ISSN: 2414-1895 DOI: 10.6919/ICJE.202301_9(1).0009

Spinal Posture Recognition based on Support Vector Machine

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Abstract

Spinal health problems have attracted much attention, and the research of auxiliary diagnosis for patients with scoliosis has become a hot topic in the medical field. In this study, the combination of surface electromyography (sEMG) and machine learning (ML) was used to identify the spinal posture, so as to provide reference for the future diagnosis and screening of patients with scoliosis. The study included 15 participants and 540 data sets, and the accuracy of normal, right and left spine posture was more than 89%. This study has important reference value in the auxiliary diagnosis of scoliosis.

Keywords

Scoliosis; Spinal Posture Recognition; Surface Electromyography; Support Vector Machine.

1. Introduction

Scoliosis is a three-dimensional deformity of the spine, including lateral curvature in the coronal plane, normal physiological curvature changes in the sagittal plane of the spine and vertebral rotation in the cross-sectional surface [1]. The Scoliosis Research Society defines scoliosis as the use of the Cobb method to measure the lateral curvature of the spine in a standing upright total spine x-ray with the angle greater than 10°. The patient's disease is generally progressively developed, mild patients are generally better, only appear including high and low shoulders, pelvic asymmetry and other symptoms of appearance deformity, will not lead to serious complications, as the Cobb angle continues to increase, the patient will gradually aggravate the deformity and psychological abnormalities due to appearance, patients will have joint and muscle pain, thoracic deformation, cardiopulmonary function impairment and other symptoms in severe cases, which will lead to decreased mobility and even paralysis[2-3].

sEMG is a complex bioelectric process formed by muscle excitation or activity, it carries rich neuromuscular control information and muscle activation information, which can reflect muscle activity [4]. By extracting the sEMG signal features of the paravertebral muscles of healthy subjects in different postures, and using ML to construct a spinal pose recognition model, the feasibility of the experimental method in this study for early screening and auxiliary diagnosis of patients can be verified. This will lay the foundation for the completion of sEMG signal acquisition in patients with scoliosis in the future and the development of a system to predict the risk of progressive scoliosis using ML.

2. Method

2.1 Placement of the Patch Electrode

A medical alcohol cotton pad was used to wipe the skin on the subject's back where the electrode was attached to remove the oil and sweat on the skin surface to reduce the interference to the EMG

Volume 9 Issue 1, 2023
DOI: 10.6919/ICJE.202301_9(1).0009

collected. The paraspinal muscles tested include: trapezius, latissimus dorsi, and erector spine [5-8], as shown in Figure 1, the patch electrodes were placed symmetrically along the muscle fibers of the target muscles on both sides of the participant's spine.

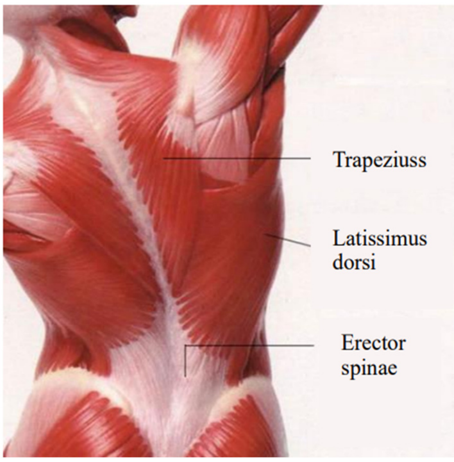

Fig 1. Electrode placement

2.2 sEMG Measures

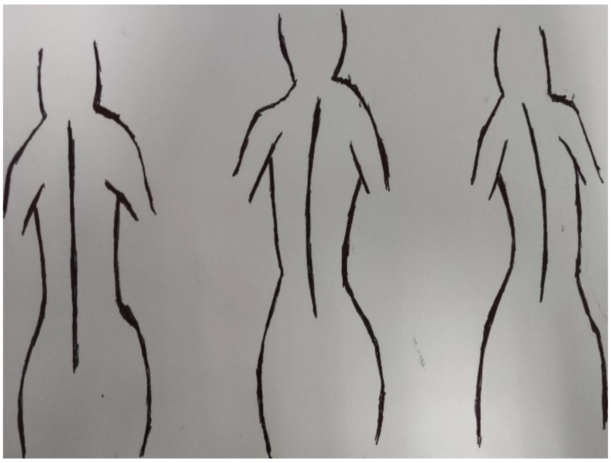

Fig 2. Spinal postures

Fig 3. Position of experiment

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Fifteen participants, aged 22 to 26 years old, were selected for the experiment. They had no strenuous exercise within 24 hours before the experiment, no back neuromuscular disease or muscle fatigue. During the signal acquisition process, the participants made three spinal postures: normal , right bend and left bend, as shown in Figure 2,and realized the contraction and generating force of the target muscle through dynamic trunk flexion and extension, as shown in Figure 3 [9]. The participants were asked to stand with their feet shoulder-width apart, to bend the torso until the tip of the middle finger touched the instep, to resume standing. The entire cycle was performed at a constant speed comfortable to the participants, and all movements were required to be completed in 3 seconds, with the movement cycle repeated 12 times in each posture. For the first three days of the experiment, each participant was asked to practice dynamic trunk flexion and extension twice a day in all spinal postures.

2.3 Training and Testing the SVC Model

In this study, the machine learning analysis tool selects support vector machines (SVM), SVM initially solves the linear separability problem, and then Boster et al. proposed the SVM that introduces kernel techniques, which has made great progress in the field of nonlinear research [10,11].

Firstly, the time domain and frequency domain characteristic information of the sEMG is extracted, including Mean Absolute Value (MAV), Variance (VAR), Root Mean Square (RMS), Mean Power Frequency (MFP) and Medium Frequency (MF). Then, the MAV ratio, RMS ratio, VAR ratio, MPF ratio and MF ratio of the sEMG on both sides of the target muscle spine are calculated as input feature values, and a mapping relationship is established between the three spinal postures to construct a good posture recognition model to achieve the accurate recognition of the three spinal postures: normal, right bend and left bend.

The construction of the spine posture recognition model based on SVC requires the training of the recognition model first, then the selection of a better model through the verification set, and finally the use of the test set to evaluate the performance of the model. Fifteen participants underwent 12 times of dynamic trunk flexion and extension with three spinal postures, and 540 sets of experimental data were obtained, among which 480 sets were used for training the model and 60 sets were used for testing the model. In the training process of SVM model, the data sets were divided by five-fold cross validation. The SVC model construction process is shown in Figure 4.

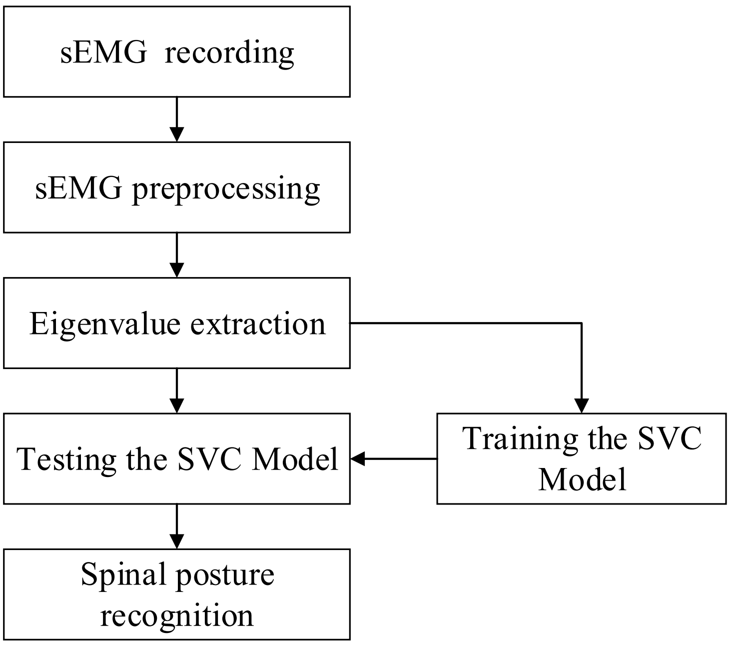

Fig 4. SVC model flow chart

3. Results and Conclusion

The SVM model can distinguish the normal, right bend and left bend posture of the spine, and the recognition accuracy rate is more than 89%, the recognition results are good, which shows the feasibility of surface sEMG and ML applied to the auxiliary diagnosis of scoliosis, this study has important reference value in the diagnosis of scoliosis and the exploration of etiology. The existing research is still insufficient, because :1) Fifteen participants, narrow age distribution, small number of participants, follow-up work to expand different age groups of participants for experiments, to ensure that the data sample information is sufficient; 2) Although the spinal pose recognition model is well trained, there is a lack of experimental data experiments for scoliosis patients to verify the subsequent auxiliary diagnosis hypothesis.

In future work, we aim to further improve the existing work by completing the collection of information on patients with scoliosis, which is expected to provide objective evidence for diagnostic screening, prediction of spinal curve progression, and evaluation of rehabilitation programs.

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