Prevalence of Work-related Musculoskeletal Disorders (WMSDs) and associated ergonomics risk factors among Military aircraft maintenance Personnel

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ABSTRACT

Work-related musculoskeletal disorders (WMSDs) are a common health problem throughout the industrialised world and a major cause of disability. This study investigates the prevalence of Work-related musculoskeletal Disorders (WMSDs) among Military aircraft maintenance Personnel and to determine association between individual risk factors (Gender, Age, BMI, Education Level, Working Duration, years of working) with WMSDS symptoms. Forty (n=40) military aircraft maintenance Personnel were assessed for prevalence of WMSDs using Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). The effect of risk factors on WMSDs was analysed. The highest prevalence of WMSDs for the past 12 months is at shoulders and knees with percentage of 90.0% (n = 36), followed by lower back 77.5%% (n = 31), neck 70% (n = 28), wrist 62.5% (n = 25). The highest prevalence of WMSDs for the past 7 days is at shoulders with percentage of 60% and followed by neck, upper back, and lower legs 45% (n= 18). Chi square analysis for the one-week prevalence shows that there is association between age (p=0.012) and duration of services among military aircraft maintenance personnel. (p=0.008) with musculoskeletal symptoms. Age and duration of services is directly associated. It can be concluded that military aircraft maintenance personnel experience body pain and discomfort which leads to the risk of contracting WMSDs.

Keywords: Work-related musculoskeletal Disorders (WMSDs), ergonomics risk factors, prevalence, Military aircraft maintenance Personnel

INTRODUCTION

According to the International Labor Organization (ILO), 2.2 million people die each year because of work-related sickness or injury. Again, the World Health Organization (WHO) approximates it (Azizpour, et al., 2013). Work-related stress and strains, such

as work-related musculoskeletal problems, tend to be common in jobs with high work demands and variable work schedules, work-related stress, heavy workload, low control on the job, and little work experience (Azma, et al., 2015). As a term used to describe "musculoskeletal discomforts of arm, neck, shoulder, knee, wrist, forearm, lower back and upper back not caused by acute trauma or by any systemic disease" (Hagen, et al., 2012; Hales et sl., 1994), MSDs were first coined in the Netherlands and were known to result in serious and occasionally fatal warning signs, including pain, numbness, and tingling. Musculoskeletal disorder is a skeleton muscle disorder, and one can feel the problem in the muscles of the body, joints, nervous system, and cartilage bone. This problem of MSDs is caused by the repetition of motion, use of wrong body postures and load of work. MSDs also affect the upper limbs, legs, shoulders, neck and back. Pain in the lower back, pain in the neck, and pain in the shoulder are common musculoskeletal disorders (Britain, 2021). The system of the aircraft maintenance industry is complex, where factors like organizational and work environment may increase the chance of a crash and other damage to aircraft. Workers in the aircraft maintenance industry perform several activities depending on their assigned tasks, and all assigned tasks are performed by the manual material handling of workers. It is the job of workers in industry to handle all large and small components of aircraft. The strong relationship between lower back MSD and manual material handling is well organized in the literature. (Chaffin, & Park, (1973). Musculoskeletal disorders (MSD) are a widespread problem in armed forces worldwide (Cohen et al., 2012), especially in air force personnel (Rintala,etal., 2015; Kelley,et al., 2017; Posch et al., 2019) and army soldiers Roy et al., 2013; Monnier et al., 2015; Halvarsson et al., 2018; Monnier et al., 2019). Recently it was reported that MSD have increased over time among Swedish deployed soldiers (DS) (Halvarsson, et al., 2019) and Dutch Air Force personnel (Thoolen, et al.,2015). In Malaysia, they are concerns on the increased ergonomics risk and handling hazards faced by aircraft technicians of the RMAF. There has been lack of risk assessment and ergonomics safe operating procedures noted in earlier research (Thulasy, et al., 2021). Moreover, musculoskeletal injuries and disorders are the main reason for morbidity and temporary disability in military populations. The main aim of this study was to determine the prevalence of musculoskeletal discomfort and to determine the association between individual risk factors (Gender, Age, BMI, Education Level, Working Duration, years of working) and WMSDs among military aircraft maintenance personnel.

LITERATURE REVIEW

A recent analysis of Global Burden of Disease (GBD) data showed that approximately 1.71 billion people globally have musculoskeletal conditions *(Cieza, 2020). In 2017,* the Global Burden of Disease (GBD) found that MSDs comprise most of the top causes of years lived with disability (YLDs) worldwide and musculoskeletal conditions are also the highest contributor to the global need for rehabilitation (WHO, 2018). In Malaysia, it is reported by the "Department of Occupational Safety and Health (DOSH)" that MSDs are the highest reported occupational diseases compared to other occupational diseases and increasing yearly, resulting in sickness absenteeism as well as loss of productivity (DOSH, 2018).

Aircraft maintenance was the duty area resulting in the largest number of lost workdays for the USAF from fiscal records of the years 1993 through 2002 (Copley et al., 2003). Aircraft mechanics and avionics equipment technicians experience high

rates of workplace injuries, but injury risk exposures have not been systematically measured across the various jobs/tasks performed in this industry (Asadi et al., 2019). Musculoskeletal disorders (MSD) are common among soldiers and constitute the most common reason for discontinuing military service within different military populations worldwide. (Halvarsson, et al., 2019). Aircraft maintenance technician (AMT) is the most critical profession in the aircraft maintenance system. WMSD can adversely influence the work performance of Aircraft maintenance technician and may cause them to make errors that put the flight safety in danger. In contrast to the importance, there are a limited number of studies on risk factors for MSD of Aircraft maintenance technician (Yazgan et al., 2021). Dave et al., (2020) found that large numbers of defense personnel involved in maintenance and repair suffer from WMSDs. Aches and pain arising from work are taken as acceptable norms or as a usual part of life by these personnel. The researchers also concluded that there was a lack of awareness about prevention, treatment, and ergonomic care among defense personnel. The WHO Burden of Disease study has previously defined occupational ergonomic risk factors into four categories by occupation, these being background exposure (defined by manager and professionals as occupations); low exposure (clerical and sales workers); moderate exposure (operators and service workers); and high exposure (farmers) (Murray et al., 2004).

Work-related musculoskeletal symptoms are frequently reported among aircraft mechanics and avionics equipment technicians. Body regions affected include the low back, shoulders, legs and feet, neck, arms, and hands (Chae and Kim, 2005; Kemp et al., 2010; Zungu and Nigatu, 2015; Fajardo Rodriguez et al., 2016; Nogueira et al., 2012; Irwin and Streilein, 2015). For example, aircraft maintenance is the top duty area for civilian worker injuries in the U.S. Air Force, resulting in 33% of all lost workdays from 1993 to 2002 (Copley et al., 2010). Other studies have raised concern with low back pain (LBP) after observing prevalences of 12.9%–65% among surveyed aircraft maintenance technicians (Fajardo Rodriguez et al., 2016; Zungu and Nigatu, 2015; Chae and Kim, 2005).

METHODOLOGY

The sample population in this study includes military aircraft maintenance personnel from various RMAF units located in RMAF Base Subang, Selangor. Based on the Krejcie and Morgan 1970 sample size calculation, this research required a minimum sample size of 40 participants. Thus, 45 military aircraft maintenance personnel (Engineering department) were randomly selected to participate in this research via simple random sampling (n = 40). The specific work maintenance location includes six main workstations, namely the structure inspection area (engine inspection, avionic, electric, airframe, and instruments), engine bay, tire bay, hydraulic bay, Non-Destructive Test (NDT) bay, and modification bay. Note that only willing personnel were allowed to participate in the research. In this study only male participant involve as there is no female involve in maintenance works.

The RMAF maintenance functions are divided into two areas namely scheduled maintenance works and unscheduled maintenance works. The scheduled maintenance work comprises the bulk of the workload and is the focus of this study. Scheduled maintenance work is organized into three levels of work. These three maintenance levels are Organisational Level Maintenance (OLM), Intermediate Level Maintenance (ILM) and Depot Level Maintenance (DLM) Figure 1. In this study aviation

maintenance personnel who deal with OLM, and ILM only will be involved as DLM involves an external contractor to do the maintenance work. The specific workstation involved maintenance task in Structure Inspection area (engine inspection, avionic, electric, airframe and instruments), Engine Bay, Tyre Bay, Hydraulic Bay, Non-Destructive Test (NDT) Bay and Modification Bay. Estimation of sample size in research using Krejcie and Morgan is a commonly employed method. Krejcie and Morgan (1970) used the following formula to determine sampling size;

S = X2NP (1-P)/ d2 (N-1) + X2P(1-P)

S = required sample size

X2 = the table value of chi-square for one degree of freedom at the desired confidence level

N = the population size

P = the population proportion (assumed to be .50 since this would provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (.05)

Table 3.1

Table for Determining Sample Size of a Known Population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*

Questionnaires

The prevalence of MSDs was evaluated using Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). The CMDQ is a 54-item questionnaire comprising a body map diagram and questions about the prevalence of musculoskeletal aches, pain, or discomfort in 18 regions of the body an individual experienced over the previous week (Figure 2). Using a Likert scale, they were expected to rate the frequency (how often they experience pain) and the intensity (how much pain) by using Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). The CMDQ questionnaires began with demographic questions regarding Individual Risk Factor (Gender, Age, Education Level, Working Duration, years of working). Questionnaires have been used in many forms to collect data regarding numerous issues within Human Factor design evaluation.

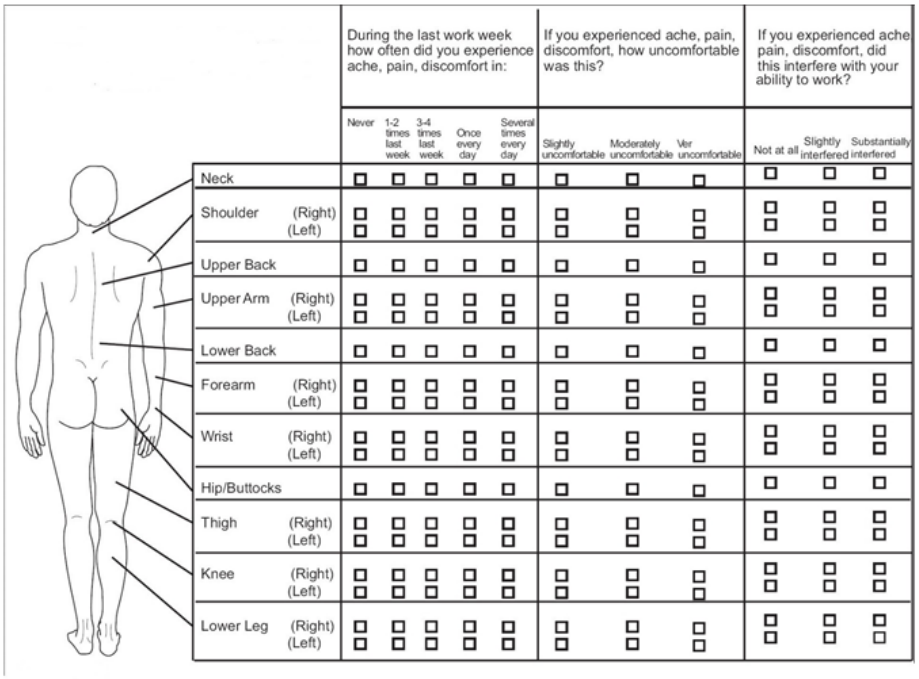

Figure 2: Cornell Musculoskeletal Discomfort Questionnaire, male version.

RESULTS AND DISCUSSION

Table 1: Respondent's demographic profile

Characteristics		Frequency (n)	Percentage (%)
Gender	Male	40	100
	Female	0	0
	Total	40	100.0
Ethnicity	Malay	37	92.5
	Indian	1	2.5
	Chinese	0	0
	Others	2	5
	Total	40	100.0
Age group	20–25	0	0
	26–35	32	80
	36–45	8	20
	46–55	0	0
	> 55	0	0
	Total	40	100.0
Working duration	1–7	1	2.5
	8	34	32.3
	> 9	5	12.5
	Total	40	100.0
Highest education level	PMR	0	0
	SPM	24	60
	STPM	0	0

	Diploma	0	0
	Degree	16	40
	Others	0	0
	Total	40	100.0
Work location	Structure inspection area	17	42.5
	Engine bay	10	25
	Tire bay	4	10
	Hydraulic bay	3	7.5
	Non-Destructive Test (NDT) bay	4	10
	Modification bay	2	5

Table 1 shows the respondent's demographic profile. Generally, all respondents in this study were males and mainly from the Malay ethnic. In this work location only, male workers are involved in the maintenance task. They were generally composed of two aged groups of 26–35 (80%) and 36–45 (20%). Accordingly, 17 personnel worked at the structure inspection area, while the remaining were stationed at the engine bay (10), tire bay (4), hydraulic bay (3), NDT bay (4), and modification bay (2).

Table 2: The prevalence of WMSDs for each body region last 12 months

No.	Body region	Prevalence (%)
1.	Neck	28 (70.0)
2.	Shoulders	36 (90.0)
3.	Upper back	19 (47.5)
4.	Upper arm	23 (57.5)
5.	Lower back	31 (77.5)
6.	Forearm	20 (50)
7.	Wrist	25 (62.5)
8.	Hands	26 (65.0)
9.	Hip/buttocks	11 (27.5)
10.	Thighs	16(6.4)
11.	Knees	36 (90.0)
12.	Lower legs	22 (55.0)
13.	Ankles/feet	15 (37.7)

The highest prevalence of WMSDs for the past 12 months is at shoulders and knees with percentage of 90.0% (n = 36), followed by lower back 77.5%% (n = 31), neck 70% (n = 28), wrist 62.5% (n = 25).

Table 3: Chi-Square test showing an association between socio-demographic data and exposure risk factors of Musculoskeletal Disorders (12 months)

Variables	X^2	*df*	*p-value*
Marital Status	21.982	17	0.185
Highest Educational Level	16.042	17	0.521
Race	33.108	34	0.511

Weight	368.056	374	0.577
Height	284.444	289	.0565
Age	194.524	221	0.900
Working Duration (in hours)	32.647	34	0.534
How long have you been working with the Royal Malaysian Air Forces?	537.222	510	0.195

Table 4: The prevalence of WMSDs for each body region last week

No.	Body region	Prevalence (%)
1.	Neck	18 (45.0)
2.	Shoulders	24(60.0)
3.	Upper back	18 (45)
4.	Upper arm	14 (35.0)
5.	Lower back	10 (25.0)
6.	Forearm	6 (15)
7.	Wrist	11 (27.5)
8.	Hands	12 (30.0)
9.	Hip/buttocks	6 (15.5)
10.	Thighs	5 (12.5)
11.	Knees	17 (42.5)
12.	Lower legs	18 (45.0)
13.	Ankles/feet	9 (22.5)

Table 5: Chi-square analysis

Variables	X^2	*df*	*p-value*
Marital Status	8.769	17	0.947
Highest Educational Level	13.993	17	0.668
Race	47.324	34	0.064
Weight	391.861	374	0.252
Height	322.667	289	0.084
Age	271.452	221	0.012
Working Duration (in hours)	31.912	34	0.570
How long have you been working with the Royal Malaysian Air Forces?	590.278	510	0.008

Back pain is an exceptionally common medical problem and remains a significant aeromedical issue. Because of this challenge to both maintenance of flight status and the longevity of an aviator's career, back pain in the aviation community may be underreported or unreported, making it difficult for clinical researchers to quantify Gaydos,2012; Knapik, et al., 2004). Revealed that large numbers of defence personnel involved in maintenance and repair suffer from WMSDs (Dave et al.,2020). Based on review article studies conducted by Ramlee et al., 2024 most of the maintenance personnel experienced with MSD symptoms depend on the body region and work activities.

In this study, the researcher found that the highest prevalence of WMSDs for the past 12 months is at shoulders and knees with percentage of 90.0% (n = 36), followed by lower back 77.5%% (n = 31), neck 70% (n = 28), wrist 62.5% (n = 25). The highest prevalence of WMSDs for the past 7 days is at shoulders with percentage of 60% and followed by neck, upper back, and lower legs 45% (n= 18). Same result reported by Tegern et. al., (2020) as the higher prevalence of MSD (i.e. neck, shoulder, and thoracic regions). Asadi, et al 2019 indicated that the low back was the most reported region of the body experiencing aches, pain, and discomfort (41% of participants), while knees were the highest (68%) in cabin maintenance, likely due to constraints in the aircraft cabin. The knee was the most common anatomic location for MSD in both cohorts. Across each anatomical location (neck, upper back, low back, shoulders, elbow, hand, hip, knee, lower leg and foot), both point prevalence ($p < 0.039$) and one-year prevalence ($p < 0.005$) increased significantly from 2002 to 2012. (Halvarsson, et al., 2019). However, a study reported by Nogueira et al. (2012) indicates the lower back as the most affected body region of aircraft maintenance personnel. Yusuf et al., 2023 found that the highest prevalence was detected in the lower back region. Chae and Kim 2005 found that the prevalence of symptoms was (12.9%) in the lower back, (10.2%) in the shoulders, (9.4%) in the legs/foots, (9%) in the neck, (5.9%) in the hands/wrists/fingers, and (2.7%) in the arms/elbows. There is significant positive effect on WMSDs, and an increase in tasks performed by aviation maintenance workers led to an increase in WMSDs Mahmood et al (2022). Many participant claimed pain in their shoulders, knees, lower back and neck. The pain is due to bad posture used during the accomplishment of tasks in the workplace. These primarily tasks may lead the workers to a dangerous limit of MSDs. To lift heavy products, workers of the industry move their bodies forward or backward consistently to accomplish the required task. This movement of the body leads the workers to a significant level of back pain (Pronk, et al., 2012). Workers affected by MSDs must receive medical treatment because the increased level of MSDs causes the workers to die (Smith, et al., 2012).

Chi square analysis for the one-week prevalence shows that there is association between age ($p=0.012$) and duration of services among military aircraft maintenance personnel. ($p=0.008$) with musculoskeletal symptoms. Age and duration of services are directly associated. It can be concluded that military aircraft maintenance personnel experience body pain and discomfort which leads to the risk of contracting WMSDs table 5. The frequency of having musculoskeletal symptoms in any body region was increased with age, lower education level, female gender, high BMI, job tenure and lifestyle (Krishnan, et al., 2021). However, diastolic blood pressure (DBP) work duration, gender, sleep duration) and poor exercise behaviors were the identified independent risk factors of WMSS among workers (Oluku, et al., 2020).

However, according to Abdullah and Dawal, 2020 there is no association between individual factors (age and working experience) and musculoskeletal discomfort.
Based on observations and interviews, researchers have suggested potential musculoskeletal injury risk factors include bending and working with twisted trunks (Zungu and Nigatu, 2015), lifting of aircraft parts (Kemp et al., 2010), high physical loads (Zungu and Nigatu, 2015), rapid muscle fatigue, and extended overhead activity (Irwin and Streilein, 2015). Injury risks were not limited to only task demands; studies have also suggested that the duration of employment (Zungu and Nigatu, 2015) and technicians' time in the office (Fajardo Rodriguez et al., 2016) may also be predictors for work-related musculoskeletal injuries. Overall, different physical exposures may differentially increase the risk of WRMSDs at different body parts. Physical risk factors can be classified into eight categories: (a) awkward body postures such as twisting, bending, or cramping positions; (b) strenuous arm movements such as reaching or arms over shoulders level or arms away from body; (c) repetitive, forced, or prolonged works; (d) frequent or heavy lifting; (e) squatting or kneeling; (f) pushing, pulling, and carrying objects; (g) manual material handling (MMH); and (h) use of vibrating machines. Choi et al. (2016) stated that prevention programs for WMSD not only reduced the likelihood of these injuries but also improved ergonomic programs, increased morale, productivity, and profitability of an organization.

CONCLUSION

As conclusion in this study participant experienced with the MSD symptoms. Researchers suggested that the job rotation stretching exercise and WMSD awareness program as intervention for preventing the development of MSDs.

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