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Full Length Research Paper

An empirical investigation of the detrimental effects of the intensive use of computers in the business world

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Occupational injuries pose a major problem in workplaces where computers are widely used. Intensive, repetitive and long period computer use results in costly health problems (direct cost), and lost productivity (indirect cost). This paper presents the findings from a scientific research to determine the effect of musculoskeletal discomfort factors that contribute to musculoskeletal disorders resulting from intensive use of computers in the workplaces. In this context, a questionnaire was given to 84 intensive computer users working for the university sector in North Cyprus. The present article aims at investigating the factors that contribute to such disorders using a questionnaire and a mathematical model, which is developed by assessing and analyzing workplace ergonomics, worker attitudes and experiences on computer use. The findings from this study shows that the gender (OR=3.37, CI: 2.38-4.77), psychosocial factors (like working with computers, OR=0.050, CI: 0.001-0.623), office ergonomics qualities such as availability of foot support [OR= 0.295, CI: 0.092-0.041] and availability of sufficient lightening [OR=3.477, CI:1.232-9.810] were significant factors of the formation of work-related musculoskeletal disorders (WRMSDs). Additionally, it was shown that physical exposures are associated with increased risk of upper extremity disorders. The current research also provides an evidence that the symptoms of musculoskeletal discomfort (such as pain), and the frequency of these symptoms were also significant in the development of WRMSDs.

Key words: Musculoskeletal discomfort, computer use, risk assessment modelling.

INTRODUCTION

Research problem

Musculoskeletal disorders have been observed and experienced widely at workplaces where the computers are frequently used. Intensive use of computers in the business world is known to result in work-related musculoskeletal disorders (WRMSDs) and sick leave, which affects the physical health of workers and pose financial burdens on the companies, governmental and non-governmental organizations. Most of the studies on the formation of WRMSDs in human-computer interaction have been focused on the gender differences, physical, psychological and psychosocial aspects of the user.

However, they have not yet considered extra-rational factors such as the perceived musculoskeletal discomfort types and their frequencies. This study addresses the contribution of these extra-rational factors to the formation of WRMSDs, and thus formulates a significant association in order to identify how to relieve the imposed economic burden.

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Research aim and objective

The present paper aims at investigating the factors that contribute to WRMSDs and developing a risk assessment model in order to analyze workplace ergonomics, worker attitudes and experiences on computer use. Furthermore, this research aims to model the capabilities and the limits of human being at computer workstations; and to find out applications (recommendations) of this model in the organizations and how to manage and fix symptoms in these organizations.

Research questions

This research addresses worker perception and attitudes towards computer use, and their experiences with musculoskeletal symptoms and diagnoses. Most of the studies on the formation of WRMSDs in human-computer interaction have been focused on the gender differences, physical, psychological and psychosocial aspects of the user. In this research, as well as these aspects, we studied the factors that contribute to musculoskeletal disorders resulting from intensive use of computers in the workplaces also by regarding extra-rational factors such as the perceived musculoskeletal discomfort types and their frequencies which have not been yet considered.
The research questions, therefore, are:

1. Does an association exist between worker perception and attitudes towards computer use and musculoskeletal symptoms and their diagnoses?
2. What physical and psychosocial factors contribute to the formation of WRMSDs due to intensive computer use?
3. Which extra-rational factors are related to the formation of WRMSDs due to computer use?
4. Do the perceived discomfort types and their frequencies contribute to the formation of WRMSDs due to computer use?

This study illustrates the idea of understanding how demographic structure, physical and psychosocial job characteristics, office ergonomics, perceived musculo-skeletal discomfort types and their frequencies may affect formation of musculoskeletal disorders. It then provides the evidence on the symptoms of musculoskeletal discomfort types and the frequency of these discomforts which are significant in the development of WRMSDs due to computer use. Our risk assessment models also provide guidance for solving problems related with costly health problems (direct cost), lost productivity (indirect cost), and relieving the imposed economic burden. The contribution of this study to industries is to reduce the work-related musculoskeletal disorders associated with the intensive, repetitive and long period computer use.

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Previous studies provide the information that, for disorders of the upper extremities (such as Carpal Tunnel Syndrome), repetition, constant force, and vibration are particularly important work-related factors. Work-related psychosocial factors recognized include rapid work pace, monotonous work, high job demands, low job satis-faction, and job stress. A number of characteristics of the individual appear to affect vulnerability to Work-Related Musculoskeletal Disorders (WRMSDs), including increasing age, gender, body mass index and a number increasing age, gender, body mass index, and a number of individual psychological factors. These factors are important as contributing and modifying influences in the development of pain and disability and in the transition from acute to chronic pain.

The results of the conducted previous studies revealed that musculoskeletal symptoms are related with intense computer work. The use of computer keyboard was a direct causative agent for hand and wrist disorders (Punnett and Bergqvist, 1997). Another study by Amell and Kumar (1999) showed that repetitiveness of the keyboarding task, the tendency of users to type with excessive force and the maintaining user prolonged awkward and static postures may result in cumulative trauma disorders (CTD). According to Matias et al. (1998), the main causation of carpal tunnel syndrome (CTS) is job design; the secondary is posture associated with the workplace design and the least contributing factor to CTS causation is the individual’s anthropometric make-up.

Moreover, Tittiranonda et al. (1999) found that computer users, with a long daily duration of computer keyboard and mouse use, experience more musculo-skeletal symptoms than those with a short duration. Babski-Reeves and Young’s (2002) logistic regression result indicate that for diagnosed CTS, hand movement were the only repetition measure to have a significant relationship, and was tentatively concluded to be the best predictor. Epidemiological studies confirmed that the work which is related with computer use brings higher risk for the development of musculoskeletal symptoms. Evans and Patterson (2000) tested the hypothesis that poor typing skill, hours of computer use, tension score and poor workstation setup are associated with neck and shoulder complaints, and they found out that tension score and gender were the only factors to predict neck and shoulder pain. Jensen et al. (2002) found that the duration of computer work is associated with neck and shoulder symptoms in women, and hand symptoms in men. Additionally, the use of mouse was observed to have an increase in hand/wrist and shoulder region symptoms among the intensive users of computers. Moreover, Karlqvist et al. (2002) concluded that for both genders the duration of computer work was associated with the musculoskeletal disorder symptoms, and women are at more risk of exposure to such disorder as they have less variability in work tasks.

Fogleman and Lewis (2002) studied the risk factors associated with the self-reported musculoskeletal discomfort in a population of video display terminal (VDT) operators, where their results indicated that there is a statistically significant increased risk of discomfort on each of the body regions (head and eyes, neck and upper back, lower back, shoulders, elbows and forearms, and hands and wrists) as the number of hour of keyboard use increases. Blatter and Bongers (2002) studied the association of the effect of the gender differences, physical work factors as well as the psychosocial factors. However, their results showed that psychosocial factors were not related with the duration of computer use, whereas computer work of more than 6 h per day was associated with musculoskeletal symptoms in all body regions of men, and computer work of more than 4 h per day entailed the association with musculoskeletal disorders in women. Intensive computer use is associated with an increased risk of neck, shoulder, elbow, wrist and hand pain, paresthesias and numbness. Repetition, forceful exertions, awkward positions and localized contact stress are associated with the development of upper limb cumulative trauma in computer users. Ming and Zaproudina (2003) presented the results of repetitive computer causes cumulative trauma as they continue on neck, shoulder, arm and hand muscles and joints.

In their model, Carayon et al. (1999) stipulated that psychosocial work factors (e.g. difficulty of job, working with deadlines, supervisor's pressure, lack of control), which can cause stress, might also influence or be related to ergonomic factors such as force, repetition, and posture that have been identified as risk factor for WRMSDs. Peper et al. (2003) reviewed the ergonomic and psychosocial factors that affect musculoskeletal disorders at the workstation, and their results showed that there was a significant difference in right forearm extensor-flexor muscle tension and in right middle trapezius muscle tension between type tasks and rest. Shuval and Donchin (2005) examined the relationship between ergonomic risk factors and upper extremity musculoskeletal symptoms in VDT workers, by taking into account individual and work organizational factors, and stress. Their results of RULA (Rapid Upper Limb Assessment) observations indicated that there were no acceptable postures of the employees whom were exposed to excessive postural loadings.

METHODOLOGY

A questionnaire was given to 84 persons, who work intensively with the computers, such as; staff, research assistants and faculty members of Eastern Mediterranean University (EMU), engineers, government officers, public relation officers, marketing officers, bank officers, customer representatives, commissioners, consultants, travel agents and translators. The reasons for targeting such diverse disciplines is that the target population is expected to use computers intensively especially for work/business purposes and several other auxiliary purposes including personal and communication. Thus the results are guaranteed not to be task-related, instead work-related. The participants of this study were invited to answer the questionnaire through the Internet. The questionnaire was prepared by Quask Form Artist software which allows an online access to the questionnaire. The questionnaire included six modules of questions based on the type of each question. These modules were related with the demographic structure of the participant, physical job characteristics, psychosocial job characteristics, office ergonomics, types of musculoskeletal discomforts experienced, body regions where the musculoskeletal discomfort arouse, and the personal medical history of the person.

The demographic structure of the participants includes the data from answers to the questions on gender, age, height, weight, and occupation. The type of computer, input device, keyboard used, and daily time spent on computer and years of computer use are characterize by the physical job characteristics. On the other hand, the next group of factors such as finding the job interesting, personal satisfaction from the job, relationship with the supervisor, sharing the office, working with computers, type of job done (repetitive/non-repetitive), taking adequate rest breaks and smoking investigates the psychosocial job characteristics.

The data obtained on office ergonomics include qualities of the workstation (from the question on; if it supports the vertebrae (1-yes, 0-no)), elbows whether they form 90° angle with shoulders, the posture of the feet whether they are comfortable on the floor, the centering of the seat and hands on the keyboard, the symmetrical sitting, the placement of the mouse and the keyboard at the finger-tips and the mouse and the keyboard side by side on the same level, the location of the monitor at the eye level and the monitor at arm's length away from the eyes, the availability of sufficient lightening without glare and elbow/arm/foot supports, the neutrality of the wrist position, head and neck, the changing of sitting position every 15 min taking active breaks, taking frequent micro-breaks and being trained in posture.

The respondents self-reported answers on the type and frequency of discomfort, experiences of ache, pain, cramp, tingling, numbness, heaviness, weakness, tightness, feeling hot and cold, and swelling. These discomforts can be associated with several body regions such as the neck, shoulder, elbow/forearm, hand/wrist, finger, upper back, and lower back. The last group of data was obtained from questions on having a recent accident, the diagnosis of any WRMSD or its medical symptoms (which might contribute to its formation) by a physician, and exercising and making sport activities.

The method of analysis consisted of descriptive statistics and multivariate analysis. Descriptive statistics used the mean, variance, and frequencies. In order to avoid the multicollinearity between independent variables that are used to fit the mathematical models in this research, a correlation analysis was performed to determine relationships among independent variables. As a result, the variables which are highly correlated (With a correlation coefficient greater than r=0.5) are found and only one of them is used in the multiple regression analysis (Hair et al., 1995). All the 84 respondents provided complete responses, resulting in 84 observations available for analysis. There were 168 variables in the study. After the correlation analysis, the number of variables was reduced from 168 to 95 by considering a 5% significance level.

In modeling, the logistic regression was used to predict the presence or absence of a characteristic or outcome based on values of predictor variables. The dependent variable was the diagnosis of WRMSDs. The dependent variable was regressed against different set of independent variables that results in 7 different models. These models were named as: Demographics structure, physical job characteristics, psychosocial job characteristics, office ergonomics, musculoskeletal symptoms, frequency of musculoskeletal symptoms, and medical history.

RESULTS

Female respondents (58.33%) appeared to be dominating the male respondents (41.67%). Around 71.08% of the participants were between 20 to 30 years old (Figure 1). More than half of the respondents (53.57%) were from EMU. Around 23.81% of them were faculty members, and 22.62% of them were research assistants. Participants who are not from EMU were around 46.43%. The keyboard and mouse were reported to be the most popular (94.05%) input devices, whereas only 5.95% of the respondents were using the touchpad

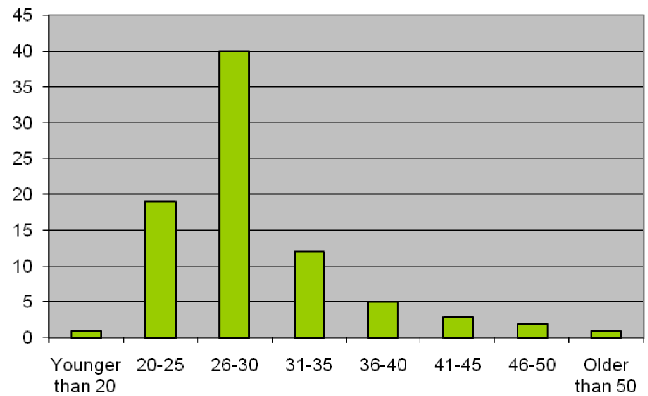

Figure 1. Age distribution (n = 84).

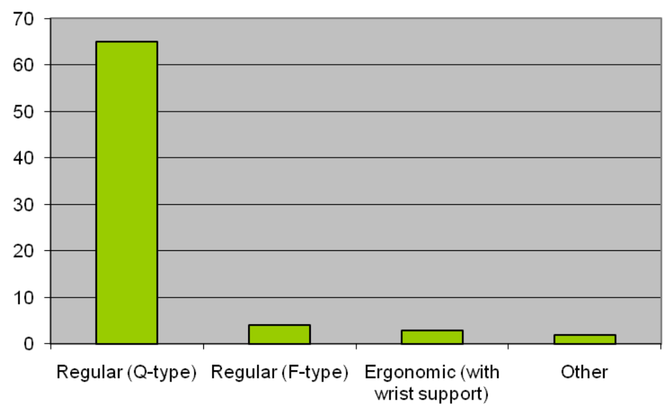

Figure 2. Keyboard type distribution (n = 84).

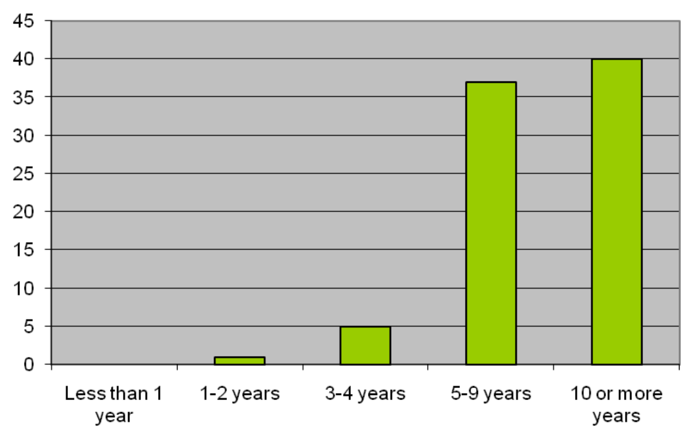

Figure 3. Distribution of years of keyboard use (n = 84).

and the keypad as primary input devices. Moreover, 87.84% of the respondents were using regular (Q-type) keyboards. Additionally, 75% of the respondents were using desktop and 25% of the respondents were using laptop computers (Figure 2). Regarding the keyboard use, it was found that 48.19% of the respondents have been using keyboard for 10 or more years, and 44.58% have been using keyboard for at least 5 years (Figure 3). Around 27.38% of the respondents reported their daily keyboard use as 5 to 6 h per day, 28.57% of them as 7 to 8 h per day, and 21.43% of them as more than 8 h per day (Figure 4).

Table 1 presents the results obtained on the ergonomic qualities that were built in the workstations. The results

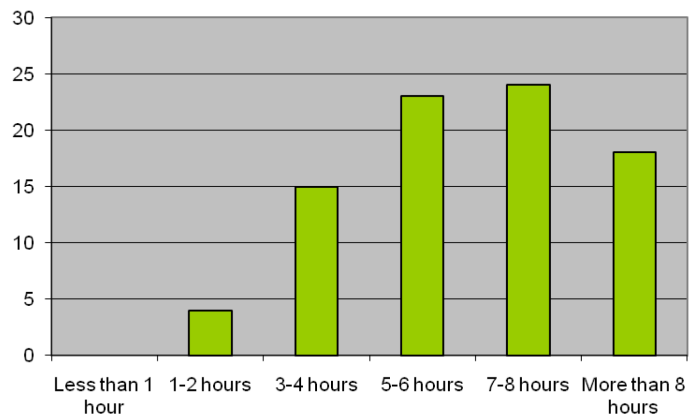

Figure 4. Distribution daily keyboard use (n = 84).

Table 1. Office ergonomics qualities (n = 84).

Office ergonomics	Yes (%)	No (%)
Lean back to support vertebrae	63.10	36.90
Elbows form 90 degrees from shoulder	36.90	63.10
Feet are comfortable in the front	69.05	30.95
Seat and hands are centered on the keyboard	82.14	17.86
Sit symmetrically	42.86	57.14
Keyboard and mouse are at the fingertips	78.57	21.43
Keyboard and mouse are at the same level	78.57	21.43
Screen is arm length away from the eyes	76.19	23.81
Monitor is at the eye level	64.29	35.71
Sufficient lightening available, no glare	65.48	34.52
Talk on phone between head and shoulder	32.14	67.86
Neutral wrist position	76.19	23.81
Neutral head and neck position	60.71	39.29
Elbow and arm support available	42.17	57.83
Foot support available	26.51	73.39
Change sitting position every 15 min	60.71	32.29
Take active breaks	61.90	38.10
Take frequent micro breaks	41.67	58.33
Trained in posture	15.48	84.52

show that the majority of the respondents did not have 90° angles between their shoulders and elbows. They did not sit symmetrically, and they used the phone by having the handset between the head and the shoulder. Elbow, arm or foot supports also were not available in the respondents' workstations. Moreover, the majority of the respondents (84.52%) were not trained in posture (Table 1). Table 2 shows that the ache and the pain were the most common types of discomforts which are experienced at the neck, shoulder, upper and lower back regions. However, the discomforts are more pronounced at shoulders, necks, upper backs, and hands/wrists, respectively (Table 2). Discomforts were most frequently experienced at the neck, upper back, shoulder, and the lower back regions as can be seen from the Table 3. Among the participants in this survey, 14 had a car accident. Around 6 out of 14 had this accident within 12 months (7.14% of the whole population). Moreover, 12 participants reported that they were diagnosed to have a work-related musculoskeletal disorder by a medical doctor, and 7 out of 12 (8.33% of the whole respondents) reported the diagnosis had been made within the last 12 months.

In order to determine a meaningful and statistically significant relationship between perceived work-related musculoskeletal disorders and computer keyboard use, we developed a mathematical model. The dependent variable is the WRMSD diagnosis by a medical doctor

Table 2. Type of discomfort.

Part of the body	Feeling									
	Ache (%)	Pain (%)	Cramp (%)	Tingling (%)	Numbness (%)	Heaviness (%)	Weakness (%)	Tightness (%)	Hot and cold (%)	Swelling (%)
Neck	39.29	38.1	7.14	0	0	13.1	5.95	11.9	1.19	1.19
Shoulder	45.24	34.52	4.76	2.38	3.57	25	10.71	7.14	2.38	2.38
Elbow/forearm	17.86	9.52	3.57	8.33	11.9	5.95	13.1	0	1.19	0
Hand/wrist	15.48	16.67	4.76	15.48	16.67	4.76	13.1	3.57	5.95	5.95
Finger	10.71	13.1	5.95	15.48	11.9	4.76	4.76	1.19	2.38	3.57
Upper back	38.1	34.52	1.19	2.38	5.95	14.29	7.14	7.14	1.19	1.19
Lower back	33.33	29.76	3.57	1.19	1.19	9.52	4.76	7.14	1.19	1.19

Table 3. Frequency of discomfort.

Part of the body	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Very often (%)
Neck	5.95	9.52	26.19	25	11.9
Shoulder	4.76	8.33	27.38	20.24	11.9
Elbow/forearm	16.67	13.1	15.48	5.95	4.76
Hand/wrist	11.9	14.29	20.24	11.9	3.57
Finger	15.48	17.86	17.86	3.57	3.57
Upper back	3.57	9.52	28.57	20.24	11.9
Lower back	7.14	15.48	23.81	15.48	10.71

Table 4. Demographic structure.

Significant predictor	p	Odds ratio	95% CI
Occupation	0.039	0.484	0.243-0.965
Gender	0.038	0.025	0.001-0.812
Age	0.016	0.410	0.199-0.844

(dichotomous dependent variable), and the independent variables were as determined earlier in methodology. The independent variables are selected from 95 factors which are divided into 8 models. The first concern was the determination of the sample. It is well known that there should be 5 observations for each independent variable (Hair et al., 1995). The sample size, 84 observations, meets the proposed guideline for the ratio of observations to independent variables. This can assure that, no danger of over fitting the sample, and results would be valid to ensure the generalizability. The next concern is to develop mathematical models to determine the risk factors that cause WRMSDs. In this respect, we developed 7 different models by using logistic regression, where the dependent variable in each model is the WRMSDs diagnosis by a medical doctor. The independent variables were selected among the variables of the 7 models that were discussed earlier.

The logistic regression was used because many of the independent variables were qualitative and the normality of residuals cannot be guaranteed. The analyses of WRMSDs predicted with significance level ($p<0.05$) that, occupation (OR=0.484, CI: 0.243-0.965), gender (OR=0.025, CI: 0.001-0.812), and age (OR=0.410, CI: 0.199-0.844) are the significant demographic factors associated with the formation of WRMSDs (Table 4). Also, the number of years in using the computer (OR=1.527, CI: 0.001-0.623) was found as the only significant factor for the physical job characteristics model (Table 5). Plus, the factor 'like working with the computer' (OR=0.050, CI: 0.791-2.983) was found as the only significant factor for the psychosocial job characteristics model (Table 6). Besides, the availability of the foot support (OR=0.295, CI: 0.092-0.041) and sufficient lightening (OR=3.477, CI: 1.232-9.810) were found to be the significant office ergonomics factors that are associated with the formation of WRMSDs (Table 7).

Additionally, the pain in the elbow (OR=44.06, CI: 1.171-1133.80), pain in the fingers (OR=0.074, CI: 0.013-0.972), pain in the upper back (OR=0.121, CI: 0.023-0.894), pain in the lower back (OR=0.173, CI: 0.034-1.000), heaviness in the shoulders (OR=0.676, CI:0.523-

Table 5. Physical job characteristics.

Significant predictor	p	Odds ratio	95% CI
Years of computer use	0.049	1.527	0.791-2.983

Table 6. Phsychosocial job characteristics.

Significant predictor	p	Odds ratio	95% CI
Like working with computers	0.02	0.050	0.001-0.623

Table 7. Office ergonomics.

Significant predictor	p	Odds ratio	95% CI
Availability of foot support	0.039	0.295	0.092-0.041
Availability of sufficient lightening	0.019	3.477	1.232-9.810

Table 8. Symptoms.

Significant predictor	p	Odds ratio	95% CI
Pain in the elbow	0.022	44.06	1.171-1133.80
Pain in the finger	0.047	0.074	0.013-0.972
Pain in the upper back	0.038	0.121	0.023-0.894
Pain in the lower back	0.049	0.173	0.034-1.000
Heaviness in the shoulders	0.003	0.676	0.523-0.874
Swelling in the hand	0.023	0.091	0.013-0.732

Table 9. Frequency of the symptoms.

Significant predictor	p	Odds ratio	95% CI
Very often in the neck	0.046	0.192	0.051-9.444
Very often in the shoulders	0.027	0.354	0.062-2.154
Never in the elbows	0.036	0.734	0.122-4.502
Often in hands	0.046	0.213	0.043-1.111
Very often in the fingers	0.025	0.053	0.001-0.683
Very often in the lower back	0.003	0.032	0.001-0.324

Table 10. Medical history.

Significant predictor	p	Odds ratio	95% CI
Recent diagnosis of WRMSDs	0.043	0.54	0.001-0.904

0.874), and swelling in the hands (OR=0.091, CI=0.013-0.732) were found as significant symptoms experienced while using a keyboard or a mouse (Table 8). Besides that, the significant symptoms of experiences are very often in neck (OR=0.192, CI: 0.051-9.444), very often in shoulders (OR=0.354, CI: 0.062-2.154), never in the elbow (OR=0.734, CI:0.122-4.502), often in hands (OR=0.213, CI:0.043-1.111), very often in fingers (OR=0.053, CI=0.001-0.683), and often in lower back (OR=0.032, CI: 0.001-0.324) (Table 9).

In the last model where the variables related with personal medical history are considered as independent variables, only recent (within 12 months) diagnosis of the WRMSDs (OR=0.540, CI: 0.001-0.904) was found to be

Table 11. Model summary

Model	-2LL	Cox and Snell R^2	Nagelkerke R^2
Demographic structure	58.833	0.142	0.253
Physical Job characteristics	58.446	0.500	0.087
Psychosocial Job characteristics	13.591	0.285	0.488
Office ergonomics	50.782	0.119	0.159
Symptoms	51.002	0.191	0.203
Frequency of symptoms	13.461	0.485	0.863
Medical history	12.366	0.467	0.849

the only significant factor associated with the formation of the WRMSDs (Table 10). Model summary presents the information for which the model provides better fit. For a good model, the log likelihood (-2LL) value should have a value of zero, or at least close to zero. Good models also have high Cox and Snell R^2 values and the Nagelkerke R^2 values should be close to 1 for a perfect fit model. The number of predictor variables ranges for each of the model is between one and six. The strength of the model also varies according to the model parameters. Having the log likelihood values close to zero (0) and Nagelkerke R^2 values close to one, model 7 (N.R^2:0.849, -2LL:12.366), model 6 (N.R^2: 0.863, -2LL:13.461), and model 3 (N.R^2:0.488, -2LL:13.591) were strong models. Moreover, having higher Cox and Snell R^2 values of the model 6 (0.485) states that the association is relatively strong, and the predictors of WRMSDs diagnosis have a strength of 48.5% of explaining the variance (Table 11).

DISCUSSION

Most of the studies on the formation of WRMSDs in human-computer interaction have been focused on the gender differences, physical and psychological aspects of the user and have not yet considered extra-rational factors such as the perceived musculoskeletal discomfort types and their frequencies. This study presents the idea of understanding how demographic structure, physical and psychosocial job characteristics, office ergonomics, perceived musculoskeletal discomfort types and their frequencies may affect formation of musculoskeletal disorders.

The results from this research emphasized that formation of musculoskeletal disorders are related with demographic factors, physical and psychosocial job characteristics, office ergonomics, symptoms experienced during computer use and the medical history (individual factors). The musculoskeletal health depends on psychological and social conditions, physical ergonomic factors, and individual factors (Jensen et al., 2002) According to an extensive review of WRMSDs conducted by National Institute of Occupational Safety and Health (NIOSH) in the USA (NIOSH, 1997), psychosocial factors which can cause stress, might also influence or be related to ergonomic factors such as repetition of work and posture that, have been identified as risk factors for musculoskeletal symptoms (Buckle and Devereux, 2002). Monotonous work and prolonged static posture for 6 to 8 h/day (OR:3.32, CI: 1.79-2.49), high perceived stress as neck flexion for 6 to 8 h/day (OR=3.91, CI: 1.27-2.38) and wrist flexion for 6 to 8 h/day (OR=3.58, CI: 1.76-7.46), and physical ergonomic factors in terms of elbow, arm or wrist/hand symptoms for computer work of 6 to 8 h/day (OR=2.01, CI: 0.71-2.19) are related to musculoskeletal symptoms (Blatter and Bongers, 2002).

The disorders of the upper extremities, such as carpal tunnel syndrome, repetition, constant force, and vibration are particularly important work-related factors (Farangaransu and Kumar, 2003). The recognized work-related psychosocial factors include rapid work pace, monotonous work, high job demands, low job satisfaction, and job stress (Jensen et al., 2002). A number of characteristics of the individuals appear to affect the vulnerability to WRMSDs, including increasing age, gender, body mass index, and a number of individual psychological factors. These factors are important as contributing and modifying influences in the development of pain and disability and in the transition from acute to chronic pain. The findings from this study shows that the gender (OR=3.37, CI: 2.38-4.77) is a significant factor of the formation of WRMSDs and this finding is consistent with the findings of Jensen et al. (2002), and Karlqvist et al. (2002). In contrast to Blatter and Bongers (2002), we found that, psychosocial factors (like working with computers, OR=0.050, CI: 0.001-0.623) contribute to the formation of WRMSDs.

Additionally, this current research brings into significance, office ergonomics qualities [such as availability of foot support (OR= 0.295, CI: 0.092-0.041)] and availability of sufficient lightening (OR=3.477, CI: 1.232-9.810) with the association of the formation of WRMSDs. These findings are consistent with the findings of Tittiranonda et al. (1999). In both studies, it was shown that physical exposures are associated with increased risk of upper extremity disorders. Another distinct attempt of the current research is that, the current research provides an evidence that the symptoms of musculoskeletal discomfort (such as pain), and the frequency of these symptoms are also significant in the development of

WRMSDs. Therefore, this study fills the gap in the literature by proving guidance for solving problems related with costly health problems (direct cost), lost productivity (indirect cost). This is done through addressing the significant factors in the formation of WRMSDs and making interventions accordingly to eliminate the imposed economic burdens. 'Occupation' as a risk factor can be taken under control with appropriate interventions. Psychosocial and physical occupational risk factors should be analyzed in detail to understand the effect on the organization. Primarily, the working conditions should be analyzed for awkward postures and repetitive jobs. Also, stressful conditions, such as working with deadlines, should be addressed for a change. Moreover, scheduling is another approach to be addressed in order to manage the working hours and shift divisions. Protecting the staff against environmental working conditions could result in better decision making and better implementation of work to have better efficiency and utilization.

In many studies on 'gender' differences, reports showed that women have been experiencing more complaints than men (Blatter and Bongers, 2002). The reason of this difference can be either the expression of pain, or the exposure to risk factors at work or outside work. Physically, women on average have smaller body dimensions, lower muscle force and lower aerobic capacity. Hence, women can have different coping strategies to deal with work-related stressors than men. Therefore, assigning women to job should be done according to their physical and psychosocial capabilities. WRMSDs, repetitive strain injuries (RSI) and cumulative trauma disorders (CTD) cause pain, slow responses, increased probabilities of accidents, reduced quality of life and working ability in 'aging' working population (Jensen et al., 2002). Thus, assessment of work which requires neuromuscular ability should be carried out to position an employee who is at appropriate age. Both of our statistics and mathematical model show that 'unavailability of foot support' and 'sufficient lightening' contributes to the formation of WRMSDs. The foot support should be available to rest the foot, and prevention of glare should be maintained to prevent the formation of WRMSDs. 'Pain in elbow and finger 'could be the result of constant blockage of motor responses to the finger and blood circulation in the hands. 'Swelling in the hand' could be a further phase of these conditions if no intervention is applied and might result in carpal tunnel syndrome (CTS). Use of mouse and keyboard supports, together with elbow support helps to prevent the pain in the fingers and elbow, and arm support will help to relieve the 'heaviness in the shoulders'. Supporting the back should be also taken into consideration to avoid the complaints on 'upper back and lower back pain'.

The collection of data from a wider area of recruitment would provide greater generalizability to the study. Moreover, a wider array of technological background and especially educational level may yield different results. Including people other than the college community would also increase the reliability of psychosocial aspect of this study. More research needs to be done on the area of psychosocial factors of musculoskeletal symptoms, associated with computer use. Further research is also needed in the area of perception and attitudes towards computer use. Replication of this study with more precise quantitative scales, as well as different musculoskeletal disorder types would verify the results presented in this study.

Since, perception and privacy issues differ from person to person because of culture and living standards, which may not be shared in such study. Further research is needed on how income would affect the computer keyboard use, and the musculoskeletal experience.

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