Development of Biofeedback Device for Improvement of Muscle Endurance Using Muscle Fatigue Index

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***Abstract*— In recent years, the age of the population has increased, and the aging of the population has increased. Besides, the cost of disease prevention and personal medical expenses are increasing in Japan. From this, older people are required to have physical strength and walking ability to live as much as possible. In elderly people, walking movement becomes inadequate because movement disorder and muscle strength decline with age, and walking in daily life become difficult. Therefore, the promotion of walking and the recommendation of light exercise have been made to prevent muscle weakness in the elderly. In the current elderly people are electromyography analyses to muscle fatigue. We are examining fatigue by MPF, and there is no device to analyze the condition in real time and feedback on the condition of fatigue. This study aimed at "Development of a biofeedback device based on muscle fatigue."**

***Keywords*— biofeedback devices, Electromyogram, Muscle fatigue**

I. INTRODUCTION

In recent years, with the declining birthrate and the aging of the population, sufficient support cannot be provided to the required assistance and carers due to an increase in the number of required assistance and carers, and the burden of medical expenses on the country further increases. The increase in preventive expenses and the burden of medical expenses on individuals are increasing in Japan. From this, elderly people are required to have physical strength and walking ability to live as much as possible. Elderly people are walking movement becomes inadequate because movement disorder and muscle strength decline with age, and walking in daily life becomes difficult. Furthermore, elderly people are a risk of easy to fall accident due to the decrease in balance. Therefore, at present is recommended to promote walking and exercise light to prevent muscle weakness in the elderly.

Skeletal muscles that move the human body are roughly divided into fast-twitch muscle fiber(Type II muscle fibers) and slow-twitch muscle fiber(Type I muscle fibers). Type II muscle fibers can cause strong muscle contraction, but resistance fatigue is low, and the duration is short. Also, Type I muscle fibers shrink slowly, but resistance fatigue is present, and duration is longing. Furthermore, although skeletal muscle atrophy with age, it is said that the loss of Type II muscle fibers, in particular, is large and it is impossible to move quickly. Therefore, resistance training for Type II muscle fibers is said to be effective in training elderly people. However, although resistance training is effective as a prescription for exercise for healthy elderly people who exercise regularly from a normal level, injuries and accidents are more likely to occur in elderly people with lack of exercise and weakness it is conceivable that.

Elderly people who do not exercise regularly, extend the duration of exercise while considering fatigue rather than training aiming to improve muscle strength, and gradually increase the amount of training among them and type I It is necessary to increase fibers. Besides, the training of muscle endurance uses the “Aerobic energy supply mechanism” which is a feature of the type I fiber energy supply mechanism. There are two types of this aerobic energy supply mechanism, "citric acid cycle" and "Electron transport chain." In particular, the citric acid cycle (TCA cycle) is composed of oxygen and "glucose," "amino acid," "fatty acid" Produces energy (ATP). It is possible to create a body by improving the type I fiber that is not easily fatigued, so the number of activity increases and QOL can be improved.

Therefore, elderly people and people of obesity are controlling fatigue and making it possible to exercise for a long time, and it is possible to create a situation where fatty acids are easy to burn. It is thought that it can prevent the complications caused by obesity in the elderly and adults by exercise. Muscle fatigue is said to occur when muscle exertion cannot exert muscle power according to individual requirements. Muscle fatigue is classified into peripheral muscle fatigue and central muscle fatigue. In peripheral fatigue, it is affected by energy exhaustion, and it is mentioned that the performance of muscles decreases in the repetition of a short time. Central fatigue may be caused by a decrease in alpha motor neurons in the brain. The target of this study is to measure local muscle fatigue for peripheral fatigue in order to focus on muscle endurance(1).

The characteristics of local muscle fatigue are said to cause fatigue when the concentration of glycogen depleted and the metabolite lactic acid rises above a certain level. There have been many analyses of local muscle fatigue to date. The estimation method of fatigue accumulation and recovery status is the comparison of performance test before and after exercise, urine test, blood test, exhalation gas, blood lactate concentration, and electromyogram comparison. Tests compare many of these tests before and after exercise, and most of them cannot be measured during exercise. Furthermore, muscle fatigue may be measured by methods such as lactic acid, blood oxygen saturation, muscle sound, and electromyography.

However, in the current measurement, it is general to analyze after the end of exercise without feedback in real time. Also, there is various frequency analysis as an analysis method of muscle fatigue of EMG. Methods include

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measuring superimposed M waves induced by electrical stimulation during regular voluntary contraction exercise, comparison of mean power (Mean Power Frequency: MPF) or Median power frequency (MF), measurement of muscle fiber conduction velocity, and the like(2)-(4). Most of the general training equipment are devices based on the respiratory system such as treadmills and bicycle ergometers, and there is currently no training equipment based on muscle fatigue. This is because many studies using heartbeats that are easy to measure have been conducted because of measurement methods. However, analysis methods for feedback in real time have not been established. Also, muscle fatigue measuring devices have been studied, but they have not been established as devices(5)-(7).

So, this study aims at "Development of biofeedback device for improvement of muscle endurance based on muscle fatigue."

II. BIOFEEDBACK DEVICE SYSTEM

Planned development system has been presumed each joint part of a body by 3D analysis, acquires a location coordinate by fixation time interval it by a CSV format using depth indicator (intel company, D435i). The phase of each part and the movement of a human body are analyzed based on an acquired location coordinate. To presume linear fatigue by this research, the muscular activity moving using the EMG is measured. Electromyography (Furusawa Labo Co., Ltd.) was derived from the muscle belly of the biceps brachii using the skin surface bipolar induction method.

The outline of the system that depth indicator was combined with the EMG is indicated in figure 1. It is input to PSOC (Cypress Semiconductor Corporation) through an amplifier from the electrode as shown in a figure. It is input to a PC through a filter from PSOC. It is analyzed together with data of depth indicator, and the price of the degree of fatigue and MPF is shown to a display. Later, figure 2 indicated an analysis of muscle fatigue and flow until indication. First, the EMG is taken in by 800Hz. The bandpass filter has from 400Hz from 20Hz. The data is then subjected to frequency analysis. Besides, the time window is determined by calculating the movement time of muscle flexion by 3D analysis. After the time window is determined, the data is frequency analyzed to calculate the power spectrum graph. The MPF value is calculated from that value and used as an indicator of fatigue. This device displays the change of the value graphically and displays the change in color. Fig. 3 shows the acquisition scene of EMG and the experimental scene of its analysis. Currently, it has become possible to acquire EMGs and analyze and display them. In the future, we plan to synchronize with the depth gauge, set the time window, and display in time series.

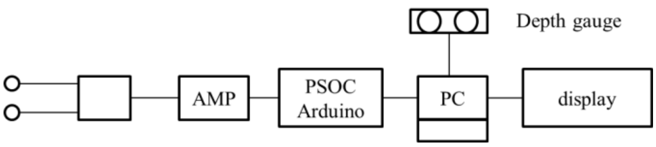


Figure 1 Equipment overview

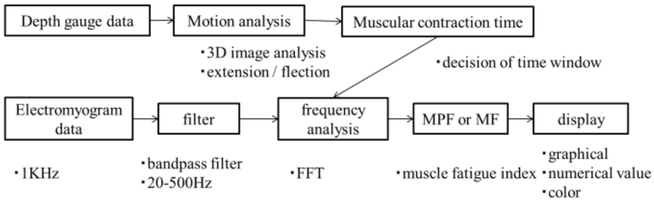
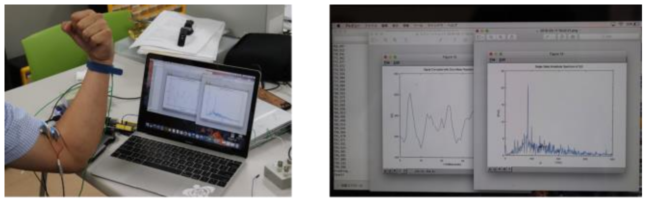


Figure 2 System overview



Acquisition of EMG

Real-time frequency analysis
【In development】

Figure 3 Acquisition scenery of electromyogram and experiment scenery of the analysis

III. CONCLUSION

In this research and development, we developed to estimate muscle fatigue in real time and perform biofeedback. In this study, it became possible to measure fatigue in real time using EMG. Also, it was possible to measure muscle activity in real time by measuring the operation time when determining the time window of FFT with a depth gauge. Besides, it is thought that this study will help to improve muscle endurance by examining the movement and fatigue level in real time.

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