Report on Individual Design Idea: Posture Correction

Human Centred Design of Assistive and Rehabilitation Devices

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Introduction

The number of jobs based sitting down is growing (1), and sedentary working is becoming a large concern: in middle and high-income countries, office workers often sit still for half the day (2). This behaviour has strong mental and physical ramifications of decreased cognitive function and quality of life, and depression (3). More recognisably, sedentary behaviour lends itself to bad posture, causing musculoskeletal disorders (4). Musculoskeletal disorders are a diverse set of conditions that affect bones, joints, muscles, and connective tissues to cause potentially debilitating fatigue and pain (5–7).

Many people have low postural awareness (8), so don't realise they are sitting with "bad" posture until they develop pain. To improve posture when sitting at desks for extended periods, ergonomic chairs, posture back-straps, and increasing the height of monitors (9) have been popularised commercially.

Design idea

My design idea is a wearable device that mimics the shape of a soft neck brace. It will detect when the user's seated posture is not optimum and inform the user by providing haptic feedback on the side of the neck that is not in the right position. I chose this after recognising how difficult I find it to know if my posture is good or not because the difference in physical sensation when seated in different postures is not apparent, so I cannot self-correct and am not sure the posture to self-correct into. The literature supports this as a common problem, compounded by the conflicting advice on the internet for the 'ideal' posture.

Augmented function

This device augments the users' ability to detect their posture and guides them to improve their seated posture through a combination of haptic feedback and a supporting app. In doing so, it supports healthy spinal functioning and prevent musculoskeletal disorders. This is particularly useful for those who work seated for long periods, and don't realise their posture is sub-optimum until they develop more serious problems.

Interface design development

The design will require both a physical device to detect and provide feedback regarding the user's posture, and an app to advise correct positioning. It will target the "Forward head posture", a common sub-optimal postural position for those who spend long amounts of time using a mobile phone or a computer at a desk (10).

Designing the hardware

Forward head posture can be detected by measuring a craniovertebral angle (CVA) of less than 48-50 degrees (11). This will be detected in my device by two MPU6050 sensors: one placed on each side of the C7 to measure the tilt angle. The MPU6050 sensor has both an accelerometer and gyroscope to measure the change in acceleration in three dimensions of the user's neck, and the angular velocity of the user's neck movement. The combination of these measurements will enable a comprehensive understanding of the user's neck movement around C7, and thus an indication of forward head posture. A mini vibration motor will also be positioned underneath each sensor to provide haptic feedback upon sub-optimal CVA, and all four components will be connected to an Arduino, shown as a prototyping circuit in Figure 1.

The electronic circuit will be sewn into a soft woven polyester collar that has a polyethylene mesh sewn in at the back to support both neck posture and the electronic circuit (Figure 2). The collar will be closed around the neck and held together with Velcro (Figure 3).

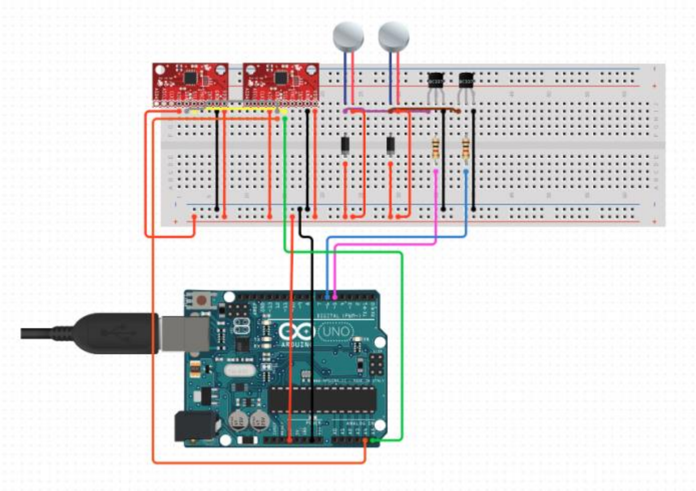

Figure 1: Circuit diagram of prototype version of the device using a breadboard.

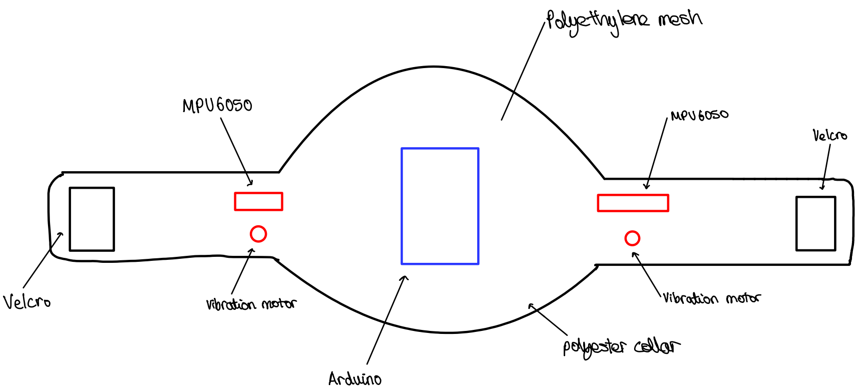

Figure 2: Diagram of the neck brace device.

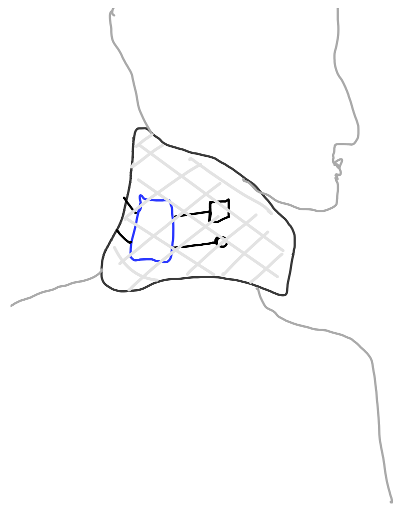

Figure 3: Diagram of the neck brace device being worn.

Calibration

The device must be calibrated to the “ideal” posture to measure subsequent deviation. To do this, the user must wear the device, then follow guided instructions on the accompanying app to reach the desired neck position. This will be achieved by the front-facing camera on the user’s phone through the design’s app. It will use pose detection algorithms to locate key body joints, before mapping a virtual skeleton and classifying the user’s position compared to predefined optimum postural alignments. From this, the sensors will take a reading to establish a baseline angle and position of the neck.

In-use functioning

Once the device has been set up and calibrated, it will be programmed on Arduino to take continuous readings that are ran through a complementary filter to combine the accelerometer and gyroscope data and improve the stability of readings. It will be written into the code to calculate the change in angle of the MPU6050 by using trigonometric functions on the accelerometers’ readings to determine the tilt and compare this with the original “optimal” angle. If the change in angle exceeds 12 degrees (12), then the Arduino will send a signal to the motors to vibrate for 3 seconds with 1 second intervals until the user corrects their posture and the optimum position is restored. This will need to be trialled with the user and the app, due to the differences in angle defined as forward neck and optimum neck for different users, but being the difference between mean optimum and sub-optimum values, 12 degrees will be used as the starting point (13).

App interface

For initial calibration and prolonged user engagement, the app will incorporate gamification, proven to help promote intrinsic motivation (14). This is most likely to create health behaviours that are long lasting, to improve wellbeing of the users (15). The UI will need to be fun and bright, and the app must connect the user to educational tools to learn other exercises to improve their posture, further promoting intrinsic motivation.

Challenges

There are many challenges that could arise with this design, as listed below:

1. Initial calibration: The user might not successfully calibrate the device at home, and because the change in angle is different for each user, the product won't work successfully if not calibrated successfully.
2. Accuracy of readings: Beyond calibration, the readings might be inaccurate, and therefore the device might vibrate unnecessarily, causing irritation for the user and misleading them on what posture they should maintain.
3. Comfort: The device must be comfortable enough for the user to wear it during their whole workday (up to 9 hours).

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