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GENDER COMPARISON IN EMG AMPLITUDE DURING MAXIMAL VOLUNTARY CONTRACTIONS OF THE UPPER LIMB MUSCLES

TAN TIAN XIANG

Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Engineering in Mechatronics Engineering

Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

June 2016

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering in Mechatronics Engineering.

Signature :

Name of supervisor : DR. NIZAM UDDIN AHAMED

Position :

Date :

Signature :

Name of Co-supervisor : MR. WAN HASBULLAH BIN MOHD ISA

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Signature :

Name : TAN TIAN XIANG

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P-value	Probability value
R	Coefficient of Regression
R^2	Coefficient of Determination

LIST OF ABBREVIATIONS

ACL	Anterior Cruciate Ligament
BF	Biceps Femoris
CMRR	Common Mode Rejection Ratio
CoV	Coefficient of Variation
DOMS	Delayed Onset Muscle Soreness
EMG	Electromyography
FFT	Fast Fourier Transform
GUI	Graphical User Interface
iEMG	Integrated Electromyography
LE	Lumbar Extensors
LG	Lateral Gastrocnemius
MAV	Mean Absolute Value
MG	Medial Gastrocnemius
MNF	Medial Frequency
MPF	Mean Power Frequency
mV	milliVolts
MVC	Maximal Voluntary Contractions
MVIC	Maximal Voluntary Isometric Contractions

PM&R	Physical Medicine & Rehabilitation
QF	Quadriceps Femoris
RF	Rectus Femoris
RMS	Root Mean Square
sEMG	Surface Electromyography
ST	Semitendinosus
STD	Standard Deviation
TA	Tibialis Anterior
VL	Vastus Lateralis
VM	Vastus Medialis

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ABSTRACT

In earlier studies of Electromyography (EMG), many researchers used surface Electromyography (sEMG) to investigate the relationship between the EMG signal and the muscle activation among males and females. The purpose of this study is to compare the EMG amplitude on upper limb muscles (Biceps and Forearm) during maximal voluntary contractions (MVC) of isometric exercise between males and females. Ten right hand dominant (5 male and 5 female) subjects with different anthropometric characteristics participated in the experiment. The participants performed isometric contractions by gripping the hand dynamometer at 50%, 75%, and 100% of their MVC. This EMG analysis was carry through in the time domain by calculating the amplitude of the EMG signals in root mean square (RMS) and mean absolute value (MAV). The statistical analysis included linear regression to examine the relationships between the EMG signals (mV) and the force value exerted by males and females. The 2 sample t-test about the value of RMS and MAV with force value was performed in Minitab to test the significance among these variables. The calculation of mean, standard deviation and coefficient of variation (CoV) to describe the dispersion of the variables and the steadiness of the EMG signals between genders. The results disclose that the regression analysis of the EMG with the force exerted by male subjects (R^2 = 0.890, P-value < 0.05) during isometric contraction was greater than that obtained from female subjects (R^2 = 0.678, P-value < 0.05). In addition, the EMG signals generated by male forearm muscle (3.16%) express less variability than that generated by female forearm muscles (4.21%). This EMG data analysis results can provide useful information for the analysis and further study in the fields of medical research, rehabilitation engineering and health technology. Last but not least, this results is also contribute to the developing of prosthesis hand or robotic arm and the biomechanics movements of males and females.

ABSTRAK

Dalam kajian awal Electromyography (EMG), ramai penyelidik menggunakan Electromyography permukaan (sEMG) untuk mengkaji hubungan antara isyarat EMG dan pengaktifan otot di kalangan lelaki dan perempuan. Tujuan kajian ini adalah untuk membandingkan amplitud EMG pada otot anggota badan atas (bisep dan lengan) semasa pengecutan sukarela maksimal (MVC) senaman isometrik antara lelaki dan perempuan. Sepuluh tangan kanan dominan (5 lelaki dan 5 perempuan) subjek dengan ciri-ciri antropometri yang berbeza telah mengambil bahagian dalam eksperimen. Pengecutan isometrik dilakukan oleh para peserta dengan menggenggam dinamometer tangan pada 50%, 75%, dan 100% daripada MVC mereka. Analisis EMG dijalankan melalui dalam domain masa dengan mengira amplitud isyarat EMG dalam punca min kuasa dua (RMS) dan nilai min mutlak (MAV). Analisis statistik termasuk regresi linear untuk mengkaji hubungan antara isyarat EMG (mV) dan nilai daya yang dikenakan oleh lelaki dan perempuan. 2 sampel ujian-t mengenai nilai RMS dan MAV dengan nilai kuasa telah dilakukan dalam Minitab untuk menguji signifikan antara pembolehubah ini. Pengiraan min, sisihan piawai dan koefisien variasi (CoV) untuk menggambarkan penyebaran pembolehubah dan kemantapan isyarat EMG antara jantina. Keputusan mendedahkan bahawa analisis regresi daripada EMG dengan daya yang dikenakan oleh subjek lelaki (R2 = 0,890, P-nilai <0.05) semasa penguncupan isometrik adalah lebih besar daripada yang diperolehi daripada subjek wanita (R2 = 0,678, P-nilai <0.05). Di samping itu, isyarat EMG yang dihasilkan oleh otot lengan lelaki (3.16%) menyatakan kepelbagaian kurang daripada yang dihasilkan oleh otot lengan wanita (4.21%). Keputusan analisis EMG data ini boleh memberikan maklumat yang berguna untuk analisis dan kajian lanjut dalam bidang penyelidikan perubatan, kejuruteraan pemulihan dan teknologi kesihatan. Akhir sekali, keputusan ini juga memberi sumbangan kepada membangun tangan prostesis atau lengan robot dan biomekanik pergerakan lelaki dan perempuan.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Upper limb muscles are essential for human to carry out the daily activities which include upper limb movements, such as dressing, bathing, playing smart phone, lifting object and etc. Some people who undergo accident or tragedy may affect them loss of the physical ability to use upper limb muscle for simple movements. Physical Medicine and Rehabilitation (PM&R) that aims to restore the function ability and quality of life to those disabled or injured people, they improve the existing robotic system to assist physically handicapped people can perform simple daily activities. Electromyography (EMG) can analyse and study muscle movement through nerve cells that located in the nervous system and manipulate motor neurons, which deliver electrical signals in order to generate the required data for the use of development in robotic arm movement. There are differences in the complexity of the muscle strength between males and females,

thereby in creating of the robotic arm for different genders, many aspects need to be taken into consideration. For example, the force or torque of muscle movement which produce by different genders are different.

Males are more prominent in the muscle strength comparing with females and this will affect the electrical signal produced by males and females also differently. Therefore, a comparison in EMG amplitude during Maximal Voluntary Contractions (MVC) of upper limb muscle between genders was probed to collect the required data for further study. Maximal Voluntary Contractions (MVC) is the maximum force which can produced by a human during some specific isometric exercises such as hand press, wall push off and etc. During isometric exercises, the muscle length does not vary and the affected joint also does not shift. Isometric exercises can help in enhancing stabilization by maintaining the position of the affected area. For example, isometric exercise may help someone who had been injured to stabilize the shoulder in order to maintain shoulder strength during recovery. EMG amplitude can be determined by calculate the root mean square (RMS), mean absolute value (MAV), integrated EMG (iEMG) and wavelength over the same contraction period by using the raw data recorded from subjects and perform calculations inside the MATLAB in order to find the results of EMG amplitude.

Surface Electromyography (sEMG) is a technique for assessing the muscle function by which the surface electrodes are positioned on human skin overlying muscle to detect and record the electrical signal of the muscle. When a muscle contraction signal was disseminate from motor neurons across the groups of muscle fiber, electrochemical and electrophysiological processes are take place which generate an electrically

computable polarization event known as action potential. By placing surface electrodes on the skin, sEMG can detect the action potential signals from different muscle fibers and each action potential will produce a particular amount of energy in electrical signal. The contraction intensity of muscle is manipulated by how frequently the action potentials arrive and excites the groups of muscle fiber. When the more frequently of the action potentials arrive, the muscle will contracts more forcefully and the level of sEMG signal will increases. The advantages of sEMG over other types of EMG are it does not need to involve piercing the skin and the participants do not feel hurt when they take the sEMG experiment.

1.1.1 Electromyography (EMG)

Electromyography (EMG) is an electro diagnostic technique for recording and measuring electrical activity generated in skeletal muscles in order to prevent neuromuscular diseases. Normally, the muscle is electrically silent when it is at rest, but if the muscle is active or during voluntary contraction, there will be an electrical current is generated out. When a person contracts his or her upper limb muscle more forcefully, there will be more groups of muscle fiber in arm are recruited and activated then causing more electrical activity during EMG testing. Motor neurons are nerve cells that located in the nervous system which help to deliver electrical signals that make muscles to contract. The responsibility of EMG is to translate these electrical signals into graphs or numerical data for specialists to study and evaluate. An electromyography machine contains electrode and recorder to detect and record the muscle stimulation during contraction in order to help diagnose muscle and nerve illness. From the EMG results,

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