Ergon-Novel Ergonomics for Neck Discomfort - An Easy & Affordable Solution[1]

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ABSTRACT

In today's world of advancements, nearly 84% of people face neck and back pain at some point in their lives, of which 90% is attributed to bad posture. This leads to cervical and lumbar spondylosis, kyphoscoliosis and paraspinal muscle spasm. Poor posture can also lead to more pain along with the degradation of the tissues surrounding our joints. To tackle this health issue, we have developed a novel solution in the form of an AI-enabled smart wearable device that enables one to correct their posture at any time of the day by alerting them about their incorrect posture through haptic vibrations. "ERGON" uses flex sensors, a Bluetooth HC-O5 module, an Arduino Nano and a vibrator module to create a life style improvement habit making device. The device will be inserted into a cotton sleeve which will be strapped onto the body with the sensor on the spinal region. "ERGON" is affordable, almost one-third of the cost of similar devices sold in market, light weight and small that can be worn comfortably under clothes. It is worthwhile to mention that ERGON has undergone multiple rounds of prototype refinement where the initial version using infrared sensors to the improved current version of ERGON which uses flex sensors, which changes its readings on being bent. The market viability and customer acceptance of the product was corroborated through need identification surveys where 71% of people replied that they face back and neck problems in their day-to-day life, and that this product will be highly beneficial for them. Additionally, our application allows the user to go through weekly posture progress reports, notifications and free training links and videos helping them gain good postural integrity.

Keywords: Neck pain; Sensors; Medical device; Artificial intelligence; Posture

INTRODUCTION

Now a day's people use mobile phone for long hours and get the neck pain very often. Most of the parents and children hooked up on mobile phones for long time be it in online classes, surfing the phone for news and social media interactions. This constant use of phones for a long time leads to abnormal neck posture leading to pain and discomfort and ultimately cervical spondylosis and bad spinal alignment further leading to pain. According to a study in 2022, people spend a daily average of 3 hours and 15 minutes with mobile phones, checking their phones at an average of 58 times every single day. The result? Headaches, neck spasms, and creaky shoulder joints, caused by holding one's neck still, for long periods. When you're working on a computer or looking down at your phone, the muscles in the back of the neck have to contract to hold your head up. The more you look down, the more the muscles have to work to keep your head up. These muscles can get overly tired and sore from looking down at our smartphones, working on computers, or looking down at our tablets all day. That's what we call **"tech neck."**

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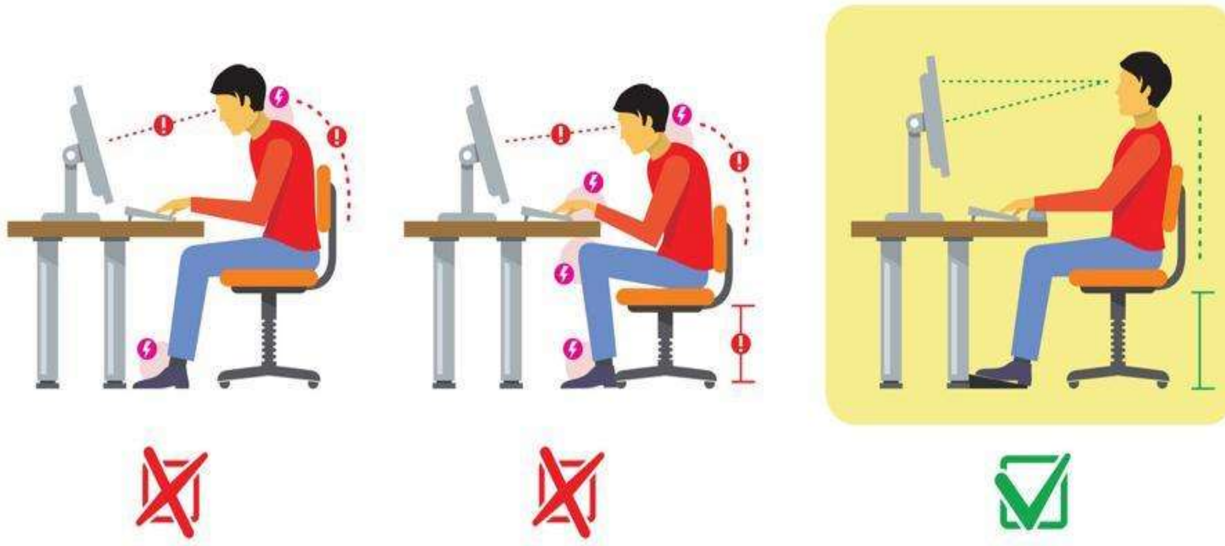


Figure 1: Incorrect vs Correct Seating Posture

Problem Statement

When you're working on a computer or looking down at your phone, the neck muscles have to contract to hold up the head. The more you look down, the more the muscles have to work to keep your head up. These muscles can get overly tired and sore from looking down constantly leading to abnormal neck posture resulting in pain and discomfort and ultimately cervical spondylosis and bad spinal alignment. Novel ergonomics device here is an attempt to reduce strain, fatigue, and injuries by improving posture in long working hours. The goal is to achieve comfortable, and relaxed posture which can prevent landing up on permanent and irreversible damage to joints and muscles.

A large number of the working population have office jobs that require long hours of sitting, and students spend most of their time on laptops devices leaning forward and these habits lay significant strain on the neck and back. We wanted to access the magnitude of problem and health issues arising from forced work standards and remedies there upon. The device that we have formulated was based on the idea to reduce chronic pain that results from poor posture which ultimately will help to reduce the stress and pressure on the spine and prevent musculoskeletal disorders and structural deformity of spine.

Benefit to Society

- Reduce chronic pain that results from poor posture.
- Decrease the stress and pressure on the spine.
- Prevent musculoskeletal disorders and structural deformity of spine.
- Train users to maintain good back posture until it becomes a daily routine.

Objectives

Prolonged static posture leads to muscle spasm and subsequently to various ailments such as cervical and lumbar spondylosis, kyphoscoliosis and bone demineralization and ultimately leads to sufferings and pain. If a device is made which can alert the user to correct their posture, then certainly such ailments can be avoided. An application that uses the recorded data can also give the real time idea to the user about his postural status and solutions to improve spinal health.

There is wide spread acceptance now that spine related disorders are caused by sedentary life style and prolonged use of systems or gadgets [1, 2]. This became more evident during COVID period when people were subjected to work from home, students gluing to mobile phones and TV or computer system for long durations leading to neck and back discomfort and some landing up in reversible or irreversible spinal diseases. Sushilowati et al. in one of the studies reported Complaints of musculoskeletal origins were recounted by 70.5% of the total respondents, with a majority of the reports said to affect the neck (86.4%), lower back (75.9%), and right and left shoulders (76.2%) in a questionnaire based studies on a population based sample size of 51,472 people [3]. Complaints about the neck were the most discomfort reported by the said community while operating electronic gadgets, as a consequence of the neck posture assumed while staring at screens or monitors during the use of these devices. Despite widespread acceptance that work related spinal disorders and back pain can be prevented by fixing the posture through ergonomic solutions such as adjustable chairs or other modifications applied to the workstation, there exists very few reliable and accurate methods of continuously monitoring posture in any environment for postural modification. Recently, wearable sensing technologies targeting posture monitoring have been attracting increasing attention, making postural monitoring not restricted to a single location, thus enabling real time measurements and monitoring of posture [4].

Different solutions for monitoring postural activity are reported in the literature, researchers working on such technologies are attempting to integrate wearable computing devices and sensors into textiles for data collection [5]. However, due to the novelty of this field and unavailability of datasets and information on sensor development done by previous researches, most effort is still directed towards the development of the measuring method and accuracy. Thus, the integration of the sensors into a complete system as well as aspects like comfort, aesthetics and wearability are undergoing a process of evolution [5,6,7,8].There has been multiple previous work done for the same we have tried out[9-11].

The major cause of health issues secondary to prolonged use of smart phones and gadgets are because of neck position due to prolonged declination. Kennith H reported in one of the studies while the standard weight applied on the spinal cord is normally 10 - 12 lbs., when the Cervical Spine is collinear with the spinal cord it rises steeply to 60 lbs., when the user's neck is declined at 60 degrees from the body's longitudinal axis [12]. Author used Accelerometer device to ascertain the bend in neck and resulting changes in the pressure [13].

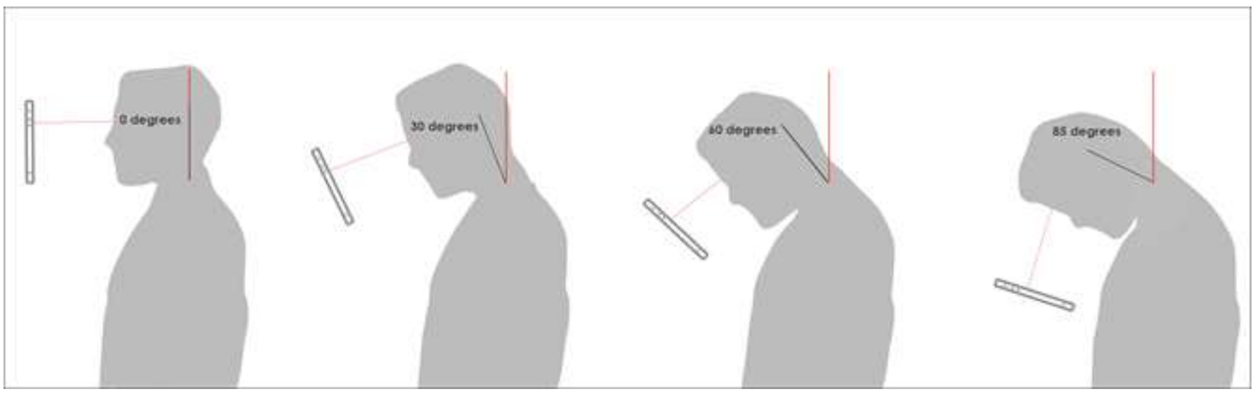


Figure 2: Declination to view smartphone screen

Sensor	Degree	X-axis	Y-axis	Z-axis
Accelerometer	0	0.11	9.75	0.51
	30	0.17	8.34	5.20
	60	0.28	4.84	8.61
	85	0.21	1.81	9.66

Table 1: MPU 6050 Accelerometer data from bending of spinal column

MATERIALS AND METHODS

To achieve the desired goal, we started working on this project with sensor device with use of infrared sensors and in due process revised different versions till we come up version 2.2.

Version 1.0 (Posture Correction Sensor Device)

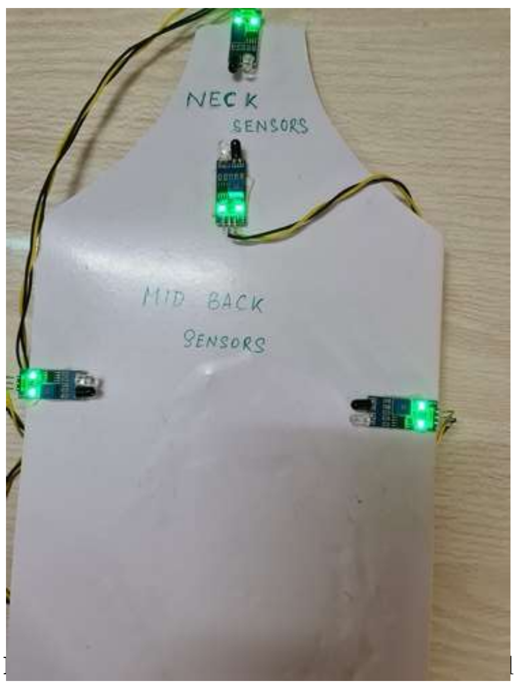
Positioning of Sensors -

We have used 4 infrared sensors which basically react when some object blocks the path of light -

- ONE infrared sensor in the neck region.
- ONE in the Centre of the back.
- TWO in middle back area.

Working Principles and Mechanism -

When the body is completely in a comfortable posture or if the back and brain stem is straight then the IR sensors are aligned in a line. In that case one IR sensor blocks the path of the other sensor and the buzzer snoozes. But in case of compression the sensors are not aligned and thus the buzzer turns on and a sound comes indicating that the posture is not correct and thus we change our posture.



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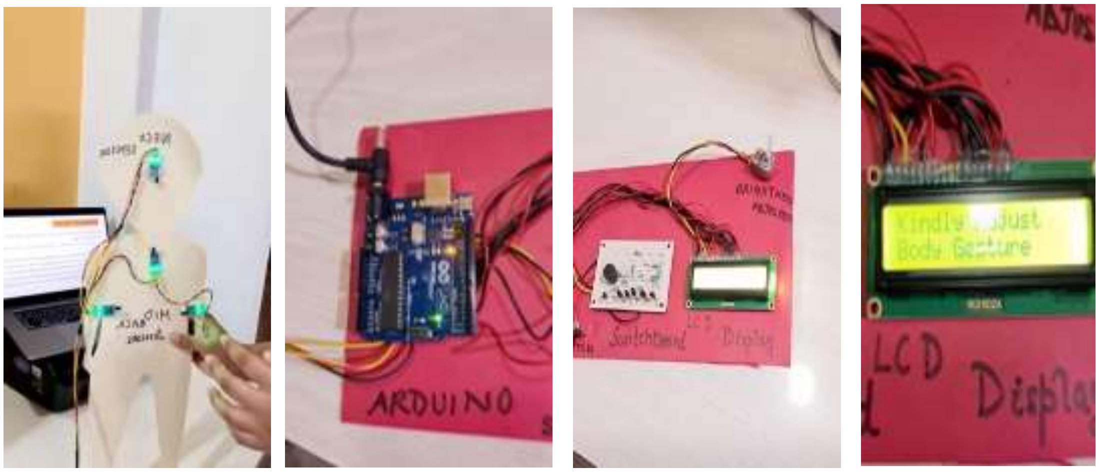

Figure 4: Complete setup of Posture Correction Device

The presentation project was prepared with these components. We came across various drawbacks, which helped us to think how we can make a good, innovative, economical, and compact and a user friendly posture correction device.

Drawbacks of first experiment -

Impractical Design –

i) In the original prototype, we used 4 Infrared Sensors which increased the size of the entire product. Along with that, the original prototype was not user friendly, since it had a huge circuit and very large components. This would cause discomfort to the user since the components may be protruding.

ii) Also the positioning and alignment of the product to make it an easily wearable device would be difficult and would need the user to wear it with such great difficulty every time they use it.

Inaccuracy in Readings –

i) Other than that, the infrared sensors worked on a principle of proper alignment of the spine, which would result in false positives, since the spine of every individual is not the same and it is never perfectly straight (there is a natural spinal arc in the human body) and this would thus lower the effectiveness of the product.

ii) During testing, we have noticed that the measured angle, although initially accurate, drifts by a small value with time. Therefore, after some time as the user continues to sit in an upright position, the system may detect a false positive.

iii) On testing we identified another issue, which was that the readings changed in the presence of external heat sources or any source resulting in the change in temperature of the surroundings, e.g., in presence of sunlight.

Version 2.0

Selection of New sensors and Working mechanism

- The previous model (i.e., Version 1.0) was discarded because of the above-mentioned drawbacks.
- Ergon was thus enhanced with the use of a new mechanism, one which used flex sensors.

- The flex sensor proved to be the most appropriate for sensing the neck position. The flex sensor acts as a flexible potentiometer, whose resistance increases as the bend angle increases. Flex sensor performed reliably under bending and returned to a stable level when straight. A variety of positions for the sensor around the neck, chin, and side of face were explored with the neck being the most practical in terms of data collection and ease of wear.
- This led to the selection of flex sensors for the new model.

Positioning of Sensors

Sensors were placed from T1 to T4 vertebral level and the T1 is calculated from C7 vertebral prominence as anatomical landmark which is nuchal protuberance (the protruding bony structure at nape of the neck level).

Integration of Circuit

The newly constructed circuit now consisted of a Flex Sensor, a Bluetooth HC-05 module, an Arduino UNO, and a Mobile Vibrator module.

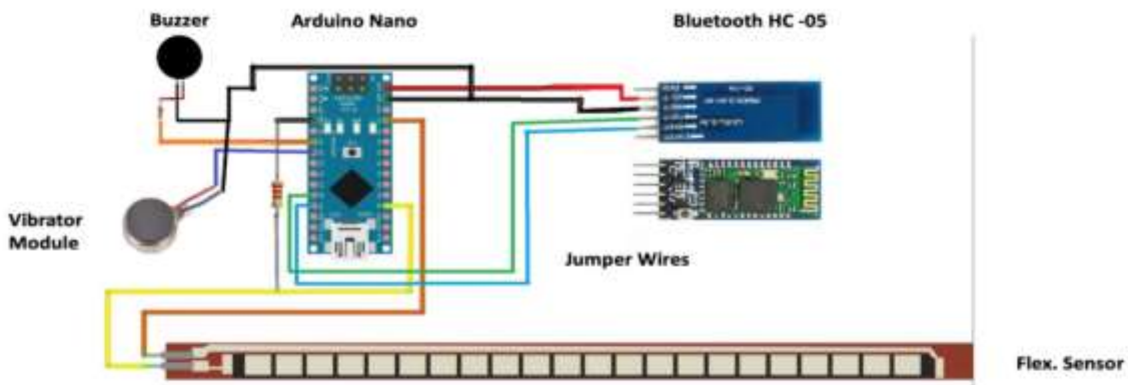

Figure 5: Circuit Diagram for Posture Correction Device

Working Principles and Mechanisms

- The flex sensors in Ergon work on the principle of variation in resistance, resulting in a change in the voltage drop received by the Arduino.
- The sensor strapped onto the back of the user, on bending of the user's back, bends, resulting in a different output relative to the one given out when the posture of the user is straight.
- When the user sits in a straight posture (or any comfortable posture depending upon the user's postural conditions), they calibrate the sensor to set that output reading as the reference. All other readings and alerts will be given out in accordance with the chosen reference.
- Once the reference is fixed, a particular deviation (fixed by the device) is taken as the window within which the posture is considered to be normal. If the readings exceed the deviation fixed, the vibrator starts buzzing, and the user is alerted to correct his/her posture.
- The real-time postural status readings and the corresponding data will be transferred and accessible to the user through the Ergon application which contains the real-time bending angle of a user's back, the cumulative weekly posture progress report, and free training links and videos for the user to maintain good spinal health.
- Further changes made in the model i.e., Versions 2.1 and 2.2 were relatively small compared to the changes made in the transition from Versions 1.0 to 2.0.

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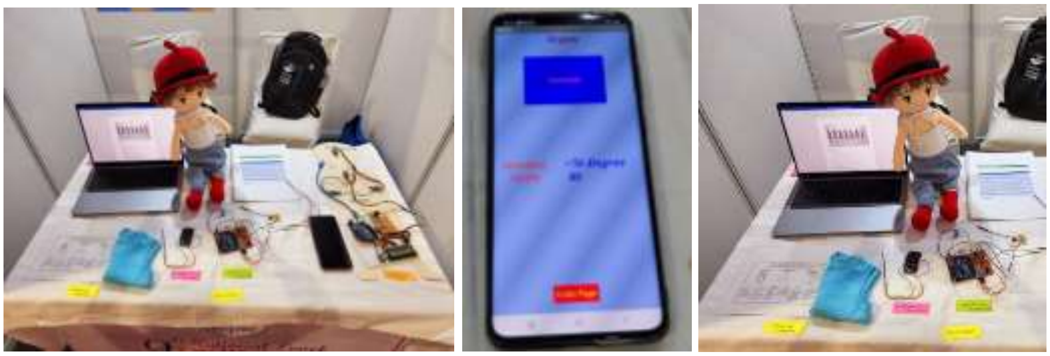

Figure 6: IR Sensor based first ever circuit trial

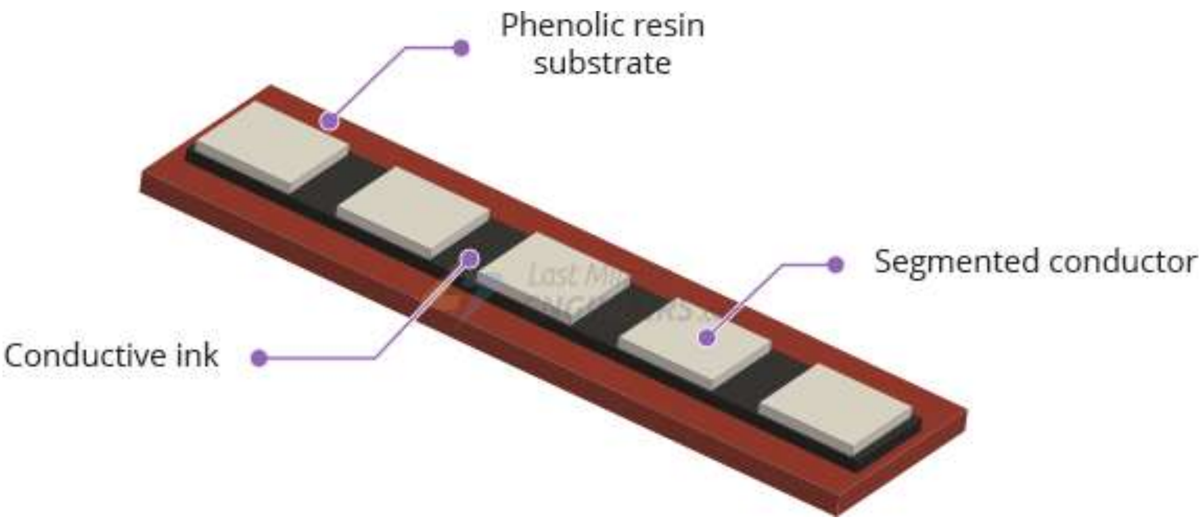

Figure 7: IR Sensor based first ever circuit trial

Flex Sensor Working Mechanism – On bending the sensor, the ink expands, thereby increasing the length of the segment it is in by a small value. The sum of change in length of all segments leads to the total change in the length of the resistor, thereby increasing its resistance and thus increasing the voltage drop across the resistor. This new voltage drop leads to a different reading for different bending angles and thus helps us to identify different postures and through a conditional code, identify and detect any abnormality in the posture.

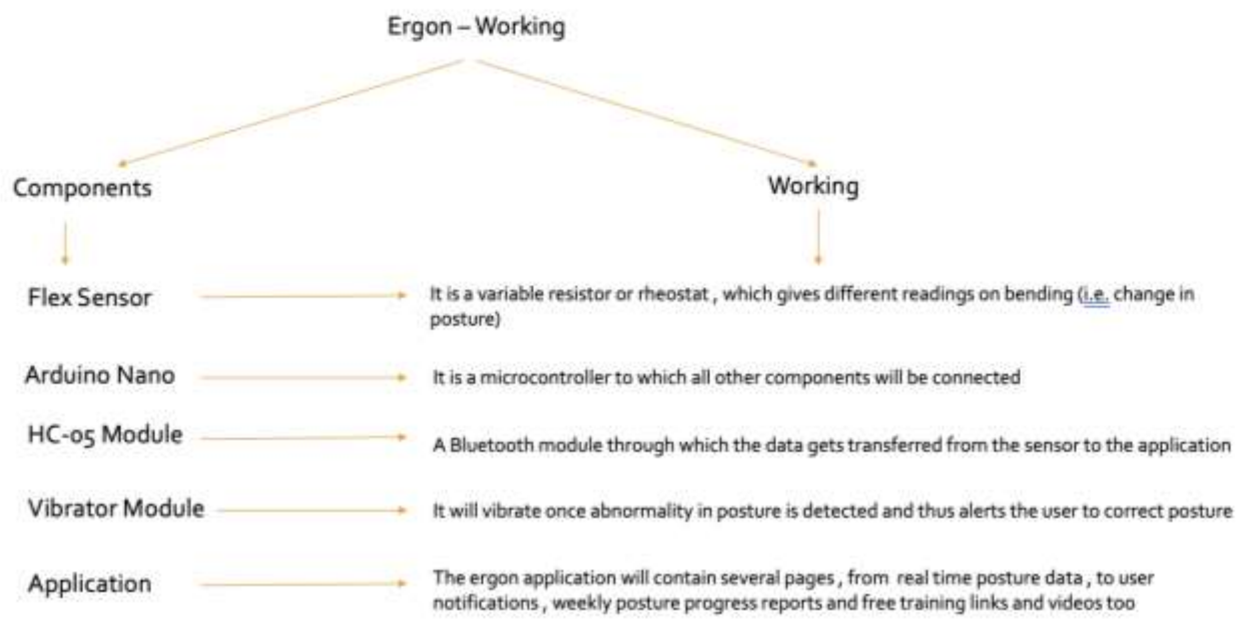

Figure 8: Electronics Components & it's working principle

Version 2.1

Addition of Technology into Previous Version

Hardware Specification

Arduino Nano:

- Operating voltage: **5 volts**
- Input voltage: **5 to 20 volts**
- Digital I/O pins: **14 (6 optional PWM outputs)**
- Analog input pins: **8**
- DC per I/O pin**: 40 mA**
- DC for 3.3 V pin: **50 mA**
- Flash memory: **32 KB, of which 2 KB is used by bootloader**
- SRAM: **2 KB**
- EEPROM: **1 KB**
- Clock speed: **16 MHz**
- USB: **Mini-USB Type-B**
- DC Power Jack: **No**

Figure 8: Arduino Nano

Flex Sensor

Flat Resistance: **10K Ohms**

- Resistance Tolerance: **±30%**
- Life Cycle: >**1 million**
- Flex Length: **4.5 inch**
- Temperature Range: **-35°C to +80°C**
- Bend Resistance Range: **60K to 110K Ohms (depending on bend radius)**
- Power Rating: **0.50 Watts continuous, 1 Watt Peak**

Figure 9: 10K Flex Sensor

Vibration Motor:

Dimension: **10mm diameter, 2.7mm thick**

- Voltage: **2V - 5V**
- 5V current draw: **100mA, 4V current draw: 80mA, 3V current draw: 60mA, 2V** current draw: 4**0mA**
- **11000 RPM at 5V**
- Weight: **0.9 gram**

Figure 10: 5V Vibrator Motor

Bluetooth Module:

- Bluetooth protocal: Bluetooth Specification v2.0+EDR
- Frequency: 2.4GHz ISM band
- Modulation: GFSK (Gaussian Frequency Shift Keying)
- Emission power: ≤4dBm, Class 2
- Sensitivity: ≤-84dBm at 0.1% BER
- Speed: Asynchronous: 2.1Mbps (Max) / 160 kbps, Synchronous: 1Mbps/1Mbps
- Security: Authentication and encryption
- Profiles: Bluetooth serial port
- Power supply: +3.3VDC 50mA
- Working temperature: -20 ~ +75Centigrade
- Dimension: 26.9mm x 13mm x 2.2 mm

Figure 11: HC05 Bluetooth Module

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Version 2.2

Addition of Technology into Previous Version

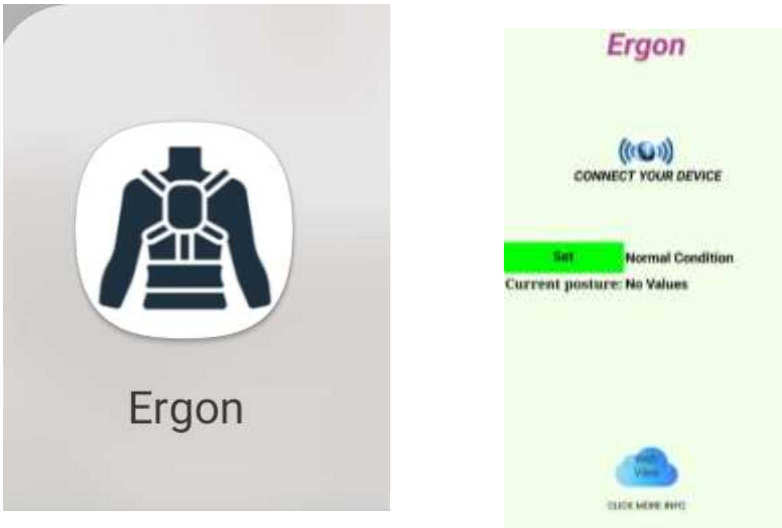

Figure 12: ERGON Mobile Application Interface

Figure 13: Web interface for Data log

Figure 14: Posture Correction Device Version 2.2

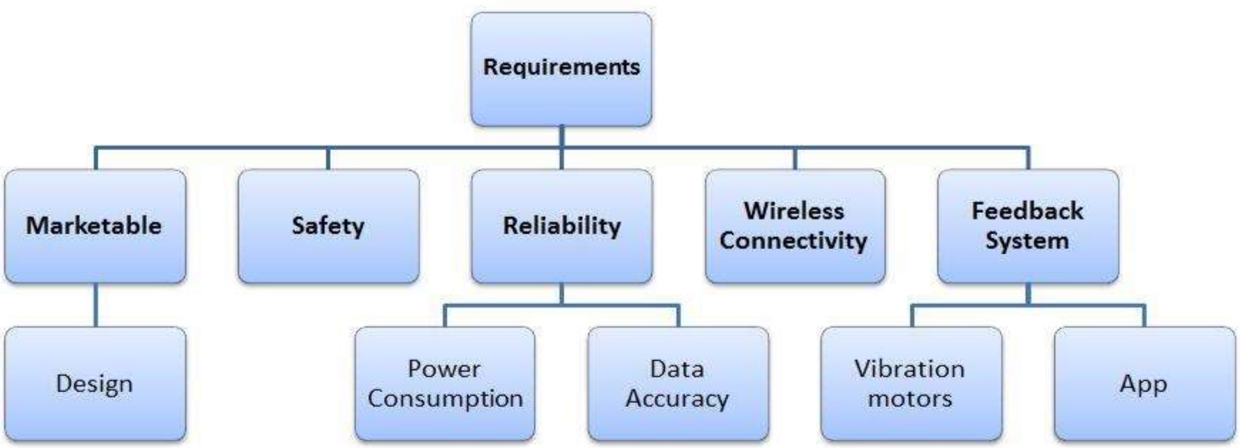

Figure 15: Further requirements for the work

Version 2.3

Addition of Technology into Previous Version

Improved Design for Comfort Wearing

The newly redesigned posture correction device, aimed at providing individuals with a comfortable and effective solution for improving posture. By prioritizing user comfort, we have developed a device that promotes better alignment of the spine and supports natural body movement, thereby reducing strain and discomfort associated with poor posture.

Figure 16: Improved Design of Device

Key Features:

1. Ergonomic Design: The redesigned posture correction device incorporates an ergonomic design that conforms to the natural curves of the body. By considering the contours and movements of the human body, we have created a device that fits seamlessly and comfortably around the user's shoulders, upper back, and waist.
2. Breathable and Lightweight Materials: We understand the importance of breathability and weight when it comes to wearing a posture correction device for extended periods. Our new device utilizes lightweight materials that allow for proper ventilation, preventing excessive sweating and discomfort. The breathable fabric ensures improved airflow, enhancing overall user comfort.
3. Adjustable Straps and Customizable Fit: Recognizing that every individual has unique body shapes and sizes, we have integrated adjustable straps into the device. Users can easily adjust the tension and fit to their preference, ensuring a personalized and comfortable experience. The customizable fit ensures the device can be worn discreetly under clothing without compromising comfort or range of motion.
4. Soft Padding and Cushioning: To maximize comfort, the redesigned device includes soft padding and cushioning at key contact points. This feature prevents chafing or rubbing against the skin and offers additional support, minimizing any discomfort caused by extended wear.

3D Printed Flexible Casing for Flex Sensor

In the quest for improving posture correction devices, a 3D printed flexible casing for flex sensors is implemented. This innovative casing provides enhanced functionality, comfort, and accuracy to posture correction devices, revolutionizing the way individuals can improve their posture.

Figure 17: 3D Printed Flexible Casing showing Flex Sensor & Vibrator

1. Flexibility and Adaptability: The 3D printed casing is designed to be flexible, allowing it to conform seamlessly to the body's movements. This flexibility enables the sensor to accurately detect changes in posture without restricting natural body motion. It ensures a comfortable and natural user experience, enhancing the effectiveness of the posture correction device.
2. Lightweight and Durable: Using 3D printing technology, we have optimized the casing to be lightweight yet durable. The lightweight nature of the casing prevents it from adding unnecessary weight or bulk to the posture correction device, ensuring maximum comfort during extended wear. Additionally, the durable construction guarantees long-lasting usage without compromising functionality.
3. Customization and Precision Fit: The 3D printing process enables customization and precision fit for each user. By tailoring the casing to specific body dimensions, it ensures a snug and secure fit. This customization eliminates any discomfort or inconvenience associated with ill-fitting devices, allowing users to wear the posture correction device with ease and confidence.
4. Seamless Integration with Flex Sensors: The casing is specifically designed to house flex sensors, which accurately detect changes in posture. The seamless integration of the flex sensors within the casing ensures precise and real-time monitoring of body movements. This accurate data collection enables the posture correction device to provide immediate feedback and adjust accordingly, facilitating effective posture correction.

Separate Casing for Electronics Component

A 3D printed separate casing for electronics components has been developed. This casing addresses comfort and convenience concerns by keeping the electronics away from the user's back, allowing for a more comfortable wearing experience and facilitating easy charging. This upgrade marks a significant advancement in the usability and functionality of posture correction devices.

Figure 17: Casing for Electronics Components

Key Features:

1. Electronics Component Separation: The 3D printed separate casing effectively isolates the electronics component from the user's back. By keeping the electronic components away from direct contact with the body, it eliminates any discomfort caused by pressure, heat, or irritation that could be associated with direct contact with the electronics.

Figure 18: Inside view the Device Casing showing electronics components

2. Enhanced Comfort: With the electronics component housed separately, the posture correction device becomes more comfortable to wear. Users no longer have to deal with the sensation of the electronic component pressing against their back, ensuring a more pleasant and ergonomic experience during extended usage periods.
3. Easy Disconnection for Charging: The separate casing allows for easy disconnection of the electronics component from the flex sensor module. This feature enables convenient and hassle-free charging without the need to remove the entire device. Users can simply detach the electronics component from the flex sensor module, ensuring a seamless charging process and minimizing any disruption to their daily routine.

Benefits:

1. Improved Comfort and Freedom of Movement: By separating the electronics component from the user's back, the posture correction device offers enhanced comfort and freedom of movement. Users can wear the device without feeling any pressure or discomfort caused by the electronics, enabling them to go about their daily activities with ease.
2. Convenient Charging Process: The ability to disconnect the electronics component from the flex sensor module simplifies the charging process. Users can effortlessly charge the device without the need to remove the entire device, saving time and ensuring a seamless charging experience.
3. Customized and Secure Fit: The customizable design of the separate casing ensures a secure fit for the electronics component, eliminating any potential movement or instability. This secure fit enhances the device's reliability and effectiveness, providing users with consistent posture correction support.

PCB based Electronics Board

In our ongoing efforts to enhance the safety and reliability of posture correction devices, we have implemented a PCB-based electronics board. This innovative solution replaces traditional wiring systems, significantly reducing the risk of short circuits. By utilizing a printed circuit board (PCB), we ensure the integrity and efficiency of the electronics, providing users with a safe and reliable posture correction device.

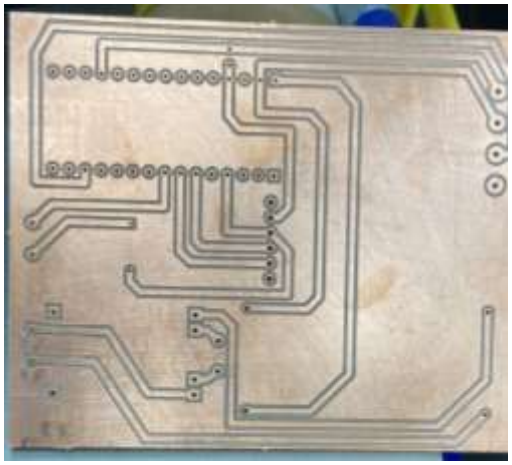

Figure 19: Printed Circuit Board for Device

Key Features:

1. Elimination of Wiring Systems: The implementation of a PCB-based electronics board eliminates the need for complex wiring systems. Instead, the various electronic components are directly mounted onto the PCB, allowing for a streamlined and efficient design. This elimination of wiring reduces the potential for loose connections, crossed wires, and short circuits, ensuring optimal safety.
2. Enhanced Electrical Integrity: The PCB acts as a reliable electrical pathway, providing a secure connection between the different electronic components. The board's design incorporates conductive traces that guide the flow of electricity, minimizing the risk of electrical interference, signal loss, and accidental contact. This enhanced electrical integrity ensures consistent performance and reliability of the posture correction device.
3. Compact and Space-Efficient Design: The compact nature of a PCB enables a more space-efficient design for the posture correction device. The electronic components are tightly integrated onto the board, optimizing the use of available space. This compact design not only improves the device's portability but also reduces the chances of accidental damage or disconnection of wires, further enhancing safety and reliability.
4. Simplified Troubleshooting and Maintenance: The use of a PCB simplifies troubleshooting and maintenance processes. With a clear layout and organized connections, identifying and resolving any issues becomes more

efficient. Components can be easily accessed and replaced if necessary, minimizing downtime and improving the overall usability of the posture correction device.

Benefits:

1. Enhanced Safety and Reliability: By replacing traditional wiring systems with a PCB-based electronics board, the risk of short circuits and related safety hazards is significantly reduced. Users can have peace of mind, knowing that their posture correction device is built with a reliable and safe electrical infrastructure.
2. Improved Performance and Consistency: The PCB's design ensures proper electrical flow and connectivity, resulting in improved performance and consistent functionality of the posture correction device. Users can rely on accurate data collection, timely feedback, and effective posture correction support, maximizing the device's benefits.
3. Durability and Longevity: The integration of a PCB-based electronics board enhances the durability and longevity of the posture correction device. The secure connections and reduced risk of wire damage or disconnection contribute to the device's overall robustness, ensuring long-lasting usage without compromising safety or functionality.
4. Efficient Troubleshooting and Maintenance: The organized layout and clear connections on the PCB simplify troubleshooting and maintenance processes. Identifying and resolving issues becomes more straightforward, reducing downtime and minimizing disruptions to the user's posture correction routine.

Rechargeable Unit

In our continuous efforts to improve the functionality and convenience of posture correction devices, we have implemented an enhanced rechargeable unit. This upgraded unit incorporates a 1000mAh LiPo battery, TP4056 charging module, and XL6009 boost converter. By integrating these components, we offer users a reliable and efficient power solution for their posture correction devices.

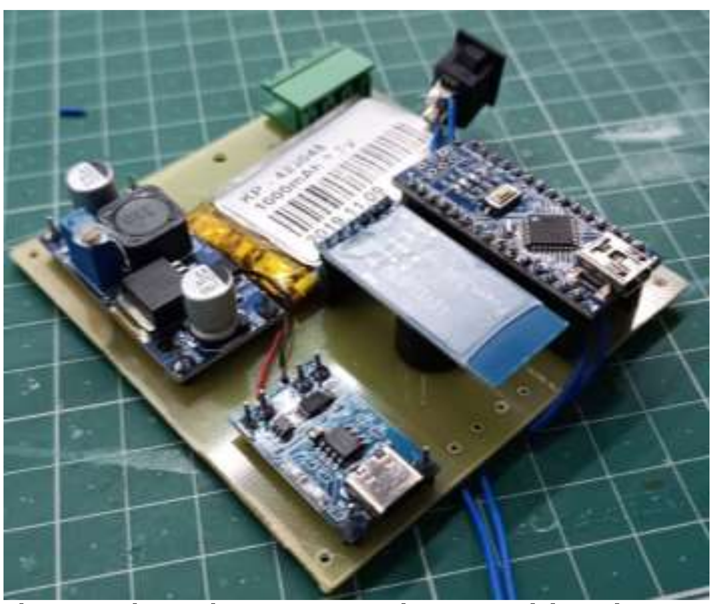

Figure 20: PCB with 1000mAh LiPo battery, TP4056 charging module, and XL6009 boost converter

Key Features:

1. 1000mAh LiPo Battery: The inclusion of a 1000mAh Lithium Polymer (LiPo) battery provides a high-capacity power source for the posture correction device. The LiPo battery offers a good balance between energy density and weight, allowing for extended usage periods without frequent recharging. It ensures a reliable power supply for the device, enhancing convenience for users.

2. TP4056 Charging Module: The TP4056 charging module is integrated into the rechargeable unit to facilitate efficient and safe charging of the LiPo battery. This module offers features such as overcharge protection, short circuit protection, and temperature monitoring, ensuring the battery is charged optimally while safeguarding against potential risks.
3. XL6009 Boost Converter: The XL6009 boost converter is employed to regulate the voltage output from the LiPo battery. It efficiently boosts the battery's voltage to the required level, providing stable power to the posture correction device. This ensures consistent and reliable performance, even as the battery's charge level decreases.
4. Enhanced Charging Convenience: With the rechargeable unit, users can conveniently charge their posture correction devices. The TP4056 charging module facilitates charging via a USB connection, enabling users to recharge the device using a computer, wall adapter, or portable power bank. This flexibility allows for easy and accessible charging, ensuring uninterrupted usage.

Benefits:

1. Extended Battery Life: The 1000mAh LiPo battery offers a significant boost to the device's battery life, enabling users to utilize the posture correction device for longer durations between charges. This enhanced battery capacity minimizes the need for frequent recharging, providing convenience and uninterrupted usage.
2. Safe and Efficient Charging: The integration of the TP4056 charging module ensures safe and efficient charging of the LiPo battery. The module's protective features safeguard against overcharging, short circuits, and excessive heat, protecting the battery and ensuring optimal charging performance.
3. Stable Power Supply: The XL6009 boost converter maintains a stable voltage output from the LiPo battery, regardless of its charge level. This stability ensures consistent and reliable power supply to the posture correction device, supporting its performance and functionality.
4. User-Friendly Charging: The rechargeable unit's USB charging capability offers convenience and versatility to users. They can easily charge the device using various power sources such as computers, wall adapters, or portable power banks, ensuring that charging the device fits seamlessly into their daily routines.

CONCLUSION

The implementation of an enhanced rechargeable unit with a 1000mAh LiPo battery, TP4056 charging module, and XL6009 boost converter elevates the functionality and convenience of posture correction devices. The extended battery life, safe and efficient charging, stable power supply, and user-friendly charging options contribute to an enhanced user experience. Users can rely on a reliable and long-lasting power source, ensuring optimal performance of their posture correction devices.

Version Comparison

Version	**Version 1.0**	**Version 2.0**	**Version 2.1**	**Version 2.2**	**Version 2.3**
Sensor Used	Infrared Sensors	Flex Sensors	Flex Sensors	Flex Sensor	Flex Sensor

Circuit Components	Infrared Sensors, Arduino Uno, LCD Display, Switch, Buzzer	Flex Sensors, Arduino Uno, Bluetooth HC-05 Module, Application (Ergon), Switch, Vibrator Module	Flex Sensors, Node MCU, Website (Ergon), Vibrator Module	Flex Sensors, Arduino Nano, Bluetooth HC-05 Module, Vibrator Module, Website (Data Tracking)+App Switch,	1000mAh LiPo Battery, TP4056 Charging Module,XL6009 Boost Converter, 10K Flex Sensors, Arduino Nano, Bluetooth HC-05 Module, Vibrating Module,56K,1 W Resistor Website (Data Tracking)+App Switch, Vibrator Module
Merits	First Proof of Concept prototype, to prove the hypothesis formulated.	Improved accuracy in readings and detection of abnormal posture, easier data transfer and access by user through application	Improved accuracy in readings improvement in data transfer due to creation of a Wi-Fi network through the Node MCU, and compact circuit due to elimination of Arduino UNO	Improved accuracy in readings accompanied with better data transfer and real time data tracking through website as well as improved user experience through application. Arduino Nano led to the creation of a compact circuit, making it a suitable product	Improved design in terms of aesthetics & better fitment with back, Portable 3D printed casing for electronics components, Self-sustainable power storing system, PCB based electronics board,3D Printed flexible casing for Flex Sensor,
Demerits	High levels of inaccuracy in readings, Large circuit components, Disturbing buzzer, False positive readings under sunlight	Despite improved accuracy in readings circuit is still too large to integrate into a compact wearable and readings couldn't be timestamped	Due to presence of Wi-Fi network, user experience was affected since Wi-Fi networks had to be switched to that set by the Node MCU, and website couldn't provide better user experience than application		

Table 2: Comparison among all versions of Posture Correction Device

Wearable system

Design Thinking, Testing and Training

i) As mentioned above, we went through several stages of testing and improvisation and the main changes made were mainly in the sensors and the wearable device's design.

ii) While conducting surveys, many participants said that the innerwear solution was a solution that could easily be integrated into their day to day lives, but many complaints came with respect to washing the innerwear, reusing it every day and many more.

iii) After receiving this feedback, we came up with a new design , which was a cotton sleeve , within which the sensor module will be inserted and it could be stuck on the back of the user directly using adhesive strips, But it led to a couple of problems like discomfort , rashes and allergies.

iv) So we came up with another method which used buckles and straps which would be very thin and comfortable to wear, with which the user can wear the cotton sleeve on their backs and then go on with their day.

v) The use of these sleeves would make it easier to remove the sensor module and wash the sleeve at the end of every day and then wear it the next day again.

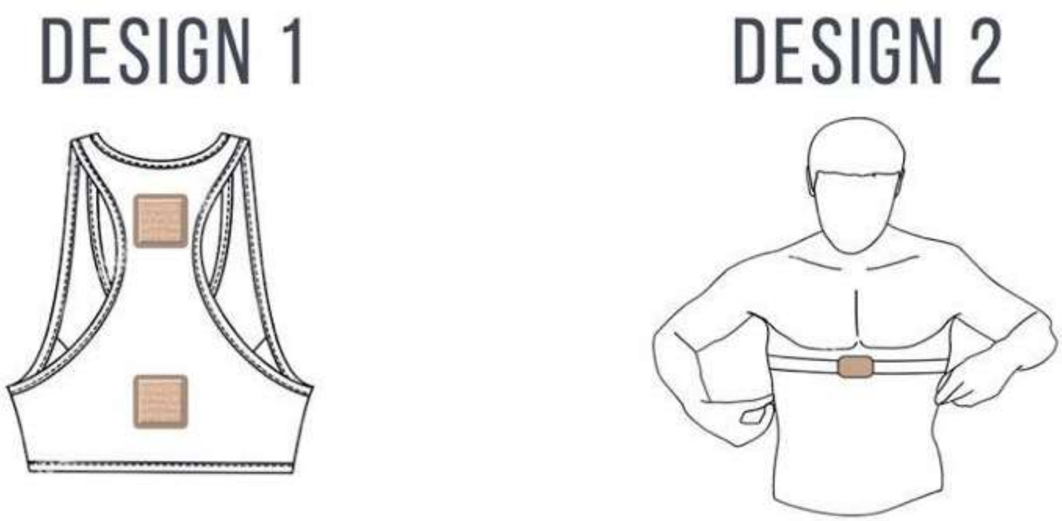

Figure 21: Concept Design Back (left) and Front (right)

SUMMARY

Ergon began with a careful study of sensors and their integration into a compact design which will be easy to wear, user friendly and comfortable. To detect the variation in posture, we first used infrared sensors. Infrared sensors or IR sensors basically detect the heat radiation (infrared radiation) that changes over time and space due to the movement of people. Thus we kept them in such a way that two sensors blocked each other's path when the back was in a straight posture. On bending, they would no longer be on the same line and thus the buzzer would detect and abnormality in the posture and then would alert the user through a buzzer.

This was however inaccurate and also impractical, since the back of any individual is never in a perfect straight line , and thus this mechanism would give false positive readings even if the back was in a proper posture (since the natural spinal arch would be detected as an abnormality). IR sensors also gave inaccurate readings in the presence of sunlight and their placement would make the overall device very large and thus would not be comfortable to wear by a user.

We had to thus explore more options, which was when we came across the 'Flex Sensor'. A Flex Sensor is basically a variable potentiometer, which on bending gives different resistances and thus different voltage drop. This mechanism was far more accurate compared to the initial one since it was now easy to set a particular range of bending angles which would indicate a correct posture, and thus would give more accurate readings. This would also be compact and thus easy to integrate into a smaller system, making it user friendly and thus a more usable version.

To construct our circuit we needed certain key components which include a microcontroller (Arduino Nano), a Vibrator module (Flat 1034 Mobile Phone Vibrator Motor), a Bluetooth module (Bluetooth HC-05) and a flex sensor. All the components are compact and thus they were easy to integrate into a small circuit.

The data collected was transferred through the Bluetooth module to our application, which would then display the postural status of the user in real time, organisation and tabulation of this data over a time of 1 week would allow us to display weekly posture progress reports, and the app also contains free training links and videos to stay fit and healthy.

This circuit was then placed into a cotton sleeve, which would be strapped onto the body of a user. Several design ideas were thought of but the easiest to wear and incorporate in one's lifestyle was the strap one. In that, the circuit placed in the cotton sleeve would be strapped onto the user's body underneath their shirt or undershirts in such a way that the sensor is placed in the lower neck region so that postural changes can be tracked with accuracy.

RESULTS AND DISCUSSION

i) The device presented in the above report (Ergon) is an innovation in the preventive healthcare segment. Compared to devices available in the market , which focus on using large products to massage or reduce pain in the back , our device , not only prevents pain in the back , but it reaches out to a way larger section of the society in terms of its need as well as its cost effectiveness.

ii) Other solutions in this field range in terms of pricing range from a minimum of Rs 3000 to prices up to Rs 20,000, compared to Ergon, which is priced at Rs 1500 - Rs 2000. In terms of usage and user experience, Ergon is extremely compact, allowing a better experience for the user, and at the same time through an app, enables the user to track their postural status in real time, helping in identification of not just day to day postural status, but also early detection of abnormalities in the spine, resulting in early diagnosis and treatment of problems such as cervical and lumbar spondylosis, kyphoscoliosis and bone demineralization.

iii) To test the market viability of the product, we sent out questionnaires to 78 people which contained questions like what consisted of their daily lifestyles, if they faced back problems on a regular basis and if they spend most of their day working on gadgets or on a chair, so we got many responses in the affirmative for all questions. Approximately 71% of the people told that they faced back or neck pain in some point of the day, and many of them also told that it was usually after they sat on a chair for prolonged hours for activities like working or studying.

iv) After testing the need of the product in the market through surveys, Ergon is now in the final stage of development and after approvals from the Ethics board, official testing for the product will begin.

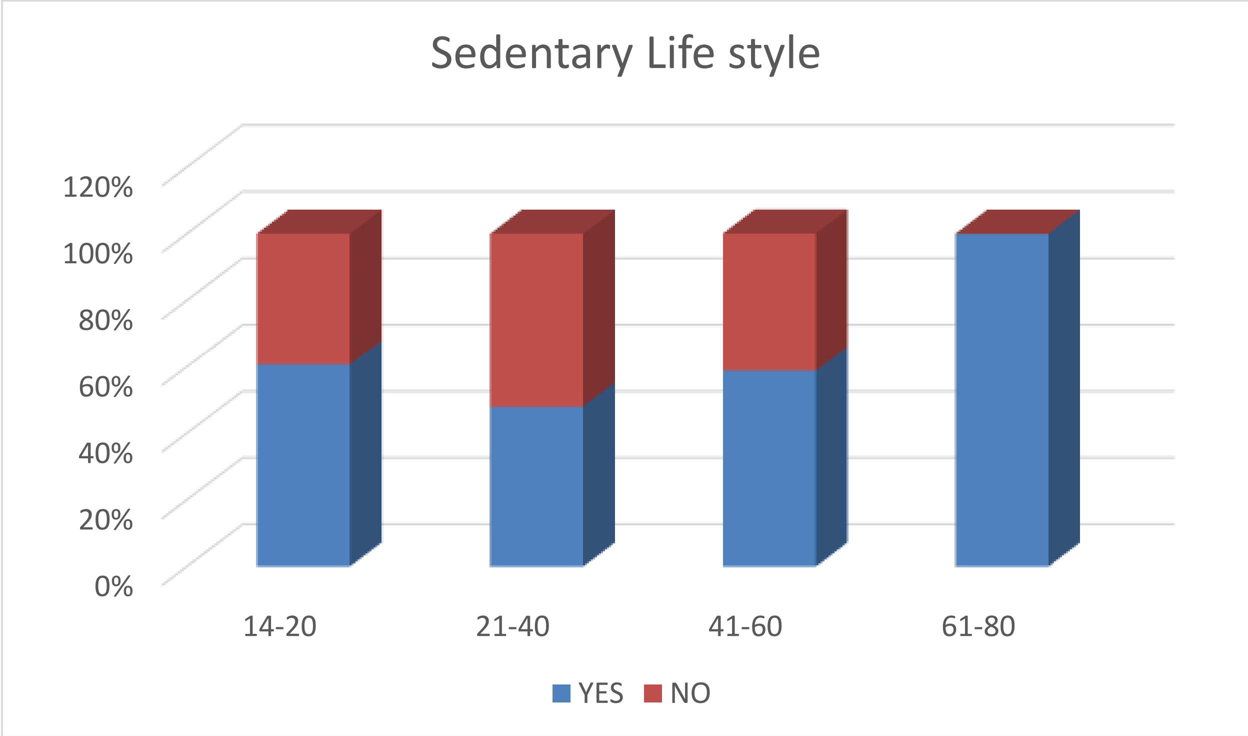

Figure 22: Graph showing lifestyle between different age groups

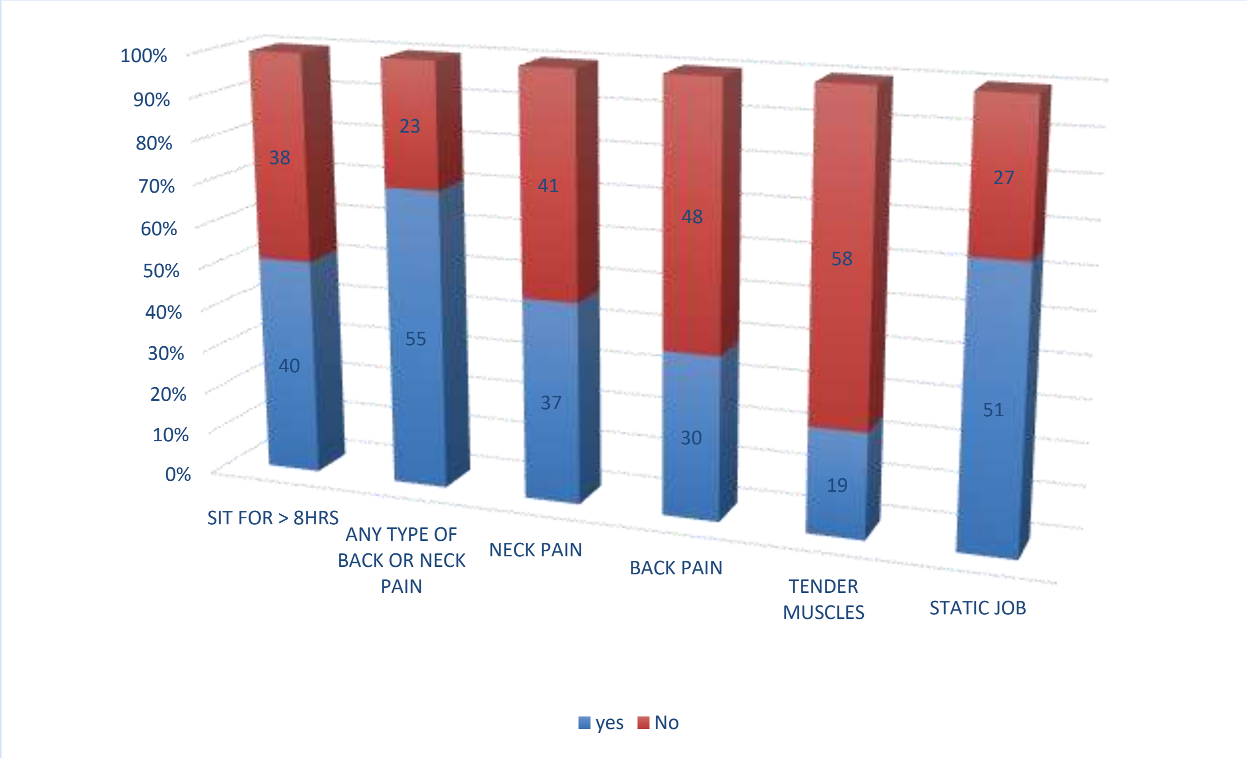

Figure 23: Graph showing health condition leading to the problem

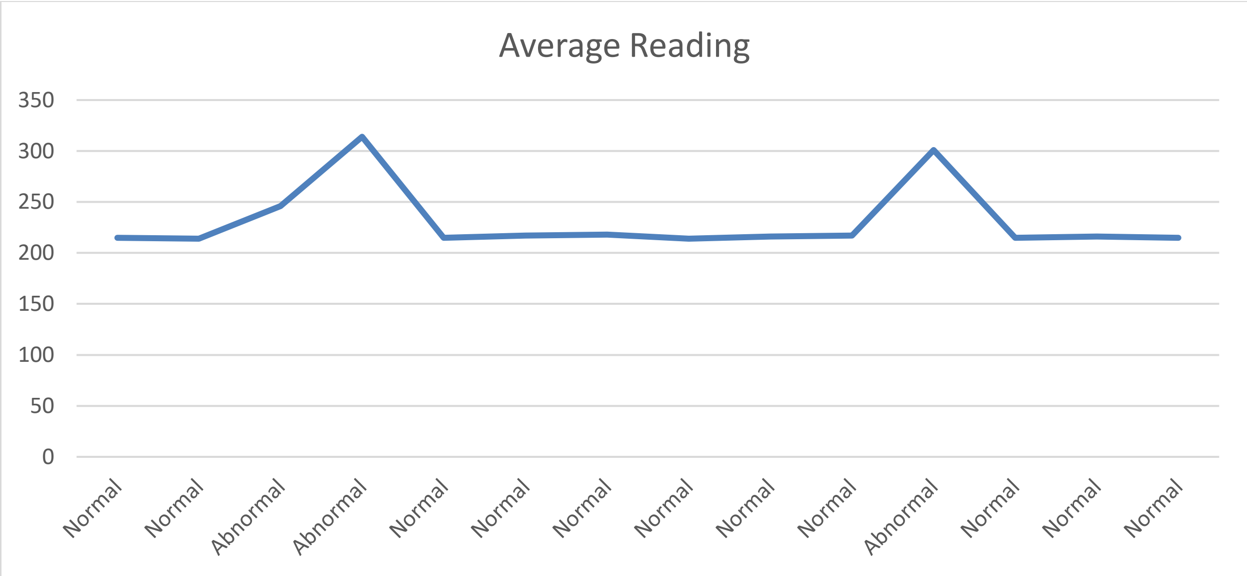

Figure 24: Graph showing average reading values

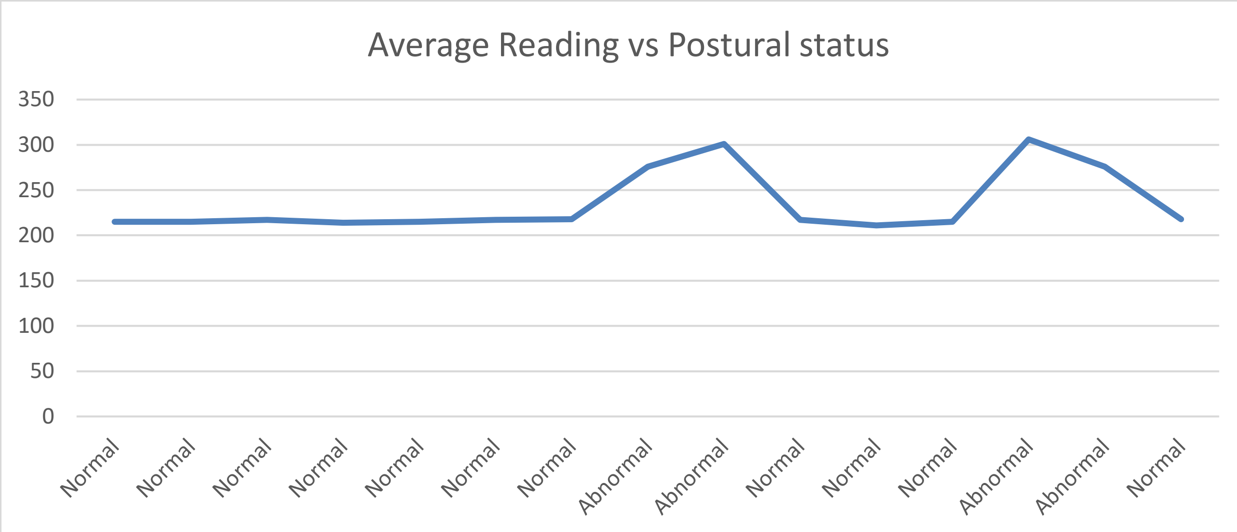

Figure 25: Average Reading against Postural Status

CONCLUSION

Low back and neck pain are one of the most common reasons for doctor visits. Having poor posture has been found to be a main cause of lower back and neck pain as it impacts the back and neck muscles. Maintaining a good posture and changing one's position from time to time is considered to significantly improve and maintain one's health. The world has witnessed a vast amount of smart monitoring devices that are used to enhance the quality of life by providing different types of support. Smart wearable technology has been the main focus of this century, specifically in the medical field, where the advances range from heartbeat monitors to hearing aids. This report highlights the design, development and validation process of a compact wearable device that uses multiple sensors to accurately track the back postural status of a user in real time and notify them once an abnormality in the posture is detected. This has wide scale applications, from being a habit making device, to even a medical standard posture tracking device for medical professionals, especially in the field of neurology, orthopaedics and physiotherapy.

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