Posture alert system for prolonged neck flexion while using smart phones

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Abstract. As the world gets digitalized, the use of smart handheld devices, namely mobile phones, has significantly increased along with the problems associated with their usage. One of the issues that are being faced by the user due to prolonged usage of mobile phones in wrong postures is the bending of the cervical spine. The stress injury caused due to constant neck flexion while using a mobile phone creates a modern spine ailment called Texting Neck or Turtle Neck. The paper discusses a technique by which the user can get prompt alerts with the help of a mobile application that continuously monitors the right posture for holding the mobile phone. This technique uses the inbuilt android mobile sensors such as Accelerometer, Geomagnetic Field Sensor. The warning alerts created in vibrations form, which reminds the user to straighten their posture, which eventually prevents stress injury caused at the cervical neck spine.

1. Introduction
As the world progress in research and technology, one powerful daily tool that has become a vital part of our lives is wireless devices, more specifically, smartphones. As much as they are full of advantages and information, they also comprise of their fair share of disadvantages. These downsides of smart devices can be either mental or physical. In our paper, we have dealt with one of the physical downsides of Smartphone use, that is, the posture-based ailment called “Texting-Neck” that results from holding the mobile in wrong positions.

The new term was termed by US chiropractor Dr. DL Fishman for frequent stress injury and neck pain caused by Smartphone usage, more explicitly texting, web browsing, and watching a movie on the device is called the Text neck [1]. This condition is labelled as an anterior head syndrome or Turtle neck. It has become a trending lifestyle health condition among the current population, and it indeed affects their physical health with the usage of smartphones.

Texting neck syndrome not only results in neck pain, but it can also cause other severe long-term complications such as upper back pain, shoulder pain, headaches, flattening of thoracic kyphosis, increased thoracic kyphosis. Disc herniation/compression, Spinal Degeneration, Early-onset arthritis, Loss of Lung capacity, Pinched nerves, muscle spasms, and eventual weakening of Muscles and Carpal tunnel pain [2]. Overall, texting neck syndrome can harm the Cervical Spine [3,4].
The cervical spine region is a continuous and coordinated network of muscles, nerves, blood vessels, and joints, the pathway that goes from the brain to the spinal cord. Irritation along this pathway leads to pain [5]. A recent systematic review article by Xie Y et al. was performed at Hoink Kong that imply this constant mobile phone usage leads to the musculoskeletal problems with increasing smartphone practice that are high, for the neck pain ranging from 17.3% to 67.8% [5,6].

2. Methodology
This project work is developing, an android based application that is capable of working in the background while the user works on the other apps. The android application designed in such a way that it gives prompt vibration alerts and notification while the mobile phone held at a certain angle that would put the cervical spine under stress. The alert vibrations for straightening posture is given at certain pitch angles when the neck flexion puts pressure on the cervical spine. (Neck flexion angle >20 degrees) [6]. Figure 1 shows the developed Android application.

Figure 1. The developed Mobile Application is showing a pitch angle value of 0° while held in a straight, erect position.

Pitch angle works in such a way that the angle becomes negative when the one of the top edge of the mobile phone device is away from the ground. The values ranging from -180° to 180°. The pitch angle is chosen out of three possible axes (Azimuth, Roll, and Pitch) as in Figure 2 because it’s the only axis that tells about the mobile viewing angle corresponding to neck flexion [7,8]. The pitch angle of the mobile phone is obtained at various positions of the devices with the help of inbuilt mobile phone sensors, as discussed below.

2.1. The Android Sensors:
The Android application platform provides two sensors that help you to decide the orientation of a gadget: The Geomagnetic field sensor and The Accelerometer.

2.1.1. Accelerometer: Accelerometers sensor found in the smartphone used to detect the orientation angle of the phone. The dimension to the accelerometer information is provided the gyroscope. This is done by tracking twist or rotation of the mobile phone. Gyroscope is used to detect and sense the acceleration event of mobile phone. The linear acceleration of movement is measured by accelerometer. The output from the accelerometer is given as three axes, namely Azimuth Pitch, and Roll. The acceleration is obtained as the raw data stream from the Accelerometer shown in figure 2 [9].
2.1.2. Geomagnetic Field Sensor: The geomagnetic rotation vector sensor makes use of a magnetometer instead of a gyroscope and, the mechanism is similar to the rotational vector sensors. The accuracy of the geomagnetic rotational vector sensor is lesser than that of the regular rotation vector sensor, and thus there is a reduction in the power consumption. This sensor used to collect certain rotational information from the background without much drainage in the battery. This sensor used in conjunction with a batch, and they are beneficial [10].

3. Defining the Neutral Position while using smart device:
The project and the application development take into consideration of neck flexion angles corresponding to the holding of the phone in various positions. Works of literature are exhaustively reviewed to find the most appropriate definition of the neck tilt angle, and the stress imposed on the neck. A reference point is necessary to apply any recommendations further. The neural position is that reference position of the neck when the mobile phone user is in a straight, erect position. The Neutral position is defined by Dennis R. Ankrum in his paper as “the posture of the head/neck when standing erect and looking at a visual target at eye level; the posture of the head/neck when standing erect and looking at a visual target 15” below eye level; and “normal erect posture.” A proper, strain free posture is defined when the ears are perfectly aligned with the shoulders, the “angel wings,” or the withdrawn shoulder blades [11]. The head posture landmarks and metrics are shown in Figure 3 where C stands for cervical.
4. Defining the critical angle of neck flexion for warning alert
From the below representation and as per Chief of Spine Surgery Kenneth K. Hansraj, MD, New York spine surgery & rehabilitation medicine New York, it can be observed that the weight imposed on the neck increases with the increase in the neck flexion angle.

The preferable neck angle of viewing the phone founded to be the neutral angle when the weight put on the cervical spine is at the least. Neck flexion angles greater than 20° has a higher risk of musculoskeletal disorders [12–14]. The weight on neck corresponding to neck flexion is seen in Figure 4.

![Figure 4](image)

**Figure 4.** Picture showing the amount of weight resulted that is increased at the spine with progressive neck flexion at different angle [12].

5. Results and discussion
With the use of the developed mobile application, the degrading effect on the cervical spine is measured in terms of mobile pitch angle and their relation is tabulated in Table 1 and 2.

**Table 1.** Mobile pitch angle for various neck flexion angle for different subjects.

| Neck Bending Positions (On Clinometer) | Neutral position | 15° | 30° | 45° | 60° | 90° |
|---------------------------------------|------------------|-----|-----|-----|-----|-----|
| Subject 1 Pitch Angle                 | -21              | -33 | -39 | -52 | -62 | -   |
| Subject 2 Pitch Angle                 | -20              | -35 | -40 | -53 | -60 | -   |
| Subject 3 Pitch Angle                 | -20              | -36 | -40 | -54 | -59 | -   |
| Subject 4 Pitch Angle                 | -19              | -34 | -42 | -52 | -61 | -   |
| Subject 5 Pitch Angle                 | -20              | -36 | -40 | -53 | -59 | -   |
Table 2. Average Mobile pitch angle for various neck flexion angle and load on cervical spine.

| Neck Bending Positions | Neutral position | 15° | 30° | 45° | 60° | 90° |
|------------------------|------------------|-----|-----|-----|-----|-----|
| Force exerted on the Neck region | 10–12 lbs | 27 lbs | 40 lbs | 49 lbs | 60 lbs | Not Measurable |
| Average Mobile Pitch Angle | -20 | -35 | -40 | -53 | -60 | - |

6. Conclusion
The Android Application developed that gives prompt vibration warning at Pitch angle > -35 degrees, which corresponds to the Neck Flexion angle >15 degrees. Hence, the user, while on phone texting, web browsing, or watching a movie, by holding the phone in certain pitch angles which would put stress on the cervical bone, can now straighten up and this constant reminder prevents Texting Neck in regular mobile phone users. In future, the work would be extended for the whole spine for complete posture analysis then and there.

7. References:
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