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Review article

Electromyography (EMG): A bio-medical technique used for acquiring data during mastication of food

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ABSTRACT

The main objective of this study was to understand the technique of Electromyography. In this technique activities of muscles were governed on the basis of generated my electrical signals. Electromyography instrumentation consists of data acquisition unit, Universal interface module, Connector, adaptor and software. Various parameters like chew number, mastication time, total burst duration, total muscle activity, burst duration, inter burst duration, cycle time, muscle activity and amplitude were used for analysing the data acquired during mastication of food at entire mastication, per chew and at three different stages (early, middle and late) of mastication.

Keywords: Electromyography, Universal Interface Module, Mastication, Signals

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INTRODUCTION

Electromyography (EMG) is the technique which is used for the detection and analysis of mayo electrical signals which are produced during activation of muscles by flow of ions across the cell membrane. Due to the movement of ions there is generation of small electrical current which are detected with the help of electrodes. In mastication, masseter muscles of mouth were used for obtaining and recording the data. For qualitative as well as quantitative analysis, the signal to noise ratio should be minimum i.e. noise in the background must be attenuated, so that more information should be obtained from the signals. The signals must be amplify maximum, so that various mastication parameters will be studied from them accurately. This must be achieved by using combination of amplifiers, filters, hardware, software and digital signal processing.

Electromyography- mp 150 system

During muscle activation, for acquiring data and their analysis MP150 systems with Acknowledge software is one of the important parts of EMG instrumentation. The MP System is a computer-based data acquisition integral part of EMG instrumentation. It performs same functions as like any other data output device in terms of their pictorial form. It is in its advance stage as it resolves the physical limits such as paper width or speed associated with them [1]. The MP150 system through AD Converter change the incoming analogue signal into digital signals, which are then process through various methods for their analysis. Interface modules were also used for recording audio signals.

The MP150 system is either attached to the computer via Ethernet adaptor for single access or through switch box with adapter in case of multiple to make the accesses of the system compatible with computer window [2] .Multiple channels are used for recording the data at variable rate for maximizing the storage efficiency of the system.

The setup of EMG instrumentation is one of the major steps for obtaining and recording the data. For acquisition and storage of EMG data MP150 system uses digital computers. Signals were viewed i.e. display on the screen and measured accurately by maintain the gain and sweep speed. Electromyography is an instrument from which we obtain EMG signal while the record is called electromyogram. During signal processing using amplification of the analogue signal and ADC (analogue-to-digital converter) at defined time interval assigns a digital value to the signal amplitude [3]. In experimental as well as in controlled setup, for data acquisition the setting must be same. MP-150 System consists of following parts:

Data Acquisition Unit (DAU)

The data which is acquired through DAU is the most important component of the MP150 System. The internal microprocessor which is present inside MP150 controls the data acquisition and data communication. An external trigger is with 16 analogy input channels and 2 output channels [4]. The digital lines can be programmed in such a manner that all of them function as either inputs or outputs in block with 8 channels. Each block with its I/O lines programmed in such a manner that either all of them work as inputs or

as outputs, independently of other block.

Universal Interface Module

UIM100C is behaving like a bridge between the MP150 and external system. At input side UIM100C is used to bring pre-amplified and digital signals input to the MP150 unit while it is connected to the electromyogram at output side. The UIM100C is designed in such a manner so that it may serve as common interface to various types of equipment present in the laboratories. At the input side UIM100C is compatible with various types of input devices. In BIOPAC Systems, UIM100C is connected directly to analog signal connectors through series of cables. The UIM100C and the MP150 acquisition unit are connected to each other with the help of two cables, one for each i.e. for analog and digital signals [5].

Ethernet connector, cable and adaptor

Ethernet connector connects a high speed network with the help of USB port. The adapter's attach with USB ensures high speed of network without any disturbance. There are two types of Ethernet cable used in the EMG instrumentation [6]. One is used to connect the MP150 system with an Ethernet Switch which is further connected to a local area network while other one is used to connect the MP150 system with an Ethernet.

Acknowledge Software

Acknowledge (Biopac Systems Inc.) is advance version software which acquired and analyzed and stores the data easily and performs data analysis at faster rate [7]. It performs various mathematical algorithms and statistical methodologies for obtaining the results. It generates the reports with in short time as copying the data from one place to another place is easy.

Working of Electromyography

Biological signals were recorded and analysed by electronic based diagnostic instruments. EMG instrumentation consists of various parts which includes, Surface electrode (to detect signals), Amplifiers (to increase the strength of signals), Filters (remove noise signals), ADC (Analog to Digital) converter and Software for analysis [1].EMG represents a graphical representation of the myoelectrical activity of the masseter muscles.

EMG machine is also used for the excitation of nerves and muscles which may generate various stimuli (electrical, visual or auditory). Trigger or stimulator was basically used as external devices which will generate the signals [2]. The raw signal were rectified and integrated to form a single waveform. With the help of surface electrodes, mayo electrical signals as well as noise were recorded and moved to the amplifier with the help of electrode cable through input side. These cables attached with the electrodes are mainly responsible for the creation of noise.

Thus for removing the unwanted noise differential amplifier were used. This will magnify the myoelectric signals several times and remove all the unwanted noise. There are several filters which help in the reduction of noise like analogue or digital filters [3]. Several algorithms like averaging, smoothing etc. were also used for the removal of attenuated noise. Various research have been conducted for noise reduction like development of advance and better algorithms, improvement of already existing methodologies and detection techniques and during acquisition of EMG signals [4].

EMG machine displays and measure the myoelectric signals. These signals were assessed with the help of sound of signal which may be generated either through analogue hardware or digital technology of computer. Various mathematical models like wavelet transform, higher-order statistics along with Artificial Intelligence techniques were used for signal processing [5, 6]. The signals which were generated and processed were finally analysed with the help of software.

Acquiring EMG data during Mastication of food

Subject was seated on straight backed chair (Figure 1) comfortably with position of face in opposite direction to the screen of computer system on which EMG display. This is generally done for avoid any chance of error which may be generated by human subject during mastication [8]. Prior to the experiments all human subjects were explained with the experimental set up of EMG, so that they feel familiar with the technique [9]. All subjects were familiarised with this EMG setup and we collect their consent before starting of the experiment in terms of consent form.

Figure 1: Human subject with bipolar surface electrode

All recordings were taken in silent room with same time of a day, so that all environmental condition becomes constant which otherwise bring about variations in the results. Before placement of the Bipolar surface electrodes (EL 503, Biopac system Inc.) [10] on the masseter muscles on both sides of the face, left and right, skin resistance was reduced by scrub the area with 70% alcohol using tissue paper [11]. The conductance of the test is also improved by use of pre gelled electrodes during the experiment.

The masseter muscles were identified while the subject clenched the teeth and then electrodes were placed 2 cm apart over this area. On left wrist of human subjects reference electrode was also placed [7]. Electrode position must be maintained throughout the

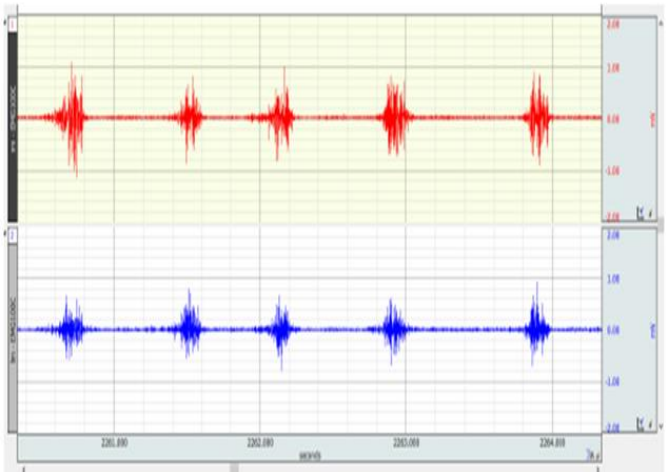
experiment by isolated the electrode circuit from patient during experiments otherwise electrode wires bring load on the electrode when placed on human subjects.

Food was kept for 15- 20 min. at room temperature after they are taken out from refrigerator, so that food was bringing to room temperature before it served to the human subjects. Five food items with two replicates were served to human subjects in random order along with control food which can be chewing gum or any one test food used to check the correct position of the electrode and base line which otherwise bring interference with the results. Certain time two to three initial recordings with control test food were omitted as during those trials subjects jaw movement adaptive with EMG experimental set up.

The subject took food sample by themselves and masticates them in normal habitual manner of chewing because impose chewing result in error [12]. Human subjects were asked to raise their right hand whenever they finished with swallowing. In between two food sample human subjects were allowed to drink some water, so that they rinse their mouth and no two recordings of different food shows any chance of error. For avoidance of muscle fatigue subjects were given with time interval of 2-3 min. in between two recordings. Each complete process of experiment with different food lasted for 15-20 minutes.

From both right and left masseter muscles EMG signals were recorded [9] (Figure 1), filtered (10-500Hz) with removal of noise at 50Hz caused by the power supply. The noise free signals were amplified (1000X) times using EMG 100C amplifiers (Biopac System Inc.). EMG signals (Figure 2) were saved on computer using MP-150 system (Biopac System Inc.) at 1000Hz frequency.

Figure 2: EMG recording for a food



Analysis of EMG Variable

EMG signals which were obtained as shown in Fig. 2 are studied and stored by using software (Acknowledge, Biopac System Inc.). EMG variables obtained for entire mastication, per chew and at three different stages (early, middle and late) of mastication were calculated**.** Early, middle and late stages are represented by first few chews, middle few chews and last few chews during mastication [7, 8]. Data generated from both right and left side during mastication and thus averaged before used for the analysis. The variables analysed for data acquired during mastication of food were as follows:

For entire mastication

Chew number, which represent the total no. of burst, before swallow which will be read directly.

Mastication time, the total time required for chewing of food, read directly (seconds).

Total burst duration, the sum of all burst duration (seconds)

Total muscle activity, the sum of all time integral of EMG voltage (milli Volt second)

For per chew mastication

Burst duration, time interval from the onset to the cessation of EMG activity at per chew (seconds)

Inter burst duration, duration between two burst (seconds)

Cycle time, sum of one burst and one inter burst duration (seconds)

Muscle activity, time integral of the EMG voltage (milli Volt second)

Amplitude, the peak to peak voltage (milli Volt)

For early stage of mastication (first few chews): Burst duration, Muscle activity and Amplitude.

For middle stage of mastication (middle few chews): Burst duration, Muscle activity and Amplitude.

For late stage of mastication (late few chews): Burst duration, Muscle activity and Amplitude.

CONCLUSION

Electromyography is one the upcoming and emerging non-invasive method which governs the bioelectrical potential of masseter muscles during chewing and thus provides real time information for mastication. Electromyography is used to explain various mechanical attributes of food for their texture analysis and perceptions. Electromyography tends to be a reliable technique if there protocols are standardized for acquiring and analysing the data during mastication of food.

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