# Anthropometric Home Office Computer Workstation Setup for Online Learning

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**Abstact :**Online learning is form of study which acquires vogue, both at undergraduate and graduate degrees. It comprises all forms of electronically supported learning and teaching. Therefore computer use highly involved in such learning programs. This study aims to design anthropometric home office computer workstation setup for online learners. Anthropometric measurements were collected from 10 respondents (7 male and 3 female) to design a home office computer workstation to reduce the perceived musculoskeletal discomfort. Electromyogram experiments – before and after intervention – ontwo different computer workstationswere conducted to find out the muscle groups exposed to pressure during online learning activities. Analysis of variance (ANOVA) results show that the design of computer workstation for online learners has validated impact on risk factors of musculoskeletal discomfort. Correlation analysis confirms that the relations between surface electromyogram (sEMG) activities in new design were less than those in the old design. Discriminant analysis shows that the classification scores were significantly reduced by the developed new computer workstation design. The significance of this study is to provide muscle discomfort reducing furniture and user-friendly interfaces during online learning. Such proper home office computer workstation is necessary to prevent strain injuries which can lead to long-term disabilities.

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## 1. Introduction

The effects of increasing advances in technology can also be seen in learning and teaching methods. Having the involvement of computers in education technology, new learning methods are evolving. Online learning has become a predominant form of higher education. It comprises all forms of electronically supported learning and teaching. Online learning is essentially the computer and network-enabled transfer of skills and knowledge. Therefore computer use highly involved in such learning programs.

Online learning is defined by the Institute of IT Training as "the delivery of learning with the assistance of interactive, electronic technology, whether offline or online". 'Electronic technology' at the present time includes the internet technologies such as email, web pages and conferencing, along with computer based learning tools and resources, computer-based assessment tools, and computer-based management systems such as virtual learning environments.

In online learning, various audiovisual equipmentis used and computer-based learning is the most common tool. Online learners access course content by using personal computers or laptops that can reach to their highest level of quality by using interactive communications between learners and teachers. Learning and use of computers are two main indivisible components that should be planned to fit together.

With increasing use of computers, musculoskeletal disorders and injuries have greatly increased. Improper use of computers and laptops can be a serious physical injury to the user even if the duration of use is less trivial. Finding correct exposure while using a computer can dramatically help to prevent such injuries. The most common injuries while using the computer are back and neck pain.If not prevented, such injuries may result in surgery, which are time consuming and costly.

## 2. Literature Review

Virtual and cyber education got the name as Online Learning as the education experience is delivered via computer and internet. It came into existence in year 1989 when University of Phoenix introduced online university program for the first time across the globe. Online courses are those where 80% of education is delivered through the medium of internet. Remaining is achieved by self-research and little face-to-face interactions. By 2006, 3.5 million students participated in on-line learning at institutes for higher education in United States of America. By fall of 2010, over 6.1 million students were pursuing at least one online course, which is an increase of 560,000 of students over the previous year (Sloan Consortium report on online education, 2009).

Online learning has become a predominant form higher education. Enrollments for fully online learning increased by an average of 12–14 percent annually between 2004–2009, compared with an average of approximately 2 per cent increase per year in enrollments overall. Almost a quarter of all students in higher education were taking fully online courses in 2008 (Allen and Seaman, 2008).

In 2009, 44 percent of higher students in the USA were taking some or all of their courses online, this figure is projected to rise to 81 percent by 2014 (Ambient Insight Research, 2009). During the fall 2011 term, 6.7 million students enrolled in at least one online course (Babson Research Study, 2013).

Online learners are required to work on computers motionlessly and without interrupting for hours. However, our bodies are not designed for such repetitive and static work. Revelle et al. (2000) conducted a research of effects of technology on the way of living and working. Users are spending more time sitting and using computers, which has greatly increased the occurrence of related musculoskeletal disorders. Long-term static work and repetitive movements during computer use increases the risk of musculoskeletal discomfort (Jensen et al., 2002). The most frequently reported disorders related to health were eyestrain affecting nearly 85% and, upper back and neck pain affecting 70% of computer users. Identifying college students at risk for CTDs and other musculoskeletal discomforts provides a prime opportunity for health education professionals to intervene at an early stage (McMahan & Lutz, 2003).

Working at a computer workstation for prolonged periods is considered to be a risk factor for musculoskeletal injury. This is commonly due to the fixed position of the screen, keyboard and mouse in relation to each other, and the awkward postures that result. It is important that workstation design and adjustment is coupled with regular movement of the body in order to offset the static loading effect on musculature and compressive forces on the spine (Computer Workstations: Design & Adjustment, 2009).

It has been widely accepted that the most critical design features of workstations are display heights and desk designs.Straker et al. (2008) found out that there had not been consistent evidence as to the effect of forearm support on posture. However, their results showed that there was no substantial interaction between display heights and desk designs, yet lower display heights increased head and neck flexion, and spinal asymmetry.Moreover they discussed that curved desks, designed to provide forearm supports, increased scapula elevation and protraction, and shoulder flexion and abduction.

Robertson et al. (2009) examined the effects of office ergonomics training coupled with a highlyadjustable chair on office workers' knowledge and musculoskeletal risks. They found that perceived control over the physical work environment was higher for both intervention groups as compared to workers inthe control group. Also, they observed a significant increase in overall ergonomic knowledge for the intervention groups.

Use of forearm support is known to alleviate physical stress of PC users in computer workssuch as typing. Zhu and Shin (2012) addressed the importance of proper positioning of forearm support bycomparing neck and upper extremity muscle activities between conditions with varying heights of forearm support inkeyboard typing.

Garza et al. (2012) studied the differences of keyboard-intensive and mouse-intensive works at different levels.They measured muscle activityand postures of the shoulder and wrist and velocities andaccelerations of the wrists, percentage keyboardand mouse use, and four individual anthropometric factors (handlength, shoulder width, age, and gender). They found out that although hand length, shoulder width,and age were each significant predictors of at least one medianmuscle activity, posture, velocity, or acceleration exposure,these individual factors explained very little variability inaddition to percentage keyboard and mouse use in any of thephysical exposures investigated.

One of the reasons that the makes pressures on the body organs is the mismatch of the work place with the capabilities of the user's body. Sweere (2002) stated that the anthropometric data can be used to create a user friendly, ergonomically correct computer work environment. Moreover, Kim et al. (2005) stated that online teaching and learning is making a significant impact on the fabric of higher education.Thus, the significance of this study is to provide muscle discomfort reducing furniture and user-friendly interfaces during online learning. Such proper home office computer workstation is necessary to prevent strain injuries which can lead to long-term disabilities.

## 3. Methodology

Ten healthy subjects seven men and three women, aged between 19 and 29 years (average 25.9 years) with a height ranging from 158 to 192 cm (average 172.9cm) participated voluntarily in one laboratory session. All of subjects were students in Eastern Mediterranean University who are actively using computer for learning/teaching purposes. Participants had not history of significant chronic musculoskeletal disorder in the neck and upper limb, no current neck and/or upper limb pain and no diagnosed rheumatic or acute or chronic musculoskeletal condition.

Two typical work situations were simulated: the standard computer workstation and L-shape computer workstation designs. Standard computer workstation with non-adjustable desk and chair were used considering that those are commonly used in places where adjustable furniture is not available. The desk and seat heights were determined for fixed office tables and chairs. The seat height was 46 cm and a backrest slightly tilted backwards (about 100 degree). The desk height was 75 cm and keyboard and mouse was on the desk.

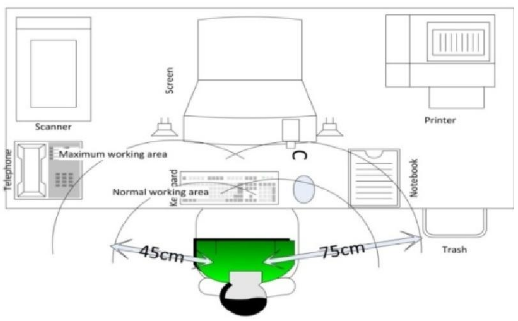


Figure 1: Standard normal computer workstation design

New workstation (L-shape desk) was designed based on analysis of the anthropometric data collected from the standard computer workstation. In this design three components were adjusted by the subjects before of each test:

(1) Position of the monitor,

(2) Inclination of the screen,

(3) Height of the chair and chair's position on the floor.

The height of the L-shape desk was fixing (75 cm) and the seat height was between 45-60 and keyboard and mouse tray was 67 and the height of the placement of monitor position was 95 cm.

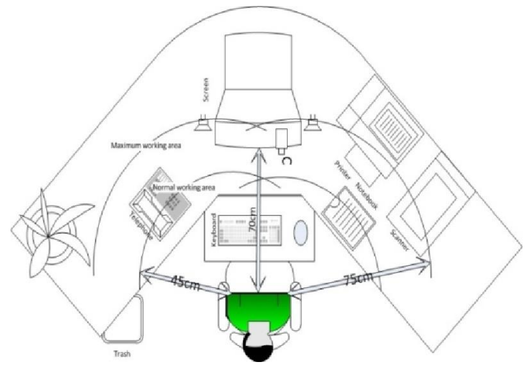


Figure 2: New workstation design

The both workstations' computer equipment were similar when considering the screen (17"), keyboard (27 cm _ 9 cm) and key (1.2 cm _ 1.4 cm) sizes, and the screen readability. Main differences in workstations design were how to take place of the needed equipment and the height of keyboard position.

The surface electromyogram (sEMG) device was used to recording the muscles activities of the participants on 6 body regions (hand, forearm, neck, and shoulder, upper and lower back) in each workstation. The sEMG device has two channels and we can record just two muscle groups' data at a time. For each participant, the test was repeated 3 times in each workstation using the sEMG.

Figure 3(a): Placement of sEMG electrodes on hand (musculilumbricalesmanus) and forearm (extensor carpi radialis)

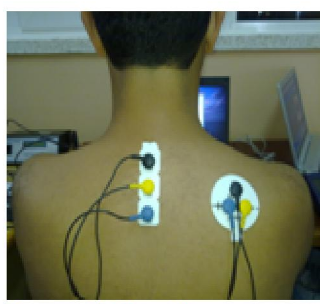

Figure 3(b): Placement of sEMG electrodes on shoulder (posterior deltoid) and neck (posterior upper trapezius)

Figure 3(c): Placement of sEMG electrodes on upper back (posterior upper trapezius) and lower back (sacropinalis)

The subjects performed a standardized test for online learners on two different workstations. This software was used to provide standard computers tasks and online learning functions to the participants.

The sequence of the 20 experimental tests (2 workstations x 10 participants) was systematically alternated among subjects. Before each test, the subjects were asked to adjust at their own convenience some components of the workstation. Each test lasted 10 min and consisted of simulating writing an assignment essay and the use of the component required for online learning. The essay required typing a new written text with a comparable degree of difficulty at a free work place without correcting any keying mistakes, and the use of resources from the Internet. The subjects were asked to type continuously for the last 10 min without modifying the workstation setting.

The sample of subjects was restricted to non-experienced computer ergonomic users to ensure the same baseline experience with both workstation designs.This choice was considered the best alternative in the context of the present study even though it has some implications for the generalization of the results in other populations. As muscles contract, microvolt level electrical signals are created within the muscle that may be measured from the surface of the body. A procedure that measures muscle activity from the skin is referred to as surface electromyography (sEMG). Six body region (hand, forearm, neck and shoulder, upper and lower back) motions were measured by a biaxial electromyography and muscle activity of six body region muscles was recorded. Subjects completed 10 minutes typing test in each computer workstation.

Descriptive statistics were calculated to understand the differences in the data collected from the different design. Charts were used to compare and illustrate these differences in the data between the old and the new designs of the computer workstations.

Correlation analysis was performed to find out relationships among the collected data by anthropometric measurements and sEMG experiments.

A hypothesis testing was used to analyze the data collected through sEMG. For each body region, Two-Factor Factorial analyses with fixed effects were conducted for the proposed and new computer workstation designs. Analysis of variance (ANOVA) was used to confirm and validate the impact of significant changes in the design of computer work stations for online learners on risk factors of musculoskeletal disorders. The hypothesis ($H_0$) was: there is no significant difference between mean of the musculoskeletal discomfort in 2 types of computer workstation.

Discriminant analysis was conducted to determine difference between the musculoskeletal discomfort before and after the intervention. Classification scores for each design were calculated to provide the evidence that computer users suffer from less musculoskeletal discomfort during online learning.

## 4. Results

The dimensions of respondent's bodies have been measured and the data are shown in table 1.

T able 1: Seated body dimensions of Respondents data (in cm)

| Anthropometric measures | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Respon dent | Sitting height (erect) | Eye height sitting | Elbo w rest height | Thigh clearance height | Knee height | Buttock knee length | Poplitea l height | Elbow-to-elbow breadth | Hip breadth |
| Men | 1 | 90 | 81 | 27 | 17 | 54 | 59 | 44 | 54 | 39 |
| | 2 | 89 | 78 | 27 | 17 | 53 | 58 | 43 | 52 | 39 |
| | 3 | 95 | 84 | 28 | 18 | 58 | 61 | 45 | 57 | 43 |
| | 4 | 96 | 85 | 29 | 18 | 58 | 64 | 47 | 59 | 44 |
| | 5 | 87 | 78 | 24 | 17 | 52 | 56 | 43 | 51 | 38 |
| | 6 | 86 | 77 | 22 | 16 | 50 | 56 | 42 | 50 | 37 |
| | 7 | 94 | 84 | 28 | 17 | 55 | 63 | 44 | 54 | 41 |
| Women | 8 | 81 | 70 | 21 | 16 | 47 | 52 | 38 | 44 | 39 |
| | 9 | 88 | 79 | 26 | 17 | 50 | 56 | 40 | 53 | 46 |
| | 10 | 83 | 76 | 23 | 15 | 47 | 53 | 39 | 49 | 43 |

Table 2 shows the percentile of body dimensions of respondents. The $5^{th}$ percentile column indicates that 5 percent of populations are smaller than the sizes given. The $95^{th}$ percentile column indicates that 95 percent of people are smaller than the sizes given. The $50^{th}$ column values are simply the mean of these two values.

Table 2: Percentile of body dimensions

| Body dimensions (cm) | Male (n=7) | | | Female (n=3) | | |
|---|---|---|---|---|---|---|
| | 5th | 50th | 95th | 5th | 50th | 90th |
| Sitting height, erect | 84.42 | 91 | 97.58 | 78.07 | 84 | 89.93 |
| Eye height, sitting | 75.46 | 81 | 86.54 | 67.46 | 75 | 82.54 |
| Elbow rest height | 17.25 | 24.71 | 32.18 | 19.19 | 23.33 | 27.47 |
| Thigh clearance height | 16.01 | 17.14 | 18.28 | 14.36 | 16 | 17.65 |
| Knee height | 49.38 | 54.29 | 59.19 | 45.15 | 48 | 50.85 |
| Buttock knee length | 54.3 | 59.57 | 64.85 | 50.24 | 53.67 | 57.09 |
| Popliteal height | 41.31 | 44 | 46.69 | 37.36 | 39 | 40.65 |
| Elbow-to-elbow breadth | 48.53 | 53.86 | 59.18 | 41.25 | 48.67 | 56.08 |
| Hip breadth | 35.85 | 40.14 | 44.44 | 36.89 | 42.67 | 48.44 |

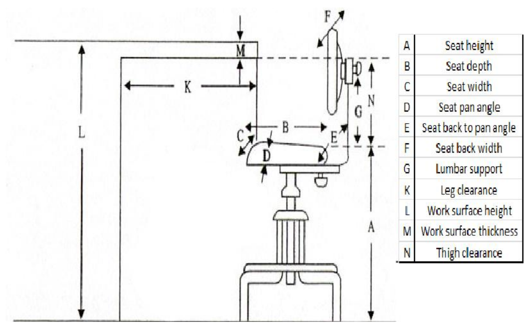


Figure 4: Seat parameters

A new workstation for online learners was designed based on the anthropometric analysis of the above data and the functional ability of the learners (figure 4).

The seat parameters has been measured for both workstations based on figure 3 and the seat parameters data are shown in table 3 and table 4. The seat parameters before the intervention were the same for all respondents.

Table 3: Seat parameters (in cm) - before intervention (for all respondents)

| A | B | C | D | E | F | G | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|
| 46 | 43 | 43 | 10 | 100 | 44 | 25 | 66 | 75 | 3.5 | 26 |

Table 4: Seat parameters (in cm) - after intervention

| Respondent | A | B | C | D | E | F | G | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 53 | 43 | 43 | 14 | 117 | 44 | 25 | 60 | 75 | 3.5 | 18.5 |
| 2 | 52 | 43 | 43 | 16 | 120 | 44 | 25 | 60 | 75 | 3.5 | 19.5 |
| 3 | 54 | 43 | 43 | 14 | 127 | 44 | 25 | 60 | 75 | 3.5 | 17.5 |
| 4 | 55 | 43 | 43 | 17 | 130 | 44 | 25 | 60 | 75 | 3.5 | 16.5 |
| 5 | 52 | 43 | 43 | 13 | 119 | 44 | 25 | 60 | 75 | 3.5 | 19.5 |
| 6 | 47 | 43 | 43 | 10 | 115 | 44 | 25 | 60 | 75 | 3.5 | 24.5 |
| 7 | 48 | 43 | 43 | 12 | 111 | 44 | 25 | 60 | 75 | 3.5 | 23.5 |
| 8 | 45 | 43 | 43 | 10 | 109 | 44 | 25 | 60 | 75 | 3.5 | 26.5 |
| 9 | 46 | 43 | 43 | 7 | 109 | 44 | 25 | 60 | 75 | 3.5 | 25.5 |
| 10 | 45 | 43 | 43 | 8 | 107 | 44 | 25 | 60 | 75 | 3.5 | 26.5 |

Seat parameters after Intervention are shown in table 4. Five seat parameters were changed after intervention (seat height, seat pan angle, seat back to pan angle, leg clearance and thigh clearance) and six parameters have not been changed. All parameters were constant before intervention. Four parameters were variable in new workstation design and seven of them were constant.

The sEMG provides the information about muscles activity over time. During of the recording data on time by sEMG, after 2, 4, 6, 8, 10 minutes the mean value was reading. The Unit of measurement for muscles activities is microvolts. The mean, standard deviation, and 95% confidence interval of sEMG(in μV) data recorded on 2,4,6,8 and 10 minutes after beginning the teston the old workstation design for all respondents are provided in table 5.

Table 5: Mean, standard deviation, and 95% CI for 10 respondents on old workstation design

| | Hand | Forearm | Neck | Shoulder | Upper back | Lower back |
|---|---|---|---|---|---|---|
| **Count** | 50 | 50 | 50 | 50 | 50 | 50 |
| **Mean** | 733.052 | 2142.683 | 915.557 | 790.706 | 858.487 | 2244.589 |
| **Std. Dev.** | 1191.613 | 1252.573 | 1101.240 | 1139.794 | 1522.099 | 1264.150 |
| **CI** | 10.567 | 11.108 | 9.766 | 10.108 | 13.498 | 11.211 |
| **Conf. range at 95%** | 722.485 | 2131.575 | 905.791 | 780.598 | 844.989 | 2233.378 |
| | 743.620 | 2153.791 | 925.323 | 800.814 | 871.985 | 2255.800 |

In order to test the hypothesis ($H_0$ = mean of musculoskeletal strain in time of the 6 body region does not differ) ANOVA is applied to the sEMG data collected from the old workstation designfor each respondent.Table 6 shows the summary of ANOVA results, where $F_0$ ratio for old workstation design for all respondents (six men and 3 women) except one (respondent 5) the $H_0$ is rejected and the mean of musculoskeletal strain in time of the 6 body region differ in old workstation design.

Table 6: Summary of ANOVA results for old workstation design

| **Respondent** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| $F_0$ | 37.26 | 6.8 | 27.45 | 229.56 | 0.8 | 48.17 | 135.05 | 491.64 | 55.07 | 144.64 |
| $F_{crit}$ | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 |

The mean, standard deviation, and 95% confidence interval of sEMG (in μV) data recorded on 2,4,6,8 and 10 minutes after beginning the test on new workstation design for all respondents are provided in table 7.

Table 7: Mean, standard deviation, and 95% CI for 10 respondents on new workstation design

| | Hand | Forearm | Neck | Shoulder | Upper back | Lower back |
|---|---|---|---|---|---|---|
| **Count** | 50 | 50 | 50 | 50 | 50 | 50 |
| **Mean** | 539.257 | 1086.897 | 754.519 | 972.739 | 442.749 | 1041.593 |
| **Std. Dev.** | 889.197 | 1040.023 | 801.704 | 978.608 | 887.234 | 643.211 |
| **CI** | 7.885 | 9.223 | 7.110 | 8.678 | 7.868 | 5.704 |
| **Conf. range at 95%** | 531.371 | 1077.674 | 747.409 | 964.061 | 434.881 | 1035.889 |
| | 547.142 | 1096.120 | 761.628 | 981.418 | 450.617 | 1047.297 |

For the same hypothesis, this time ANOVA is applied to the sEMG data collected from the new workstation design for each respondent.Table 8 shows the summary of ANOVA results for the new workstation design. It is clearly shown that for all 10 respondents the $F_0$ ratio is less than $F_{critical}$. Based on result for all of the users, working with computer in new workstation design has significant impact in preventing the occurrence of musculoskeletal disorders on 6 different body regions.

Table 8: Summary of ANOVA results for new workstation design

| **Respondent** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| $F_0$ | 2.37 | 2.6 | 0.9 | 0.66 | 2.5 | 1.93 | 2.47 | 2.02 | 2.4 | 2.52 |
| $F_{crit}$ | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 | 2.62 |

Correlation analysis was constructed to find out relationships among the collected data by sEMG experiments.Table 9 shows correlation coefficients both before and after the intervention. It was observed that in the old design, there were 14 positive and 1 negative correlations between the variables. Similarly, it was observed that there were 11 positive and 4 negative correlations in the new workstation design.

**Table 9: Correlation coefficients before and after intervention**

| Variable 1 | Variable 2 | Correlation Coefficient: Before Intervention | Correlation Coefficient: After Intervention |
|---|---|---|---|
| Hand | Forearm | 0.57 | 0.377 |
| Hand | Neck | 0.922 | -0.117 |
| Hand | Shoulder | 0.844 | 0.640* |
| Hand | Upper back | 0.567 | -0.067 |
| Hand | Lower back | 0.421 | 0.068 |
| Forearm | Neck | 0.306 | 0.193 |
| Forearm | Shoulder | 0.636 | 0.466 |
| Forearm | Upper back | -0.005 | -0.19 |
| Forearm | Lower back | 0.136 | -0.447 |
| Neck | Shoulder | 0.687 | 0.432 |
| Neck | Upper back | 0.782 | 0.226 |
| Neck | Lower back | 0.467 | 0.142 |
| Shoulder | Upper back | 0.447 | 0.38 |
| Shoulder | Lower back | 0.249 | 0.457 |
| Upper back | Lower back | 0.659 | 0.699* |

Table 9 illustrates that the relations between variables – except 2 cases (shoulder-upper back and upper back-lower back) – weredecreased after the intervention.

The ultimate objective in any pattern recognition issues is separating the two sets of samples to several different classes. Also in this research the independent variables separate into two groups (group 1= old design, group 2= new design).

Linear Discriminant Analysis (LDA) method was used to predict the categorical variables and to find a linear combination of variables and separates into two classes of workstations.

The aim of LDA is to create a discriminant function which shows different output data for different rates. The independent variables were selected to be seat height, seat pan angle, and seat back to pan angle, leg clearance, thigh clearance and average of sEMG activities in 10 minutes of hand, forearm, neck, shoulder, upper back and lower back. The result of separating of variables into two workstations by using LDA is shown in table 10 which shows the coefficient of the linear discriminant function for each workstation design.

**Table 10: Linear discriminant functions**

| Classification Function Coefficients | | |
|---|---|---|
| **Body region** | **Group: Old** | **Group: New** |
| **Hand** | -0.004 | -0.0037 |
| **Forearm** | 0.0042 | 0.0013 |
| **Neck** | 0.0041 | 0.0042 |
| **Shoulder** | -0.0008 | 0.0013 |
| **Upper** | -0.0017 | -0.002 |
| **Lower** | 0.0038 | 0.0021 |
| **(Constant)** | -8.1607 | -2.5886 |

The classification functions are used to determine to which group each case most likely belongs. The classification scoresfor before ($C_1$) and after ($C_2$) intervention are applied by the formulae below:

$$C_1 = -8.1607 + (-0.0040)x_{11} + (0.0042)x_{12} + (0.0041)x_{13} + (-0.0008)x_{14} + (-0.0017)x_{15} + (0.0038)\,x_{16}$$

$$C_2 = -2.5886 + (-0.0037)x_{21} + (0.0013)x_{22} + (0.0042)x_{23} + (-0.0013)x_{24} + (-0.0020)x_{25} + (0.0021)\,x_{26}$$

Where;

$x_{ij}$ = the average of sEMG average for the $j^{th}$ variable,

for $i = 1$ before intervention, and $i = 2$ after intervention.

After taking the averages of the sEMG activities in 10 minutes of six body regions in both workstations, the classification scores for all respondents' EMG activities were calculated as shown in table 11.

Table 11: Classification scores

| Respondents | C1 (Old design) | C2 (New design) |
|---|---|---|
| 1 | 7.87 | -0.184 |
| 2 | 9.776 | -0.565 |
| 3 | 2.548 | 3.706 |
| 4 | 11.206 | 1.913 |
| 5 | 12.94 | 6.438 |
| 6 | 18.58 | 4.049 |
| 7 | 1.83 | 4.429 |
| 8 | 7.478 | 0.65 |
| 9 | 5.775 | 2.777 |
| 10 | 3.606 | 2.673 |

After computing the classification scores for both cases, it is easy to decide how to classify each case: in general classifying the case as belonging to the group for which it has the highest classification score. The preferred design for the computer workstation could be identified by comparing the classification scores for both cases. Table 11 shows that new design classification scores are significantly lower than the old design classification scores (except respondents 3 and 7). This is another indication of the reduction of the musculoskeletal discomfort by an improved design.

## 5. Discussion

Given the infectious spread use of computer in daily life and online learning, despite the many benefits of this technology, the prevalence of musculoskeletal disorders are increasing and muscles fatigue as an indicator of progression repetitive injuries of work is considered.

The continuous pressure on body regions such as hand, forearm, neck, and shoulder, upper and lower back during working with computer can lead to musculoskeletal discomfort.

This study has provided to a computer workstation design for online learners to reduce musculoskeletal strain by analyzing muscle activities during online learning activities.Thus, this study can be used as a basis by computer workstation designers to provide an optimum design for online learners.

## 6. Conclusion

After collecting muscle activities data from the old computer workstation design, the hypothesis was rejected for all cases except one case (respondent5). This finding states that there is significant difference between mean of the musculoskeletal discomfort in the old computer workstation design.

A new workstation has been designed based on anthropometric data collected and the ergonomic standards. Therefore ANOVA results confirm that there is no significant difference between mean of the musculoskeletal discomfort in the recommended computer workstation design based on hypothesis test and the hypothesis was accepted for all cases.

Thus, it was proven that the new workstation designhas significantly less impact on the occurrence of musculoskeletal disorders.

The correlation analysis confirms that the relations between sEMG activities in new design were less than those in the old design.

Discriminant analysis shows that the original grouped cases were correctly classified and the classification scores were significantly reduced by the developed new computer workstation design.

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