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Investigating the Circadian Rhythm Type and its Relation to the Problems Caused by Shift work: a Case Study-Workers in one of Iran's Iron-Ore Mines

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ABSTRACT

Nowadays, shift work systems are a very common work schedule in developed and industrialized societies. The human body needs to adapt itself to different cycles of sleep and awakening. These will predispose persons to various physical, psychological, and social problems. This study was aimed to investigate the circadian rhythm type among workers in one of Iran's iron-ore mines. Furthermore, the relationship between the circadian rhythm amplitude and stability was also evaluated. In the present cross-sectional study, 356 persons were investigated who were working in their daily shift work in an iron-ore mine. The samples were collected randomly and for data collection, the standard questionnaires of "Survey of Shift Workers" (SOS) and "Determination Checklist of Circadian" (CTI) were used. Data were analyzed using SPSS software version 11. ANOVA, T-test, and Chi-square tests were applied. According to the research objectives, 356 participants, 75.2% (268 persons) were shift-workers, and 24.8% (88 persons) were fixed-shift workers. The average age of the shift workers was 35.22 ± 5.40 year-olds. In addition, the most frequent reason for choosing a night-shift for the shift workers was organizational constraints (57%). The results showed that working based on shift work schedule had a significant effect on individual activities ($p = 0.034$) and family life ($p = 0.0001$) compared to fixed-shift workers. It was also found that among inflexible individuals, problems such as digestive and psychological problems were less specified than shift workers. Shift-workers with stable circadian rhythms showed more flexibility to the sudden changes occurring in their inner rhythm and relatively had less shift-working issues. On the contrary, those who had rigid circadian rhythm, they were resistant to sudden changes. Consequently, these individuals were susceptible to problems caused by shift work. Stability (FR) and amplitude (LV) variables of circadian rhythms can be used as predictive indicators for employment and help to select appropriate individuals for the shift work system to prevent the occurrence of shift-working problems.

KEYWORDS: *Shift Work, Fixed-Shift Work, Circadian Rhythm, Shift-Working Problems*

INTRODUCTION

Although the shift work system is unavoidable in the modern industry, it is associated with lifestyle problems and various health disorders [1]. The number of shift workers increased over the last decade where 15 percent of the workers in the United States and 20 percent in Europe are employed as shift workers [2]. Many industries and social systems are forced to use their machinery and employees in a 24/7-hours shift work system in which employees are faced with disturbances in their biological rhythms and disrupt their bodies physiologically due to various physical, psychological, and social problems [2-3].

The human body's biological clock plays an important role in shift work related issues. Biological rhythms are greatly impaired during the night-shift. Therefore, it may a source of disturbances in social and family life which harm the performance and social relationships of individuals [4].

Biological rhythms are the natural cycle of daily changes in the human organ's specific functions. This adaptation system helps the body's organs and hormonal system to optimally perform their specific task simultaneously. In recent years, the molecular basis of biological rhythms has been detected. This molecular basis is composed of genes that are known as Clock Gens controlling the 24-hour rhythms [5].

Different humans have various levels of alertness, energy, and ability in specific times of day which is differing person to person [6]. The circadian rhythm regularly repeats these features every 24 hours [7]. Numerous studies have confirmed the definite connection between the biological rhythms of the body and the natural tendency for night sleep and daily wakefulness. Sleep-wake cycle interruptions disrupt the body's rhythms and circadian regulators [8]. In order to analyze the characteristics of the circadian cycle, it could be evaluated like a sinusoidal wave, amplitude, and stability [9]. The stability and the amplitude of the circadian rhythm were determined using flexible/rigid and languid/vigorous intervals, respectively. Individuals with flexible circadian rhythms pattern showed more flexibility when they were facing to sudden changes in their inner rhythms (such as staying awake all night). On the contrary, individuals with stable rhythm were resilient to sudden changes. Individuals with a weak circadian rhythm (L) were flexible also resistant to sudden changes. These individuals with a weak circadian rhythm range (L) which were called weak had more difficulty overcoming sleepiness and lethargy due to lack of sleep. Adversely, lively individuals (V) were able to resist the feeling of drowsiness [10].

In a study, Besoluk concluded that to determine the impact of circadian type on the university entrance scores, morning students showed better performance in morning tests [11]. The results of another study showed that three-shift nurses with flexibility features were less likely to get insomnia and could work and sleep at any time of the day. Furthermore, nurses with specific weaknesses showed higher levels of sleepiness, signs of anxiety, and depression [12]. In another study, 34% of men unintended on night shifts working because they could not sleep at the day-time and subsequently felt tired during the night as a result of which about 23% suffered from digestive problems. A large proportion of men workers' diet and sleep patterns were affected regardless of their experience for working two shifts for several years [13].

Therefore, considering the important role of workers in industries and mining ores, in this study, the problems of shift workers in iron ore mines were examined and compared with fixed-shift workers. In addition, the relationship between these problems and the circadian rhythm types were analyzed to identify the most important problems and new appropriate approaches suggestions including systematic planning and eventually recruit appropriate individuals which can reduce the shift work-related problems.

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METHODS AND MATERIALS

In this cross-sectional study, 356 shift-workers were selected as sample size. The Cochran formula was used to determine the ideal sample size by a 95% confidence interval. The subjects were selected using a random sampling method among the workers in one of Iran's iron mines in Yazd province, Iran. The data were collected using Survey of Shift Workers (SOS) and CTI questionnaires.

The Survey of Shift Workers (SOS) was developed by the MRC / ESRC Social Psychology Unit shift research group in the United Kingdom. The reliability of this questionnaire using the alpha coefficient was considered 0.86. The validity of the questions and skills was reported between 0.21 and 0.71[14]. In addition to demographic data and individual characteristics, this questionnaire contains questions about the work shift system, job satisfaction, psychological, digestive, cardiovascular, sleep hours, sleeplessness, sleep deprivation, skeletal and muscular disorders, undesirable effects of shift work on individual life (such as rest, study, exercise, going to the lab, visiting the bank), adverse effects of shift work on family life (lack of enough time to do homework, taking care of children and parents, and contributing to the family celebration), and some undesirable impact on social life such as; attending various social events, celebrations, religious ceremonies, sports, etc.

CTI questionnaire designed by Di Milia was used to determine the type of circadian rhythm, [15]. This questionnaire contains three factors including stability of sleep habits, an individual's ability to work, and early waking up habit. A type of the circadian rhythm based on the expert opinions was observed considering answers to the questions such as falling asleep in unusual hours, falling asleep at 6 a.m., sleeping and waking in a specific time, and so on. The validity of the cardinality circulation type of this questionnaire has been proved in many studies abroad in different languages.

Jafari et al. performed a study to evaluate the Persian version of the Circadian Type Inventory (CTI) among nurses. The questionnaire validity and Cronbach's alpha values were calculated 94% and 0.76, respectively [10]. The CTI checklist had 11 questions based on "yes" or "no" answers while it covers two independent factors. The first factor is flexible/rigid interval which represents the stability of the circadian rhythm and includes questions 2, 4, 6, 8 and 10. Higher factor's scores represent more working flexibility and capability in a shift work system with the ability to waking up at abnormal times of day or night. The second factor is the inactive name, which represents the circadian rhythm range and includes questions 1, 3, 5, 7, 9, and 11. Those who scored in the second factor would be called weak people who cannot overcome sleepiness and laziness due to sleep deprivation and are more likely to be affected by work routine [15].

Persons who their score in the first factor (FR) was above 18.55 percentile out of 5 questions, their type of circadian rhythm was considered to be flexible. These people can stay awake at unusual times all day long. Whereas people who scored more than 22.5 out of the 6 questions, except for a percentile of over 75 based on the second factor (LV), their circadian rhythm type was considered to be loose in terms of scope. For these people, it is more difficult to overcome sleepiness [10].

The purpose of the study was explained to all participants. Data were analyzed using Chi-square and one-way ANOVA tests via SPSS software version 11.

RESULTS

A total of 356 iron-ore workers participated in this study, 75.2% (268 persons) were shift workers and 24.8% (88 persons) were fixed day workers. The marital status of participants included 21.6% single (77 persons), 75.8% married (270 persons), and 2.6% divorced (9 persons). Out of 60.4% of participants had diplomas and under diplomas degree (215 persons), 29.5% had an upper secondary degree (105 persons), 7.6% had a bachelor's degree (27 persons), 2.5% had master degrees (9 persons). Some demographic characteristics and information about individuals have been shown in Table 1.

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Table 1. The average value of some shift system features and sleeping time among the study group

Variable	Shift workers Average (SD) N = 268	Fixed day workers Average (SD) N = 88
Age (years)	35.52 (5.40)	34.42 (6.36)
Work experience (years)	8.16 (9.6)	9.18 (14.26)
Shift-working history (years)	9.32 (8.7)	4.56 (2.63)
Work hours per week (hours)	42.84 (6.86)	41.65 (2.71)
Average sleep in the morning hours (work)	6.8 (1.4)	7.01 (0.81)
Average sleep in the evening hours (work)	7.01 (2.03)	……
Average sleep in the night hours (work)	4.82 (1.98)	……
Number of children		
≥2	196 (8.80)	68 (5.3)
<2	72 (4.20)	20 (2.1)
Smoking		
Yes	106 (39.55)	25 (28.4)
No	162 (60.45)	63 (71.6)
History of stomach ulcers		
Yes	104 (38.8)	40 (45.45)
No	164 (61.2)	48 (54.5)

The subjects' common sleeping patterns after the night shift work were divided into four main categories, 54.85% (n =147) individuals immediately after the night shift and reaching home, 21.6% (n=58) had 2 to 3 hours delay between 9 a.m. to 12 p.m., 17.2% of subjects (n = 46) between 12 p.m. to 4 p.m. after lunch, and 35.5% of subjects (n = 17) after 10 p.m. (after night shift work) and with the largest delay, compensate for the lack of sleep due to night work.

The results showed that the shift work had a significant effect on individual activities (p= 0.034), family life (p = 0.0001), and social life (p = 0.023). The shift work had a significant effect on day work people, and shift workers focus hardly on performing their works (p=0.01) and had a lack of confidence (p=0.041). According to the results of shift workers, they suffered from insomnia (p = 0.001) in comparison with their fixed day shift colleagues. Furthermore, shift workers and fixed day workers comparison showed that shift workers use sleep medications significantly more than fixed day workers (p = 0.03). Moreover, shift workers suffer more insomnia than fixed day workers (p = 0.0001).

The prevalence of gastrointestinal disorders between two groups (shift workers and fixed day workers) has been presented in Table 4. The results of Chi-square test showed some digestive problems such as decreased appetite, maladaptation of digestive system, nausea, stomach cramping, and stomach shedding.

Table 2. Shift workers' response status to shift work variables

Variable	Frequency of response (percent)
Sleep hours after the end of night work	
Less than 6 hours	123 (45.9)
6 to 8 hours	63 (23.5)
8 to 10 hours	54 (20.15)
More than 10 hours	28 (10.45)
Supporting family members from night work to provide comfortable sleep conditions (silence, proper nutrition, etc.)	
zero	24 (9)
Low	43 (16)
medium	150 (56)
Much	51 (19)
Possibility to sleep at night shift	
No	21 (7.8)
Less than 1:30 hours	27 (10.1)
Between 1:30 and 2:30 hours	99 (36.9)
More than 2:30 hours	121 (45.2)
Reasons to choose a night work	
Organizational compulsion	153 (57)
Job interest, economic reasons, home, and office affairs, the next day, lightening the work in some sectors	41 (15.3)
Lack of power	10 (3.7)
Failure to answer the question	64 (24)
Total	**268 (100)**

A comparison of psychological and mental problems between shift workers and fixed day workers has been presented in Table 3.

There was no significant difference in the cardiovascular problems between two shift groups and the fixed day workers (p = 0.1).

The results of Chi-square test showed a significant relationship between job satisfaction and shift work (p = 0.0001) so that fixed day shift workers had more job satisfaction than shift workers (OR = 1.97 CI: 1.02-3.67)

In addition, the Chi-square test's results proved that there was a significant relationship between job satisfaction and resentment from insomnia (p = 0.0001). Accordingly, workers who were less likely to have insomnia had significantly higher job satisfaction (OR: 3.4 CI: 1.9-6.03).

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Table 3. A comparison of psychological and mental problems between shift workers and fixed day workers

Variables related to psychological problems	OR odds ratio	Confidence interval 95%	p-value
Headache and dizziness	1.7	1.26 - 3.26	0.01*
Feeling angry	1.44	0.94 - 2.27	0.54
Lack of focus on work	3.05	1.37 - 7.07	0.001*
The number of mistakes	1.24	0.52 - 3.43	0.42
Impatience	2.36	1.52 - 3.72	0.001*
Depression	4.49	2.39 - 8.57	0.0001*
Irritability	3.09	1.66 - 5.87	0.0001*
Feeling fatigued during the day	1.85	1.23 – 2.84	0.026*

Table 4. A comparison of digestive problems between shift work and daytime workers

Digestive problems	Shift workers (%)	Fixed day workers (%)	p-value
Increased appetite	46 (13.57)	3 (4.41)	0.25
Reduce appetite	40 (11.8)	5 (7.35)	0.0001*
Constipation	34 (10.03)	5 (7.35)	0.55
Gut polyps	4 (1.18)	0 (0)	0.63
Indigestion	24 (7.08)	4 (5.88)	0.003*
Digestive wound	24 (7.08)	4 (5.88)	0.207
Stomach ache	7 (2.06)	8 (11.77)	0.07
Diarrhea	6 (1.77)	1 (1.47)	0.74
Nausea	29 (8.55)	5 (7.35)	0.002*
Flatulence	41 (12.1)	7 (10.3)	0.07
Gastritis	20 (5.91)	5 (7.35)	0.68
Intestinal colitis	10 (2.95)	3 (4.41)	0.91
Hiccups	25 (7.37)	7 (10.3)	0.02*
Stomach Sweating	29 (8.55)	11 (16.18)	0.03*

The circadian rhythm stability and amplitude have been presented in Table 5. As shown in this table, 23% of the subjects had a higher percentile (loose) rhythm of the circadian (loose) and 77% below the 75th percentile (resistant). In the current study, 10.1% of the subjects had a circadian rhythm consistency percentile over 75 and had flexible rhythm and 89.89% of the subjects had a percentile below 75 and had a rigid rhythm.

In Tables 6 and 7, the frequency of shift work problems distribution based on the domain characteristics and stability of the circadian rhythm in the studied workers was presented. The results of the Chi-square test showed that the prevalence of gastrointestinal problems and psychological problems in both F and R groups was significant (P <0.05). Therefore, circadian rhythm stability affected the incidence of these problems. Consequently, individuals with flexible gastrointestinal and psychosocial had fewer problems than intolerant ones. However, this test showed that the frequency of shift work problems between two L and V groups was not significant (P> 0.05).

It could be concluded that the circadian rhythm probably did not affect these problems.

Table 5. Amplitude and stability status circadian rhythm among studied subjects (n = 356)

Variable	Condition	Percentage	Frequency
Circadian rhythm amplitude (LV)	Percentile above 75 (Languid)	23	82
	Percentile below 75 (Vigorous)	77	274
Circadian rhythm stability (FR)	Percentile above 75 (Flexible)	10.11	36
	Percentile below 75 (Rigid)	89.89	320

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Table 6. Shift work problems frequency distribution based on the circadian rhythm characteristics amplitude in subjects

Shift work problems		Circadian rhythm amplitude (LV)		p-value*
		Languid	Vigorous	
Digestive problems	Shift-workers (n=244)	(72) 29.51%	(172) 70.49%	0.14
	Day-workers (n=68)	(9) 13.23%	(59) 86.76%	
Cardiovascular problems	Shift-workers (n=26)	(4) 15.38%	(22) 84.62%	0.27
	Day-workers (n=10)	(1) 10%	(9) 90%	
Psychosocial problems	Shift-workers (n=230)	(54) 23.48%	(176) 76.52%	0.16
	Day-workers (n=51)	(9) 17.65%	(42) 82.35%	
Musculoskeletal problems	Shift-workers (n=61)	(8) 13.11%	(53) 86.89%	0.21
	Day-workers (n=18)	(1) 5.5%	(17) 94.5%	

Table 7. Shift work problems frequency distribution based on the characteristics of circadian rhythm stability in subjects

Shift work problems		Circadian rhythm stability (FR)		p-value*
		Flexible	Rigid	
Digestive problems	Shift-workers (n=244)	(18) 8.6%	(223) 91.4%	0.001*
	Day-workers (n=68)	(17) 25%	(51) 75%	
Cardiovascular problems	Shift-workers (n=26)	(9) 42.3%	(15) 57.7%	0.18
	Day-workers (n=10)	(2) 20%	(8) 80%	
Psychosocial problems	Shift-workers (n=230)	(46) 20%	(184) 80%	0.001*
	Day-workers (n=51)	(13) 25.5%	(38) 74.5%	
Musculoskeletal problems	Shift-workers (n=61)	(26) 42.6%	(35) 57.4%	0.16
	Day-workers (n=18)	(7) 38.9%	(11) 61.1%	

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DISCUSSION

This study was aimed to investigate the circadian rhythm type among workers in one of Iran's iron-ore mines. Furthermore, the relationship between the circadian rhythm amplitude and stability regarding the shift work hours and the related problems also was evaluated.

In a study conducted by Di Milia et al., the CTI tool was used to validate shift workers and day workers at the university. Vigorous type (loud) was more alert in terms of circadian rhythm (loose) during the day, and a significant consciousness difference was observed between type F (Flexible) and L (Loose) in 16 to 22 hours. So, they concluded that the F type (Flexible) was less affected by circadian and wakefulness factors during this mentioned time. Besides, the F type (Flexible) accounted for a lower amount of sleep than the R (Flexible) type. Finally, based on their finding, people with V (lively) circadian range and F (flexible) circadian rhythm stability were more suitable for shift working. In the present study, flexible people (F) in terms of the circadian rhythm stability had fewer digestive and psychological problems than the rigid type (R) and were proposed for working in shift system [9].

Nowadays, especially in developed countries, shift working is a common working system. However, this system is not suited to the human body and may disrupt night rhythms. This study showed that 91% of workers in shift work and 77% of day workers had at least one of the symptoms of gastrointestinal discomfort. In a study Saberi et al., determined the prevalence of gastrointestinal symptoms among shift working and fixed day nurses 81.9% and 52%, respectively [16] which a half value of these results observed in YOO's study [17]. This study showed fewer gastrointestinal disorders including loss of appetite, dyspepsia, hiccups, and stomach acid secretion among shift workers compared to fixed day workers. Bilski found the spread of bowel habit disorder among shift nursing however there was no significant difference in the incidence of other symptoms such as constipation, diarrhea, and gastric ulcer with other fixed day workers [18].

The shift workers' digestive, mental, and psychological disorders possibility was calculated by Chubineh et al. 40% and 20% was more than fixed day workers [19]. Similarly, the study of Ziman and Colleagues regarding Shiraz Medical Sciences Hospital staff's gastrointestinal disorders showed that an increase/decrease in appetite and gastric ulcer among shift workers were significantly more than non-incipient workers [20]. In many studies, swirling and digestive problems significant relationship was found [21-22-23]. As many studies about shift workers reported more symptoms of gastrointestinal disorders than regular workers [24-25]. This prevalence could be attributed to the inconsistency of the work program with the circadian rhythms of shift workers. However, the differences in the prevalence of disturbances among shift workers and constant day workers in various studies, as well as the prevalence of some gastrointestinal symptoms in different studies, could be attributed to environmental factors, social factors, and even inappropriate responses to the questionnaires.

The results of this study showed a significant level of headache and dizziness, decentralization at work, distress, depression, irritability, and feeling of fatigue during the day among shift workers and fixed day workers which were consistent with the studies of Choobineh and Soltanizaded. Although, a comparison of anger and similar mistakes cases was not significantly correlated and inconsistent with Choobineh et al., and Sultanzadeh et al., studies. [26- 27].

In this study, the most and the least important reason for shift work switching was force (57%) and workforce shortage (7.7%), respectively. According to the results of this study, 15.3 percent of the workers want to switch their shift work willingly and eagerly. The results of Choustine and Colleagues proved higher job satisfaction more willingness to work in the shift system among workers who choose shift working with interest rather than forced workers group [26]. This finding was also consistent with other studies [27].

For rotating shifts, it could be in the morning, afternoon, and night. This type of shift work mode is called the forward shift work system consistent with clock rotation, on the contrary, this

state is the time to change the shift of the night, afternoon, and morning. In order to change the shift work a counterclockwise and a backward turning system can be used. Studies have shown that front-wheeling was more suitable for shift workers and they could tolerate it better as a result of and consequently may improve productivity, well-being, and quality of sleep as well as physical and social health [14]. In the present study, the possibility of rotating shifts in the opposite direction of the clock showed less job satisfaction in shift workers and some difficulties caused by shift work which was similar to the results of Choustineh et al. assessment about technicians of the operating room chamber [26].

The research findings showed that the rotation of work should take place for more than a week and maybe after three weeks to four weeks. A work rotation less than a week may lead to more work accidents, less efficiency, insomnia, gastrointestinal disturbances, mental fatigue, physical-psychological disorders, and depression. Despite all the mentioned evidence, many employees in rotational industries, turn out weekly and counterclockwise [28].

The results of Chi-square test showed that there were no significant differences between the shift worker and the fixed day worker regarding the L and V groups (P> 0.05). Therefore, the circadian rhythm may be affected by work-related problems such as digestive system problems which become ineffective. However, this test showed that digestive and psychosocial and mental problems were significantly different in both F and R groups (P <0.05). Hence, the stability of the circadian rhythm was likely affecting these problems as such flexible individual's gastrointestinal and psychosomatic problems were less than inflexible or rigid. In a study by Natvik et al., investigated the personality factors associated to shift work tolerance among two or three shifts nurses and concluded that the nurses with flexibility were less likely to suffer from insomnia and could work and sleep at any time of the day. On the contrary, such outcomes were not observed among nurses by two shifts. Furthermore, nurses with a weakness (in both groups of two and three shifts) showed higher levels of sleepiness, signs of anxiety, and depression [12].

CONCLUSION AND SUGGESTIONS

According to the findings of this study, it could be concluded that flexible individuals had fewer shift work problems occurrence. The results of the circadian rhythm (FR and LV) stability and range provided a useful framework for selecting appropriate persons with at least health problem The results of the current study showed that the systematic rotation of the shift and voluntary work may enhance job satisfaction and relatively decrease the shift work shortage, so workers and managers were able to determine network complications of and take notable measures to reduce them. Having considered these findings, these may help to prevent professional and non-professional mistakes at workplace caused by insomnia, fatigue, and memory concentration disruption [29].

The shift work schedule should be designed based on ergonomic, health care, and social support indicators in order to minimize shift workers' problems without any disruption, provide preventive, and corrective measures [27]. It is also possible to shorten the night working hours and to provide short-term sleep during the night, desirable daylight brightness (12000-7000 lux), warm and healthy food, as well as prevention of the use of elderly and early-morning risers during shift work to reduce the work-related problems [30-31]. Ultimately, to increase productivity and prevent the occurrence of physical and mental disorders symptoms such as physical complaints, depression, anxiety, etc. Correct ways of supervising, considering the nature of the work and its suitability with the talents of individuals, paying attention to the salaries and wages following the conditions, different working hours and the value of their work, attention to the promotion and career progression of this group of employees and efforts to empathize with them.

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