55.9549, which was slightly less than the post-trial variance, which was 66.7178. The standard deviation on the first day of data collection was 7.4803, and on the last day it was 8.1682. When comparing the average slouch value before and after the trial, the p-value was 0.002486; therefore, the scientist rejected the null hypothesis.

TABLE 2: STATISTICAL TABLE FOR GOOD POSTURE THRESHOLD

The Effect of Wearing the Posture Trainer on Minutes Participants Sat in "Good Posture" Threshold		
Descriptive Information	***Before***	***After***
Mean	2.43	16.71
Median	0.71	19.3
Range	12.73	28.48
Variance	16.31	116.96
Standard Deviation	4.0383	10.814
Before vs. After: t(9): t=5.0518, p=0.000344, therefore reject null		

The purpose of this experiment was to determine the effect of the scientist's posture trainer on the time each participant sat in the "good posture" threshold. Before wearing the device with vibration feedback, the mean value was 2.43 min; after the trial, it considerably increased to 16.71 min. The median value before was 0.71 min., which was much smaller than the median value after, 19.3 min. The variance for the pre-trial was 16.31, and it was 116.96 for the post-trial. For the first day, the standard deviation was 4.0383, and on the last day it was 10.814. When comparing the minutes spent in good posture before vs. after the trial with vibration feedback, the p-value was 0.000344, so the scientist rejected the null hypothesis.

TABLE 3: ANOVA TABLE FOR SECOND HYPOTHESIS

The Weight of Posture Trainer Affecting the Participants' posture		
Descriptive Information	***With posture trainer***	***Without posture trainer***
Mean	656.5	648.9
Median	657.5	655.5
Range	76	67
Variance	487.05	442.29
Standard Deviation	22.06920932	21.03069186
With vs. Without, p=0.0212, therefore reject null		

From table 3, it is observed that with posture trainer the participants are able to sit in a particular position for 656.5 seconds whereas the value reduced to 648.9 seconds without the posture trainer. The p-value for the experimentation showed about 0.0212, thereby the hull hypothesis could be rejected and it can be statistically confirmed that the weight of the posture trainer is not affecting the posture of the participants.

IV. MODELLING TO CLASSIFY LOWER BACK PAIN

Poor posture negatively affects many people all around the world. This issue’s importance continues to rise as more people sit in a desk working at a computer for hours on end every day. Poor posture not only displays a less confident, weaker appearance, but can also lead to a surplus of health risks, including back and neck pain, muscle fatigue, and breathing limitations (Brody, 2015). There are many different posture aids on the market right now ranging from simple over-the-shoulder braces to expensive electronic devices. Although these aids are good reminders to keep good posture, they cannot successfully measure the wearer’s natural spinal curves, which is an important aspect to maintaining good posture.

A. Data Collection

The posture trainer is distributed to 100 different participants where some are having lower back pain and others do not. The participants are working professionals mostly having a sitting job. They are asked to wear the posture trainer during their work for 30 days. The data collected by the posture trainer includes the pelvic tilt, duration by the participant in the wrong posture, time he is working in the sitting job and if the person has lower back pain or not.

The angle formed by a line from the middle of the sacral endplate to the centers of the bifemoral heads and the vertical axis is known as the pelvic tilt (Benzon and Nader, 2008). The average ranges of anterior and posterior pelvic tilting are 13.0 ± 4.9°, and 8.9 ± 4.5°, respectively (Takaki et. al., 2016). The data collected for the pelvic tilt is the maximum angle recorded by the by the flex sensor for more than 10 second of duration at a stretch. The 10 second is duration is set due to the fact that a person does not take more than 10 second to change its position and during that time the flex sensor can record highest change in pelvic tilt angle. The second column of data recorded by the posture trainer is the time duration the participant is sitting at the highest recorded pelvic tilt angle. The third column of data records the time in years for which the participant is in that desk job. Finally, the fourth column records the class that is if a participant has lower back pain or not.

B. Logistic Regression

This type of statistical model, often known as a logit model, is extensively used in classification and predictive analytics. Logistic regression determines the probability that an event, such as voting or not voting, will occur based on a collection of independent factors. Since the outcome is a probability, the range of the dependent variable is 0 to 1. The odds, or likelihood of success divided by probability of failure, are converted using the logit formula in logistic regression. This logistic function, often known as the log odds or the natural logarithm of odds.

C. Classification

The collected dataset is stored in a comma separated values (CSV) file and loaded in the Python 3.11 using the Pandas library. The dataset is divided in the ratio of 80:20 where the 80% of the dataset are used for training and the remaining 20% of the data are used for testing. The accuracy, precision and recall value of the developed model is shown in table 4.

TABLE 4: ACCURACY, PRECISION AND RECALL VALUE OF THE DEVELOPED MODEL

Accuracy	**Precision**	**Recall**
Accuracy: 0.9	0.83	1.0

The heatmap for the confusion matrix and Receiver Operating Characteristic (ROC) curve for the model developed in shown in figure 4 and 5 respectively.

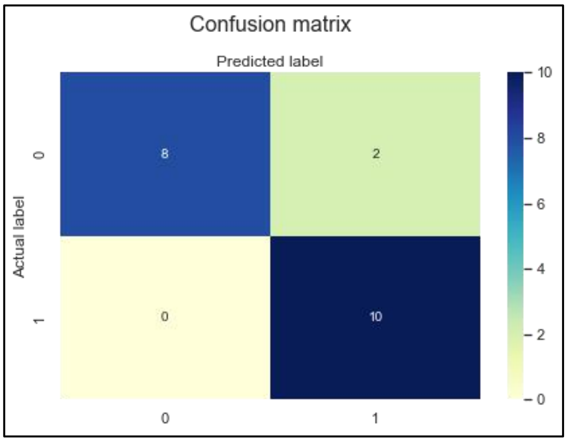


Figure 4: Heatmap of the confusion matrix

20% of the dataset are used for testing the data which is 20 dataset. Out of the 20 dataset, 10 dataset belongs to lower back pain class and remaining 10 belong to normal class. From figure 4, it is observed that for 8 instances out of 10, the model correctly classified the lower back pain class and 10 instances out of 10, the model correctly classified the normal class. However, the model falsely classified 2 instances of lower back pain class as normal class. Figure 5 shows the ROC curve of the developed model. The Area under the ROC curve is 0.99 which implies that the model is 99% capable of distinguishing between the two classes.

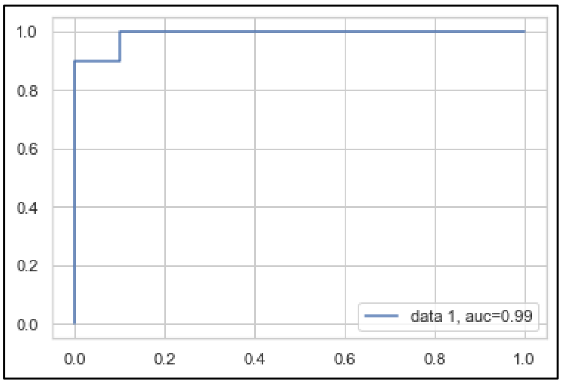


Figure 5: ROC curve

V. DISCUSSION

An uncontrollable factor of this experiment was the participant's bias. They were not informed of the exact objective of the experiment, but it was probable that they may have been able to figure out a broad purpose. If they were to suspect the scientist was measuring their posture, they could have tried to sit a certain way on purpose to improve their results, damaging the validity of the data. Also, the boundary of the "good posture" threshold was subjectively determined by each participant based on what they thought was good posture. This specific position likely varied from participant to participant, so some may have sat with what they thought was good posture, but to others it may have been bad posture. This could have affected how much each participant improved after their trial.

An experimental error occurred during the first participant's trial with the posture trainer. The scientist's computer shut down while data was being collected, and it was deleted. Participant 1 had to sit for an extra 30 minutes in 1 day. This could have altered their individual results, affecting the overall data. Another error that occurred was the placement of the posture device with vibration feedback. Twice, the scientist strapped it too low on one participant's back. When they visibly slouched, the device did not vibrate, so the scientist had to readjust the device on their back. When this happened, a few minutes of the vibration feedback could have been lost to the faulty placement, possibly slightly altering the participants' end results. If the project were repeated, the scientist would vigilantly watch their computer to ensure it did not shut down mid-experimenting and lose any data. They would also take a few extra minutes before the participants used the posture trainer each time to confirm with certainty that the device is in the correct position.

In a similar experiment to further evaluate the effects of the posture trainer, the scientist would use a much larger sample population. The participants would all wear the posture device with vibration feedback for 30 minutes for 3-4 weeks. On day 1 and then after each week, the scientist will measure the average slouch value for each participant and the minutes they spend in the good posture threshold. The larger sample population and the longer experimentation time would produce stronger and more applicable results. The scientist would also create an improved posture trainer prototype that is smaller and more comfortable.

The posture trainer is used to detect the lower back pain. It is distributed to 100 participants who are normal and also suffering from lower back pain. The data collected by the posture trainer includes the pelvic tilt, maximum duration for which the participant is in that posture, the time in years for which the participant is working in that place. Then logistic regression is used to classify the two classes. The developed model showed an accuracy of 0.9, precision of 0.83 and recall of 1.0. The area under the ROC curve showed 0.99. From the overall discussion, it can be concluded that the posture trainer along with the logistic regression is capable of predicting and categorizing the lower back pain from normal.

VI. CONCLUSION

The purpose of this experiment was to create a posture trainer and determine its effect on sedentary posture. The findings from this experiment support that wearing the device correlates with improved posture. After the participants wore the posture trainer with vibration feedback for a week, on average they sat in the "good posture" threshold for a longer period of time than their first day wearing the device. They also had a lower average slouch value at the end of their trial. The scientist rejected the null hypothesis, so the posture trainer had a significant effect on the participant's time in good posture and their measured slouch.

A. Application to Society

The posture trainer that the scientist engineered may be able to help improve people's posture more efficiently than competing methods by specifically measuring the arch in the lower back to produce efficient posture training. This would be especially beneficial to those who sit at a desk for school or work for many hours a week and suffer from bad posture's negative effects. Poor posture can lead to back and neck pain, breathing limitations, a weaker appearance, and many other risks. If people wear this posture trainer design, they will start to naturally support their muscles better with correct posture and may be able to limit these negative effects on their body. The scientist believes this device could be very beneficial to many people that suffer from bad posture

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