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Electromyography based analysis about ergonomic risk factors of upper extremity disorders

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Abstract — **Repeated movements of upper extremities cause to overuse injuries however, it is really challenging to determine which of them do so. Primary aim of the project is to determine the effect of different shoulder positions on gripping capability of hand and electro physiologic activity of upper extremity muscles. 23 case report data which have ages ranging between 18 and 30 are analyzed. According to our results, as the shoulder flexion increases, muscular activity and depending on this the muscular exhaustion also increases whereas the functional quality of hand decreases. The case is both a risk factor for an occupational disease and a situation that decreases skillful functioning of hands. For the next researches, advantages of exhaustion reducing apparatus and ergonomic systems, which can be used during works requiring over shoulder movements, are EMG results.**

***Keywords*—Ergonomy, electromyography, musculo skeletal disorder, overhead work, signal processing**

I. Introduction

It is known that repeated exercises of upper extremities result in extensive usage injuries however, it is really challenging to distinguish which of them do so. It is also known that 1/3 of the occupational disorders have not been classified yet. Therefore, application of evidence based healing and prevention approach gets more complicated (1). Upper extremity regions are mainly influenced from trauma and extensive usage injuries in terms of its functional importance. High level static contraction, working with static loads of long durations and with in appropriate posture causes the workers to have upper extremity disorders. Work related disorders are injurious disorders in which muscles, joints and ligaments are influenced badly from work dependent activities. A prevalent belief is that working above shoulder level results in upper extremity disorders. Working with long term shoulder elevation, causes the exhaustion of shoulder muscles therefore appearance of some disorders as a result (2, 3, 4).

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II. Material Method

This study is carried out with students of Gelişim University at Collage of Health Sciences. 23 voluntary healthy university students that have ages between 18 and 31 took part in the study. Signals of electromyogram and hand gripping which are analyzed in this project are recorded by busing BIOPAC system. Measurement from a single participant is saved as a single file and lasts for 8.5 min. Then this file is analyzed by the help of MATLAB program. During the procedure 15 gripping action was made, an algorithm is improved to calculate the instant of gripping. Inside the signal of gripping force, the points greater and lower the mean value are determined, and the points greater than the mean value are defined as gripping point. Then in order to increase the accuracy of algorithm the disconnections that are shorter than 3 seconds during gripping are connected, and gripping instants shorter than 3 s are eliminated. Root mean square values of electromyography (EMG) signals, corresponding to gripping instants, are calculated by the Formula below. Then the average value for 3 repeated gripping action values is calculated, lastly the entire process is repeated for each participant and the average value for the group is calculated. Thus results from 3 different channels in 5 different positions for each participant are compared by taking their RMS values into consideration.

In this study, the students: with an undergone muscular and skeletal disease causing neurological disability, with severe cardio pulmonary diseases, with high degrees of hearing loss, who experienced a surgical operations in last 6 months, who had epileptic seizures and who had chronic neurologic diseases were not involved.

Students who had hairy skin on arm were told to get them cut and before measurements arms of students were shaved. Before the measurements, participants were informed about main goals and procedure of measurement, gripping and resting durations, movement positions and repetitions. Before beginning the study, documentation of medical ethics was taken from Sadi Konuk Research Hospital local committee of ethics, and the project received approval from Gelişim University Administration; in addition each participant was provided with informed consent form. For the measurements, electrodes were placed with 0,5 cm intervals into: anterior fibers of deltoid muscle and motor points of hand wrist extensor and flexor muscles determined by a physiotherapist. Earthing electrodes were placed on ulnar styloid, olecranon and on forehead for these 3 muscle groups. Before starting the measurement hand gripping force unit was chosen as Ibs and EMG measurements were chosen at interval between 0 and 1000 mhz. Measurements are taken at 5 positions of which with 4 different shoulder angle and 1 standard hand grip force; with 3 repetitions of gripping for each. (7-9,11-13)

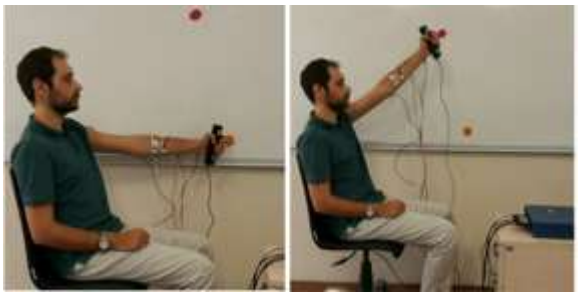

Figure 1 :Hand Grpping and Electro Myography Measurements

III. Results

In Figure – 2, RMS of all 3 channels and maximum gripping force of the dominant hand can be seen for 40 participants at different shoulder flexion degrees. The graph shows that, the greatest muscular activity in hand gripping is observed in extensor muscles. As the shoulder flexion angle increases activity of deltoid muscle increases at approximately two times greater rate. The hand wrist flexor muscles activity does not change dependent on the shoulder flexion angle. In Figure-3 changes of gripping forces for each participant in different measuring positions is present.

As a result, the most active muscles in performing the gripping action are the extensor muscles of hand wrist. This situation is satisfied in maximum shoulder flexion angle as well, but as the shoulder flexion increases deltoid muscle starts to take part. As the shoulder flexion increases, total muscular activity increases nonetheless the gripping force decreases. This case will be touched upon in evaluation part in detail.

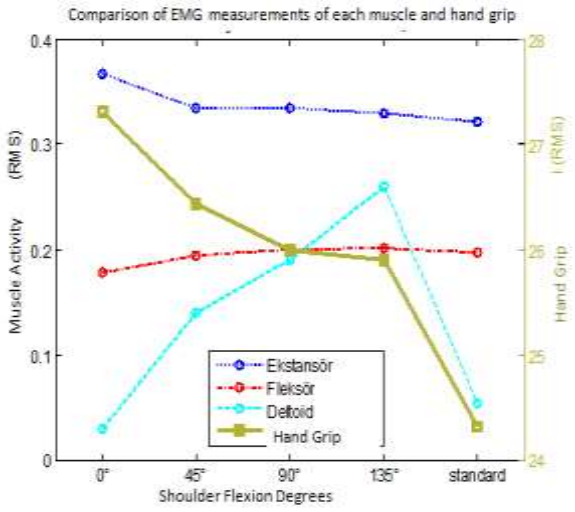

Figure 2 : Results of Hand Grpping and Electro Myography Measurements

I. Discussion

In previous researches, it has been shown that working out overhead level is a serious risk factor for upper extremity disorders. In our research, we focused on the change in upper extremity electromyography values and hand gripping force at different degrees of shoulder flexion. Our purpose in this study is to be able to observe the effect of overhead working on electrophysiology of upper extremity muscles and level of functioning of hand (1, 2).

Our study has shown that, working above shoulder level is the most exhausting position for upper extremity muscles and as the arm steepness in upright position increases the hand functioning deteriorates. According to this outcome, working overhead is a risk factor for work related upper extremity disorders, and the hand gripping force deteriorates as the upper extremity muscles exhaust to stabilize the arm in the upright position. Third result derived from our study is that, in addition to reaching and gripping the upper extremity muscles have a crucial third function which is stabilizing.

Won-GyuYoo and his friends investigated the effect of working out above the shoulder level on electrophysiologic muscular activity in their research. They described that working out overhead brings about exhaustion in superior trapezius muscle and causes shoulder joint discomforts by affecting the scapular position. In our research we found out that at shoulder flexion of 135°; activation of deltoid muscle, which is a shoulder region muscle, is reasonably high compared to that of other regional muscles. According to these results, it can be claimed that working overhead is exhausting to muscles that are directly and indirectly inserted to shoulder (2).

Haggand and his friends, in their electro physiologic research on hand gripping force, found out that hand wrist flexor muscles shows a greater exhaustion than extensor muscles during ghand gripping. Snijder and his friends, indicate that hand wrist extensor muscles display contractions against flexors muscles during gripping, therefore explained why extensor wrist muscles become more active during the hand gripping. In another biomechanical modelling, relationship between the hand wrist extensors and flexors is clarified by using the torque principle between hand and the wrist. Once in our research as well, in hand gripping at all shoulder flexion degrees and at standard hand gripping position hand wrist extensor muscles were more active. In our study we observed that extensor group muscles are crucial stabilizers for upper extremity. Whereas flexor muscles performing flexion of fingers for first part of the gripping, in fact hand wrist extensor muscles performed greater activity to stabilize the hand wrist. According to our study, upper extremity in addition to its two known functions, reaching and gripping, exert considerable energy for its stabilizing function (14). Gripping force is closely related to upper extremity muscular force. Shoulder joint provides stabilization during action of hand gripping so that motion takes place in the urged way. Shoulder flexion is the main movement of shoulder and frequently used in daily life activities. Therefore, in our research investigated is the way how this motion of shoulder joint influence gripping force. We did not encounter with any research investigating the relationship. In our research, the greatest hand gripping force was observed in 0° shoulder flexion position and depending on increase in shoulder flexion angle, it showed a reasonable decline (6, 5, 10, and 14).

According to this outcome of our study, upper extremity exerts force to rise up and stabilize the arm during the shoulder flexion as a result of this hand gripping force declines. Decline of hand gripping force depending on the increase in shoulder flexion increase can be interpreted as decline in hand functioning. In this regard, overhead work both causes exhaustion in shoulder muscles and prevents the effective functioning of hand. This situation is inconvenient in terms of both worker health and working efficiency.

Working over head is a crucial risk factor in terms of work related disorders. Since the worker cannot perform adequate hand gripping, both he exhausts more and the efficiency decreases. If the amount of effort exerted by the worker to stand his arm upright is lowered, then both an important risk factor for disorders will be reduced and efficient utilization of hand will be provided. This will bring about the acquisition of health, time and workforce. (1, 15)

According to our research, working overhead is a risky working position to which ergonomic solutions should be developed and it lowers the efficiency. In order to prevent the exhaustion of muscles and decline of hand gripping force, load carrying system may be used for the weight carried by worker hand. Moreover, it is recommended to have a rotation among the works for the overhead workers and to have intervention to protect upper extremity muscles such as protection exercises (16, 17).

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