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Analysis of Ergonomic Risk Factors in Relation to Musculoskeletal Disorder Symptoms in Office Workers

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Abstract

The development of technology has increased the number of activities workers are able to perform while using visual display units (VDUs), as well as the amount of time spent executing those activities; the developing technology, however, has also increased the probability of musculoskeletal disorders (MSDs), which can decrease a worker's productivity and result in a company's economic loss. Workers at PT. X use VDUs 8 hours per day. This research aimed to analyse the risk factors that are the likely cause of some MSD symptoms experienced by PT. X workers, such as individual and psychological factors, the work environment, VDU, chair and the work patterns. This research was a cross-sectional study that used proportional stratified random sampling with 95 participants. The study found that most of the workers experienced MSD symptoms (78.6%), of which 70.52 percent were chronic complaints, 1.37 percent were acute complaints and 6.71 percent were a combination of both acute and chronic complaints. On the other hand, 16.84 percent of the respondents did not have any MSD complaints. Risk factors that were shown to be related to MSDs include high BMI (p = 0.031), work patterns period (p = 039), job stress perception (p = 0.005) and work posture (p = 0.036). Work posture relates to seat length (p = 0.041) and seat height (p = 0.005). Job stress perception is related to the details of assignments or work (p = 0.047), duration of work (p = 0.04), duration of rest (p = 0.000), work demands (p = 0.018) and job control (p = 0.009). Based on multivariate analysis, the most dominant risk factors associated with MSD complaints were the duration of rest, work posture and job stress perception.

Keywords: MSDs, office ergonomics, VDU, work posture

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1. Introduction

Technological developments have led to changes in activities performed by office workers using visual display units (VDUs) to complete required tasks. The number of VDU users has increased since 1989, and this increased use can lead to musculoskeletal disorders (MSDs) [1–4]. Since the occurrence of MSDs in the workplace has become one of the most prevalent occupational diseases, it is an issue of concern to some governments, such as those of the North American and Nordic countries, Thailand, India and Japan [5–7]. The disadvantages of MSDs include a decline in work productivity and economic loss [8–10]. MSDs begin with symptoms of localised pain in one or more parts of the body, the level of which may differ depending upon the individual [11]. The PT. X office workers' activities are most often performed with VDUs, approximately 8 hours per day. At present, the research on MSDs conducted by PT. X is limited. Therefore, this study aimed to analyse risk factors that are the likely cause of some of the MSD symptoms experienced by the PT. X workers, such as individual and psychological factors, the work environment, VDU, chair and work patterns.

2. Methods

This study used a cross-sectional design to analyse the relationships between independent variables comprising individual characteristics (age, sex, BMI, working period, body posture, job stress), work pattern (duration of rest and duration of work), environmental factor (lighting and illumination), psychosocial factors (work demands, social support, job satisfaction, job control and work stress), size of desk and chair, and the workers' anthropometry with MSD complaints as dependent variable. The study was conducted on office workers in PT. X during February through May 2017. The population in this study is 95 workers found by proportional stratified random sampling method using Slovin's formula.

The research instruments used in this study were: a digital camera, the company's documented reports (worker's anthropometry, size of desk and chair), checklist of MSD complaint by Nordic Body Map (NBM), a checklist of body posture by ROSA (Rapid Office Strain Assessment) and a checklist of psychosocial factors by COPSOQ II (Copenhagen Psychosocial Questionnaire II) as references. Authors also conducted the validity and reliability test of psychosocial factors checklist. The data were analysed via three different methods: univariate analysis (frequency distribution table), bivariate analysis (chi-square test or Fisher's exact test) and multivariate analysis ordinal regression) using SPSS statistics 23.0.

3. Results

As seen in Table 1, the relationships between ergonomic risk factors and MSD complaints are BMI (p = 0.031; OR = 0.141; CI 95% = 0.016 – 1.251), work period (p = 0.039; OR = 4.444; CI 95% = 1.175 – 16.815), p = 0.007; OR = 8.700; CI 95% = 1.092 – 69.312), job stress perception (p = 0.005; OR = 3.732; CI 95% = 1.514 – 21.730), rest duration (p = 0.001; OR = 7.948; CI 95% = 2.454 – 25.745) and duration of work (p = 0.040; OR = 4.034; CI 95% = 1.116 – 14.585).

Table 1: The relationship of individual factors and work pattern with MSD's complaints on the workers in PT. X in the year 2017.

Category		Symptoms Present		Symptoms Not Present		p	OR	CI 95%	
		n	%	n	%			Lower	Upper
Gender	Women	21	22.1	4	4.2	0.896	1.086	0.315	3.741
	Men	58	61.1	12	12.6				
Age	> 30 years	54	56.8	13	13.7	0.302	0.498	0.130	1.907
	< 30 years	25	26.3	3	3.2				
BMI	Obese	16	16.8	0	0	**0.031***	0.141	0.016	1.251
	Overweight	18	18.9	8	8.4		0.402	0.046	3.524
	Thin–Normal	45	47.4	8	8.4				
Working period	> 5 years	50	52.6	3	3.2	**0.039***	4.444	1.175	16.815
	< 5 years	41	43.1	13	13.7				
Body posture	> Action Level	29	30.5	1	1.1	**0.036***	8.700	1.092	69.312
	< Action Level	50	52.6	15	15.8				
Work Stress	Job Stress	45	47.4	3	3.2	**0.005***	5.732	1.514	21.730
	No Job Stress	34	35.8	13	13.7				
Duration of Rest	High risk	68	71.6	7	8.4	**0.000***	7.948	2.454	25.745
	Low risk	11	11.6	9	9.5				
Duration of work	High risk	71	74.7	11	11.6	**0.040***	4.034	1.116	14.585
	Low risk	8	8.4	5	5.2				

Note: * = p-value < 0.05 = Significant Correlation.

As seen in Table 2, variables that significantly correlate with the suitability of tools used on the job and work posture are length of the chair and popliteal bottom (p = 0.04; OR = 2.647; CI 95% = 0.996 – 7.033), height of the chair and height of the popliteal to work posture (p = 0.005; OR = 5.625; CI 95% = 1.543 – 25.500). As shown in Table 2, environmental factors are not related to the body posture of the workers while using VDUs.

Table 2: The relationship of working tools suitability. Environmental factors to workers' body postures in PT. X in the year 2017.

Category		Body Posture				p	OR	CI 95%	
		> Action Level		< Action Level					
		n	%	n	%			Lower	Upper
The width of back chair: Shoulder width	Not suitable	0	0.0	2	2.1	0.332	0.677	0.589	0.779
	Suitable	30	31.6	63	66.3				
Height of armrests: Height of elbow sitting	Not suitable	18	18.9	38	40.0	0.887	1.066	0,441	2.573
	Suitable	12	12.6	27	28.4				
Length of chair: Popliteal	Not suitable	23	24.2	36	37.9	**0.041***	2.647	0.996	7.033
	Suitable	7	7.4	29	30.5				
Width of chair: Hip width	Not suitable	0	0.0	0	0.0				
	Suitable	30	31.6	65	68.4				
Height of chair: Height of popliteal	Not suitable	27	28.4	40	42.1	**0.005***	5.625	1.543	25.50
	Suitable	3	3.2	25	26.3				
Height of desk: Height of elbow sitting + popliteal	Not suitable	29	30.5	56	58.9	0.121	4.661	0.563	38.6
	Suitable	1	1.1	9	9.5				
Temperature	Not suitable with NAB	3	3.2	5	5.3	0.704	1.333	0.297	5.986
	Suitable with NAB	27	28.4	60	63.2				
Lighting	Not suitable with NAB	8	8.4	12	12.6	0.420	1.606	0.577	4.464
	Suitable with NAB	22	23.2	53	55.8				

Note: * = p-value < 0.05 = Significant Correlation.

As presented in Table 3, the work organisation and psychological factors that were observed to relate to job stress are job description (p = 0.047; OR = 0.320; CI 95% = 0.112 – 0.992), job demands (p = 0.018; OR = 2.693; CI 95% = 1.175 – 6.176) and job control (p = 0.009; OR = 3.031; CI 95% = 1.300 – 7.063).

Partial tests of rest duration, work posture and job stress (sig. < 0.05) showed that these three factors serve in part as sources of MSD complaints. The result of goodness of fit showed a chi-square value of 45.611 ($p < 0.001$). This result indicates that rest duration, work posture and job stress significantly and simultaneously influence the occurrence of MSD complaints.

Table 3: The relationship of work pattern factors and psychological factors with job stress in PT. X in the year 2017.

Category		Job stress		Not Job stress		p	OR	CI 95%	
		n	%	n	%			Lower	Upper
The details of work	High risk	33	34.7	41	43.2	0.047*	0.322	0.112	0.992
	Low risk	15	15.8	6	6.3				
Job demand	High	29	30.5	17	17.9	0.018*	2.693	1.175	6.176
	Low	19	20.0	30	31.6				
Social support	Low	18	18.9	27	28.4	0.052	2.250	0.989	5.119
	High	30	31.6	20	21.1				
Job satisfactio	Low	22	23.2	18	18.9	0.457	0.734	0.324	1.661
	High	26	27.4	29	30.5				
Job Control	Low	21	22.1	33	34.7	0.009*	3.031	1.300	7.063
	High	27	28.4	14	14.7				
Note: * = p-value < 0.05 = Significant Correlation.									

Table 4: Multivariate analysis.

Parameter	Sig.	Goodness of fit			95% Confidence Interval	
		Chi square	p	R2	Lower Bound	Upper Bound
Rest duration	0.002	45,611	0.000	0.290	2.693	73.578
Work body posture	0.017				2.144	68.612
Job stress	0.005				1.933	47.670

4. Discussion

4.1. The relationship between MSD complaints and individual factors

In this research, the percentage of respondents who experienced MSDs was around 83.15 percent, while the percentage of those who did not experience MSDs was approximately 16.84 percent. These results indicate that MSDs do not occur as acute complaints but rather accumulate continuously and/or slowly over a long period of time.

The results of this study also demonstrate that there is no relationship between gender or age with the occurrence of MSDs. This is in line with the theory [12] that there is no maximum capacity index on static activity; muscle strength is therefore not related to MSD complaints. In addition, with respect to the age factor, a previous study [13] found that there was no association between age and MSD complaints. In this study, 70 percent of the respondents were 24–40 years old and therefore still productive. This condition can influence the workers' physical activities and life habits. However, the information provided in this study reflects only the working conditions at PT. X and cannot be generalized to working conditions in other industries.

This study also showed that MSD complaints were related to the workers' BMI, work period, work posture and work stress [14]. Based on field observations conducted by the researcher, most PT. X workers have BMIs that can make them susceptible to MSDs. In this research, there was also a relationship between MSDs and a work period of > 5 year.

The occupational seat-posture risk level can be identified based on the value on the ROSA form. If the posture is below the action level, workstation and posture conditions are acceptable. If posture is over the action level, the workstation and worker posture are in poor condition and have the potential to cause injury to the worker. This study revealed that MSDs are associated with work postures over the action level. This is consistent with a study [15] that found that awkward posture can lead to an increased risk of injury. Based on the observations, most PT. X workers had not applied ergonomic principles even though they had been using seats based on their anthropometry. In terms of the display screens used, 72 percent of the workers at PT. X use laptops, which cause awkward posture and increase the risk of neck pain while working. At the time the workers were interviewed, most were unaware of the risks of using laptops for long periods of time [16]. Illustrations of workers' activities while using VDUs are presented in Figures 1, 2 and 3.

In this study, there was a correlation between MSDs and workers with job stress perception. This finding is consistent with studies [12, 17] indicating that workers with job stress perception have a higher risk of experiencing MSD complaints and tend to spend 30 more minutes interacting with VDUs. The job stress perception of the workers at PT. X showed that job stress can be influenced by job demands and job control. The workers with job stress perception tend to spend more time working with computers.

Figure 1: Knee angle > 900. The thigh is too short—more than 3 inches. The backbone does not lean on the back of the chair. Monitor is too low < 300. The keyboard is too high, so the shoulders are too high.

4.2. The relationship between work equipment risk factors and posture

In this study, the researcher found no relationship between the width of the backs of workers' seats and the occurrence of MSD complaints. Ninety-eight per cent of the seats used by the workers in PT. X provide adequate support for the workers' shoulders; however, most of the workers do not use the backs of the seats because their size and height do not conform to the workers' popliteal height. This condition is in accordance with the theory [18, 19] suggesting that the optimal dimensions of

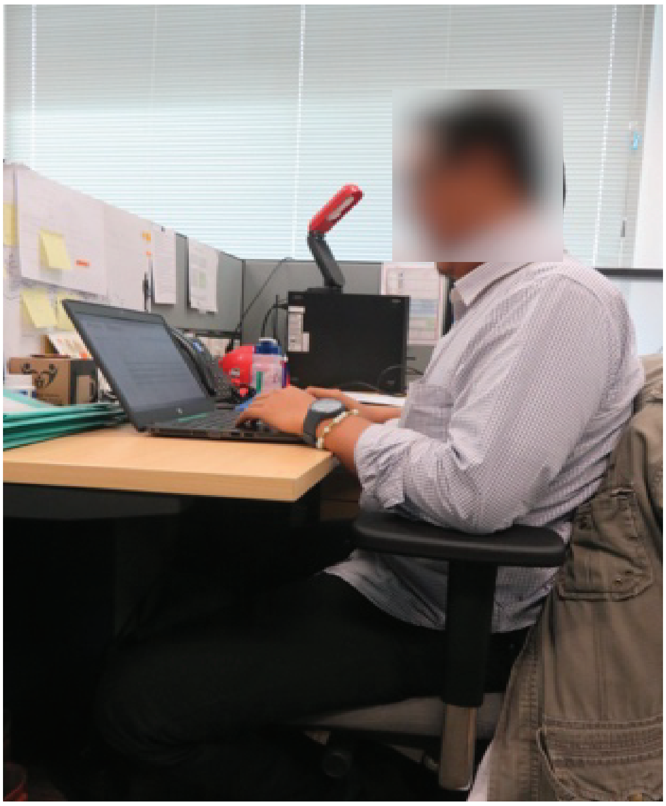

Figure 2: Knee angle > 900. Monitor is too low—i.e., < 300. The keyboard is too high. Hand position when typing is > 1.

work equipment are measured by looking at the reach capacity of the users, such as whether or not the size of the backs of seats can support the spinal cord.

The function of arm rests is to support the weight of hands, arms and the upper body parts while providing flexibility. In this study, the researcher found that there was no relationship between posture > action level and workers whose chairs have high arm rests (i.e., conform to elbow height while sitting) and workers whose chairs have high armrests (i.e., do not conform to elbow height while sitting). The field observations showed that the workers were less likely to use arm rests, but generally use the desk surface for their hand support when they are typing or using the mouse. Most of the workers indicated that the arm rests of their chairs do not correspond to the size of the desk arch.

In this study, the researcher found that there is a relationship between the posture action level of workers who use the chair length that conforms to the popliteal length and the workers who use the chair length that does not conform to the popliteal length. This result is in line with the theory [20] that states that if the user's seat size is not appropriate, the body mass will not be effectively distributed, resulting in an awkward position. Based on field observations, workers who do not have a seat size

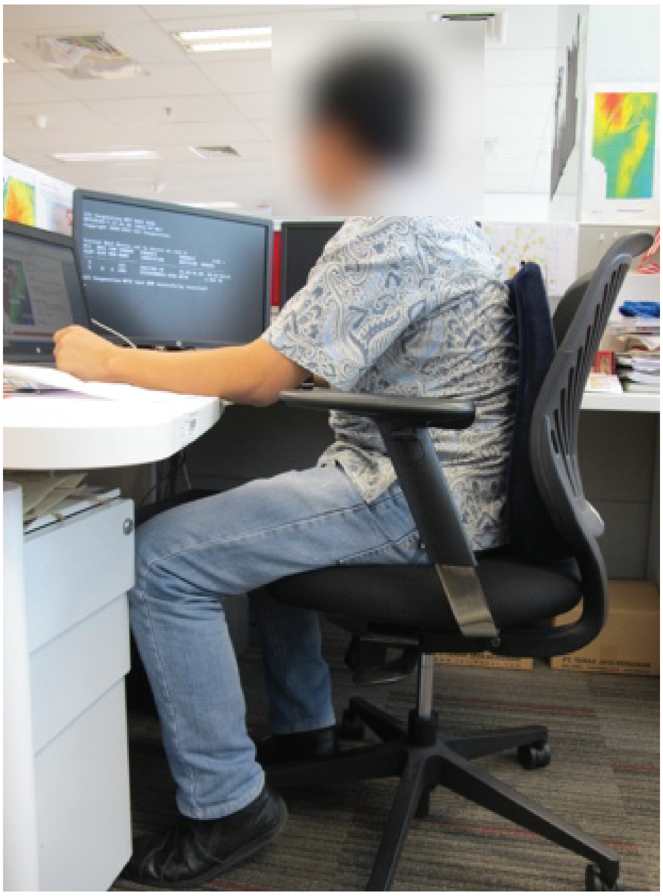

Figure 3: Leg room > 3 inch. Neck twisting > 30°.

that matches the length of the popliteal butt tend to bend their body forward so that the spine does not lean back to rest on the backs of the seats. This condition increases the risk of MSD complaints.

The analysis of the width of chairs cannot be processed because all respondents used the seats having an appropriate width. Results of the analyses of the workers' chair heights and work postures concluded that there is a relationship between work posture > action level and the workers who have high seats that conform to their popliteal height and the workers who have high seats that do not conform to popliteal height. According to a previous study [18], the seat height significantly influences the worker's posture when using the chair. If the seat height is less than the popliteal height, the user tends to incline the spine, making an acute angle between the thigh and the spine itself.

Workers' desks of an ideal size can reduce MSD complaints. The results of this study showed that there is a relationship between work posture over action level and the workers who use an appropriate table. This is consistent with findings [12, 18, 21] that suggest that the inappropriate use of a work table may lead to MSDs. To obtain an appropriate working height, workers with short legs who work at high tables should adjust their seats continuously. As a result, the workers tend to sit on the front edge of the chair and thus lose support from the back. In contrast, if a worker lowers the chair, the elbow position will rise, thereby causing neck and shoulder problems.

4.3. The relationship between environmental risk factors and posture

Exposure to cold temperatures can decrease the agility, sensitivity and strength of workers. If this exposure is not balanced with the energy supply to the muscle, the blood circulation will be disturbed, and the oxygen supply to the muscle will be decreased, creating an accumulation of lactic acid that can cause muscle pain [22, 23]. This research revealed no relationship between posture > action level of the workers in ambient temperatures that comply to the TLV (Threshold Limits Value) and the workers working in ambient temperatures that do not comply with the NAB. During the researcher's observations, 91 percent of the environmental temperature at PT. X was consistent with the recommendation given by the Ministry of Health, Act No. 48 (2016).

Illumination is a quantity that is closely related to the power of light [22]. If the workplace illumination is inadequate, it causes flexion of the neck (bowing) and body (bending), which increases the risk of MSDs [24]. The standard levels for office illumination are 300–500 Lux, based on the Ministry of Health, Act No. 48 (2016). In this study, no relationship was found between work posture below the action level and the work area lighting level. The observations revealed only a few work areas at PT. X that were insufficiently illuminated, and 55 percent of the company's remaining work areas had already implemented lighting that meet the standard levels.

4.4. The relationship between work pattern factors and MSDs

High-risk work durations are also related to MSD complaints. This is consistent with previous findings [20, 25–27] indicated that a long work duration (4–8 hours in 1 day) causes localized job stress, discomfort, decreased muscle performance and muscle contractions that reduce the blood supply, thereby significantly increasing the risk of MSDs.

The duration of irregular breaks is also related to MSD complaints. More frequent breaks of short durations are better than one long break. The implementation of having more frequent short breaks has a positive effect by reducing MSD complaints, especially for workers who use VDUs with short breaks at 20-minute intervals [22, 27–29].

4.5. The relationship between work pattern and psychological factors with job stress perception

The details of a job description present detailed activities that should be done by a worker within the organization in terms of managing work-related stress, which affects the occurrence of MSD complaints [4]. This idea is in line with the results of this study, which indicates that there is a relationship between MSD complaints and the high-risk tasks. The field observations in this study demonstrated that workers with high-risk job tend to spend most of their work time in front of VDUs.

Based on the analysis of the job demand factor, this study found a relationship between job demands and MSD complaints. The VDU workers' combination of psychosocial demands, such as tasks that cause mental pressures and require high concentration, and physical demands, such as posture and motions that tend to increase muscle tension or strength while using the keyboard or mouse, potentially result in MSD complaints [27]. During the interviews, the workers stated that they generally have high job demands that require continuous motivation and ideas as well as repetitive activities and motions.

This study found no relationship between MSD complaints and social support. Based on the interview results, most of the workers received good social support from their families or co-workers.

Job satisfaction is an emotional condition whereby workers feel happy or unhappy with their jobs. In this research, no association between job satisfaction and MSDs was found. Most of the PT. X workers stated that they were sufficiently satisfied with their job prospects as well as with the management.

Previous studies have shown that a low level of control related to decision latitude potentially causes MSDs [25, 30], a finding consistent with the results of this study, which found that there is a relationship between job control and MSD complaints [1].

5. Conclusions

In this study, 78.6 percent of the respondents experienced MSD complaints. Ergonomic risk factors that were found to be associated with MSD symptoms are individual factors, such as BMI, work period, job stress perception and work posture. The equipment risk factors that contribute to the occurrence of MSD symptoms include the length of the seat and the seat height. The work organization risk factors that lead to MSD symptoms are duration of work and duration of rest. In addition, the psychological factors, through job stress, that also cause MSDs symptoms are job description, job demands and job control. Finally, the factors which most contribute to ergonomic risks that cause MSDs symptoms are rest duration, posture and job stress perception.

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