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Sensor Based Ergonomic Cushion for Posture Detection and Correction

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ABSTRACT

Awkward postures are associated with a number of musculoskeletal disorders in almost all work sectors. Various studies have indicated the prevalence of awkward postures in different work setups and have provided ways to assess postural deviations and their unfavourable effects on general wellbeing of the workers. The need of the hour is to have an aid that provides a means not only to assess the awkwardness of a posture, but also to correct it as soon as it is identified. The study, here, is designed to develop a solution for assessment and correction of the awkward posture as soon as it is attained. An ergonomic cushion is presented which is fitted with printed flex sensors to detect the awkward postures, considering lumbar curve, thoracic curve and cervical curve. A mobile application is used to configure the sensing range of the sensors. The application collects the data for the flex pressure sensors positioned at different points and warn the user to correct the posture. If not corrected within the stipulated time, the cushion automatically corrects the posture with the help of a microcontroller that expands or deflates the cushion as per postural requirement.

Keywords: Ergonomic design, Sensors, Posture detection and correction

INTRODUCTION

Most of the contemporary work setups require the workers to perform sedentary work and remain in seated position for prolonged periods of time. The unfavourable effects of attaining these static and uncomfortable positions while working include physical conditions like incidence of musculoskeletal disorders, psychological conditions like aversion from work and cognitive conditions like lack of concentration and focus at work. Exposure to such work conditions leads to decline in overall performance of the workers as well as lowered sense of general wellbeing. Continuous interaction with machines especially VDTs is a common work practice in almost every work setup. General ergonomic solutions can be derived by a comprehensive understanding of the physical and cognitive aspects of user-machine interface at work, workplace design and workspace layouts, physical environment, psychological environment and the attributes of job design. Flexible workstations like sit-stand workstation to decrease the pressure of continuous sitting have been tested in different studies in different time frames, but workers eventually ended up performing the work throughout the day sitting for prolonged

periods and rarely using the standing workstation, which justifies Bridger (2019) quoting *Sitting is the new smoking*. The posture that needs to be acquired at work is determined by the design of displays of the machine the worker is interacting with, the control mechanisms that need to be operated and the panel layouts. Practically, the nature of work is difficult to change, but appropriate measures can be taken to reduce the strain imposed on the workers while being seated at work for prolonged hours. The National Institute of Occupational Safety and Health estimates that more than fifty percent (50%) of the workforce in the United States experiences repetitive stress injuries, primarily back ailments (acute, chronic, and repeated) brought on by sitting for extended periods of time while performing a range of tasks.

An ergonomic seating design is one of the most practical solutions to the problem. Various studies have been conducted to develop such solutions, and some effective designs have been created to deal with the postural problems that arise due to constant need to sit at work. Various technology-based solutions have been devised till date for assessment of postural deviations at work so that corrective actions can be taken. The study, here, presents a comprehensive preventive and corrective measure to deal with such postural issues at work. The sensor based ergonomic cushion that can be used with any chair, does not only detect an awkward posture but also corrects it as soon as it is attained.

PAST WORKS

Prommanon (2015) conducted a study to determine how a back care pillow (BCP) affected individuals with chronic non-specific low back pain in terms of discomfort, lumbar range of motion (LROM), and functional impairment (LBP) and concluded that BCP combined with physical therapy had better pain, lumbar ROM, and functional disability outcomes than physical therapy alone. Lee et al. (2018) developed a gel cushion made of thermoplastic styrene-ethylene/butylene-styrene elastomers to assess the impact of the gel cushion and found it to be very effective in managing back pain in professional drivers. Chapman et al. (2006) developed a computerized system for cushion design and material testing by allowing the input of data on protrusions (small parts protruding from the major surface) and more latitude on the design of cushion systems. Kamara et al. (2019) developed a smart cushion integrated with e-textile pressure sensors to monitor activities on a chair including occupancy, sitting duration, and body posture and orientation. Luo et al. (2017) developed a smart cushion composed of three parts, pressure data acquisition module (internet of things), data receiving and processing module, data storage and analysis module and found out that the design was capable of the dynamic and real-time measurement of the pressure center in the sitting posture, and cumulative effect calculation. Makhsous et al. (2009) suggested that sitting with reduced ischial support and enhanced lumbar support results in reduced sitting load on the lumbar spine and reduces the lumbar muscular activity, which may potentially reduce sitting-related LBP.

DESIGN OF SENSOR BASED CUSHION

People are prone to adopting awkward postures in order to adjust themselves for any working or resting position. This can be attributed to the natural capability of adaptation, which should not ideally exceed the prescribed limit. As a consequence of these unnatural postures, a host of musculoskeletal problems come into being. Keeping in mind, that it is quite difficult to train individuals to attain a posture as close to the natural curvature as possible, the design of the sensor based posture detector and corrector ergonomic cushion is proposed.

An ideal sitting posture requires the individual to maintain these gaps

- *1.5 to 3 cm between the cervical spinal bone and the chair*
- *1.5 to 3 cm between the thoracic spinal bone and the chair*
- *1.5 to 3 cm between the sacral spinal bone and the chair*

When a person is sitting in a chair in an optimal position, usually these gaps between the spinal column and the chair are observed.

- *25 to 30 cm between the cervical spinal bone and the chair*
- *7 to 12 cm between the thoracic spinal bone and the chair*
- *3-5 cm between the sacral spinal bone and the chair*

As the worker changes position to a more relaxed one, these gaps tend to change, altering the pressure experienced at different parts of the body. These gaps usually become:

- *2 to 3 cm between the cervical spinal bone and the chair*
- *Approx. 1cm between the thoracic spinal bone and the chair*
- *12-20 cm between the sacral spinal bone and the chair*

Similarly, as different postures are acquired to suit the demands of the work or adjust to the design of furniture and equipment, these gaps change and undue postural deviations are observed. This calls for the seat cushion to accommodate the body providing it as much comfort as desired, and minimise the stress imposed on the spinal column. Usually, the conventional design of the cushions is not suited to meet these requirements of the user and the user might thus be required to attain an awkward posture while remaining seated.

Typically a cushion for a work chair is 46–57 cm in height and 33–40 cm in width. An ergonomic sensor based cushion is developed here to create a solution for the attainment of unnatural postures at work or for relaxation. The specific areas of the cushion bloom and sag once the sensor identifies the deviation from the natural posture and a microcontroller handles the operation of expansion and deflation of the cushion to correct the posture. A smart printed flex sensor is deployed that provides the pressure readings which will provide instant activation to the part for support.

CONCLUSION

An ergonomic approach to designing of products used while performing different types of tasks is the best way to deal with various situations leading to work related musculoskeletal disorders. Technology based designs are most sought out solutions to such problems nowadays. The modern work world mainly comprises activities that require prolonged sitting from the worker leading to attainment of unnatural awkward postures at work. The design of the sensor based ergonomic cushion presents a solution not just for identification and analysis of such awkward postures, but also for correction of the posture as soon as it deviates from the natural posture beyond the acceptable limit.

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