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Study of Bio-Feedback Signal Analysis Algorithm Associated with the Development of the Low-Frequency Face Muscle Motion System

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Abstract: In this study, the bio-feedback to prevent the overuse of the low frequency stimulation was studied in the method of using the parameters of the EMG. First of all, before you start the low-frequency stimulation at the position of the face of the electrode to measure the EMG signal during muscle contraction. Observe the measured EMG signals and records the extracted parameter values. After stimulation of the face of the subject in low-frequency stimulation that lasts a certain period of time (up-30 sec) by observing the EMG signal to extract the parameter values. In the present study, the EMG before adding the low frequency stimulation to the mask face, measured normal contraction, EMGs when facial muscles are paralyzed can't be actually measured and only thought tends to shrink the appropriate facial muscles based on the virtual paralysis muscles protocol presented in this study, actually without shrinkage was measured EMG. Result of comparison of parameters used for the feedback to the subject 17 men and women subjects is as follows. Parameter RMS EMG measured under the assumption of a virtual paralysis muscles, decreased than normal systolic RMS average to <50% there was a statistically significant difference. Virtual paralysis muscle EMG parameters were measured under the assumption of ZCR has been increased by more than the normal shrinkage ZCR a portion was reduced. Also, there was a statistically significant difference. Paralyzed muscles because it does not actually contracted, the protocol of the virtual paralysis muscle is effective for selection of parameters for bio feed back to prevent excessive least low frequency stimulation, practical things considered.

Key words: EMG, parameter, low frequency stimulation, RMS, facial mask, frequency

INTRODUCTION

Functional electrical stimulation in the treatment method using electrical stimulation, functional neuromuscular stimulation, therapeutic electrical stimulation and a number of methods such as low frequency stimulation is used, muscle strengthening, pain relief, rehabilitation, therapy, etc., electrode stimulation is used in various fields. Low frequency transcutaneous electrical nerves stimulation therapy helps to relief, recovery and run through a weak low-frequency massage on the human body directly stimulate the muscles that promotes blood circulation and soothe the nerves to the muscles. Physiological activity of muscles, promotion of blood circulation, lipolysis effect to induce reduction of the near spasms, enhances the functionality of the cells an effect of relieving muscle pain. Expansion of personal medical devices using low frequency is increasing. This market is expanding by giving a significant impact on the market cosmetic products is released suddenly. Pain was improved by using a low frequency as well as the clinical validation of the anti-wrinkle effect using the equipment of the anti-wrinkle cosmetic devices is a reality that relies on expensive imported products (Nozomu, 2003; Kim *et al*., 2003).

In particular, the use of low-frequency stimulation in order to eliminate the stress and pain but is universal, there is no product to bio-feedback system has been applied. Therefore in this study, wrinkle improvement of to study the bio-feedback signal analysis algorithms necessary for the development of the mask system of the low-frequency face for application to the beauty of the skin.

MATERIALS AND METHODS

System configurations: A control system composed of a target subject for this study is illustrated in Fig. 1. Subject is intended for people who want to transdermal low-frequency stimulation there is a function of improvement and pain suppression of the blood circulation of the face. The control system uses the parameters of the EMG measured from the subject for bio-feedback to be able to prevent the excessive use of

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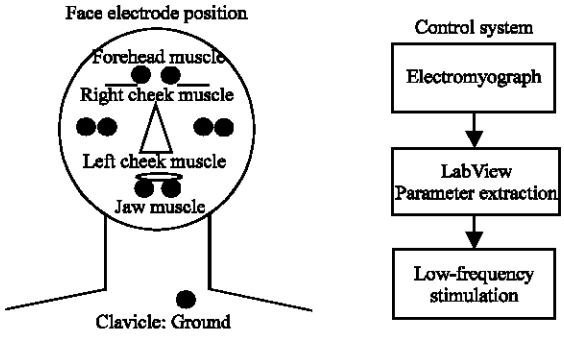

Fig. 1: Face electrode position feedback control and control system configuration

the low-frequency stimulation of facial transdermal position of the electrodes for EMG measurements grounded as shown in Fig. 1 is a clavicle, muscle forehead, the right and left sides of the cheek muscle, a jaw muscles (Eom *et al*., 2000).

Experimental method: Process for preventing excessive use of low-frequency stimulation of facial transdermal is as follows. First of all before you start the low-frequency stimulation at the position of the face of the electrode to measure the EMG signal during muscle contraction. Observe the measured EMG signals and records the extracted parameter values After stimulation of the face of the subject in low-frequency stimulation that lasts a certain period of time (up-30 sec) by observing the EMG signal to extract the parameter values (Shin *et al*., 2013).

Parameter extraction: Surface electromyogram measured at the site of muscle, through some politics analysis, since, it can be clinically useful utilized. In this study, we want to use the parameters extracted from the EMG of the subject for biofeedback that can prevent excessive use of low frequency stimulation during treatment.

In the parameters of the EMG have been classically extraction, iEMG (Integrated EMG), RMS (Root Mean Square), ZCR (Zero Crossing Rate R) MDF (Median Frequency) there is such as MPF (Mean Power Frequency). The formula for each parameter of the above is as follows:

$$iEMG = \frac{1}{N}(x+a)^n = (x+a)^n = \sum_{n=0}^{N-1}|x(n)| \quad (1)$$

$$RMS = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1}x^2(n)} \quad (2)$$

$$ZCR_{(q=0...N)} = \begin{cases} ZCR+1: x(n-1)\times x(n) \le 0 \\ ZCR+0: x(n-1)\times x(n) > 0 \end{cases} \quad (3)$$

$$\frac{\sum_{f=0}^{MDF}P(f)}{\sum_{f=0}^{\frac{Fs}{2}}P(f)} = \frac{1}{2} \quad (4)$$

$$MPF = \frac{\sum_{f=0}^{\frac{Fs}{2}}fP(f)}{\sum_{f=0}^{\frac{Fs}{2}}P(f)} \quad (5)$$

P (f) is the power spectrum of the EMG signal x(n) at the frequency f Fs is the sampling frequency. EMG, RMS and ZCR the above parameters can be extracted directly from the electromyogram signal x(n). However, MDF and MPF may be after the calculation of the power spectrum P(f) of the electromyogram signal x(n) is extracted. In addition, iEMG and RMS, reflecting the degree of muscle contraction and muscle tone, ZCR, MDF and MPF reflects the degree of fatigue information of muscle. The power spectrum of the EMG signal reflects the muscle fatigue because it represents the conduction velocity of the muscle fibers (Lee *et al*., 2015).

Statistical comparison of the parameter: Excess facial muscles when the muscles paralysis occurs shrinkage transdermal low frequency stimulation of the face because impossible, direct parameter that may indicate a characteristic of EMG during shrinkage and non-contractile in trying to use the RMS and ZCR.

Further, since, it is impossible to actually measure the EMG when the amount muscle can occur when an excess of the low-frequency stimulation of the facial transdermal, left cheek muscle, right cheek muscle and Jaw muscles were paralyzed in this study, using the virtual paralysis muscle protocol as follows (Choi *et al*., 2016):

- It is only thought to try to shrink the corresponding facial muscles
- In fact it does not shrink

The parameters and time parameters contraction of the plurality of measured with the appropriate muscles in accordance with the virtual paralysis muscles protocol electromyogram signals, used for biofeedback compared with each other if there is no statistically significant difference can do. Therefore, we compared the parameters of the subject in the match set t-test in the comparison method of statistics (paired t-test). The reference of significance was set at $p<0.01$ (Kanchana and Menaka, 2015; Cho *et al*., 2015).

RESULTS AND DISCUSSION

Experiment subjects and parameter extraction: Subjects who participated in the experiment was to target a total of

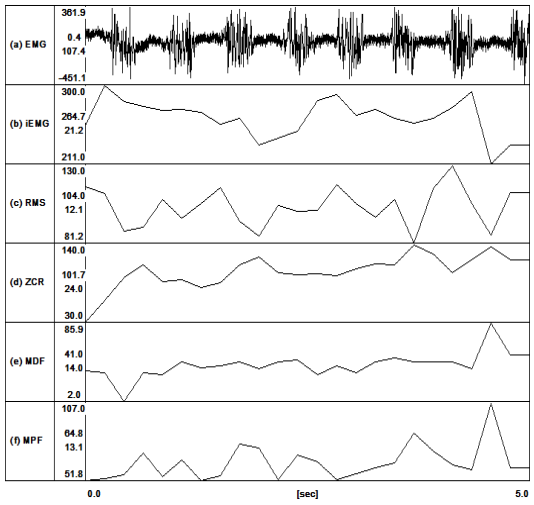

Fig. 2: The extracted parameters from the repeated contraction of the right EMG signal cheek muscle

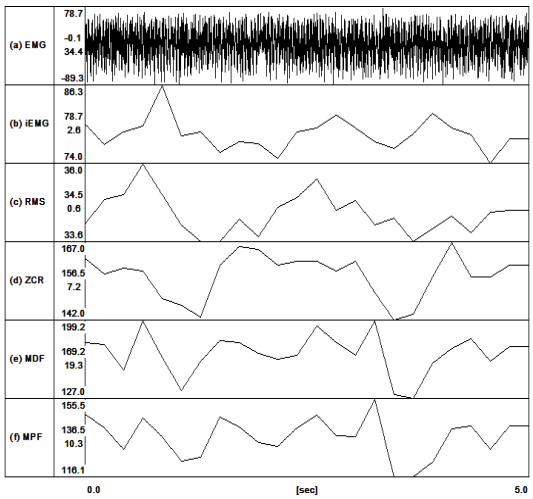

Fig. 3: The extracted parameters from the non-contraction of the right EMG signal cheek muscle

17 people with 12 people and women 5 men of 21-43 years of age is not a disease of the muscles. And in the case where the muscles of the corresponding face from each subject to contract normally if you have not contracted on the basis of the virtual paralysis muscle protocol is to measure each EMG signal from the EMG signal It was extracted parameters.

Figure 2 and 3 show the parameters extracted from the muscle contraction state and the non-systolic EMG signal of the face. (A) of Fig. 2 is a facial muscle contraction during the Electro Myography Signal (EMG) is between the minimum -451.1 maximum 361.9, the RMS of (c), the EMG signal (a), mean (standard deviation) is 104.0 (12.1),

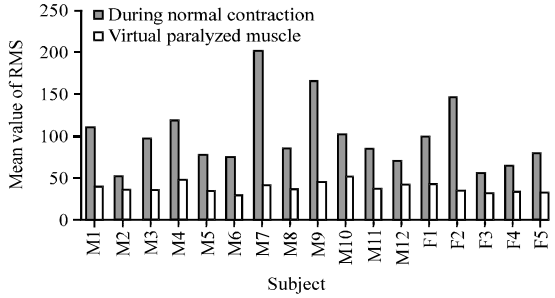

Fig. 4: Comparison of the RMS non-shrink to normal muscle contraction and the virtual paralysis of the forehead muscle

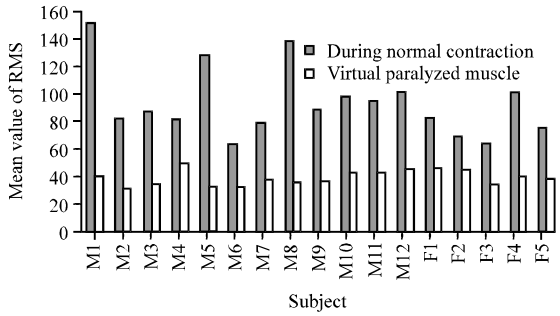

Fig. 5: Comparison of the RMS non-shrink to normal muscle contraction and the virtual paralysis of the right cheek muscle

(d-) is a ZCR, mean (standard deviation) is 101.7 (24.0). On the contrary (a) in Fig. 3, during the non-contraction of facial muscles that is electromyography signal of a virtual paralysis muscle (EMG) is between the minimum -89.3 up 78.7, (c) the average of the RMS EMG signal (a) (standard deviation) is 34.5 (0.6) (d) is a ZCR, mean (standard deviation) is 156.5 (7.2).

Therefore, the parameter RMS of muscle contraction during the EMG signal of the face is large but contrary parameters ZCR than during the non-contraction of the virtual paralysis muscle, it is smaller than the non-contraction of the virtual paralysis muscle an excess of low-frequency stimulation you can know the possibility of a feedback parameter to prevent.

Parameter comparison: Figure 4-7 is forehead muscles of the facial muscles, respectively, left cheek muscle and when the subject all the right cheek muscle and Jaw muscles was successfully shrink, the parameters RMS when not contracted on the basis of the virtual paralysis muscle protocol a comparison.

In Fig. 4, each subject as a percentage of non-systolic RMS virtual paralysis muscle on the forehead near systolic RMS was reduced by an average 38.2% up to

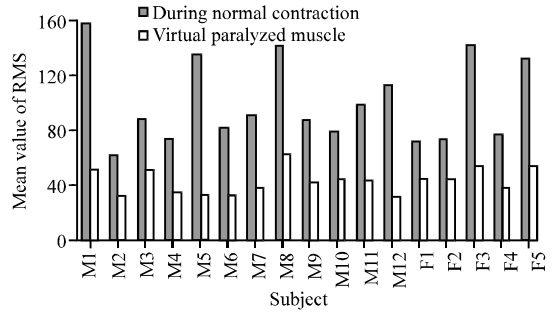

Fig. 6: Comparison of the RMS non-shrink to normal muscle contraction and the virtual paralysis of the left cheek muscle

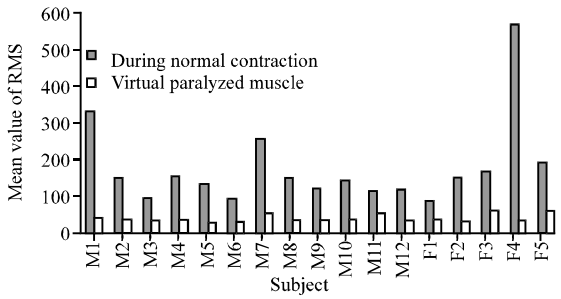

Fig. 7: Comparison of the RMS non-shrink to normal muscle contraction and the virtual paralysis of Jaw muscle

20.6-68.0%. As a result of the matching sets t-test between them there was a significant difference ($p<0.01$).

In Fig. 6, each subject as a percentage of non-systolic RMS virtual paralysis muscle of normal systolic RMS of left cheek muscle was reduced by an average 43.0% up to 24.4-62.7%.As a result of the matching sets t-test between them there was a significant difference ($p<0.01$).

In Fig. 7, each subject is a non-shrink when the ratio of the RMS as a virtual paralysis muscle of normal systolic RMS of jaw muscle was reduced by an average 22.1-5.8-47.7%. As a result of the matching sets t-test between them there was a significant difference ($p<0.01$).

Figure 8-11 is forehead muscles of the muscle of each face, left cheek muscle and when the subject all the right cheek muscle and jaw muscle was successfully shrink, parameters when you do not have contracted on the basis of the virtual paralysis muscle protocol ZCR a comparison of the.

In Fig. 8, each subject as a percentage of non-systolic ZCR virtual paralysis muscle on the forehead near systolic ZCR up 115.9-1015.8% it was increased by an average of 215.2%. As a result of the matching sets t-test between them there was a significant difference ($p<0.01$).

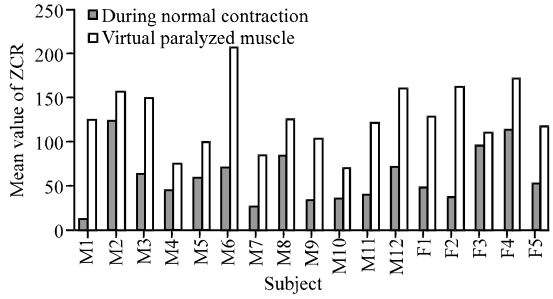

Fig. 8: Comparison of ZCR non-shrink to normal muscle contraction and the virtual paralysis of the forehead muscle

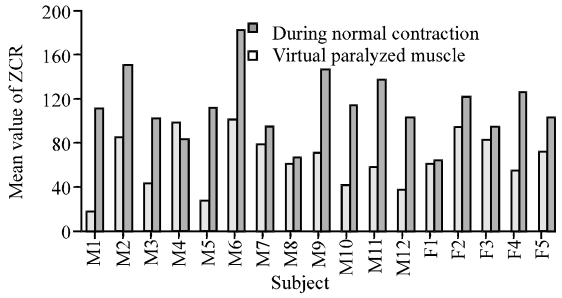

Fig. 9: Comparison of ZCR non-shrink to normal muscle contraction and the virtual paralysis of the right cheek muscle

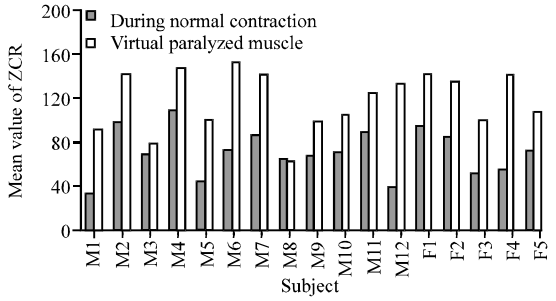

Fig. 10: Comparison of ZCR non-shrink to normal muscle contraction and the virtual paralysis of the left cheek muscle

In Fig. 9 each subject as a percentage of non-systolic ZCR virtual paralysis muscle of normal systolic ZCR of right cheek muscle up to 84.6-628.2% it has changed an average 176.5%. As a result of the matching sets t-test between them there was a significant difference ($p<0.01$).

In Fig. 10 each subject as a percentage of non systolic ZCR virtual paralysis muscle of normal systolic ZCR left cheek muscle up to 96.9-346.9% has changed an average 167.5%. As a result of the matching sets t-test between them there was a significant difference ($p<0.01$).

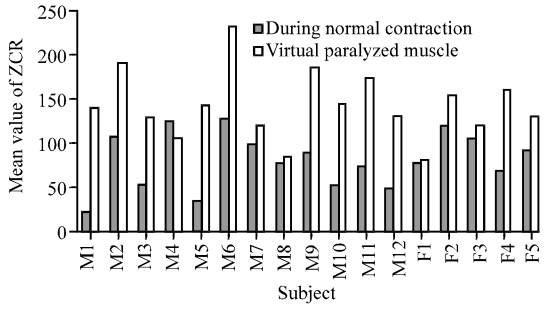

Fig. 11: Comparison of ZCR non-shrink to normal muscle contraction and the virtual paralysis of Jaw muscle

In Fig. 11 each subject is the proportion of non systolic ZCR as a virtual paralysis muscle on systolic ZCR of jaw muscle varied average 2.123.3% up to 91.3-47.7%. As a result of the matching sets t-test between them there was a significant difference ($p<0.01$).

Perverted Fig. 4-7, the results of comparison of the RMS of facial muscles to the non-shrinkage during RMS decreases as the virtual paralysis muscle than in RMS normal contraction it was confirmed that statistically there is a significant difference. Moreover, Fig. 8-11 results of a comparison of muscle ZCR facial, uncontracted during ZCR is varied as a virtual paralysis muscle than the normal shrinkage ZCR but it was confirmed that statistically there is a significant difference, the RMS to reduce all as, the parameters used for feedback, since, no ZCR also increased all scheduled it was possible to know that is inappropriate. Therefore, appropriate parameters for the low-frequency stimulation biofeedback was confirmed to be RMS.

CONCLUSION

In this study, before applying a low-frequency stimulation of the facial mask EMG it was measured during normal contraction. Since, the electromyogram when the facial muscle paralysis in this study can actually be measured only the idea of contraction of the facial muscles according to the protocol of the virtual muscle paralysis and electromyogram were measured without actually shrink. Result of comparison of parameters used for the feedback to the subject 17 men and women subjects is as follows.

Parameter RMS EMG measured under the assumption of a virtual paralysis muscles, decreased than normal systolic RMS average to <50% there was a statistically significant difference.

Virtual paralysis muscle EMG parameters were measured under the assumption of ZCR has been increased by more than the normal shrinkage ZCR, a portion was reduced. Also, there was a statistically significant difference.

In conclusion in order to prevent an excess of low frequency stimulation, the parameters of the EMG to be used in bio-feedback it was confirmed that the RMS. In other words, under the assumption of a virtual paralysis muscle, it showed a tendency to decrease specific EMG parameters gun moths, consistently than normal contraction. In contrast, the parameter ZCR is there was a statistically significant difference and the parameters ZCR of EMG was measured under the assumption of a virtual paralysis muscle or increased, some of the in order to decrease. It did not show a tendency consistent as RMS.

In this study, instead of actually measuring the EMG of paralyzed muscles with the protocol set of virtual paralysis muscle, it was compared with the EMG parameters of the normal contraction. Therefore, it is necessary to experiment targeted a subject facial muscles are paralyzed, however, paralyzed muscles because it does not actually contracted, the protocol of the virtual paralysis muscle is effective for selection of parameters for biofeedback to prevent excessive least low frequency stimulation, practical things considered.

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