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Multi dimensional system for evaluating preventive program for upper extremity disorders among computer operators

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Abstract. Typing is associated with musculoskeletal complaints (MSCs), caused by multiple risk factors. Although a wide variety of ergonomic intervention programs were conducted to reduce risk factors and MSC's, only few of them were found evidence based. This study aimed to test the efficacy of a workplace intervention in reducing MSC's among computer workers. 66 computer workers were assigned randomly to one of three intervention programs: ergonomic intervention including biofeedback, intervention without biofeedback and control group without intervention. The efficacy was tested by advanced assessment including; pain location and severity, posture at work, upper extremity 3D kinematics, muscle activity and psychosocial status. Working hypothesis; significant score differences will be found between the study groups which underwent ergonomic intervention and the control group on the following measures: pain complaints, upper extremity kinematics, muscle activity and psychosocial status. Significant differences were found between pre and post intervention and between research groups and the control group in pain, posture and motion. The ergonomic intervention with biofeedback had no unique contribution in comparison to other interventions. In conclusion**;** the proposed intervention program was found efficient for reducing pain among computer workers.

Keywords: upper extremity work-related disorders, computer work, ergonomic intervention, surface EMG biofeedback

1. Introduction

Computer settings points to a number of risk factors which may induce the development of musculoskeletal complains of the upper extremities (UEs), neck [10-11] and low back pain (LBP) [20,34]. An activity analysis of computer settings pointed to a number of risk factors for musculoskeletal complaints (MSCs), among which were repetitive work, and awkward postures of the trunk, neck and upper limbs, [10-11,16,19,21] . Other reported risk factors relate to the hands: hyperextension of the 5th digit's metacarpophalangeal joint, isolation of the 1st and 5th digits [32], maintaining static hand positions [13-14], mechanical pressure on the distal forearm [11,12] [23,35], and exerting force while typing [7,22,38] Reports in the literature also note the effect of mental demands on muscle tension, defined as "non-biomechanical muscle activity". Mental demands of the assignment and the individual's characteristics, e.g. typing style, speed, directly influence muscle activity [2,28-30], and could be associated with pain of hand, forearm, neck or low back [2,15] during typing. Various preventive intervention programs have been developed to treat the increased occurrence of UE -WRMSD among computer operators. Nevertheless, many of these programs do not meet the criteria of level of evidence due to several methodological limitations. Literature review [37] dealing with prevention, effectiveness of therapy and instruction given to employees at the workplace (811 papers) found fifty-three of the papers dealt with the reduction of symptoms of UE-WRMSD, and of these, only eight met the criteria of quality and level of evidence. A survey of various prevention methods, including the use of biofeedback [1, 8, 9 25, 26, 27, 33, 37, 39], revealed that most of the studies had serious methodological limitations that affect the validity of the results. These include the absence of similar studies that duplicate results, small sample size, absence of a control group, and non-standardized outcome measures. Moreover, much of the knowledge and evidence for prevention programs has focused on a single risk factor, [6, 11, 24, 31] while further proof is lacking regarding the efficacy of comprehensive prevention programs in the field. The small number

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of evidence-based information on preventive programs may be due to the measurements used to evaluate success or failure. The objective of this study is to test the efficacy of primary and secondary preventive intervention programs for reducing UE-WRMSD.

2. Methods and materials

2.1 Participants

The study was approved by the Institutional Review Board of the hospital in which the research was conducted. Each participant signed a consent form before enrollment. A total of 66 (23 males and 43 females) computer operators from four different High Tech companies agreed to participate in the present study. All participants currently work more than four hours per day in front of a computer and are right hand dominant. Participants suffering from orthopedic injury or neurological deficit with the exception of the diagnoses of Upper Extremity – Musculoskeletal Complains (i.e. Rotator cuff syndrome, Lateral epicondylitis, Cubital tunnel syndrome, Carpal tunnel syndrome, Flexor-extensor peri-tendinitis or teno-synovitis of the forearm-wrist region, De Quervain's disease and Nonspecific MSD), medical conditions that cause swelling of the joints or hand numbness (pregnancy, diabetes, heart condition, arthritis) were excluded from the study. All participants who started the program finished it. The characteristics of demographic data as well as work descriptions are presented in Table 1

The participants were assigned randomly to one of three intervention programs:
a) Ergonomic intervention, including biofeedback, n=22, b) Ergonomic intervention without biofeedback, n=23, c) Control group without intervention, n=21.

Table 1:
Characteristics of study participants

	Minimum	Maximum	Mean	SD
Age	21.00	62.00	37.33	9.35
BMI	16.77	39.06	24.35	4.34
Education in years	12.00	25.00	15.59	2.94
Workdays per week	5	6	5.01	0.12
Working hours with computer per day	4.00	12.00	7.40	1.51
Keyboard use per day in percent	10.00	90.00	55.83	17.13
Mouse use per day in percent	10.00	90.00	44.16	17.13

2.2 Instruments

2.2.1 Pain questionnaire

The Standardized Nordic Questionnaire (SNQ) was used to evaluate the prevalence and anatomical location of the MSCs, reported by the study population[18]. The questionnaire includes a detailed reference to pain in the low back, neck and shoulders. An appendix for UEs (arms, forearms, wrists and fingers) was recently added and validated in relation to the Disability Arm, Shoulder, Hand assessment questionnaire (DASH; r=.53; p < 0.001) [41], and was successfully used in a previous ergonomic study [33]. The general prevalence of MSCs in the last year and last week was calculated, i.e. assigning '1'for pain in at least one body part and '0' for no pain, and provided a literal description of the MSC. We calculated the NSQ scores by counting the number of painful body parts reported during the preceding week (between 0-9 parts), during the preceding year (between 0-12 parts), and the severity of pain in these body parts (on a scale of 0-14 for the neck and low back and 0-19 for the shoulders and UEs). The severity scores refer to the effect the pain has on carrying out work activities, the quality of leisure time, as well as the duration of pain during the preceding week and the preceding year. We added the prevalence of MSCs in the shoulder, neck, back and UE by calculating the percentage of subjects that experienced pain in the mentioned body part , i.e. by assigning '1' for pain, '0' for no pain, according to the UE appendix conducted by [41].

2.2.2 Assessment of body position and work related hazards, RULA

Operational posture at the workstation was measured at the workplace using the proposed RULA for computer user's observation (RULA), which assesses posture and force exertion risk factors of the UE as well as the trunk and lower extremities during work performance. The findings are mapped into three scores, and a grand score "C" as a global measure of the risk. The grand total score ranges between 1 and 7 will be used [36].

2.2.3 Psychosocial assessment

The Swedish Demand Control - Support Questionnaire (DCSQ) [4]) is a shorter and modified version of Karasek's Job Content Questionnaire (JCQ). The questionnaire consists of 14 statements covering psychological demands, decisional attitude and social support in the workplace. The questionnaire has two parts; the first relates to job demands with a higher score indicating higher demands. The second part refers to decisional attitude; with a higher score indicating more freedom in making decisions. The psychometric properties of DCSQ are satisfactory, valid and reliable. This tool served to assess psychosocial stress at the workplace. The questionnaire was translated and retranslated to Hebrew as recommended. The internal consistency (Cronbach alpha) after translation to Hebrew was: 0.743.

2.2.4.Myo-Trac Infinity, Surface Electro-Myograph (SEMG) biofeedback,

Manufactured by Thought Technology Ltd. Canada was used for reporting muscle activity, this SEMG device was used for intervention and pre and post evaluation. Data was collected from 45 participants due to technical difficulties. Muscle signal amplitude of the wrist extensors and upper trapezius were recorded during maximal voluntary contracture (MVC) and during the typing of a predetermined sentence. Signal was sampled at 2048 samples per second. The data was filtered automatically by the infinity system. Notch filter of 50Hz was chosen as a default. The signal was filtered with high-passed filtere, cutoff frequency of 20Hz with 4th order Butterworth.

The mean root mean square (RMS) was used and normalized with respect to MVC and expressed as a percentile of the MVC. For using RMS EMG, the filtered EMG is rectified to RMS, using blocks of 102 samples and then smoothed by a damper filter with a time constant of 0.75 for the biofeedback channel sets. Ninety percent of the collected data was included in the analysis (the first and last 5% of data was eliminated due to the wide variability in the start and end points of typing).

2.2.5 Intervention programs

Intervention Program for Control Group: A single ergonomic meeting based on NIOSH recommendations for office workers was given for the control group [16].

Intervention Program for Study Group 1:

Individual instructional course was given for each participant, over 3 – 6 sessions. The program comprised three parts, as recommended in the literature [19,25]. The first part included pain relief according to symptoms. The second part was: work station adjustments according to NIOSH recommendations [16] and personal anthropometric data. The third part included practicing relaxed work style, work and breaks periods, stretching and strengthening exercises, muscle relaxation techniques during and after typing [19,25].

Intervention Program for Study Group 2:

Identical to intervention program for study group , but training included a biofeedback system – Byograph infinity hardware and software. The system records the electrical muscle contracture during work. The signals from wrist extensors, finger and the upper trapezius are provided as immediate visual and auditory feedback of the motor performance (www [17] [5], hagg-[40]). The system was used in the workplace for the second research group.

2.3 Procedure

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RULA observation was conducted at participant's workstations. An occupational therapist who was blinded to the participant's group assignment observed all participants before and after the intervention program. Biodemographic questionnaires and the SNQ questionnaire were filled out and the markers and drive boxes were attached according to protocol to the right upper extremity

The SEMG electrodes were attached to the upper right trapezius and wrist extensors. The participants were invited to the motion lab and instructed to be seated, adjust the station to a comfortable position as they were used to and type a predetermined sentence on a standard computer with flat keyboard position. The typing task was repeated five times. Muscle tension was derived from the markers while the subject was sitting and typing. This procedure was repeated after intervention. The time between pre and post intervention was at least two months**.**

2.4.Data analysis

One way analysis of variance and Kruskal Wallis (for non parametric variables) tests were used to test whether the base line values in the study groups are similar.

In the next stage differences between pre and post values of the following variables: painful body parts in the last week, muscle tension variables and RULA score were computed.

In order to be able to see an integrative picture of the upper extremity the sum of differences in muscle tension presented as percentile of MVC of the extensors and upper trapezius was calculated. In order to prove the assumption that there will be significant differences between the control group and the study groups, one way analysis of variance for parametric variables and Kruskal Wallis for the non parametric variables were used. Significant differences were followed by LSD post-hoc tests controlling cumulative significance of $p < .05$.

3. Results

The participants were divided randomly into three groups. No significant differences were found between the groups before intervention in the following variables: pain measurements, UE kinematics, muscle tension, psychosocial status and posture at work.

3.1Pain complaints

Kruskas Wallis test was conducted to compare between the study groups in the following variable: mean differences between pre and post values of painful body parts in the last week and severity of hand pain. Significant differences were found between the study groups (see table 2). The mean score of the research groups were similar but significantly higher in comparison to control group. Significant differences were found between the biofeedback group and other groups in severity of hand pain.

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3.2 RULA- body posture at workstation

Kruskas Wallis test was conducted to compare between the study groups in posture at work (see table 3). Significant differences were found between the groups in the RULA scores. The mean difference of the research groups was similar but significantly higher than the control group. The RULA score in all groups was reduced.

3.3 Psychosocial status

No change was expected in the psychosocial status during intervention period.

3.4 Muscle activity (SEMG)

No significant differences were found between the groups in muscle activity pre and post intervention measured by percentile of MVC ($F=0.09;p=0.91$).

4.Discussion

This study aimed to evaluate the efficacy of ergonomics intervention programs for reducing MSC among computer workers. Our hypothesis assumed that significant differences will be found between the group which underwent ergonomic intervention with biofeedback, the group without feedback, and the control group. The results demonstrated significant reduction in number of painful body parts, reduction in severity score of hand pain and in the RUlA score presenting the exposure to risk factors due to body posture. Significant differences were found between the research groups and the control.

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of hand pain that was higher in the biofeedback group. These results are in concurrence with other studies,

Table 2: Pain complaints.
Comparison between the study groups in the following variable: mean differences between pre and post values of painful body parts in the last week and severity of hand pain.

Variable	Group	Pre –post differences Mean (Sd)	n	Rank	Chi square	Sig
Number of painful body parts in the last week	Control	-.19 (1.03)	21	20.64	13.30	0.001
	Biofeedback	1.13(1.35))	22	37.14		
	Without Biofeedback	1.40 (1.6)	20	38.28		
Severity score of Hand pain	Control	-.33(1.46)	20	27.45	6.71	0.03
	Biofeedback	1.31(4.34)	22	33.27		
	Without biofeedback	-.15(1.84)	20	28.63		

(Kruskas Wallis test)

Table 3: Posture at work (RULA).
Comparison between the study groups in the following variable: mean differences of the RULA score between pre and post intervention.

	Group	Pre –post differences Mean (Sd)	N	Mean Rank	Chi square	sig
RULA	Control	1.52 (1.56)	21	19.19	16.37	.000
	Biofeedback	3.20(1.10)	20	38.95		
	Without Biofeedback	2.95 (.92)	20	35.45		

(Kruskas Wallis test)

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N**o** differences were found between the research groups in reduction of number of painful body parts except to the severity

demonstrated that multi factorial occupational intervention program had similar outcomes even though there is some evidence for the efficacy of the biofeedback [12]. Muscle tension did not changed significantly [3], suggested limits for each load level in cases of long duration activities at work: The 90th percentile (peak) should not exceed 50-70% of MVC. The 50th percentile should not exceed 10-14% MVC, and the 10th percentile (static) should not exceed 2-5% MVC[3]. In our study the loads before intervention in the research groups did not exceed 10-14% MVC, which may be the reason for the non-significant changes.

Since the study population was not exposed to stress at work, the psychosocial status had no effect on MSC and changes were not expected.

5. Summary

Significant differences were found between pre and post intervention and between research groups and the control group in pain and posture. The ergonomic intervention with biofeedback had no unique contribution in comparison to other interventions. In conclusion; the proposed intervention program was found efficient for reducing pain among computer workers.

Individual ergonomic intervention may reduce pain and MSC among computer operators. The conclusions of the current study refer to the immediate efficacy of the ergonomic intervention on pain reduction. Long term efficacy cannot be concluded.

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