ExoSpine: Artificial Muscle-Driven Spine for Posture Correction

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Abstract. We present ExoSpine, a wearable external spine driven by artificial muscle that is soft, flexible, and can provide the appropriate amount of kinaesthetic feedback for posture correction. ExoSpine first detects the user's current posture via a bend sensor installed at the back of the neck, followed by the artificial muscle activation that self-corrects the user's posture when sitting. From our preliminary study, we found ExoSpine to overall perform better than vibrotactile feedback that is similar to conventional posture correctors.

Keywords: artificial muscle · posture correction · kinaesthetic feedback · artificial spine.

1 Introduction

The need to continuously face a display of various shapes, sizes and positions forces the cervical spine to be in undesirable positions for a long period of time. In the past 25 years or more, low back and neck pain prevalency and disability have increased and has become one of the leading causes of disability [5]. Even worse, the rise of COVID-19 has reduced the chance for proper physical activity [2], and the ever expansion of our telecommunication services such as 5G makes the watching online content too convenient to the point of being debilitating to one's health [1] The global incidence rate of neck pain was 16.2% and will undoubtedly bring a huge negative impact to our current social and economic status [3].

Proper physical activity was identified as the only effective method against this [4]. However, researchers and health related companies have also been looking into methods to ensure proper posture throughout the day. Posture correctors are wearable devices that provides this usually in the form of a shoulder brace that can be quite rigid. Thus, we propose ExoSpine, utilizing programmable artificial muscles to drive a correct posture via kinaesthetic feedback. The system uses a trio of artificial muscles at the spine and the lower arms provide enough force to kinaesthetically actuate the user's body to the correct posture. Our system is also safe as artificial muscles are a form of exoskeleton that is soft, flexible and lightweight.

2 Implementation

To kinaesthetically actuate the back comfortably, we surrounds the upper body, shoulder and back as shown in Figure 1(right) which mimics a conventional posture corrector. We use 7mm inner diameter air pipes and 8mm inner diameter fiber pipes for the artificial muscles itself. We also designed and 3D printed several pipe connectors shown in Figure 1(left) so that the muscles can be connected in series and transmit compressed air simultaneously across each pipe. To detect cervical curvature, a 112mm bending sensor[5] is attached to the back of the neck. When the sensor bends, its resistance value changes and this signal is obtained by an Arduino Uno, which sends this information to the pneumatic controller.

Fig. 1. modeling and prototyping process

The controller consists of two solenoid valves. When the resistance of the bend sensor changes, the Arduino Uno send a signal to the L298N drive chip. The program then reads and records the bending sensor signal transmitted from the serial port 9600 frequency signal through the python program on the computer. The overall delay is about 0.3 to 0.5 seconds, which is negligible. An air compressor provides an air input with a pressure of about 0.5KPa. Through the Arduino Uno program, it controls the switch of a 12V solenoid valve, and then controls the contraction and relaxation of the artificial muscle of the whole structure. We found that our system was able fix the posture of the participant from a 20° bend to 15° in 1 second.

3 Preliminary Study and Results

The goal of the preliminary study is to determine if ExoSpine is able to provide posture correction. To achieve this, we designed a within-subject study to com-

[5] https://www.switch-science.com/catalog/126/

pare between three conditions: baseline with no feedback, vibrotactile feedback, and Exospine. The vibrotactile posture corrector consists of a 5V vibration motor and is placed at the back of the neck, similar to the Upright Go S[6]. The participants (3 males, Mean: 26.33, SD: 1.25) were required to sit and perform activities like reading and checking their smartphone while experiencing each condition which lasts about 5 minutes and a rest period of about 2 minutes in between. The conditions are also counter balanced.

The Anova test results of each group show that the difference among three groups is statistically significant ($F = 47.556, p < 0.01$). Post hoc Bonferroni adjustment found a statistical significance between the baseline and vibrotactile condition ($p < 0.05$), baseline and ExoSpine ($p < 0.0001$), and vibrotactile with exospine ($p < 0.0001$). This shows that compared with to the baseline condition with no posture corrector, wearing a reminder device or an artificial muscle device can play an effective role in people's sitting posture. Although vibrotactile was effective, the effect is not as good as ExoSpine that actually moves the user directly into the correct posture.

4 Conclusion and Future Works

We present ExoSpine, a wearable spine driven by pneumatic artificial muscles for posture correction. Our initial findings indicate that ExoSpine is potentially more effective than conventional methods of posture correction, and we will further improve the prototype based on the gathered results and feedbacks.

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[6] https://www.uprightpose.com/