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Fatigue and Its Impact on HR Performance

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ABSTRACT

Fatigue is a biological phenomenon that causes decrements on both mental and physical performance of individuals . This circumstance occurs as a function of inadequate sleep, workload, stress, irregular nutrition , working with extended hours and etc. which would be extremely dangerous for the health and safety of people . Although its symptoms are typically visible and widespread, it requires strict research and observation to correlate the health problems caused by fatigue, by this reason, it is defined as a very complex notion.

The purpose of this research is elucidating the term of " fatigue" and finding out its correlation with workplace accidents and errors. In addition to this , proven solutions for companies to fight fatigue in their workplace and different methods of fatigue measurement and management will be discussed .

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İNTRODUCTION

Fatigue is one of today's most common problems. Problems related to private life or business life can cause fatigue and in both cases this is negative for human health.

The word ‘fatigue’ is in standard everyday use, describing a number of conditions varying from general lethargic states to specific work-induced aches, burning, and pain of one's muscles. Fatigue has a physical and a mental component. Physical fatigue is a daily phenomenon clearly known to most after periods of heavy physical work or exercise which pertains to the depletion of the energy required to sustain performance. However, physical fatigue also carries a strong mental component as in a sense of more required effort (Enoka and Stuart, 1992)[1] when fatigued which can inhibit one’s ability to continue functioning at the level required.

The researches about the effects of fatigue in the workplace are based on the middle of the 20th century. These studies have been developed over time and various methods have been discovered to cope with fatigue . In this period of time, it has been investigated what causes fatigue in the workplace and how it affects to human resources ; if it said that these researches had a huge contribute to the “future” of any organization, this would be definitely correct , because the job performance that might be badly affected by emerging fatigue issue causes the worker to fail to fulfill his / her duties properly, decrease his motivation and ability to work, and , as a result ,insufficient working of human resources in the workplace creates problems for the company to reach the short-term and long-term goals.

[1] Enoka, R. M. & Stuart, D. G. 1992. Neurobiology of muscle fatigue. Journal of Applied Physiology, 72, pp1631-1648

In first part of this study, different fatigue definitons are mentioned, short but detailed information was given about the history of the term, and types of fatigue were examined. At the same time, the causes of fatigue were examined in this part and especially the effect of the sleep factor on fatigue is taken into consideration.

In the second part of the study, the potential consequences of fatigue were examined and how the fatigue impairs the cognitive and behavioral performance was shown by using substantial examples based on a number of empirical researches and their results.

Finally, individual, organizational and environmental fatigue management methods and techniques are analyzed and compared with the aim of finding the best approach to combat with fatigue effectively.

This work is theoretical study. Sources mainly consist of books and academic articles . Personal data, observations and experiences were also utilized obtained from academic articles, magazines, published postgraduate and doctoral theses, related sites on the internet and in the interpretation of the compiled information.

CHAPTER 1 : GENERAL CLASSIFICATION OF " FATIGUE" CONCEPT

1.1 A General Overview of Fatigue – Nature of Fatigue

Fatigue can adversely influence each aspect of human performance ; it has an impact on the health and safety of people. This phenomenon was defined in different forms by scientists over the years and ,as a result from this different points of view, different approaches had been made. Some of them are listed below :

- Fatigue is 'increasing difficulty in performing physical or mental activities. Signs of fatigue include tiredness even after sleep, psychological disturbances, loss of energy and inability to concentrate. Fatigue can lead to incidents because workers are not alert and are less able to respond to changing circumstances. Apart from these immediate problems, fatigue can also lead to long-term health problems' (Shaw, 2003)[2]
- Fatigue is a state of impaired mental and/or physical performance and lowered alertness arising as a result of or a combination of hard physical and mental work, health and psychosocial factors or inadequate restorative sleep. Fatigue can be either work or non-work related or a combination of both' (BHP Billiton, 2005).[3]
- Fatigue is 'the loss of alertness and performance that results from insufficient or poor quality sleep or engaging in mentally or physically demanding activities' (Simpson, 2008).[4]
- Fatigue is the state of feeling very tired, weary or sleepy resulting from insufficient sleep, prolonged mental or physical work, or extended periods of

[2] Shaw, A. *Fatigue management*
[3] BHP BILLITON. Fit for Work/Fit for Life (Issue 1), May 2005.
[4] SIMPSON, P. Personal communications

stress or anxiety. (Canadian Centre for Occupational Health and Safety, 2017).[5]

It is difficult to suggest one comprehensive definition to fatigue because of being complex phenomenon and having connection with many different fields of science. However, if we sum up these definitions, it is possible to simply say that fatigue is a type of problem , especially generating from inadequate sleep, some mental and physical activities that will end up with visible impairments on reaction time and concentration, decreased alertness and productivity , memory-related problems and less capability of judgement.

Brief history of fatigue-related investigations

Although it is known that fatigue is something harmful to human being , the history of research on the factors that contribute to fatigue and the effects of fatigue on the worker's performance in the workplace date back to the recent past- the 19th century. The systematic observations of fatigue and human performance were based on Patrick and Gilberts' investigations in 1896 . They did an investigation on three people who exposured to 88-90 hours of sleep deprivation . As a result of research, visible deficiencies in reaction time and memory were observed.[6] In the 1930s, Nathaniel Kleitman used a variety of performance metrics such as card processing speed, multiplication speed, code transcription speed and mirror drawing and observed much the similar characteristic changes in performance and oral temperature during the 16-hour awake period.[7] As a result of these observations, correlation between sleepiness and fatigue was specified.

[5] Canadian Centre for Occupational Health and Safety, 2017. OSH Answers Fact Sheet: Fatigue. / https://www.ccohs.ca/oshanswers/psychosocial/fatigue.html (Accessed April 2019)
[6] Patrick GTW, Gilbert JA. On the effect of loss of sleep. Psychol Rev. 1896;3:469–83
[7] Kleitman N. Sleep and wakefulness. 2nd ed. Chicago: University of Chicago Press; 1963

Fatigue in the work environment has attracted the attention of new emerging industrial psychology after World War II[8] . At that time, paying attention to practical applications led to scientific assessments and changes aimed at improving the efficiency of the work environment. According to the fifth edition of the American English Dictionary of English, industrial psychology was defined as an psychology field for the effective management of industrial workers and, in particular, helps to solve the problems that employees face in a mechanized environment. As the field developed, a specific area focused on human factors and it led to starting a comprehensive investigation of the causes of fatigue and exhaustion of people in the workplace.

Sleepiness, Fatigue and Tiredness

People sometimes make mistakes in the use of the term " fatigue ". The notion of fatigue is often used instead of the terms of sleepiness and tiredness . Some people tend to use these terms interchangeably, or as synonyms ; nonetheless, the usage areas of these words are not restricted in this way and it should be known that there are apparent distinctions between the meanings of fatigue, tiredness and sleepiness. Sleepiness is considered one of the most important factors contributing to fatigue-related hazards while fatigue is the factor that causes performance decline.

Sleepiness and fatigue belongs to the adverse consequences of sleep deprivation and could be observed at the same time in the workplace. For example, "fatigue-related accidents" usually include performance impairments or decrements related to insufficient , disrupted, bad timed or scheduled sleep. However, some clear differences are seen in negative influences of these factors ; Sleepiness causes an

[8] http://www.inquiriesjournal.com/articles/1685/a-brief-history-of-industrial-psychology

individual's brain to request sleep neurobiologically . Because of that, after working at night shift or night without sleep and short naps, the degree of workers' level of sleepiness increases. While after strong physical exercise or doing tiring work , we get fatigued, but unlike being sleepiness, we are unable to sleep easily. So, it is possible to conclude from this observation that , in contrast to the sleepiness, the level of fatigue may not be reduced by sedentary activity.[9]

Fatigue has an adverse impact on task performance . In addition, it has a psychological dimension to not having enough energy to do the job and reluctance of subjects to continue a task. It means that fatigued person receives a signal from his body which means that the continuing activity (mental or physical) should be stopped. Although there are some distinctions between fatigue and sleepiness in terms of reasons and definitions, the effects of both could be the same. Basically, these effects indicate a significant decrease in their capacity to perform mental and physical performance.

When it comes to the difference between fatigue and tiredness, it should be emphasized that one of the more frequently mentioned differences between tiredness and fatigue relates to the span of time . Tiredness is considered as a comparatively short-term situation (for example as an outcome of staying awake for full day) while fatigue as more long-term or chronic (for example, the consequence of insufficient sleep over a month).

[9] (Ferrara M, De Gennaro L. How much sleep do we need? Sleep Med Rev. 2001;5:155–79. [PubMed] [Google Scholar])

Types and symptoms of fatigue

Fatigue is classified into two parts: Physical and mental fatigue.

Physical fatigue is a temporary loss or decrease of functional capability of various muscles for optimal working due to heavy physical workload or long-term prolonged activity. Reducing energy due to heavy physical activity causes pain in the muscles, general weakness, lack of ability to carry out the work, and even changes in man's behaviour, such as nervousness, frustration or dissatisfaction.

Mental fatigue is a feeling of tiredness or weakness which is usually followed by slow reaction time and lead to adverse consequences and reduction in alertness level which is required to perform the task well and the manipulation of information stored in the memory[10].

Both the mental and the physical fatigue indicate themselves with some obvious symptoms and these symptoms are also divided like physical, mental and emotional ones .[11] Generally, one of the most important symptoms of fatigue is that, people constantly complain about the lack of energy. Another important symptom is; people are unable to continue their routine work . In addition to these two important symptoms, it is possible to say feeling the need of extra energy for performing the work well, feeling physical pain , being in the state of emotional change and uneasiness, having trouble for concentrating or focusing on a subject, feeling loss of joy , being unrelated to the environment and increased susceptibility to accidents are also common indications of fatigue . Difficulty in remembering, difficulty in concentration, dizziness, nausea and unexplained weight loss can also be seen in the case of having fatigue. As a result, all these bad effects of fatigue influence healthy,

[10] Valerie J Gawron, Jonathan French, and Doug Funke. An overview of fatigue. In Stress, workload, and fatigue, pages 581–595. Lawrence Erlbaum Associates Publishers, 2001

[11] Fatigue Risk Management System for the Canadian Aviation Industry

successful, intellectual and powerful individuals adversely ; they are reluctantly willing to sleep and rest day-long and experience some difficulies in the case of going to work.[12]

Physical symptoms	•Yawning • Heavy Eyelids • Eye-rubbing • Head drooping • Microsleeps
Mental symptoms	• Difficulty concentrating on tasks • Lapses in attention • Difficulty remembering what you are doing • Failure to communicate important information • Failure to anticipate events or actions • Accidentally doing the wrong thing • Accidentally not doing the right thing
Emotional symptoms	•More quiet or withdrawn than normal • Lacking in energy • Lacking in motivation to do the task well

[12] Cantekin, I., 2009: Sard Hastalarının Uyku Kalitesi veYorgunluk Düzeylerinin Belirlenmesi, Yüksek Lisans Tez Çalışması, T.C. Atatürk Üniversitesi, Sağlık Bilimleri Enstitüsü, İç Hastalıkları Hemşireliği Anabilim Dalı.Erzurum

	• Irritable or grumpy behaviour with colleagues, family, or friends and etc.

Table 1 : Symptoms of fatigue[13]

These symptoms occur due to a wide range of internal and external reasons, and comprehensive explanations for all these reasons have been given in the next subchapter .

[13] Australian Government Civil Aviation Safety Authority " Safety Management System for Aviation" / https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/sms/download/2012-sms-book3-safety-risk-management.pdf (Accessed May 2019)

1.2 Causes of fatigue

Fatigue arises by a multiplicity of individual and work-related factors. This means that factors which create fatigue may be directly related to the individual itself, or simply caused by a number of factors that operate outside the person's management power and will.

Work- related	**Individual**
Shift schedule design	Sleep disorders
Type of work	Health
Task design	Using medicine / Drug and Alcohol
Environmental condition	Domestic commitments
Workload	Social commitments
Commuting and etc.	Nutrition and etc.

Table 2 : Some common causes of fatigue [14]

Fatigue at work can arise for a variety of reasons. Some of the most contributing factors to the occurrence of work-related fatigue are working with extended hours or working in shifts with heavy workload and lousy timing. If we give a brief description of shift work, we can briefly say that shift work is sometimes the type of work that creates the necessity to dedicate normal night sleep hours or early morning hours to work. There are a wide range of work shifts in the business world, but some programs implemented in the workplaces create problems in the context of health

[14] https://publishing.energyinst.org/topics/human-and-organisational-factors/managing-fatigue-using-a-fatigue-risk-management-plan-frmp (Accessed April 2019)

and social life , causing workers to lose their natural sleep-wake cycle and make them feel tired. Examples for such types of shifts are listed below :

- Night shift
- Shift starts or ends in very early hours of the day
- Shift that starts or ends very late hours of the day
- Very long shifts
- Shifts requiring days of work without the day off and etc.

Poorly planned shift work has a detrimental impact on workers individually as well as decreasing the quality of work. For example, working at night requires employees to stay awake and sleepless when the body naturally waits for sleep, and to sleep when they have to be alert (during the daytime) . As a result, night work can lead to increased fatigue, impaired mood, and performance decrements. Night workers also experience problems while sleeping during the day; Because the bedroom is lighter, noisy and warmer compared to the night, and they are sometimes obliged to sacrifice their sleep to participate in personal, domestic and social responsibilities.

Of course, the formation of workplace accidents is unavoidable in the context of poorly programmed work graphs and tired and sleepless workers. Because, as it is known, fatigue has bad effects on cognitive performance, perception and memory, and the small carelessness caused by them can lead to massive and terrible events, as well as the amount of money and loss of life in the workplace : Chernobl accident that occurred as a result of carelessness of the shift employees in 1986 and the oil

spill accident that occurred between midnight and 6:00 am on the Three Mile Islands are the biggest defenders of this danger.[15]

İn addition to these factors, type of work and task design also may cause the creation of fatigue in the workplace.

Various individual factors can also cause fatigue. For example having social and domestic commitments , experiencing emotional difficulties such as stress, depression and etc., working in a second job, experiencing some sleep disorders (this problem can be caused by both individual and external factors), age, health condition and etc. causes people to feel fatigue . Fatigue can occur as a direct effect of any disease (eg, flu) or as a side effect of an experienced condition (eg, fatigue due to sleep loss caused by chronic pain). In addition, some weaknesses related to age and experience of diseases create the feeling of fatigue in individuals.

Let us observe the factors that cause fatigue in separate separation and examine them all in depth.

1.2.1 Working long hours / Shift lenght

Working long hours is one of the most dominant and influential factors which induce the creation of fatigue in the workplace.

In 2008, the National Sleep Foundation conducted a phone survey under the title of "Sleep in America". In this study, 1000 American workers who work more than 30 hours a week were directed to work performance and sleep-related questions. The result of this research revealed a link between the sleep process and the business hours; The survey concluded that long working hours lead to short sleep processes,

[15] Gander P, Purnell H, Garden A, Woodward A. Work patterns and fatigue-related risk among junior doctors. Occup Environ Med. 2007;64:733–8. [PMC free article] [PubMed] [Google Scholar]

leading to deterioration of labor and occupational accidents. Thirty-seven percent of the respondents were classified as being at risk of any sleep disorder. The fact that the thirty-seven percent of the interrogation time had more bad results in the workplace than those not at risk. These results reveal that long working hours may contribute to chronic sleep loss and this may cause loss of performance.[16]

Working long hours can also cause increasing occupational injuries. One of the studies related to Hon Kong's manufacturing sector found that factory workers working more than 11.5 hours a day have an increased risk of serious hand injuries.[17] Another large cross-sectoral questionairre of 1.2 million German workers' compensation records found that the risk of fatal and non-workplace accidents rise during the second part of a long shift (after the eighth hour).[18] Studies from Scandinavia and the United Kingdom have also observed similar findings in the second part of the long-term shifts, increasing the risk of occupational accidents.

In addition to the adverse impacts of sleepiness and causing occupational injuries , working long hours decreases cognitive performance which can result from participating in long boring tasks like highway driving, monitoring equipment, and flying highly-automated aircraft .

As a result, it is not difficult to observe that working cause sleepiness, increase workplace accidents due to increased fatigue in the workplace and may cause stress, depression due to routine work and physical pain in muscles originated especially physical effort demanding works.

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[16] Swanson LM, Arendt JT, Rosekind MR, et al. J Sleep Res. 2011;20:487–94

[17] Ong C, Kogi K. Shiftwork in developing countries: current issues and trends. In: Scott AJ, ed. Shiftwork. Philadelphia: Hanley and Belfus, 1990:417–28

[18] Hanecke K, Tiedemann S, Nachreiner F, et al. Accident risk as a function of hour at work and time of day as determined from accident data and exposure models for the German working population. Scand J Work Environ Health 1998;24:43–8.

1.2.2 Working in non- traditional work hours / Shift work

There are several types of schedule and shift combinations in the worldwide that could be utilised to meet the organisations' needs . In the literature on works shifts there are some terms that are commonly used. These include the following:

-Shiftwork: Working outside of normal work time, out of 8 am to 5 pm

-Rotating shifts: Working with changing shift times. Changes in shifts of worker may be weekly or monthly

-Permanent shifts: Working one, fixed shift without any changes

-Day shift: Starts between 5 and 8 am and ends between 2 and 6 pm, also called first shift

-Evening shift: Typically starts between 2 and 6 pm and ends between 10 pm and 2 am, also called second shift

-Night shift: Typically starts 10 pm–2 am and ends 5–8 am, also called the third shift

-Split shifts: When an individual's daily work is divided into two or more shifts

-Flextime: Is a flexible arrangement where employees work a set amount of time (8 h) during a longer block of time (10 h), all workers overlap on a core amount of time in the midday.)

Due to the complexity of leading-edge business world, it is not possible to say that there is only one shift that is suitable for all tasks and ideal for all jobs, because each of them has advantages and disadvantages on their own. However, there are a number of things that must be taken into considerations in terms of workers' health and safety, so organizing a well-planned shift should be a priority for workplaces. İt includes shift duration, shift rotation, shift timing , work breaks and etc.

But nowadays, technological improvements and rapid development of the world increases the necessity of workers on multiple shifts for organisations for running the business for 24h/ day. In this case, the notion of " shift worker" arises. Shift worker is someone whose worktime is out of typical 8 am to 6 pm workday. These people are often working against circadian rhythms and the disruption of the circadian rhythm makes fatigue and increases the risk of work accidents. The night shift workers are particularly vulnerable to protecting the sleep rhythms, because circadian rhythm responds to light. They are trying to stay awake due to the necessity of work and to perform when the body encourages them sleep. An another problem arises for workers trying to sleep while the level of brain's wakefulness increases. As the brain affected by the increase of light, it decreases the secretion of the hormone "melatonin" known as the sleep hormone and the process of falling asleep becomes hard. This cycle of trying to work against the circadian rhythm will often reduce their total required sleep time [19], impairs health, also as a bad consequences of impairment, level of risk for workplace accidents increases, quality of cognitive performance of individuals decreases. In addition to specific disorders, the negative effects of working non traditional hours on workers' health also impact on their general sense of well-being. Employees regularly complain about increased levels of stress and a general feeling of weariness. This may be made worse by mental stress related to being less satisfied in the domestic and social areas of their lives.

[19] Tassi P, Muzet A. Sleep inertia. Sleep Med Rev 2000;4(4):341–53.

1.2.3 Work environment

Lighting

Researchs related to biology shows that light has nonvisual , but a huge inevitable biological effects on the human organism . Rightly arranged lighting level has a good impact on human's health, alertness, well-being, and sleep quality . Amount of lighting can influence the health, well-being, and alertness of workers, so this issue should be taken into consideration. Several studies for finding the effects of different lighting levels and high lighting levels on night workers have been investigated . In one study, it is found that improving lighting levels from 300 to 500 lux increased productivity 8%. A similar change from 300 to 2000 lux had a 20% productivity improvement. İt is also reported that higher lighting level cause significantly increased arousal levels, more alertness, and better moods. [20]. Another researchs shows that quantity, spectrum, spatial distribution, timing, and duration are key factors when studying the practical effects of lighting on humans. This also reveals that it can influence depression, sleep quality, alertness, and health.[21]

Besides the fact of " Brightly lit workplaces increases the level of safety and performance" , it has a side effect in terms of health issues . Light itself performs as a stimulant. However, sustained bright light in nighttime work environments is associated with rising health risks ; Melatonin and cortisol are suppressed by bright light[22]. In addition to this , bright light can activate autonomic nervous system mechanisms and may increase heart rate, respiration, and blood pressure. It means that night shift workers possibly have increased the risk for cancer, heart disease, hypertension, hyperglycemia, and obesity.

[20] Kroemer K, Grandjean E. 5th ed. Fitting the task to the human. 5th ed. London: Taylor & Francis; 2001.
[21] Boyce, R, Beckstead, J. Eklund H. Lighting research for interiors: the beginning of the end or the end of the beginning. Lighting and Research Technology, Dec 2004;36,(4):283–293
[22] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3686562/

Temperature

Temperature can be a concern for fatigue risk management in the workplace.

The human body attempts to arrange itself to keep a relatively stable core temperature in the range of 97–99°F. [23]If the body lapses from this limited and short range, this issue leads to major health outcomes which decrease performance, even in the worst case, death can occur.The body uses the blood circulation to adjust the temperature required for it, in other words, by increasing or decreasing blood circulation, it can hold the required body temperature .

One of the several functions of our body's circadian rhythms is to arrange body temperature. Room temperature could be perform as a stimulant to fall asleep and affects perceived comfort. As the temperature lapses from a comfortable level, our sensation of discomfort goes from annoyance to pain. This is a signal generated automatically by human body to take corrective actions whether it is to adjust our activity level, move to a new location, adjust our clothing, or manipulate the heating/air conditioning system. Overheating leads to weariness and sleepiness. Overcooling leads to restlessness, which can reduce alertness.

There are four climate factors that impact comfort:[24]

■ Air temperature

■ Air humidity

■ Air movement

■ Temperature of adjacent surfaces

[23] https://hypertextbook.com/facts/1997/LenaWong.shtml

[24] Kroemer K, Grandjean E. 5th ed. Fitting the task to the human. 5th ed. London: Taylor & Francis; 2001

The correct adjustment of these factors may increases efficiency at work and reduces the level of feeling fatigued .

Noise

Noise is described as unwanted or undesirable sound. The noise in the work environment has many physiological and physical effects that cause fatigue and adversely affect performance. It is also known that noise affects sleep patterns and reduces the regenerative effect of relaxation.

Exposure to prolonged noise may cause permanent hearing loss. The width of this damage depends on the intensity and frequency of the noise experienced. Temporary hearing loss from exposure to short-term noise can also lead to permanent hearing loss.

The possible effects of noise on human health can be summarized as follows:

-Psychological effects; nervous disorder, fear, discomfort, uneasiness, fatigue, slowing down of mental effects, insomnia and so on.

-Physiological effects; the negative effects of hearing loss, experiencing stress in muscles, increased blood pressure, change of heart rate and blood circulation and etc.

Long-term (months and years) exposure to loud noise (over 80 dB (A)) in the ear may result in non-reversible hearing loss.[25] This loss can be temporary, permanent or both together. Temporary hearing loss, also called auditory fatigue, is eliminated after a short period of time away from the noisy environment (usually one to two hours).

[25] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3199798/ (Accessed April 2019)

Workload

Workload is determined as the intensity of work . It is caused by working long hours or performing physically demanding and mentally stressful tasks. Physical load, environmental load, and mental load are the three aspects of the workload contributing to fatigue.[26]

1.2.4 Food

A person's diet style changes the way of life. Food and water intake is one of the most basic biological needs that people must meet every day in terms of renewal and performance. Overall, assessing nutritional status and adequate water intake is important for managing fatigue . The form of feeding may mitigate or intensify the effects of fatigue . For example, it is found that reducing the consumption of fried and fried foods and regularizing meals are important for reducing fatigue [27].

Nutritional effects also affect the individual's ability to react, concentration on the task or resistance to fatigue .Nutrition also has a direct impact on individuals' energy levels, alertness, and performance levels[28].

[26] . Sadeghniiat-Haghighi K, Yazdi Z. Fatigue management in the workplace. Ind Psychiatry J. 2015;24(1):12–7.
[27] Scruggs, B., 2009: Fatigue: Assessment and Management, Home Health Care Management & Practice , Volume 22 Number 1, pp 16-25
[28] IMO MANUAL, 2000: International Maritime Organization, Imo Manual of Investigation, Chapter 6: Human Factors.

1.2.5 Using medicine / Drug and Alcohol

İt is known that antidepressants, medications for the common cold, etc. cause disturbance to sleep and contribute to fatigue.[29]

Individuals who consume an overdose of caffeine have a greater risk of being tired than others. Caffeine is available in coffee and chocolate. Although short-term caffeine-containing beverages are becoming increasingly common, they should not become a continuous method to increase alertness. Because a stimulant such as caffeine interferes with the person falling asleep and continuing to sleep, it increases the level of fatigue. The same effect is expressed in cocaine users. In addition, studies have shown that alcohol intake also affects sleep quality and sleep breathing and ,as a result , is considered a highly contributing factor to the fatigue occuring. [30]

1.2.6 Sleep-related issues/ İnadequate sleep

What is sleep/ Sleep cycles

Sleep is one of the most requisite necessities for human beings to lead a life. When we're asleep, our muscles rest and our body prepares itself for the new day by restoring the energy which is lost during the previous 24-hour timeframe. It is known that while there is some variation in daily sleep need due to individual differences the daily sleep demand of an average person varies between 7 and 9 hours. Besides time duration, some indicators of sleep like sleep timing, continuity, depth and quality should be taken into consideration, because the deterioration of any of these

[29] Leveille, S. G., Buchner, D. M., Koepsell, T. D., McCloskey, L. W., Wolf, M. ve Wagner, E. H. (1994). Psychoactive medications and injurious motor vehicle collisions involving older drivers. Epidemiology, 5, 591–598

[30] Landolt, H. P., Roth, C., Dijk, D. J. ve Borbely, A. A. (1996). Late-afternoon ethanol intake affects nocturnal sleep and the sleep EEG in middleaged men. Journal of Clinical Psychopharmacology, 16(6), 428–436.

indicators may affects the entire sleep system, which leads to short or long-term health problems. For example , researches have shown that , fragmented sleep (eg, 2-hour sleep periods of 2 hours each, 8-hour sleep) is ineffective in relieving fatigue compared to the effect of 8-hour steamless sleep and it means that a person who cannot get a continuous sleep may feel tired and uncomfortable during the day.[31]

Sleep Components	Definition
Duration of sleep	It should be at least 7-8 hours depending on the needs of the people and within 24-hour timeframe .
Continuity of sleep	The sleep period must be continuous
Quality of sleep	REM (Rapid Eye Movement) is necessary for repairing the energy lost by the person.
Timing of sleep during a day	Daytime sleep is not as high quality as night sleep

Table 3: Components of stimulating sleep[32]

Sleep is an activity consisting of 2 basic stages - REM and Non-REM stages. The non-REM stage also combines three different sub-stages. The first and second stages

[31] McCafferty, D.B., and Baker, C.C., 2002: Human Error and Marine Systems: Current Trends. IBC's 2nd Annual Conference on Human Error, London, England,March, 175-182

[32] Kobayashi, H.,and Murata,S., 2002: Study on the condition of an Occurrence of human error on ship's operation. MARTECH 2000- Maritime Accident is Simulation the answer? Singapore 18-20 September 2002.

of non-REM are called light sleep stages and the other two stages are called deep sleep stages. The phase of REm is the stage where our brain is dreaming.

The process of falling asleep belongs to the first stage of sleep. At this stage, some significant twitches are observed in the muscles. In the second stage, the brain enters to the light sleep phase , when a person is easily awaken by low voice, physical intervention or any external stimulus. In the third and fourth stages the brain adapts to sleep as strongly as to be insensitive to small stimuli. In the stage of Rem, which we call the dream stage, the brain focuses entirely on the dream; At the rem stage, all muscles fall into a temporary paralysis state, which is a good security system for our safety in order to avoid sudden movements in the dream. This stage is a stage with a significant impact on learning and memory consolidation. While more time is spent in the early three and fourth stages during the night, the time spent in REM sleep is increasing. In the sleep system, which consists of these 5 stages, these stages follow one another and create a cycle, each cycle covers 90- 120 minutes and repeats itself 4-5 times a night.

Stages of sleep	Duration	Diagnosis	Effects	Notes
1-Falling asleep	10 min	first phase to sleep	Sleeping without awareness	Short-Term Sleep and Auto Behavior Symptoms (muscle twitches)

2- Light sleep	15 min	light phase of sleep	Sensation and renewal feeling in a short time	50% of sleep occurs at this stage.
3- Delta sleep	15-20 min	Deep sleep	It happens in the early hours of the night, and when it is awakened, the feeling of silliness occurs.	
4- Deep sleep	20-70 min	The deepest phase of sleep	Cognitive, emotional and social	
5- REM stage	After the 70-80 min	Dreaming phase		Brain and body are energized and dreaming occurs

Table 4 : The stages of sleep [33]

Sleep deprivation

Sleep deprivation is one of the most common problems that causes fatigue. This problem often appears in people who work in night shifts, have an impairment on their circadian rhythm and similar health problems. Sleep deprivation occurs when

[33] Lamb, T., 2006: Human Factors in Ship Design: Preventing and Reducing Shipboard Operator Fatigue. U.S. Coast Guard Research Project, Department of Naval Architecture and Marine Engineering, University of Michigan

the person is not getting enough sleep to make himself feel alert and awake during the day . Although the average daily sleep requirement for an average person is between 7 and 9 hours, by taking into account the individual differences, we can say that the amount of sleep loss which cause sleep deprivation varies from person to person. Sleep deprivation make person feel sleepless all day long, experience emotional problems, decrease the quality of work and consequently deteriorate the quality of life.

People often confuse the terms " sleep deprivation" and " insomnia ".Insomnia is also one of the most common sleep disorders. Although the effects of these two sleep disorders are more or less the same, the reasons for their creation are different. Insomnia is the problem of not sleeping in the required length and quality despite having an opportunity for sleeping. Sleep deprivation is a problem that arises when the opportunity for sleep is limited by individual or some external factors.

There are some phases related to the term "sleep deprivation" which are confused by people, so it is necessary to distinguish these terms and give a clear explanations to all of them. These terms are below:

Acute sleep deprivation – This problem occur when a person is totally sleepless or has poor quality sleep during a few days.

Cumulative sleep deprivation - This situation arises when the number of sleepless days increase and continue for several months or a year.

Total sleep deprivation - This type of sleep loss is originated from an individual's refusal for sleep completely during a 24-hour timeframe.

Partial sleep deprivation - This is a problem that results from the deterioration of the sleep pattern of the individual, resulting in a decrease in the number of hours of normal sleep.

As is known, sleep loss can be acute and cumulative. Acute sleep loss is the sleep debt that arise as a result of awake 24 hours. Cumulative sleep loss is a problem when a person does not sleep well for a long time and does not sleep as much as he / she needs. For example, if a person who needs to sleep for 7 hours daily, sleeps 5 hours every day for 6 days , his cumulative sleep debt will be 12 hours. There is a misunderstanding among the people that we can pay our accumulated sleep debt by having one long sleep, but this is wrong, sometimes it takes days or even weeks to pay our sleep debt completely.[34]

Depriving of sleep leads to the arising of fatigue in individuals and it also deeply affects the cognitive performance of individuals. It is observed that the problem evaluation and decision-making skills are weakened in people who experience the sleep deprivation . The person with a tired brain has difficulties in choosing how to react to tasks which is complex and especially demand the careful planning and creativity, and tends to take too much risk because of having poor judgement . In addition, individuals' memory is weakened by sleep deprivation and the quality of performance decreases.[35]

An individual's mood is also badly affected by sleep deprivation. People who are deprived of sleep have been observed to feel overly irritable. [36]This irritability can lead to difficulties and misunderstandings in establishing relationships with colleagues at work.

[34] Belenky et al, 2003; van Dongen et al, 2003). (Belenky, G, Wesensten, N.J, Thorne, D.R, Thomas, M.L, Sing, H.C, Redmond, D.P, Russo, M.B. and T.J. Balkin (2003) Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: a sleep dose-response study, Journal of sleep research, 12(1), 1 – 12

[35] Herscovitch J, Broughton R. Performance deficits following short-term partial sleep deprivation and subsequent recovery oversleeping. Can J Psychol. 1981;35:309–22.

[36] Johnson LC. Physiological and psychological changes following total sleep deprivation. In: Kales A, editor. Sleep physiology and pathology. Philadelphia: JB Lippincott; 1969. p. 206–20.

As a result it is possible to say that the state of sleep deprivation is a strong fatigue creative factor. If the daily sleep is not achieved, the physical and mental performances of the individuals are severely weakened, if the problem of being sleepless is not solved, this state becomes chronic and brings various sleep disorders, causing the individual to become tired for a long time and making the recovery procedure difficult.

Circadian rhythm and Homeostatic drive

The human brain is programmed to sleep at night and stay awake during the day. For this reason, some health problems that cause general fatigue are frequently observed in night shift workers and the main reason for these problems is not being able to sleep at night. The individual has an internal system that regulates the daily sleep and awakening times, and this system works through the interaction between the two biological mechanisms. İn other words, sleepiness is a state that occurs when two basic biological functions work together. One of these functions is homeostatic drive, the other is circadian rhythm.[37]

The homeostatic drive for sleep is a function of the amount of time between the end of the last sleep period and the beginning of the next sleep period. A person's sleep for 9 hours during the day, directly affects the alertness and performance. Furthermore, staying awake for more than 16 continuous hours can dramatically decrease performance. Furthermore, staying awake in any situation for more than 24

[37] Goel, N., 2017. Neurobehavioral effects and biomarkers of sleep loss in healthy adults. Curr. Neurol. Neurosci. Rep. 17 (11), 89.

hours may cause various detrimental effects such as deteriorating attention, response time, attention, memory and decision-making.[38]

The other major factor is circadian rhythm that regulates the chemical and hormonal production and metabolism of the body over the 24-hour cycle. This term was brought into science by Franz Hallberg. The word meaning in Latin - circa - means diem- day, meaning a daily rhythm. Experts say the center of the circadian rhythm is in the middle of the brain and works like a clock. Body temperature fluctuations, blood pressure, secretion of some hormones are also associated with circadian rhythm. İn addition, the cycle of sleep and wakefulness in our brains also works with circadian rhythm. Kleitman proved in the 1930s that wakefulness and cognitive performance were working with circadian rhythm; peak performance was associated with higher core body temperature and has since been further described that decreased performance is correlated to increased melatonin levels . [39]

There are some elements affecting the circadian rhythm:

1. Light - The light affects the rhythm directly. The secretion of the melatonin hormone that starts with the sunset increases the sleep pressure and drives the person to sleep. The circadian rhythm, which also senses the morning sunlight, is readjusted to awaken the person.

2. Temperature

3. Jet lag - Passing time zones cause to the condition of jet lag. The main problem is that the circadian rhythms of the person are timed to the locality from which the person leaves and not to the destination environment. As a result, the environmental

[38] Lim, J., Dinges, D.F., 2010. A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. Psychol. Bull. 136 (3), 375–389. https://psycnet.apa.org/doiLanding?doi=10.1037%2Fa0018883 (Accessed April 2019)

[39] Kleitman N. Sleep and wakefulness. Chicago: University of Chicago Press

inputs collide with the person's inner rhythms and may adversely affect the biological clock, sleep / wake cycle. This situation; insomnia, loss of appetite, changes in the perception of time and distance, disruption of bowel health, bodily pain, sweating, blurred vision, causing problems such as difficulty in reacting. In order to correct the corrupted circadian rhythm and minimize the problems that may be experienced, the person should adjust the meal according to the local time, consume plenty of fluids and avoid alcohol, caffeine etc. during the flight.

4. Shift work: refers to working outside of normal working hours and changing working hours. Night shifts, rotational work changes, fixed night jobs are examples of this. The active opening of the body at the time of rest should cause the circadian rhythm to deteriorate. This leads to work accidents. For example, in one of the reports submitted by the Federal Motor Carrier Safety Administration , is shown that 32% of all fatal big truck accidents occurred at night, 16.4% occurred between 12 and 6 am, and truck driver fatigue contributed to 58% of accidents. [40]

The impairments of circadian sleep rhythm and homeostatic drive for sleep can adversely influence to health- the person may have trouble falling asleep at night and hardly waking up early in the morning and it leads to creation of various sleep diseases,as a result, fatigue.

[40] National Transportation Safety Board. Factors that affect fatigue in heavy truck accidents. Vol 1: Analysis. Safety Study NTSB/SS-95/01, Washington; 1995

CHAPTER 2 : THE CONSEQUENCES OF FATİGUE İN THE WORKPLACE AND WAYS TO OVERCOME THEM

2.1 Effects of fatigue on health and workplace safety

Although fatigue occurs for a variety of different reasons, by observing the results of a wide range of researches, it is possible to conclude that sleep deprivation or having an irregular sleep patterns usually becomes the main reason for experiencing fatigue, in other words, fatigue is generally originated by inadequate sleep system which individuals have. And if we try to find some correlations of having irregular sleep patterns with the workplace, it is possible to observe that the problem of having deprived sleep typically takes its source from working long or extended hours, working in night shifts for a long time, having poorly designed schedule and working without required breaks . For this reason, while talking about " Effects of fatigue on health and workplace safety " , it would be good idea to consider "Fatigue- Poorly designed work schedule- Sleepiness" as a main outline in this part .

Generally, the consequents of temporary and chronic fatigue are characterized by impairments on cognitive and behavioural performance in individuals. As it is said before, generally fatigue is originated by having irregular sleep patterns, and disturbances of sleep system leads to deteriorates in the circadian rhythm of human body. For the reason of circadian rhythm of the body is a core system that regulates the body's 24-hour activity, its deterioration causes serious impairments related to both our cognitive and behavioral performance, because all of these procedures are directly related to brain.

Researches have concluded that fatigue has an adverse impact on individual's hand-eye coordination, daily mood, memory, the ability of processing information, attention, decision making, ability to judge and other many cognitive and behavioral

performances. The amount of impacts is directly related to the level of fatigue which individual experience and duration of its continuity.

Fatigue and Hand- Eye Coordination

Hand-eye coordination is one of the most important skills people need to perform many daily activities. The occuring process of this coordination is a complex process because this coordination helps people perform any activity by using their abilities of seeing and acting at the same time. In other words, people need this ability to create the continuous and cooperative activity of the hands and the information received through the eyes. The ability of hand-eye coordination, which should be organized at the top level , especially for the hand-labor based tasks , is easily affected by some factors such as being drunk, being sleepless, having fatigue and etc . Several studies have been conducted to measure the affect levels of these factors, one of them is a practical study which has been operated by Reid K. and Davson D[41]. The participants in this study were divided into two groups; people in the first group were kept awake for 28 hours, while those in the second group were given alcohol , reaching until the 0.10 percent of BAC level. (BAC = Blood Alcohol Concentration, this interest rate is legally accepted as a dangerous rate to drive a vehicle in many places .) Both groups were passed through cognitive psychomotor test for the aim of measuring the hand-eye coordination levels . From the results of the study, it was clear that 17 hours of continuous sleepless and having 0.05 percent of BAC level cause disruptions at the same extent, while an 24-hour uninterrupted awakeness and having 0.10 percent of the BAC level have the similar levels of impairing influence on the hand-eye coordination .If this case is adapted on the basis of an employee's activity in the workplace, it is possible to see that if an employee who has spent most of his day fulfilling his domestic and social obligations and goes to work in the night

[41] Dawson D, Reid K. Fatigue, alcohol, and performance impairment. Nature 1997;388:235

shift without resting, is deprived of sleep for 17 continuous hours, his / her hand-eye coordination performance would be impaired at the same level with a person of having at a rate of 0.05 % BAC level. And it is possible to assume that working this employee in the night shifts and especially with high level of risky tasks would lead to the several adverse consequences because of being fatigued and having a dangerous amount of impaired hand-eye coordination.

Fatigue and Memory

It is known that the classification of memory is divided into two parts - short-term memory and long-term memory. Our daily experiences are recorded in short-term memory and the information is transmitted to the long-term memory after the brain processes new information. There are two types of long term memory - explicit and implicit memory.[42] By using explicit memory, people remember the basic information about things, events and etc . - they remember "what they are" and "which features they have" by using explicit memory . Implicit memory is the memory of the abilities, so people remember " how to do things" with the help of implicit memory. For example, the information of "the violin is a musical instrument" is stored in the explicit memory, while tools and techniques to play the instrument is sent to the implicit memory by doing some practices. These two types of memory are always interacting with one another. Some researches have revealed the fact that fatigue from sleep deprivation disturbs two essential elements on learning and recall processes of the memory. One of them is the deterioration of the acquisition part of the memory. If a fatigued individual is currently in the learning stage , his brain is affected by this fatigue and consequently he cannot concentrate

[42] http://www.human-memory.net/types_declarative.html

on new information due to fatigue and increased sleep pressure, also his attention and motivation to learn are adversely influenced . As a result, the individual's brain has difficulty to learn new information and transmitting this information from short-term memory to long-term memory. The main reason for this is that , while we are asleep the brain is able to " process", " organise", and " store" the events of the day and the things we have learned. The second distortion is a disruption in the process of recalling the information previously stored in the brain due to fatigue caused by being sleepless. Research has shown that the short naps at work are considered as a solution to this problem , because napping has a good effect on strengthening the health and memory of workers.[43]

Fatigue and Decision Making

Decision- making process is a mental process that occupies an important place in providing a healthy daily life, and therefore any inability in making decisions or predicting consequences of events may affect to individual's life in the negative side and therefore may cause some financial, social and health problems. Decision making process is generated and managed by prefrontal cortex which is located in the front of the brain.

A number of studies have been done to determine whether decision-making skills are affected by being sleepless and , as a result , feeling fatigued . One of them and most famous is the IOWA Gambling Test, which has been experienced on people who

[43] Troxel WM, Buysse DJ, Hall M, Matthews KA. Marital happiness and sleep disturbances in a multi-ethnic sample of middle-aged women. Behav Sleep Med 2009;7(1):2–19.

have been deprived of sleep for 49 hours.[44] The general purpose of this test is to observe how the brain decides and make choices during the game, and to reveal

the situation whether there is an impairment in the prefrontal cortex , which is the thinking, planning, reasoning and deciding part of our brain.At the time of the experiment, 4 card stacks are placed in front of the person and 2000 dollars is given to him as a debt . The player must bring cards from the stack of cards in front of him and he can take as many cards as he wants from any deck in any order. These cards make him reward or lose money, especially the stacks A and B are made up of cards that can bring great amount of money (and loss, so, they are also considered too risky), while the stacks C and D are made up of cards that are less risky and bring a small amount of money, but the player has no information about it. The game is stopped after 100 cards have been taken. Throughout the experiment, players are observed for whether they are prone to risky steps, or if they are willing to make small amounts of money by making smarter decisions.

This test was experienced on a group of people who were deprived of sleep for 49 hours. The results show that individuals who are tired because of being sleepless tend to make unconscious decisions without realizing the risk, so they lose too much money in the game. The same group were re-tested after resting , and they showed more positive results. As a result of this study, it is possible to say that fatigue originated by being sleeplesshas a bad effect on the decision-making part of the brain, namely the prefrontal cortex, and weakens the individual's decision-making skills.

[44] Killgore WD, Balkin TJ, Wesensten NJ. Impaired decision making following 49 h of sleep deprivation. J Sleep Res 2006;15(1):7–13.

Fatigue and Attention

It is clear from the researches that fatigue also affects the level of vigilance.[45] The terms of " vigilance" and "attention" are often confused by people ; Attention is the action of dealing with someone while vigilance is the

skill of maintaining attention over time . Jobs that require continued monitoring such as monitoring any process, keeping workers under surveillance and etc. require having high level of vigilance performance . If the individual has a certain level of fatigue, his / her attention could be damaged and this can lead to work-related accidents or delays. Generally, the human brain is capable of easily losing the concentrate, in other word, it can be readily influenced by external factors such as noise and movement, and tries to hardly maintain its attentiveness after a long time. Decreases in this performance may begin after 15-20 minutes depending on the situation. In such a case, fatigue is considered as a factor that adversely affects attention .

Some of factors which have an effect on individual's attention and vigilance performance are listed below :

- The length of time of the task - Being engaged in the work for a long time may result in performance degradation.

- Environmental factors - External factors such as noise and noise can distort attention and decrease performance.

- Being sleepless

[45] Van Den Berg J, Neely G. Perceptual and Motor Skills 2006 Performance on a simple reaction time task while sleep deprived. Percept Mot Skills 2006;102:589–99.

- Motivation - Both internal and external motivation have an effect on vigilance performance .

When it comes to the fatigue-related issues, some of the negative consequences of the effects of fatigue on attention are as follows:

- Fatigue causes the reaction time of a person to slow down.

- Fatigue due to lack of sleep has a negative effect on awareness and attention and by this reason , may cause making more mistakes during the process ;

- Being sleepless increases the time required for the task's operation. In other words, a tired brain has difficulty focusing on the task, severe problems in concentrating and maintaining the focus, so, it would lead to delayed work and loss of time.

Fatigue and Reaction Time

Reaction time is one of the vital performances that frequently evaluated in psychological researches . This period is defined as the time elapsed during the response of the brain to a stimulus. Generally, reaction is classified into two types ; simple reaction and complex reaction. A simple reaction is defined as a reflective reaction to events without the need for thinking, for example, when the phone's alarm clock sounds, we press the snooze button reflectively . The complex reaction, however, requires a certain thinking and decision making process.

In one of the studies conducted on the simple reaction of people to the events, it was concluded that there were certain disruptions and slowdown in the reaction

performance of sleepless and fatigued people.[46] In addition, it has been observed how fast a daily sleeplessness causes a decrease in reaction performance in individuals who perform monotonous work . During the study , sleep deprived participants were asked to look at a computer screen for 2 hours and press the red answer button on the side whenever a yellow dot appears on the screen. This yellow dot is displayed in four different positions of the screen, 13 times in 15 minutes. This study showed that the reaction time of sleepless people is 20% slower than the others and their reaction performances are also weaker compared with others.

2.2 Risk management approach to fatigue and preventing it in the workplace

Common Fatigue Measurement tools and techniques

As can be seen from the previous subchapters , fatigue is arised by many factors, both in the workplace and in our daily lives; factors such as experiencing sleep loss, having a physical force requiried work, working in night shifts, working with an extended hours , having heavy workload, a number of health problems and etc. result in physical and mental fatigue . Fatigue is a problem that cannot easily be determined and its intensity level cannot be measured easily because of the descriptive difficulties of fatigue, the multiplicity of factors affecting it, and being a complex problem. However, there are some measurement tests, methods and applications that determine the level of fatigue , but they are not always useful at all times, so, some issues should be taken into consideration in the application process. Firstly, it is necessary to recognize and apply the most appropriate application for each

[46] Killgore WDS, Kahn-Greene ET, Lipizzi EL, Newman RA, Kamimori GH, Balkin TJ. Sleep deprivation reduces perceived emotional intelligence and constructive thinking skills. Sleep Med 2008;9:517–26

workplace and the sector. In addition to this , it is important to obtain sufficient information about the advantages and disadvantages of each instrument used in the workplace. In this case, employees and employers can predict, identify, and manage contributors to fatigue in the workplace, also consider several coping strategies to combat fatigue.

The size of fatigue , level of its severity and other measurable criterias are determined by measuring fatigue. One of the measurement methods is using scales. Generally, these scales are designed to measure one or multiple dimensions. The most considerable dimension that typically evaluated in simple one-dimensional scales is severity of fatigue. Five-point verbal rating scales and visual analog scale could be considered as the most common one-dimentional scales. In five- point verbal rating scale, measurement begins from the point of " none fatigue" and ends in " very severe fatigue" , while in visual analog scale these points are named "no fatigue" and "worst possible fatigue " respectively in 10 cm VAS[47] .

• Another tool used in measuring fatigue level is the Piper Fatigue Scale[48]. This scale is considered to be a very comprehensive scale to define fatigue because by having additional measuring items for considering daily life activities and different fatigue arising times , it can measure exactly what causes fatigue and how often it occurs.

• ESS- "Epworth Sleepiness Scale" tool is used in the measurement of fatigue caused by sleepiness [49]. It consists of eight evaluation items and each item has a sleepiness

[47] Wierwille WW, Ellsworth LA. Evaluation of driver fatigue by trained raters. Accid Anal Prev. 1994;26:571–8. [PubMed] [Google Scholar]
[48] Stuifbergen AK, Rogers S. The experience of fatigue and strategies of self care among persons with multiple sclerosis. Appl Nurs Res. 1997;10:2–10. [PubMed] [Google Scholar]
[49] Sadeghniiat Haghighi K, Montazeri A, Khajeh Mehrizi A, Aminian O, Rahimi Golkhandan A, Saraei M, et al. The Epworth Sleepiness Scale: Translation and validation study of the Iranian version. Sleep Breath. 2013;17:419–26. [PubMed] [Google Scholar]

range of 0 to 4 point . Generally , if the result of the evaluation of the person is higher than 10 points, this is considered as high rate of sleeplessness

• The other tool used for measuring fatigue level is the Horne-Ostberg survey[50]. This survey could be an effective tool in the term of directing employees to the right shifts. The survey consists of 19 questions, the questions are designed to determine when the person wants to fall asleep and start the day. As a result of the survey , people which are more suitable for the daytime shift are classified as Lark type , people for night shifts are defined as Owl type and those that do not see a special difference between these two timeframe are classified as Indifferent type .

• It is also possible to measure fatigue in different ways in the laboratory. In this method, in order to determine the capacity of the individual to fulfill his daily duties, his reaction time performance, attention, short term memory and etc. are tested. One of the measurement tools that contains this test structure is the Psychomotor Vigilance Task test.[51]

• It is known that fatigue can be also caused by depression and excessive stress. For this point of view, the SDS – "The Symptom Distress Scale"[52] is used for fatigue measurement . This questionnaire consists of 13 items which is designed to determine the symptoms of stress and depression in the patients.

• Apart from these methods, various sleep surveys, sleep logs and etc. ar e used for the aim of learning what amount of sleep people need both in the workplace and in the laboratory .

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[50] Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol. 1976;4:97–100. [PubMed] [Google Scholar]

[51] Dinges D, Powell J. Microcomputer analyses of performance on a portable, simple visual RT task during sustained operations. Beh Res Meth Instr Comp. 1985;17:652–5. [Google Scholar]

[52] McCorkle R, Young K. Development of a symptom distress scale. Cancer Nurs. 1978;1:373–8.[PubMed] [Google Scholar]

All these items are used to identify factors that lead to fatigue risk and in next stage, studies are started for reducing the potential risk occurence related to fatigue.

Reducing risks

Risk reduction methods are classified into three categories :

- Reducing Risk at an Individual's Level
- Reducing Risk at a Medical Level (Optimizing Overall Health)
- Reducing Risk at an Organizational Level

Let's give extensive information about each category

Reducing Risk at an Individual's Level

One of the most important individual efforts to reduce the person's fatigue risk is to normalize the sleep pattern. Regular sleep is one of the basic factors for good health, because it has an effect on the human organism in terms of chemical, anatomical, psychological and neurological aspects. İf a person does not have a good quality of sleep or is deprived from his daily sleep needs, even having very good exercise schedule and nutrition regimen do not be enough to provide a high quality of life for him.

These are the main factors of a good sleep:

• Adequacy of the amount of sleep for the individual

• High quality of sleep

• Proper timing for sleep

• Not having a temporary or chronic sleep disorder

Many people have a false belief that being sleepless is not such a major problem. However, deprivation of sleep negatively affects the work and productivity, and this issue would endanger the health and quality of life of the individuals .

So, it is absolutely important to consider several issues to get regular sleep. Some of them are listed below :

- İt is important to keep bedroom cool, dark and quiet while sleeping
- İn the case of feeling hungry, eating small amounts of food with less calories is a good approach[53]
- Maintaining a regular exercise schedule contributes the good quality of sleep[54]
- Caffeine-containing drinks may deprive sleep
- İt is not recommended to consume alcoholic beverages to provide sleepiness , because it is definitely harmful to health and etc. (alcohol may initially help sleep induction, but as its sedating effects wear off after several hours, withdrawal begins, and sleep becomes disturbed)

[53] https://www.health.harvard.edu/sleep/8-secrets-to-a-good-nights-sleep (Accessed April 2019)

[54] Brett A. Dolezal , Eric V. Neufeld , David M. Boland , Jennifer L. Martin, Christopher B. Cooper "Interrelationship between Sleep and Exercise: A Systematic Review " / https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5385214 / (Accessed April 2019)

Reducing Risk at a Medical Level (Optimizing Overall Health)

Fatigue is considered as a common complaint in several medical conditions. In general, the causes of fatigue related to medical diseases can be divided into disease-specific and non-specific mechanisms. Non-specific mechanisms include decreased physical activity, muscle loss, disturbed sleep, metabolism and changes in nutrition, depression and anxiety. Specific diseases can work through the above mechanisms or alternative mechanisms to cause fatigue.

Table 4 shows some chronic medical, neurological, or psychiatric conditions that are associated with fatigue and recommended management strategies. In many cases, appropriate treatment and management will reduce fatigue.

Health Condition	Treatment	Prognosis
Heart failure	• Non-pharmacotherapy: pulmonary rehabilitation • Pharmacotherapy: bronchodilator, inhaled corticosteroid • Management of comorbid conditions including cardiovascular, psychiatric, and sleep disorders	Improvement in quality of life and fatigue and reduction of COPD exacerbation and hospital admission

Endocrine diseases	• Management of hypo- and hyperthyroidism • Management of comorbid medical condition • Management of diabetes • Management of parathyroid disorder • Management of adrenal insufficiency	Improvement in disease-specific symptoms, quality of life, and fatigue
Parkinson's disease	•Pharmacotherapy: doxepin, rasagiline, methylphenidate • Physical rehabilitation • Management of comorbid conditions including sleep and psychiatric disorders	Improvement in disease-specific symptoms, quality of life, and fatigue
Traumatic brain injury	• Neurorehabilitation • Cognitive behavioral therapy • Management of sleep disorders • Stimulants like methylphenidate • Others: piracetam; bright blue light	Improvement in disease-specific symptoms, quality of life, and fatigue

Mood disorders	•Pharmacotherapy of mood disorders • Management of comorbid medical and sleep disorders •Cognitive behavioral therapy •Graded exercise	Improvement in disease-specific symptoms, quality of life, and fatigue
Anxiety disorders	•Pharmacotherapy of anxiety disorder •Management of comorbid medical and sleep disorders •Cognitive behavioral therapy •Graded exercise	Improvement in disease-specific symptoms, quality of life, and fatigue

Table 4[55] : Medical contributors of Fatigue and recommended management strategies

Reducing Risk at an Organizational Level

As the name implies, there is a certain obligation on the employers, managers and other authorized persons to control the level of fatigue risk of individuals at of organizational level . Ergonomic conditions in the workplace, internal environmental factors, type and design of work, the amount of total working hours in a month , the number of breaks allowed to workers during shifts, and other workplace-related factors may increase or decrease level of fatigue of workers.

Traditionally, companies had such a wrong belief that , it is enough to just set up working and holiday hours to manage fatigue in workplaces. Towards the end of the 20th century, "Swiss Cheese Model"[56] designed by James Reason, based on the idea

[55] Amir Sharafkhaneh Max Hirshkowitz “Fatigue Management” 2018, 204
[56] https://en.wikipedia.org/wiki/Swiss_cheese_model

of accident causality in order to investigate the organizational impacts of accidents, proved that this thought was quietly wrong. According to this model, even if the causes are seen as the only causes contributing to the occuring of bad accidents, there are also hidden errors beyond the accidents that are affected by organizational issues .

It is possible to understand from this that it is not possible to prevent accidents caused by fatigue in the workplace by just setting working hours , the clock arrangement is only a layer of defense, and a multi-control layers are required to prevent the risk.

As a risk-prevention system that identifies a complex defensive method by incorporating the multi-control layer itself, the FRMS is one of the perfect systems used by companies (especially aviation, healthcare, transportation). The FRMS applies the principles and processes of SMS (Safety Management System) to manage the risks associated with fatigue. While SMS generally monitors all risks, the FRMS only deals with the management of risks associated with fatigue. Therefore, FRMS can be considered as a subset of SMS.

FRMS is a multilayer system in five levels of barriers to prevent fatigue-related accidents[57] :

• The first level relates to the obligation of the company to provide adequate sleep opportunities for its employees. In order to ensure that working hours don't impair employees' sleep patterns and force them staying awake for a long time which would be detrimental to their health, the company should ask itself the following question: "Do the accepted working time arrangements help employees getting sufficient sleep opportunities and provide them not staying awake more than necessary ?" . There

[57] Dawson D, Chapman J, Thomas MJ. Fatigue-proofing: a new approach to reducing fatigue- related risk using the principles of error management. Sleep Med Rev. 2012;16(2):167–75.

are several guidebooks and matrices to ensure employees are provided with sufficient sleep opportunity within their schedule. The first level outlines the management of fatigue with a traditional approach (make an arrangement for working and rest hours)

• The second level relates to the measurement of the amount of sleep achieved by workers. At this level, the organization should confirm that sufficient sleep is obtained for employees to indicate fitness for duty . The main question that employees must ask themselves is "Have I not been awake for too long to be safe for myself and my colleagues or have I recently slept enough? "

Fitting to the work could be determined by three simple calculations:

1. The amount of sleep in the last 24 hours

2. Amount of sleep in the last 48 hours

3. Measuring employees' overall waking time from the start of the day to the end of the work

• The aim of the third level is to determine the behavioral symptoms of fatigue. The main question employees should ask themselves at this level is that " Do I perform any signs of fatigue? Do my colleagues perform symptoms of fatigue? ". Because of personal differences in the sleep requirement, sleep disorders, and some idiopathic factors, the first two levels are not sufficient to guarantee that safety at work and keep performance far from risk.

• The fourth level deals with the assessment and control of minor errors related to fatigue. The critical question should be asked at this level is that " Is fatigue a contributing factor to any mistakes I make in the workplace? ". Performance testing, some observations and documented errors are some of the tools used at the fourth level of FRMS.

At the fifth level, fatigue-related incidents are evaluated and controlled. The main question for this level is that " Is fatigue a contributing factor to this event?

Any organization can monitor the effectiveness of first three levels with the help of levels 4 and 5.

As SMS, FRMS also attaches importance to an effective safety reporting culture and trainings are provided to employees to report the hazards they observe According to Fourie[58] , FRMS has 6 components, although it could be flexible to the needs of its organization.

They are as follows:

:□ Fatigue Risk Management Policy

□ Fatigue Risk Management Procedures

□ Process of reporting fatigue by employees

□ The process of investigating the potential role of fatigue in accidents

□ Fatigue management training for employees and managers

□ Internal and external auditing of FRMS

In order to the FRMS has a high level of influence in managing fatigue , the responsibilities are divided between workers, organisation and and supervisors ;

Organizational Responsibilities

-Developing an FRMS

-Providing policies and training related to work schedules and fatigue-related risks

-Assessing compliance with the FRMS

[58] Fourie, C., Holmes, A., Bourgeois-bougrine, S., Hilditch, C. ve Jackson, P. (2010). Fatigue Risk Management Systems : A Review of the Literature, London

-Investigating fatigue-related accidents as needed

Supervisor Responsibilities

-Determining jobs/workers that should be covered by FRMS

-Ensuring employees receive proper FRMS training

-Insuring work schedule provide adequate opportunity for rest

-Reporting any fatigue-related risks and/ or incidents

Individual Responsibilities

-Complying with FRMS requirements

-Taking a proactive role in learning about fatigue-related risks and managing their own well-being

-Obtaining adequate sleep, maintain overall health, and be fit to work

-Reporting any fatigue-related symptoms

-Reporting any fatigue-related safety risks

CONCLUSION AND RECOMMENDATION

It is tried to get an general idea about fatigue by contrasting different definitions and approaches given for the understanding of this phenomenon throughout the research. The research revealed that fatigue is a circumstance that often express itself with visible symptoms, such as feeling sluggish and sleepless, and appears due to various individual and environmental factors such as unhealthy food intake (for ex., consuming alcohol-containing drinks) , not getting daily required sleep, sleep disorders, working under difficult conditions, various diseases and etc. It is caused by individual and environmental factors.

It is revealed from the results of several empirical researches (noted in 2.1) that cognitive and behavioral performances of individuals are adversely affected due to fatigue;

- A tired brain cannot process information received through the eyes in the required timing and , because of that, hand-eye coordination are disrupted, resulting in difficulty with doing activities that require the simultaneous use of our hands and eyes .

- While the process of learning new information, the fatigued brain cannot often pass this information from short-term memory to long-term memory . As a result, the person quickly forgets this information . At the same time, it becomes difficult to remember

information learned in the past : as can be seen , fatigue also affects memory by weakening the inner system

- The level of attentiveness is impaired by fatigue, so fatigued people have difficulty with concentrating

-The reaction time, which is one of the types of cognitive performance, is also negatively affected by fatigue, and this problem caused by the weakening of the sensing abilities directly affects the behavioral performance.

- Fatigue also affects mood ; tired individuals become more frustrated and impatient, and prone to negative thinking

- Decision making ability of individuals also degrades by the effect of fatigue.

As stated in the study, besides individual factors , there are observed some other factors arising from the workplace ,such as the high workload, long-term night shift work, working in the workplace environment that is not ergonomically equipped and etc. cause fatigue .

Research shows that companies often do not take special actions for measuring the fatigue levels of their workers, however if we take into account all adverse effects of fatigue on the worker, it would be very obvious that this approach is directly harmful and even dangerous to the company itself, because the productivity level of employees is reduced, as well as the errors due to fatigue sometimes cause the loss of million dollars of money and expensive equipments.

So, by considering all of these issues, companies shoud implement one of the best fatigue management system – FRMS in the workplace because of having multi-layer defensive structure and considering more fatigue-arised factors except only arranging work hours.

In short, the measures that must be taken to combat fatigue should be carried out by both the individuals and the authorized persons of the organization.

Individuals should :

- Be careful to their diets

- Pay attention to their sleep patterns

- Get rid of bad habits.

- Do continuous exercises

- And should't prefer working in multiple jobs (as much as possible)

Companies should :

- Adapt work schedules of the employees to the latest standards and not force employees working out of the assigned work hours

- Do not force workers to work in shifts that adversely impair employees' sleep patterns or, more precisely, biological clocks

- In particular, the same employees should not be chosen for the night shift repeatedly

Beside to these regulations ;

- Employees should be allowed for making short breaks of while working

- Work environment is designed according to the ergonomic rules

- Organisations should prepare a comprehensive system with the aim of reducing the level of fatigue or use existing, internationally available fatigue coping strategies.

- Various tests, questionairres and techniques should be prepared for measuring fatigue level, as well as performance quality with the aim of checking the fitting level of employees to the task

- Employees should provide trainings and seminars in order to raise the level of awareness about fatigue in the workplace

- Companies should protect employees from fatigue originated by the monotonous work by making positive changes from time to time in the application or design of task

Finally, it is important to note that , fatigue is something which is impossible to eliminate completely , it is only necessary to take the right steps to reduce the level of fatigue and prevent it from becoming chronic. If all the above mentioned measures are taken, the risk of health problems due to fatigue and the possibility of occurrence of work accidents can be minimized.

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