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Assessment of Mental Workload, Workability and Musculoskeletal Disorders of Firefighters

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ABSTRACT

Introduction: Firefighting is one of the occupations that requires high physical and aerobic power due to the nature of the job and the physical demands of this profession. Therefore, the present study aimed to investigate the relationship among Workability index (WAI), mental workload, musculoskeletal disorders (MSDs) and their effective factors in firefighters.

Methods: This descriptive-analytical study was carried out on 250 firefighters in Tehran in 2019. Data were collected using WAI, NASA-TLX and Body Discomfort Chart (BDC). Data analysis was carried out using descriptive statistics, linear regression, Pearson , and Spearman correlations

Results: The mean (SD) of total mental load was 70.07 (6.58). Also, the mean (standard deviation) of the total WAI score was 38.85 (1.17). Physical workload dimension had the highest value among mental workload dimensions 93.49 (8.93). The results showed that WAI is increased by 0.14 by augmentation of one unit at the academic level of firefighters ($p = 0.03$). The most common discomfort was reported in the lower (50 people (20%)) and upper (42 people (16.8%)) regions of the back. The total WAI relationship with total mental workload was positive and insignificant ($p>0.05$). There was a significant and reverse association between WAI and discomfort in the wrist, leg, and ankle.

Conclusion: Despite the low rate of MSDs, even mild symptoms of musculoskeletal pain should be considered. Given the high level of mental workload, improving physical, psychosocial and social working conditions is important in increasing the ability of employees and augmenting the ability of their occupational activity.

Keywords: WAI, Firefighters, MSDs, Mental workload

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Introduction

Firefighting is an inherently dangerous, physically demanding occupation that requires a sufficient level of fitness to perform mandatory job duties (1). Firefighters often experience difficult conditions in their work environment. Therefore, they should have a good health condition and high physical and mental capacity. The capacity of physical work as a career needed during their career should remain at high level. Older firefighters face specific challenges to their ability to work and maintain physical fitness/ability to work and have physical fitness (2). The occupational responsibilities of firefighters can be diverse, challenging and dangerous (3) and because of the nature of their job, firefighters often need high physical fitness and excessive power (4). Tasks such as rescue of those who are in dangerous or distressing situations and extinguishing the fire require actions such as running, climbing, quick reaction, etc. (5). An occupational injury is often caused by falling, slipping and jumping, which accounts for approximately 28.7% of all injuries among firefighters (6).

In developed countries, the Fire Department and its staff are considered as the main pillar of the country's immunity and relief system. Direct exposure to harmful agents, including hazardous combustion products, toxic fumes, radiation, an environment full of stress and constant tension, working shifts and dealing with tragic stories and the high risk of exposure has classified firefighting as a serious and harmful occupation (7). For instance, firefighting in North America has been known as one of the five most dangerous jobs with a mortality rate of 48.8 per 100,000 people (8).

Therefore, in order to ensure the safety, health and comfort in the workplace and to increase the useful efficiency of people in the long run, the rationale and rational goal is that needs are adjusted in such a way that they are not more or less than the ability of an individual (9, 10). Firefighters combine physical and mental challenges while performing their job responsibilities (11).

The WAI is also defined as the extent to which the worker is able to adapt to their job requirements physically or mentally according to their own health (12). Various studies of the WAI have proven that the low level of the WAI increases the probability of sick leave, premature retirement, and even death in people (13-15). The mental workload refers to the amount of effort that the mind performs while doing a task and it is basically related to the individual's mental abilities and how the information is received and processed which ultimately leads to decisions and actions (16, 17). One of the reasons for the importance of measuring and evaluating the amount of mental work can be pointed to change the nature of work from physical to cognitive and perceptual nature (18). Several studies have shown that there are many stressful factors in relief and rescue -related occupations, such as firefighting due to its specific nature which affects the physical, mental, performance and quality of life of individuals directly (19). Weider believed that the physical and mental state of health of a firefighter can affect the safety and ability to do the optimal task (20).

Based on the results of a study by Bugajska and Sagan with the aim of investigating musculoskeletal disorders (MSDs) and the ability to do work in elderly and young workers, incidence and severity of pain in the arm/wrist, neck and lower back in both groups were accompanied by a decrease in WAI. Therefore, lower back pain in older workers was the most important risk factor in the reduction of WAI (21). Also, the study in different occupational groups revealed that age, obesity, physical inactivity in leisure time, poor musculoskeletal capacity, high psychological need, and heavy physical workload all have the negative effects on the WAI (22). MSDs are one of the most important occupational health issues in today's world and are prevalent in almost all professions (23).

These disorders account for approximately 48% of all work-related illnesses (23). In the study by Firoozeh et al., the high ability of Iranian firefighters was shown, so identifying the factors

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influencing this ability to improve their performance is necessary for subsequent studies (8). Accordingly, and in the light of recent incidents in Iran such as the Pelesko disaster which has had negative psychological effects on the firefighters, performing such studies at the current state seems to be more crucial. The aim of the present study was to investigate the relationship between the ability to do work, mental workload and MSDs as well as the effective factors in firefighters in Tehran so that the acquired outcomes can be used to plan and use effective interventions, corrective and preventive measures in order to increase the efficiency and productivity and reduce the prevalence of MSDs.

Methods

Studied type and community

The current research is a descriptive, analytical and cross-sectional study, which was carried out on 250 firefighters in the city of Tehran.

Among more than 4000 Fire Department personnel of the Fire Department in Tehran considering confidence level of 95%, the sample size was estimated to be 200. Ultimately, the mentioned size was increased to 250 people in order to boost accuracy. Cluster sampling was performed in 8 main operational areas. Eight stations in 4 geographic areas of Tehran (north, south, east, and west) were randomly selected from approximately 120 existing working stations. WAI, NASA-TLX and BDC questionnaires were used in this study. Before the completion of the questionnaires and the discomfort chart, applicants consent was obtained to participate in the study. If any of selected firefighters were excluded from the study for any reasons (absence, unwillingness to participate in the study), the next person was replaced in the list. Entry criteria also included a history of more than a year and lack of congenital diseases and those unrelated to the job. Meanwhile, those who had two jobs were excluded from the study.

Work Ability Index (WAI)

The WAI questionnaire was used in order to assess the ability to carry out work between firefighters. Finnish researchers have invented a questionnaire based on which the ability of workers to do work can be measured (12). The Persian version of the WAI questionnaire has already been presented (24). WAI includes seven dimensions which are listed in Table 1. Scoring criteria, according to Table 1, for each of the dimensions specified in the questionnaire was obtained. This table shows the composition of the WAI and the range of scores for each domain.

Table 1. Items covered by the WAI and the range of the scoring

Item	Scoring range (min & max)
Current workability compared with the lifetime best	0(very poor) 10(very good)
Workability in relation to the demands of the job	2(very poor) 10(very good)
Number of current diseases diagnosed by a physician	1(5 or more diseases) 7 (no disease)
Estimated work impairment due to diseases	1(fully impaired) 6(no impairment)
Sick leave during the past year (12 months)	1(100days or more) 5(0 day)
Own prognosis of work ability two years from now	1(hardly able to work) 7(fairly sure)
Mental resources (referring to the worker's life in general, both at work and during leisure time)	1 (very poor) 4(very good)

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Finally, WAI is classified according to four categories:

1) Ability to perform poor work (from score 7 to 27)
2) Ability to do the average work (from score 28 to 36)
3) Ability to do good work (from score 37-43)
4) Ability to do excellent work (Score 44 to 49).

Mental workload

The NASA-TLX (National Aeronautics and Space Administration Task Load Index (NASA-TLX) questionnaire was used to assess the mental workload of the firefighters. In fact, NASA-TLX is a multi-faceted tool for evaluating mental workload in a questionnaire that has been developed by the Human Performance Group at the NASA Ames Research Center (25). NASA-TLX as the most powerful tool evaluates total mental workload in six areas (Intellectual and mental load, physical load, temporal pressure, amount of effort, performance, and the amount of frustration).

The formal validity of the Persian version of this questionnaire was approved by Mohammadi et al. Moreover, the reliability of its internal consistency was evaluated as appropriate (α =0.847) (26). The mental workload in these six areas was assessed in the questionnaire. Except for the performance that was assessed between the two levels of good and bad, other domains were evaluated between two low and high levels.

The process of evaluating mental workload consists of three steps as the following: The first step is to determine the weight of each of the six scales as the goal is to determine the priority of the six-dimensional scale. The second step is to determine the rating of the load for each of the six scales. The goal of this step is to determine the effect of each of the six factors in creating mental load. After determining the load weight and load rating in the previous steps, in the third step, which is the last step, the total workload of the individual was calculated by multiplying the load weight and the rating of load according to the following formula, which is numerically between 0 and 100 (formula 1):

$$(1)\text{Total mental workload} = \frac{(W \times R)}{15}$$

Body Discomfort Chart (BDC)

Body discomfort chart (BDC) was used to investigate MSDs and the discomfort degree of people. BDC is a technique for assessing the degree of discomfort which is done based on the experience. This chart requests a history of some discomforts from firefighters. In this chart, firefighters were asked about their history/asked about the history of discomforts. In the next part, the person was asked to identify the amount of each discomfort as degrees of without discomfort, mild discomfort, moderate discomfort, and unbearable sadness according to a mental scale (27). The areas of the body that are examined in this chart consist of neck, shoulder, upper back, arm, elbow, lower back, forearm, wrists, hands and fingers, hip, thighs, knees, leg, and ankle.

Data analysis

SPSS software version 21 was used to analyze the data. The data were analyzed using descriptive statistics, linear regression, Pearson, and Spearman correlations.

Results

3.1 Descriptive information of individuals

The results of the present study showed that the mean and standard deviation of firefighters' age was 32.20 (4.54) and their ages ranged between 22 and 50 years. The mean and standard deviation of their work experience was 7.36 (4.57) years and individuals had at least one year and a maximum of 29 years of work experience. Meanwhile, 190 (76%) firefighters were married and 197 (78.8%) did not have any fire-fighting operations during the interview.

From the viewpoint of population distribution in terms of educational level, the highest rate of population was devoted to those with the education level of diploma, 114 people (45.6%). Then, 79 individuals (31.6%) with a bachelor's degree, 53 (21.2%) with an associate degree, and 4 with master’s degrees and higher were positioned in the next places. Also, all people were rotating shift

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workers and included the men only. Moreover, 233 individuals (93.2%) were cigarette smokers.

Results of the workability and mental workload and their relationship with the underlying and demographic variables

Table 2 shows the ability to do work and mental workload in different dimensions.

According to the table, the mean and standard deviation of the overall score for workability was 38.85 (1.17) which was evaluated well, according to the methodology (score between 37 and 43).

Meanwhile, the highest and lowest scores were related to the dimensions of current workability compared with the ability in the best life course and mental resources, respectively. Also, according to the information in Table 2, the dimension of physical load with (93.48 (8.93)) obtained the highest amount while feeling of disappointment and frustration (25.85 (23.88)) acquired the lowest amount in mental workload. The total mental load was also 70.07 (6.58).

Table 2. Mean and standard deviation of the workability WAI and mental workload and their dimensions in firefighters in Tehran

	WAI & Mental workload	Mean	SD
WAI Subscale	Current workability compared with the lifetime best	8.92	1.13
	Workability in relation to the demands of the job	8.11	1.06
	Current diseases diagnosed by a physician	5.12	1.78
	Estimated work impairment due to diseases	5.08	0.85
	Sick leave during the past 12 months	4.33	0.68
	Personal prognosis of workability 2 years from now	5.05	1.87
	Mental resources	2.24	0.85
	Total WAI	38.85	1.17
Dimensions of mental workload	Intellectual and mental load	92.28	10.21
	Physical load	93.48	8.93
	Temporal pressure	92.64	10.87
	Amount of effort	89.40	13.17
	Performance	26.81	21.59
	The amount of frustration	25.85	23.38
	Total mental workload	70.07	6.58

The number and the percentage score of firefighters' workability are shown in graph 1. According to the graph, job ability of a larger number of people (158 individuals (63.7%)), was good.

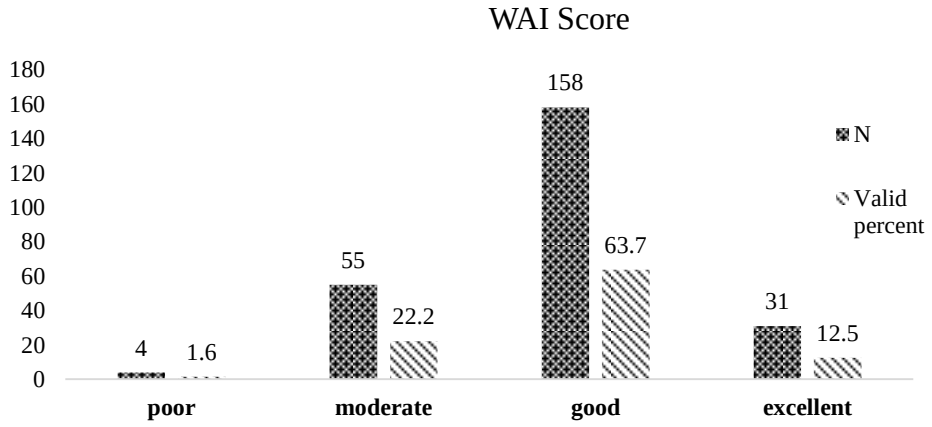


Figure 1. The overall score of the WAI in firefighters in Tehran

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The relationship between the WAI and the underlying and demographic variables in firefighters is demonstrated by linear regression in Table 3.

Meanwhile, considering the results, the WAI is augmented by 0.14 (p = 0.03) via increasing one unit in the academic degree of firefighters. As the age and level of education increased, the total workload decreased though not meaningful ((p = 0.24, β = - 0.177), (p = 0.52, β = - 0.043)). However, the total mental workload was improved with increasing work experience, although these connections were not significant (p=0.07, β=0.264).

Table 3. Relationship between WAI and demographic and background variables in firefighters

Variables	β	p	95% CI for β	
			Lower limit	Upper limit
Age	-0.23	0.11	-0.46	0.05
Education level	0.14	0.03	0.04	1.20
Work history	0.02	0.85	-0.22	0.27
Marriage	-0.07	0.22	-0.44	0.10
Smoking	0.01	0.86	-1.09	1.31
Having fire-fighting operations	-0.09	0.11	-2.14	0.23

Rate of Musculoskeletal Disorders (MSDs) of Firefighters

Table 4 shows the degree of discomfort in different areas of the body based on the BDC.

Considering the results, it is observed that the severity of discomfort of the firefighters understudy was very low and it is mild and slight in most parts such as the hip, thigh, and leg. The most common discomfort is related to the lower (20%) and upper (16.8%) regions of the back and neck (7.6%), respectively.

Table 4. The discomfort in different parts of the body based on the BDC in firefighters

Body part	The severity of discomfort, n (%)				
	Very mild	Mild	Moderate	Severe	Very severe
neck	193 (77.2)	25 (10.0)	12 (4.8)	19 (7.6)	1 (0.4)
shoulder	167 (66.8)	27 (10.8)	39 (15.6)	15 (6.0)	2 (0.8)
upper back	139 (55.6)	17 (6.8)	46 (18.4)	42 (16.8)	6 (2.4)
arm	182 (72.8)	28 (11.2)	25 (10.0)	15 (6.0)	0 (0)
elbow	168 (67.2)	34 (13.6)	33 (13.2)	13 (5.2)	2 (0.8)
lower back	133 (53.2)	20 (8.0)	33 (13.2)	50 (20.0)	14 (5.6)
forearm	190 (76.0)	26 (10.4)	20 (8.0)	14 (5.6)	0
wrist	193 (77.2)	34 (13.6)	13 (5.2)	6 (2.4)	4 (1.6)
hand and fingers	212 (84.8)	21 (8.4)	10 (4.0)	5 (2.0)	2 (0.8)
Hip	226 (90.4)	16 (6.4)	6 (2.4)	0 (0)	2 (0.8)
thigh	215 (86.0)	14 (5.6)	12 (4.8)	5 (2.0)	4 (1.6)
knee	189 (75.6)	18 (7.2)	17 (6.8)	18 (7.2)	8 (3.2)
Leg	206 (82.4)	11 (4.4)	24 (9.6)	7 (2.8)	2 (0.8)
Ankle	180 (72.0)	25 (10.0)	25 (10.0)	16 (6.4)	4 (1.6)

The relationship between different factors in this study

According to the results, WAI's relationship with total mental workload was positive but not significant (p= 0.55, r = 0.038). According to the results, WAI had a reverse and significant correlation with discomfort in wrist (p = 0.007, r = – 0.170), leg (p = 0.042, r = – 0.129) and ankle (p = 0.005, r = – 0.176) while total mental workload had a significant relationship with neck discomfort (p = 0.047, r = – 0.125).

Discussion

The results of the present study revealed that despite the high level of mental workload in firefighters, their WAI rates were good and

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desirable. WAI had a positive but insignificant relationship with the total mental workload, which was almost in contradiction with the results obtained by Safari et al. (10).

The WAI score was also relatively high in a study carried out by Firoozeh et al. (8). In a study by Safari et al., the high volume of mental workload was reported in textile workers but their workability was evaluated as average (10). They reported high mental load due to a reduction in WAI. On the other hand, a low level of MSDs in firefighters was stated as one of the results of this study which will be discussed further.

Thus, it can be deduced that people who are selected for firefighting should be physically fit and able to adapt themselves to difficult conditions, Therefore, in this study, mental workload did not have much effect on the WAI. Other studies have shown that low musculoskeletal capacity, work accidents, and poor working conditions can be a risk factor for reducing workability among firefighters (28, 29).

According to the results, individual features such as age, marital status, work experience, education level, and smoking were not effective on total mental workload which was consistent with the results of the study by Zimanian et al. (30). Based on the study carried out by Zamanian, demographic characteristics do not affect the workload and job satisfaction. Also, there was an inverse relationship between age, marital status, having firefighting operations and the total score of WAI, although it was not significant. It was indicated in a study on nurses by Hoonakker (31) that the physical burden of older nurses is lower than younger people. Meanwhile, a small number of smokers and having fire operations during the interview can be some of its insignificant reasons.

In a review article by Van den Berg et al., it was associated with the impact of lack of physical activity in leisure time, poor musculoskeletal capacity, older ages and high physical load with less WAI (22). As noted above, it can be similar in some ways and also inconsistent with the results of this study in some other cases. As it was noted, the musculoskeletal discomfort in the firefighters was very low, but the most discomfort was related to the lower and upper back. This is due to being young, having a long history of work and high physical fitness of people at the time of hiring. WAI had also a reverse and significant correlation with the amount of discomfort in wrist, leg and ankle areas. Despite the low level of these disorders during planning, preventive measures and promotion of health at work environment should be taken into account, among firefighters even mild symptoms of musculoskeletal pain should be considered. Results of a study by Punakallio et al., which was performed on Finnish firefighters in a 13-year follow-up period indicated back pain and symptoms of depression as a major risk factor reducing their ability to work (29). In another study by Airila et al., a number of key factors were acquired for the ability of firefighters to work well, such as frequent exercise, good sleep, lack of smoking, and physical activity (32). Based on the results of a study by Ilmarinen regular exercise can also maintain the physical capacity at older ages between 45 and 65 years without any changes (33), which can be considered to increase the physical capacity of individuals even in middle ages and above.

In general, various studies have expressed contradictory results in such relationships. These results are probably due to differences in the studied communities, although more studies are needed with higher sample sizes and the use of more objective methods is required. Because of the low job ability of such people, it can have adverse effects on their health and productivity. Therefore, consideration of periodic examinations and social, economic, welfare and psychological support of these people are required.

Performing studies with more populations, using more objective methods to assess job ability such as examining the maximum aerobic capacity of firefighters by methods such as treadmill, ergometer bike and stair, comparing their physical and aerobic capacity before and after work shifts as well as operations and the use of psychophysiological methods in the assessment of

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risk factors that increase the amount of workload are suggested in future studies.

Conclusion

The sectional characteristics of this study are considered as a limitation that impedes strong conclusions. In this study, increasing age, marital status and having a firefighting operation caused a reduction in WAI. Also, the ability to do work and mental workload in firefighters was high while the rate of their musculoskeletal discomfort was low. Despite the low level of such disorders when planning, preventive measures in the workplace, even mild symptoms of musculoskeletal pain should be taken into account.

Improvement of physical, psychosocial and social conditions to reduce MSDs is essential in boosting the ability of employees and as a result, increasing their occupational activity.

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