Fundamental study for the restoration of the body movement by Functional Electrical Stimulation (FES)
- EMG Analysis of the rolling-over motion -

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ABSTRACT

A method in order to restore the body movement by means of Functional Electrical Stimulation (FES) was considered. Multichannel EMG signals from a normal subject during the rolling-over motion were measured and analyzed. The results of the experiment indicated the synergetic role of the muscles during the desired motion.

INTRODUCTION

The patients with upper motor neuron disorders, caused by cerebral apoplexy or spinal cord injury, must be confined to beds for long time on account of their paralyzed body. There was no reasonable medical method to restore motor function of their body, but we have the really powerful and efficient method, i.e. Functional Electrical Stimulation (FES). The portable 30 channel FES system and very flexible multi-strand percutaneous electrode were developed[1,2], and official permission was issued for their clinical usage from the Ministry of Health and Welfare of Japan. They are now commercially available in Japan from March, 1991. We could realize to restore the hand or elbow function of the quadriplegics[3], or the locomotion of the paraplegics[4] by using the FES technique. By contrast with the application to the upper or lower extremities, the technique has not been widely applied to the body movement control.

In order to restore the movement by FES, the stimulation pattern data must be created beforehand. However, the restored motion by the data which was created through trial and error is rarely identical to the motion of normal subjects, and it seems awkward and needs more coordinated activation of muscles for the expected motion. To make the restored motion more physiologically, we would analyze the motion of normal subjects, and understand how persons activate their muscles for the desired motion through the EMG analysis. After that we could create better data, and achieve the restoration of motor function of extremities[3]. We have followed the similar procedure for the restoration of the body movement. In this paper we would like to report the fundamental EMG analysis and consider the restoration of the body movement by means of FES.

ROLLING-OVER MOTION

Since the patients can hardly move their bodies, they suffer severe bedsores (decubitus). The rolling-over motion is effective to prevent bedsores, but it requires the help of nurses or others. If the patients can perform the rolling-over motion without helpers, the workload of their helpers will be lightened, and the efficiency with which the patients are cared for may be improved. Hence in this study we measured the EMG signals from a normal subject during the rolling-over motion as the body movement[5-7].

A normal subject performed the rolling-over motion from the supine

position to the lateroabdominal position. The sequence of the motion was constructed of three phases as follows: 1) the flexion of the lower extremity, 2) the rotation of the waist, and 3) the rotation of the chest. Multichannel EMG signals were measured simultaneously by the bipolar method with percutaneous electrodes inserted into the muscles. After recording they were amplified, full-wave-rectified, and smoothed (time constant was 1 sec).

RESULTS & DISCUSSION

We obtained valuable data to achieve the rolling-over motion by FES through the analysis of the EMG signals. For example, the activity of the obliquus externus abdominis (left), the rectus abdominis (left), the erector spinae (right), and the quadratus lumborum (right) had the similar pattern during the rolling-over motion, i.e. they increased in the first phase, had a high peak and followed by a constant level in the second phase, and decreased in the third phase. These muscles are located at the same or symmetrical positions relative to the axis of the body. Hence these results indicated that they seemed to play the synergetic role for the twisting of the chest and the waist, such as the rolling-over motion.

The characteristics mentioned above can be useful to the data compression technique during the creation process for the stimulation pattern data of FES, or to the simplification of the stimulation system. The knowledge will be also applicable to the strengthening the muscles as Therapeutic Electrical Stimulation (TES).

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