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Evaluating the Microscope Users Occupational Health Status Considering Musculoskeletal Disorders and Visual Fatigue at Tehran University of Medical Sciences

ELNAZ ROUDI [1], SEYED ABOLFAZL ZAKERIAN [2*],

[1]*Department of Occupational Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran*
[*2]*Department of Occupational Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran*

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ABSTRACT

A large number of specialists, technicians, and postgraduate students use microscopes in the laboratory for a long time and are at high risk for musculoskeletal disorders and eye fatigue. Long-time working with a microscope can be negatively affecting both the visual and musculoskeletal systems. This study was aimed to evaluate the occupational health status of microscope users in two dimensions of musculoskeletal problems and eye fatigue at Tehran University of Medical Sciences. A group of 40 microscope users at Tehran University of Medical Sciences was selected in this cross-sectional study. The instrument used in this study was the Eye Fatigue Questionnaire, Flicker Fusion System (PM-SS22881-Pars Madar Asia) for measuring eye fatigue, Nordic questionnaire, and Berg scale. Eye fatigue was measured in two stages before starting work and 60 minutes after work with a microscope. The Borg scale was used to compare the amount of discomfort and pain in the upper and lower limbs before and at the end of the work. The Nordic questionnaire was also used to assess the prevalence of musculoskeletal problems. The descriptive data were analyzed using paired T-test, and simple linear regression via SPSS software version 22. More than half of the users suffered from pain and discomfort in the neck, upper back, and shoulder. There were significant differences in the mean score of visual fatigue symptoms and the mean score of flicker value between two stages, respectively ($P< 0.001$). Simple regressions were obtained for changes in the questionnaire score ($R^2 = 0.708$). The correlation coefficient indicated an inverse and significant association of flicker value changes with changes in questionnaire scores and visual fatigue symptoms. A majority of the participants were experienced musculoskeletal disorders and visual fatigue. Early symptoms recognition could be an effective way to control the incidence of visual fatigue at higher levels among microscope users. In addition, ergonomic equipment and training may be useful to decrease most musculoskeletal disorders.

KEYWORDS: *Visual Fatigue, Musculoskeletal Disorders, Microscope, Laboratory Technician*

INTRODUCTION

Laboratories workers such as pathologists, microbiologists, and other medical staff have a significant role in disease diagnosis and therapy planning [2]. The routine work of pathologists includes several hours of microscope and computer work [12]. In the health and medical care field, there is an ascending trend in the number of samples and preparations which must be examined by microscope [1]. Microscope is one of the main tools in the laboratories. The human body is not compatible with long-time working hours with a microscope but many laboratory staff has to work many hours with a microscope while most of them do have limited knowledge and awareness about the severity of problems that could be related to their job [3]. The National Board of Occupational Safety and Health have received various complaints from laboratory technicians in recent years which mainly related to vision impairments. In order to inspect a slide, microscope users have to move their eyes repetitively, place it precisely, and converge it which lead to visual fatigue and discomforts [6]. Prolonged eye activities may result in visual fatigue. Considering the microscope users working hours, they are faced with various symptoms of visual fatigue [7]. Furthermore, visual fatigue may reduce attention and vigilance level of the user and impairs the reception of visual information [8]. Specialists proposed a work and rest balance rhythm to keep eyes as one of the main body's organs in optimal performance. Otherwise, it leads to visual fatigue at the early stages and more severe complaints during the working years [9]. The vision impairments do not cause major problems but may restrict some visual performance. Chronic headaches and visual fatigue also observed even among novice operators [7]. The results of a study conducted about optical microscope users showed that up to 80% of microscope users have complained about visual fatigue, low back pain, fibromyalgia, or tension-type headaches [10]. The relationship between prolonged working time with a microscope and chronic pain syndromes and visual impairments has been recognized in various studies [4]. Microscope users may be unaware or neglect of the health risks associated with their work which may worsen their occupational health [12]. It can be concluded that the visual health of microscope workers is an important occupational health concern [18]. Some prevalence work-related musculoskeletal disorders (MSDs), also known as cumulative trauma disorders occur among microscope users due to excessive force, repetitive movement, awkward posture, prolonged static posture [4]. Darragh et al. in a study showed that the MSDs were 1.3 the cause of absenteeism [5]. Similarly, a high prevalence of musculoskeletal disorders among microscope users was founded. The findings of a study conducted by Lorasa et al., proved that among microscope users the prevalence of pain symptoms in all parts of the body in a month was 76% which negatively affect their productivity [13].

Since, a large number of specialists, technicians, and postgraduate students use microscopes in the laboratory for a long time, so they are at high risk for musculoskeletal disorders and eye fatigue. A study about pathologists, microbiologists, and other laboratory staff who work with a microscope showed that they were suffered from a wide variety of musculoskeletal and ophthalmic disorders [19]. The present study was conducted to evaluate the occupational health status of microscope users at Tehran University of Medical Sciences due to the importance of the health status of microscope users and the high prevalence of occupational problems among this group.

MATERIALS & METHODS

In this cross-sectional study, a group of 40 microscope users was selected with a minimum of one hour a day working time at Tehran University of Medical Sciences laboratories from 2018 to 2019. The sample size included pathologists, microbiologists, postgraduate students, and technicians related to pathology, microbiology, hematology, and cytology laboratories. In this study, the control group was selected among non-alcoholics, non-drug takers, as well as individuals with no uncorrected refractive error signs.

Moreover, a list of drugs taken by individuals routinely and arbitrarily for simple ailments such as headaches, etc. was prepared to exclude from the study

Corresponding author: Seyed Abolfazl Zakerian
E-mail: *zakerian@tums.ac.ir*

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ones who were consuming such drugs or were subjected to treatment for a specific disease. Afterward, a questionnaire was designed to obtain demographic information, work experience, daily working hours with a microscope, night sleeping hours, daily working hours with computer and mobile phone, use of spectacles, type of microscope used, and history of diseases.

Thereafter, quantitative and qualitative measurement of visual fatigue was performed using the Flicker Fusion System (PM-SS22881-Pars Madar Asia) and visual fatigue questionnaire (VFQ). Furthermore, evaluating the musculoskeletal disorders (MSDs) prevalence was conducted using the Nordic Musculoskeletal Questionnaire (NMQ) and Berg scale before work time start and after completing the work (with specific interval). The VFQ consists of 15 questions with four main areas: eye strain (4 questions), visual impairment (5 questions), ocular surface eye impairment (3 questions), and the outer surface of eye problems (3 questions) [17]. The questionnaire was designed based on a Likert scale from 0 to 10 in which high scores indicate greater visual fatigue and lower scores designate lower visual fatigue. The total scores of these questions were calculated and then divided by 15 [17]. The minimum and maximum final score of the questionnaire was 0 and 10, respectively. Visual fatigue levels include no fatigue (≤0.65), low fatigue (0.66- 2.36), moderate fatigue (2.37-3.88), and severe fatigue (≥3.89) [17]. This questionnaire had 15 variables including, pain and pressure in the eye, dry eye, burning eye, heavy eyelid, teary eyes, dizziness while working, blurred vision, double vision, headache, drowsiness, eye pain, near vision difficultly, far vision difficultly, needing massage and rubbing the eye and missing words while reading. This questionnaire was designed in 2011 by Habibi et al. and the validity and reliability of this questionnaire were confirmed [17].

Critical flicker frequency (CFF) is the minimum frequency at which a flickering light source seems fused to an observer and is defined as the frequency at which an intermittent light stimulus (i.e., a blinking light) appears completely fused to the spectator (i.e. steadily on, not flickering). CFF is particularly apt for studying alterations in visual signal processing and is suitable for the detection of arousal or attention abnormalities [22]. A laboratory device (PM-SS22881-Pars Madar Asia) was used to evaluate eye fatigue by applying a physiological index (CFF) and determine the eye flicker value changes. This device can objectively assess eye fatigue and is designed based on the flicker vision value. The flicker value is defined by CFF that evaluates the volume of activity and retinal accuracy in a way that CFF changes the flicker perception.

This method has a high level of sensitivity and easy to apply. The visual performance and accuracy of individuals have an inverse relationship with the amount of their visual fatigue [16]. Hence, through identifying the visual fatigue symptoms and determining the correlation between each of the major domains and symptoms of visual fatigue with flicker value changes as a constant physiological benchmark, the human error could be avoided by preventing the occurrence of eye fatigue [17].

As a result, in this study, it was tried to measure the eyes flicker value of microscope operators before beginning to work and immediately after work (with a specified interval for at least 60 minutes). Participants were asked to refrain from doing visual activities such as looking at the screen of a phone or computer, reading a book, or monitor for at least 15 minutes before entering the first stage of the study. So that, the initial flicker value of the users was measured and recorded by the measurement device.

The first phase of the VFQ was completed by users, simultaneously. The second stage of the study was repeated as same as the first stage, after at least 60 minutes. The amount of visual fatigue and correlation of each of the symptoms and main domains of the questionnaire with the flicker value changes were calculated based on the Hertz. The Berg scale was used to determine the amount of pressure and pain in the upper and lower extremities and compare the two conditions before starting to work and after completing the work, which was completed by users in two stages before starting work and after ending work.

The NMQ was also completed by the users to assess the prevalence of musculoskeletal disorders. The descriptive data were analyzed using paired T-test, and simple linear regression via SPSS software version 22.

RESULTS

This study included 40 specialists and technicians of the laboratories at Tehran University of Medical Sciences. 45% of the participants were male, and 55% of them were female. The mean and standard deviation of work experience was 5.8 ± 5.7 years. Furthermore, the mean and standard deviation of the age was 29.17 ± 5.83 years-old. The distribution frequency of the participants' age has been presented in Table 1.

Table 1. Distribution frequency of microscope users' age

Age (Years)	**20-30**	**31-51**
Frequency	25	15
Percentage	62.5%	37.5%

In the current study, optical microscopes only were used and the average hours of work with the microscope per day were 2.42 hours with a standard deviation of 1.12, which has been shown in Table 2 in terms of total working hours per day percentage.

Table 2. Working hours with a microscope in terms of total working hours per day percentage

Microscope utilization percentage	**13%-19%**	**25%-38%**	**50%-63%**
Number	11	22	7
Percentage	27.5%	55%	17.5%

The correlation between daily work hours with a microscope and the total score of the VFQ has been illustrated in Table 3. There was a positive and direct correlation between visual fatigue and working hours so that visual fatigue would be higher by increasing work hours. At least 60 minutes lead to the occurrence of symptoms of visual fatigue, and this correlation was higher among users with more work hours. (r = 0.736).

Table 3. The results of Pearson correlation analysis between daily work hours and final score variables based on the VFQ

Variable	**Daily work hours with the microscope**	
	R	**P**
Pearson correlation	0.736	< 0.001

The mean and standard deviation of flicker value scores in the first and second stages were 41.03 ± 2.4 and 39.11 ± 2 Hz, respectively, and the mean flicker value changes were 1.49 ± 2.08 Hz. The paired T-test indicated that there was a significant difference between the mean flicker value changes at two stages of evaluation ($P < 0.001$). Considering the quantitative and qualitative estimate of the visual fatigue questionnaire, the mean visual fatigue of users in the first and second stages was 0.42 ± 0.40 and 1.67 ± 1.15, respectively. The paired T-test showed a significant difference for all scores of symptoms of visual fatigue (15 questions in the questionnaire) before work time start and after work for questionnaire questions ($P < 0.001$). According to the results of the second stage, the prevalence of symptoms of visual fatigue based on the questionnaire was illustrated in Figure 1. The most common complaints were related to dry eye, burning eye, headache, drowsiness, and teary eyes.

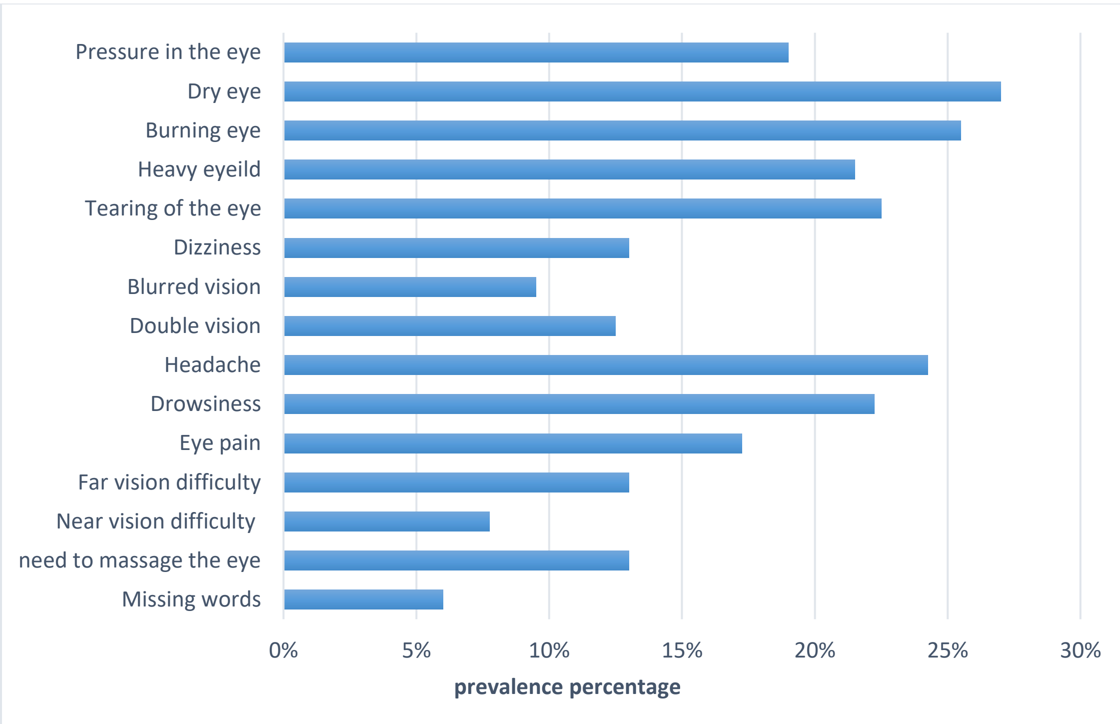

Fig 1. The prevalence of visual fatigue symptoms

The mean visual fatigue scores of participants in the first and second stages were 0.42 ± 0.40 and 1.67 ± 1.15, respectively. According to the questionnaire total score guidelines, after calculating the scores, it was found that 67.5% of the users had no visual fatigue, and none of the participants had severe visual fatigue in the first stage. However, in the second stage, the number of users with severe visual fatigue increased by 5%, and users with no visual fatigue decreased by 10%.

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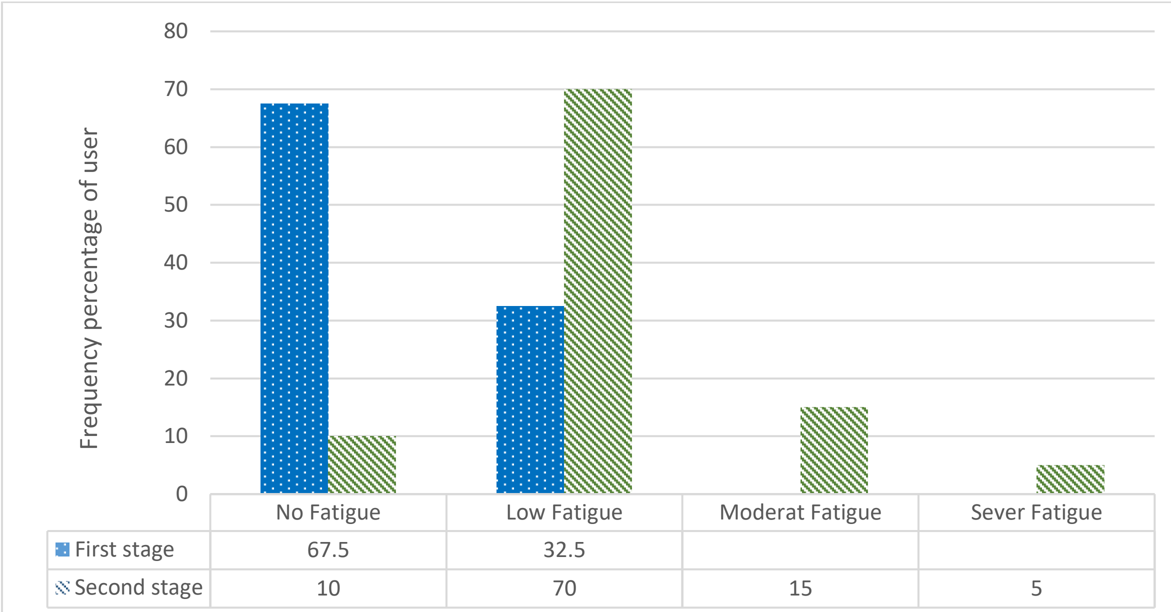

Fig 2. Users' frequency percentage with a visual fatigue sign in two stages based on the questionnaire levels

A simple linear regression test was performed for all symptoms of visual fatigue and flicker value changes. The results indicated that the highest value of the coefficient of determination ($R^2 = 0.818$) was related to changes in the total score of the questionnaire in two stages. Accordingly, changes in the dependent variable were explained by the independent variable. The negative β value indicates that the independent variable had an inverse effect on flicker value changes. Furthermore, a strong and significant correlation was observed between flicker value changes and questionnaire score changes as a subjective index ($p < 0.001$ and $r = 0.842$).

The highest coefficient of determination was related to eye pain regarding the questions and specific symptoms of visual fatigue ($R^2 = 0.33$).

Table 4. the results of independent variable effect on the dependent variable

Model	**B**	**Std. Error**	**Beta(β)**	**t**	***P-value***
Constant	1.435	0.576		2.491	
The Final score of visual fatigue	- 1.987	0.345	- 1.252	- 5.759	< 0.001

99% significant level

In this test, the flicker value coefficient was equal to 0.818, which shows 0.818% of flicker value changes were based on the final score of visual fatigue, and the remaining 0.182% was related to other variables. The dependent variable was the flicker value changes.

The flicker value estimation can be calculated using Equation 1. Where Y is the dependent variable (critical flicker frequency), X is the independent variable (total score of visual fatigue), B is the slope of line, and a is the y-intercept. Here, VF is the final score of an individual's visual.

$$Y = a + BX \quad (1)$$

$$CFF = (-1.435 - 1.987 \times VF)$$

The musculoskeletal disorders (MSDs) are other occupational health for microscope users. NMQ's data survey showed that neck pain had the highest frequency of complaint. The prevalence of musculoskeletal disorders in various periods has been denoted in Figure 3.

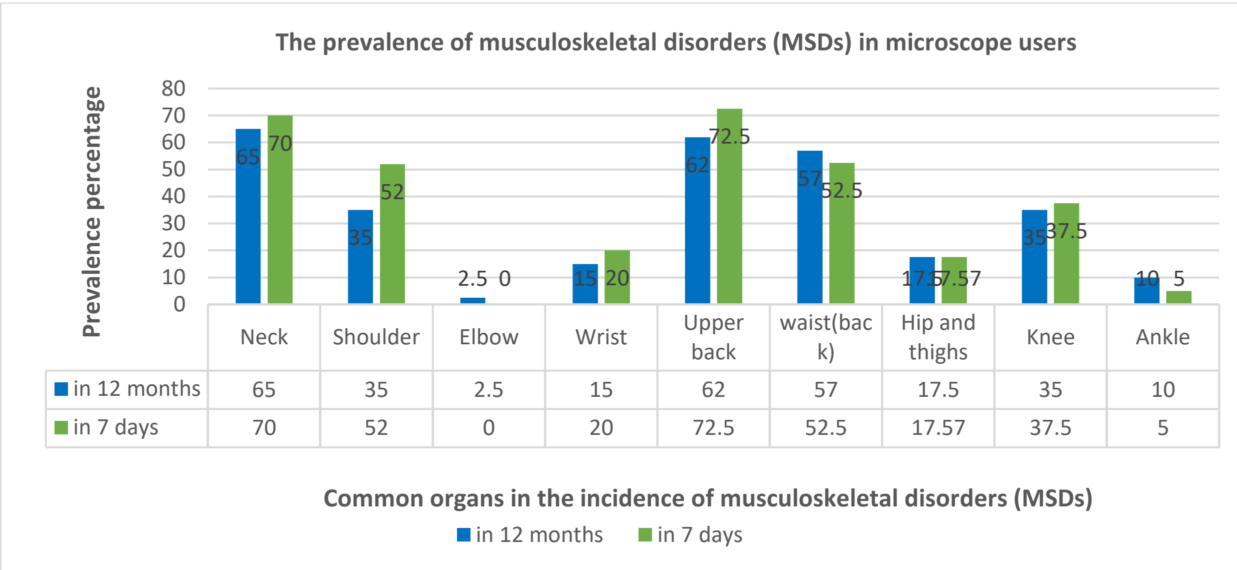

Fig 3. Musculoskeletal disorders (MSDs) prevalence percentile among microscope users

The neck pain incidence among microscope users in the upper back was higher compared to other musculoskeletal parts of the body. Based on the results, the average age of participants was less than 30 years-old, however, the musculoskeletal disorders such as pain and discomfort in the upper back and neck were the main reason for job leave in the past year (see Figure 4).

According to the Berg scale's second stage data, the highest level of discomfort and pain was observed for the neck. The Berg scale showed the degree of pain and discomfort in two stages before beginning to work and after work. The discomfort distribution frequency for musculoskeletal parts of the body in two stages before beginning to work and after work has been indicated in Figure 5. The greatest amount of discomfort and pain was marked in red.

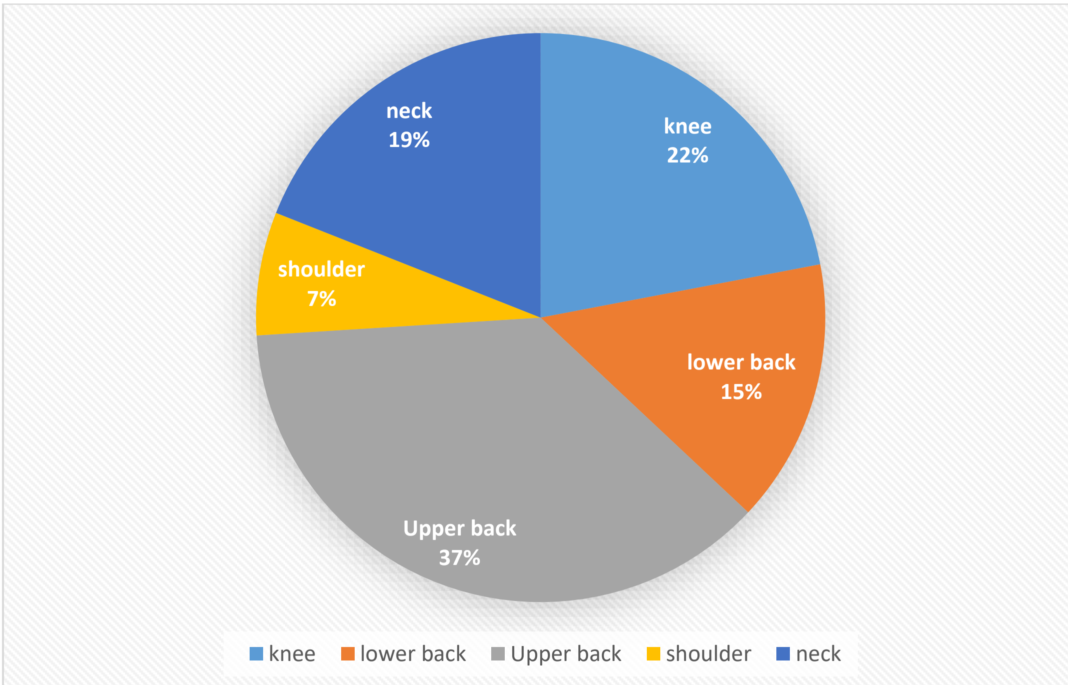

Fig 4. Musculoskeletal disorders frequency in the last 12 months

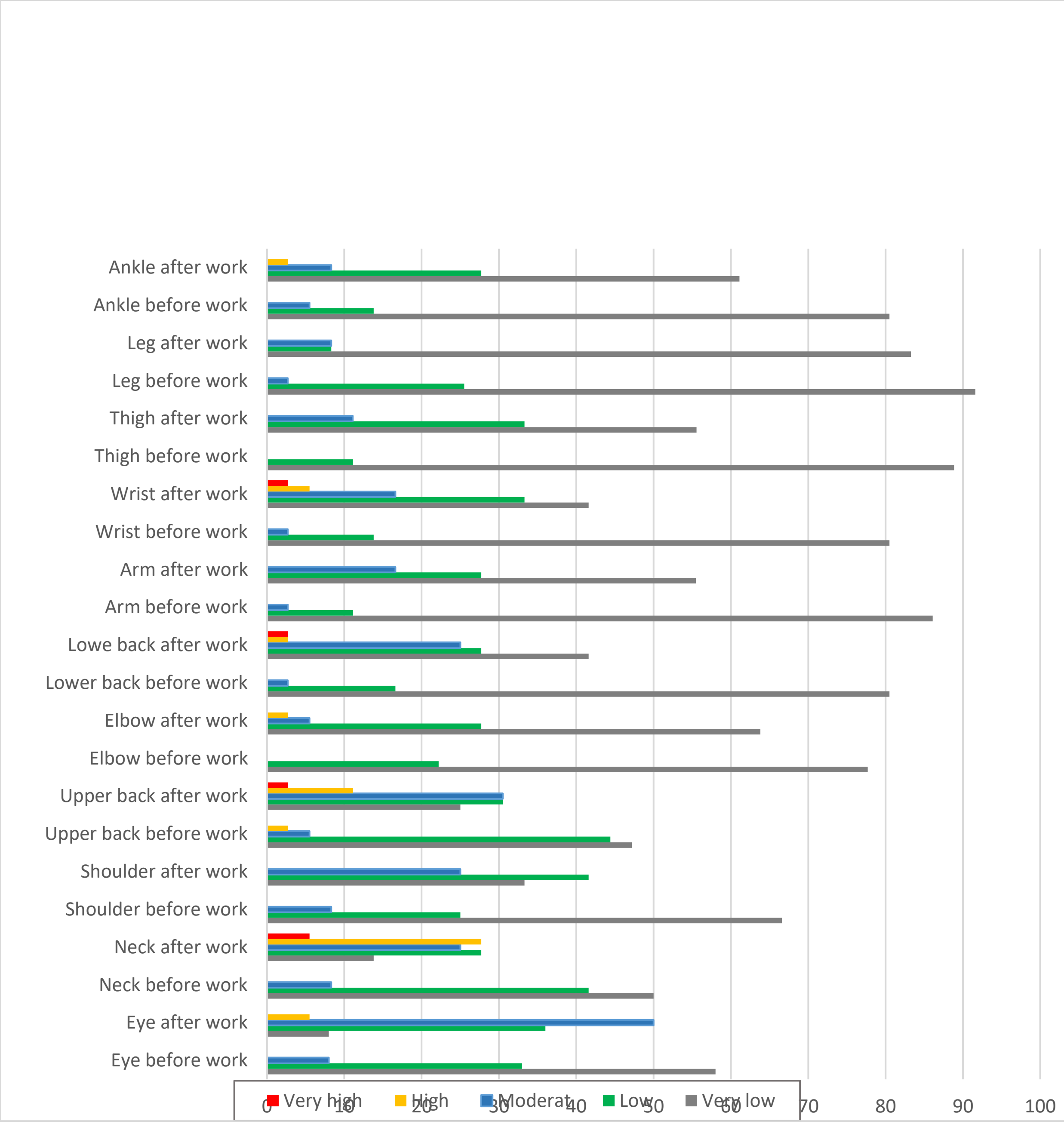

Fig 5. Comparison between pain and discomfort before beginning to work and after work

DISCUSSION

The purpose of this study was used to evaluate the microscope users' health status in terms of musculoskeletal disorders and visual fatigue. The results of this study proved that the microscope users suffered from musculoskeletal and visual problems.

In a study, Lin et al. investigated different levels of visual fatigue among microscope users and found that 63% of the participants suffered from visual fatigue which was in line with the findings of the present study [18]. Similarly, Kumar et al. showed that more than half of the participants experienced visual problems because of eye-straining activities such as long-lasting microscopy [19].

It was found that the highest visual complaints were related to burning eyes, dry eyes, and headaches during the work. The outcomes of this study were also in agreement with different studies that showed a burning eye, teary eye, headache, eye pain, as the most common symptoms reported by microscope users [1-4].

According to the results in Figure 1, the highest visual complaints were burning eye 27%, dry eye 25.5%, headache 24.5%, teary eye 22.5%, heavy eyelids 21.5%, and eye pain 17.5%, respectively. The same results by Soderbergh et al. also mentioned burning eye, teary eye, headache, eye pain as the most common symptoms reported by microscope users. In the study of Soderbergh, more than 51% of participants had these symptoms [1].

The results in Table 3 showed that there was a strong correlation between work hours with microscopes and the incidence of visual fatigue given the flicker value changes that it is a standard measure for the visual fatigue diagnosis. A study conducted by Anish et al. also represented that long-term work with a microscope leads to different levels of visual fatigue along with other musculoskeletal disorders [20]. Besides, in a study by Helander et al. concluded that although vision problems of microscope users will not result in an accident, these cause widespread discomforts among them. Numerous complaints of headaches and visual fatigue have been reported, even among newly recruited staff. Therefore, there was a direct relationship between daily working hours with a microscope and the occurrence of visual fatigue [7].

Figure 2 related results indicated that 90% of participants had experienced different levels of visual fatigue containing 70% low fatigue, 15% moderate fatigue, and 5% severe fatigue. These results were in line with the study by Jeremy Jane et al. about microscope users. A questionnaire-based study was conducted in 40 laboratory specialists, pathologists, microbiologists, postgraduate students who regularly worked with the microscope. The results demonstrated that there was a direct relationship between the incidence of vision problems and hours of work with the microscope [4].

The result of NMQ (refer to Figure 3) showed that the most common musculoskeletal disorders among microscope users were neck pain in the upper back and shoulders such that results attained by Kumar et al. on 45 laboratory individuals that the greatest reported pain was in the neck and shoulder [19].

Almost 37% of participants left their job due to the upper back pain during the past year regarding the result of NMQ in Figure 3. Additionally, 70% of the participants in the past seven days during test time had experienced neck and upper back pain and discomfort and more than half of the participants had experienced lower back pain and discomfort. The result of the Berg scale also showed that the microscope users at the end of the working hours gave very high scores to their neck, lower back, and upper back pain and discomfort (see Figure 5).

In a similar study to investigate visual problems, some symptoms were reported such as teary eye 41%, burning eye 22%, and blurred vision. A proportion of the other non-visual problems associated with the microscope use were related to physical fatigue, neck, and shoulder pain [18]. Furthermore, another study by Flavin et al. on 62 individuals using a microscope in a pathology laboratory lab based on a questionnaire reported a high percentage of vision problems and musculoskeletal disorders [3]. Various studies that focus on musculoskeletal disorders among microscope users showed that there were similar reports by microscope users as a painful region in the upper and lower extremities after working with a microscope. 73.9% of participants experienced musculoskeletal problems that most organs of the complaints were related to the neck and lower back [20].

In another study on laboratory staff, the incidence of musculoskeletal disorders among laboratory technicians was 87.35%, most of which reported in the neck and lower back [21].

CFF value significantly decreased after using a microscope. CFF decline after work can be considered useful as an indicator of eye fatigue. In a different study, decreases in CFF provided a sensitive and convenient index of fatigue [23].

To the best of our knowledge, in previous studies, an objective method based on the Critical flicker fusion frequency to measure the CFF before and after the task as a tool for identifying eye fatigue had not been applied. Although questionnaires were measured mental quantities, the flicker fusion value index was a physiological quantity objective and was answered in the same way in all human societies. Moreover, as the study implemented through face to face interview method for collecting data, so it was more reliable which can be considered as the strength of the study. It should be noted that there was a limited sample size. However, this study was evaluated the visual fatigue of microscope users at Tehran University of medical science for the first time.

CONCLUSION

The most common occupational worries over microscope users were musculoskeletal problems in neck and back areas, eye fatigue. A prolonged use of microscope may negatively affect and increase the musculoskeletal disorders and eye fatigue. Base on this study results, more than half of the microscope users were exposed to occupational hazards and had suffered from musculoskeletal problems and eye fatigue. It was recommended to immediately improve microscope users' awareness about the various occupational hazards so that they become alert about the risks and start taking all necessary precautions.

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CONFLICT OF INTERESTS

There was no conflict of interest in this study.

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