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Metabolic Syndrome Predictors among Shift Workers of Zagazig Central Railway Station: A Case-Control Study

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ABSTRACT

Background: Metabolic syndrome (MetS) describes a number of metabolic disorders involving blood glucose abnormalities, elevated blood pressure, triglycerides levels, decreased high-density lipoprotein and increased abdominal obesity which are associated with risk of developing type 2 diabetes mellitus and cardiovascular abnormalities with more mortality. MetS globally has been attributed to alterations in lifestyle, like eating patterns and sedentary life. **Objectives:** 1- To compare metabolic syndrome prevalence between shift and day workers. 2- To clarify associated risk factors for metabolic syndrome. 3- To study impacts of metabolic syndrome affection on workplace accidents, absenteeism, and workers engagement. **Materials and methods:** This cross-sectional study was conducted between shift and day workers at Zagazig Railway Station with a sample size of 244 (122 shift workers (exposed group) and 122 day workers. Data were collected by using 1- structured interview questionnaire including relevant socio-demographic, occupational characteristics, certain past and family histories data of concern, questions to assess risk factors of metabolic syndrome and questions to assess some consequences of metabolic syndrome. 2- Anthropometric measurements and laboratory investigations to assess parameters of MetS. **Results:** Studied shift workers had significant prevalence of metabolic syndrome (51.6% vs. 36.1% in day workers), fasting blood glucose, larger waist circumference and triglyceride levels compared to day workers. The prevalence of poor sleep quality complaint was significantly higher among shift workers compared to the day workers. Shift workers showed significant incidence of workplace accidents in addition to decreased work engagement compared to day workers.

Conclusion: Shift work constitutes an occupational risk for MetS development, which has its special health and work consequences.

Keywords: Shift work, Metabolic syndrome, Risk factors, Sleep quality, Workplace accidents.

INTRODUCTION

The Railway is an important industry where large numbers of human resources are involved in rotational task [(1)]. According to Egyptian National Railways (ENR), there is a large number of employees about 86,000 working in railway sector, it transports about one million passengers and provides 1,300 daily services [(2)].

There is increasing concern over shift work side effects on health. Shift work disrupts normal biological rhythms and has been associated with multiple health problems [(3)]. Much evidence showed that shift work is related to cardiovascular diseases and diabetes mellitus type 2. Some studies showed that hypertension and diabetes type 2 were associated with the metabolic syndrome (Mets) [(4)].

Multiple studies have demonstrated that shift workers are at an increased risk for metabolic syndrome, which leads to an increased risk for "the metabolic trifecta" of cardiovascular disease, stroke, and type 2 diabetes. Metabolic syndrome (Mets) describes a group of metabolic disorders including blood glucose changes, increased blood pressure, reduced high-density lipoprotein, high triglycerides, and abdominal obesity, which are associated with increased risk of developing type 2 diabetes mellitus and cardiovascular disease, as well as increased death rates [(5)].

Recent findings clarified that short sleep time can elicit a physiological and psychological stress response. Gut microbial showed altered and biases of intestinal microbial generations in circadian disrupted mice and jet lagged humans [(6)]. MetS induces an almost two-fold increase of the risk for coronary heart disease, a two or threefold increased risk for future ischemic heart attack and a greater risk for diabetes mellitus [(7)].

MATERIALS AND METHODS

Study design: Comparative cross-sectional study.

Sample size: The expected frequency of metabolic syndrome among shift workers was (37.1%) compared to (20.8%) among day workers as estimated from a previous study [(8)], taking into account power of the test (80%) and confidence interval (CI) of 95%. The sample size was calculated to be 244 (122 exposed group (night shift) and 122 comparable group (day shift). Simple random sample method was used for selection of workers groups.

Study setting: Zagazig Railway Station. The questionnaires were distributed at the different work spots and Zagazig Railway and local clinic was used for clinical examination and blood sampling.

Subjects:

- **Exposed group (Shift workers):** the working schedule of the studied shift work group was as follows: (12 hours) work followed by (24 hours) rest.
- **Comparative group (Day workers):** have fixed morning shift.

Inclusion criteria: Male workers, age 18 to 60, have no other Job and work for at least two years in Zagazig Railway Station.

Exclusion criteria: Subjects working for less than two years. - Subjects who were in a leave at the time of the

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study - Those who were on medications for long period that may affect metabolic syndrome (NSAID, corticosteroid and antidepressant) and also those who worked in another job.

Diagnosis of metabolic syndrome: based on the National Cholesterol Education Program Adult Treatment Panel III guidelines: anthropometric measures, blood pressure, and levels of serum triglyceride, high-density lipoprotein and fasting blood sugar [(9)].

Case definition of metabolic syndrome in Egypt: Metabolic syndrome was considered with any 3 of the following risk factors: (1) Elevated waist circumference: Egyptian cut-off points of WC 100.5 cm for male and 96.25 cm for female [(10)]. (2) Raised triglycerides ≥ 150 mg/dl (≥ 1.7 mmol/l) in men or receiving specific treatment. (3) Reduced HDL-cholesterol ≤ 40 mg/dl (≤ 1.0 mmol/l) in men or receiving specific treatment. (4) Raised blood pressure (in relation to age): or treatment of previously diagnosed hypertension. (5) Raised fasting plasma glucose: Fasting plasma glucose ≥ 100 mg/dl or type 2 DM.

Study methods:

I-Interview questionnaire: it was used in order to address the following:

1- Relevant socio-demographic characteristics of the studied participants (age, marital status, educational level, residence, socioeconomic level, smoking and body mass index (BMI)**.**

2- Occupational characteristics of cumulative work duration (CWD) and shift schedule.

3- Family history of medical relevance [hypertension (HPN), diabetes mellitus (DM) and obesity].

4- Sleep quality measurement (by Pittsburgh Sleep Quality Index (PSQI) measuring 7 areas):

Subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction over the last month. Scoring of answers is based on a 0 to 3 scale, whereby 3 reflect the negative extreme on the Likert Scale [(11)]. Minimum score = 0 (better) and maximum score = 21 (worse). Interpretation: Total score < 5 good sleep quality total ≥ 5 poor sleep quality [(12)].

5- Practicing exercise: whether practice exercise or not and if it is regular or not.

6- Job engagement state of workers: Job engagement is measured by Job Engagement Scale (JES) prepared and validated by **Rich *et al.*** [(13)]**.** This scale measures parameters of job engagement: physical, emotional and cognitive using 6 items for each. The items were calculated on the Five-point Likert scale (1= strongly disagree and 5= strongly agree and 2, 3 and 4 for agree, neutral and disagree respectively). Job engagement scale measured Cronbach alpha value, which was 0.734. Arabic version of Job engagement scale was validated after translation and its reliability value was 0.721.

Calculation of employee engagement index: through computing three numbers: the percent engaged, the percent responsive to engagement, and the percent disengaged.

- Engaged: All positive responses – strongly agree and/or agree - no neutral response - no negative responses – disagree and/or strongly disagree.
- Responsive to engagement: percent of employees who gave top three box responses to the level of engagement questions (including at least one neutral response but no negative responses).
- Disengaged: percent of employees who gave at least one bottom two box response to the level of engagement questions (including at least one negative response) – disagree and/or strongly disagree.

7- Number of workers exposed to accidents /injury in the last year.

8- Number of workers lost workdays > 7 days (> governmental paid yearly sick leave**).**

II-Anthropometric measurements:

The height and weight measurements to calculate body mass index. BMI=Weight (kg)/ Height (m^2).

Table (1): Classification of body mass index [(14)]

Classification	Body mass index(kg/m^2)
Underweight	<18.5
Normal range	18.5-24.9
Over weight	25-29.9
Obese class I	30-34.9
Obese class II	35-39.9
Obese class III	≥40

Waist circumference (in centimeters): It was measured by using non stretchable measuring tape at midway between the 12th rib and the iliac crest, the person stand with abdomen relaxed, arms at sides, and feet together.

III-Clinical examination: Blood pressure.

IV-Laboratory investigations: Fasting blood glucose and cholesterol lipid profile

V- Questions about workers performance at Zagazig railway station.

Pilot study: A pilot study was done to assess the feasibility and the time needed to fill out the questionnaire. It was conducted on10 % of the sample size (25 workers). They were not included in the study sample. The time needed for filling the questionnaire ranged from 20-25 minutes. Workers of low educational level (read and write) needed for some assistance. The pilot study findings showed that the Arabic questionnaire was clear except for 2 questions about job engagement that needed to be re phrased. The tools were available and made ready for use.

Ethical approval:

An informed consent was obtained from every participant before filling the questionnaire about safety and confidentiality of any obtained

information. Official permission was obtained for the manager of Zagazig Railway Station. An approval of the study was obtained from Zagazig University Academic and Ethical Committee. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc., Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. The statistical tests used for comparing the results were t-test, χ^2 and MW test. Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value ≤ 0.05 was considered significant.

RESULTS

Table (2) showed that there was significant increase of waist circumference >100.5 cm, serum triglyceride and blood glucose level among shift workers denoting Met.S among them.

Table (2): Frequency distribution of metabolic syndrome components among shift and day workers of Zagazig Railway Station

Metabolic syndrome components	Shift workers (N = 122)		Day workers (N = 122)		χ^2	p-value
	N	%	N	%		
Waist circumference ≥100.5 cm						
Yes	78	63.6	65	53.3		
No	44	36.4	57	46.7	8,74	0.03*
Triglycerides ≥150 mg/dl						
Yes	69	56.6	51	41.8	5.31	0.02*
No	53	43.4	71	58.2		
HDL-cholesterol ≤ 40 mg/dl						
Yes	48	39.3	39	32.0	1.44	0.22
No	74	60.7	83	68.0		
Blood pressure ≥130/85 mmHg						
Yes	54	44.3	48	39.3	0.60	0.4
No	68	55.7	74	60.7		
Fasting blood glucose ≥ 100mg/dl						
Yes	70	57.4	53	43.4	4.73	0.02*
No	52	42.6	69	65.6		

Concerning metabolic syndrome, figure (1) showed that the studied shift workers had higher percentage of MetS compared to the studied day workers with statistically significant difference (P < 0.05).

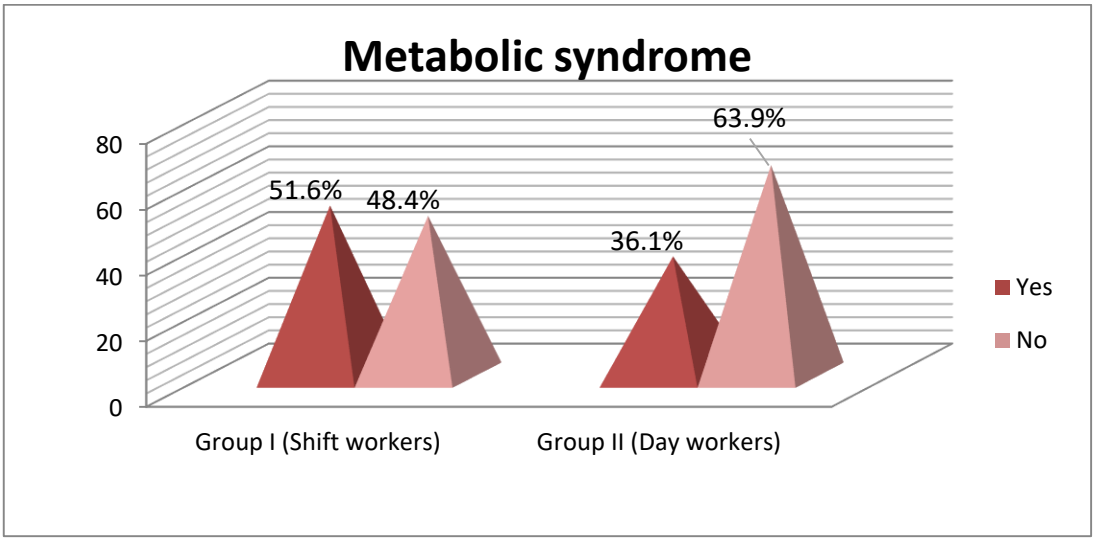

Figure (1): Frequency distribution of the two studied groups regarding metabolic syndrome

Table (3) showed that there were no statistically significant differences between the two studied groups regarding age, education, residence, and socioeconomic level.

Table (3): Comparison of the two studied groups in Zagazig Railway Station regarding relevant occupational and socio-demographic characteristics

	Shift workers (N= 122)		**Day workers (N = 122)**		**MW**	**P- value**
Cumulative working period: (CWP) in hours.						
Mean ± SD	55547 ± 23610		55777 ± 22571		1.12	0.18
Range	5376 – 96768		5640 – 10088			
	Shift workers (N = 122)		**Day workers (N = 122)**		**t-test**	**P- value**
Age (years):						
Mean ±SD	46.58 ± 6.98		46.22 ± 9.34		0.34	0.73
Min –Max	30 – 59		26-59			
	N	**%**	**N**	**%**	**χ^2**	**P- value**
Education:						
Read & write	19	15.6	16	13.1		
School	97	79.5	94	77.1	2.3	0.32
University	6	4.9	12	9.8		
Residence:						
Rural	119	97.5	114	93.4	2.38	0.12
Urban	3	2.5	8	6.6		
Socio-economic level:						
Very low	3	2.5	3	2.5		
Low	75	61.5	63	51.6	2.48	0.29
Moderate	44	36.0	56	45.9		

Table (4) showed that there were no statistically significant differences between the two studied groups regarding family history of diabetes mellitus, hypertension, smoking and obesity ($P > 0.05$). There was statistically significant difference between the two groups regarding sleep quality and physical activity ($P < 0.05$) with higher percentage of Met S. in shift workers who had poor sleep quality and low physical activity.

Table (4): Comparison of shift and day workers regarding relevant family history and lifestyle factors (sleeping quality, physical activity, and smoking)

Family history, and lifestyle factors	**Shift workers (n = 122)**		**Day workers (n = 122)**		**χ^2**	**P-value**
	N	**%**	**N**	**%**		
Family history of DM:						
Yes	14	11.5	17	13.9	0.33	0.56
No	108	88.5	105	86.1		
Family history of HPN:						
Yes	18	14.8	23	18.9	0.73	0.39
No	104	85.2	99	81.1		
Family history of obesity:						
Yes	7	14.0	5	32.0	0.52	0.47
No	43	86.0	117	68.0		
Sleep Quality:						
Poor	68	55.7	26	21.3	30.53	<0.001**
Good	54	44.3	96	78.7		
Physical activity:						
Yes	66	54.1	83	68.0	4.98	0.025*
No	56	45.9	39	32.0		
Smoking						
Yes	45	63,1	47	30.5	0.07	0.79
No	77	36.9	75	61.5		

There was significant decrease in job engagement and significant increase in exposure to accidents among shift workers with MetS (Table 5).

Table (5): Comparison of work performance between MetS affected workers and free workers

Worker's performance in Zagazig railway station	Workers with Met.S (N= 137)		Workers without Met.S (N=107)		χ^2	P-value
	N	%	N	%		
Job engagement state of workers:						
Engaged	58	42.3	78	73.0	25.2	<0.001**
Responsive to Engagement	59	43.0	19	17.7		
disengaged	24	14.7	10	9.3		
Workers Lost workdays > 7 days in the last year:						
Yes	5	3.8	4	3.7	0.63	0.802
No	132	96.2	103	96.3		
Incidence of work accidents last year:						
Yes	8	5.8	1	0.01	4.07	0.04*
No	129	94.2	106	99.0		

DISCUSSION

Metabolic syndrome (MetS) has complex relationships and multi-system affection inside the human body. Zagazig Railway Station employees' day or shift are distributed as administrative subjects, block inspectors and technicians. So, their job necessitates rotatory shifts to control trains operation. Participating shift and day workers were matched regarding socio-demographic characteristics and cumulative work period (CWP). Both working groups were either fixed day time shifts or shift workers, but under the same work regulations and hours per week.

There was a statistically significant difference between shift and day workers regarding prevalence of MetS (Figure 1) as three of its studied components were significant among them (Table 2). The same is recorded by **Guo *et al.*** [7] among two groups of shift and day workers. **Han and Lean** [15] reported eight studies from nine they reviewed and found that there were statistical differences even with controlling for socio-demographic and behavioral characteristics. The mechanisms underlying the relationship between shift work and metabolic syndrome may be due to disturbed normal circadian rhythms [16], as circadian rhythm controls several biological processes, including hormone secretion, body temperature, feeding, sleep-wake cycles, and metabolic homeostasis. **Leproult *et al.*** [17] clarified that, shift work promotes chronic misalignment between endogenous circadian oscillation and behavior cycles. This persistent circadian misalignment causes metabolic and cardiovascular events, including increased glucose and insulin levels, as well as increased mean arterial blood pressure and reduced sleep efficiency. Shift work causes sleep deprivation, changes in sleep patterns, and reduction of secretion of melatonin. Previous study confirmed that shift workers suffered from worse sleep comparing with day workers, even after retirement [18].

Also factors such as light at night, noises could cause some unfavorable changes to blood pressure, glucose, endocrine, lipids, and cardiac activity. These changes also contribute to the adverse effect of shift work leading to MetS [19]. **Peplonska *et al.*** [20] clarified that, factors as low recreational physical activity, sleep deprivation and disruption of the circadian rhythm have been proposed as potential causes for MetS and unhealthy dietary habits including meal irregularity, higher animal fat, carbohydrate and protein intake coupled with lower dietary fiber consumption, and frequent snacks taken during the night shift, all are contributing factors.

In this study, table (2) showed non-significant relation between, systolic blood pressure (SBP) and diastolic blood pressure (DB). This is in agreement with **Yu *et al.*** [21] but differs from **Guo *et al.*** [7] and **Han and Lean** [15] who commented that. Prevalence of MetS and cardiovascular diseases (CVD) is expected to rise dramatically in parallel to the global obesity. Abdominal obesity is significantly associated with increased MetS. The MetS phenotype is provoked by weight gain, particularly an increase in intra-abdominal fat accumulation, which is mirrored by a large waist circumference. The relation between elevated blood pressure and shift work is controversial, however many studies had identified a trend towards higher blood pressure among shift workers. Another cause is that the associated hyperlipidemia may affect arterial walls causing hypertension [16]. **Nikpour *et al.*** [22] found that, the most important components of metabolic syndrome are low serum level of high-density lipoprotein and abdominal obesity, which are attributable to limited physical activity and high occupational stress. **Kivimaki *et al.*** [23] explained that, by the disruption of circadian rhythm with long-term continuous work, that possibly insulin resistance and weight gain occur, and hence type two DM. Also, evidence from human studies

suggested that insufficient or poor-quality sleep is a risk factor for development and exacerbation of insulin resistance [24]. However, **Yu *et al.*** [21] detected no difference regarding that.

This study also showed that there were statistically significant differences between the comparable groups in TG level (Table 2) with higher level among shift workers (156.7 ± 13.38) compared to day workers (152.2 ± 15.5) (P=0.02). On the other hand, **Yu *et al.*** [21] detected difference but not to the level of significance between the two groups in his study.

Elevated serum triglyceride concentration (Table 2) was seen among shift workers. It was clarified by **Marqueze *et al.*** [25] who considered the timing of meals as a cause promoting alterations in enzyme activity of certain plasma hormones affecting gastric emptying, such as insulin and glucagon, as well as in some metabolites as triglycerides.

In this study, the mean HDL level among shift workers (42.83 ± 6.7) was lower than that of day workers (44.57 ± 7.19) and this difference was not statistically significant. This is similar to the results reported by **Yu *et al.*** [21] but different from what is concluded by **Guo *et al.*** [7].

Thus, table (2) showed significance in three from five components of MetS among shift workers compared to day workers, which is considered positive MetS among them according to definition of **Assaad-Khalil *et al.*** [10].

Graph (1) summarized the relationship between shift and day workers regarding MetS where there was significant increase of Met prevalence among shift workers. Prevalence of metabolic syndrome among shift workers was studied in our research and some socio-demographic & occupational characteristics were analyzed as risk factors in (Table 3). There were no statistically significant differences between the two studied groups regarding age, education, residence, and socioeconomic level. In contrast to these findings, **Chini *et al.*** [26] considered age as a confounding factor because progression in age generally is associated with decrease in natural body defense mechanisms all over the body systems.

In table (4), our study investigated the relation between relevant medical family histories among shift and day workers and there were non-statistically significant differences regarding diseases as diabetes, hypertension, hypercholesterolemia, and obesity. This is in accordance with the findings of **Shahbazian *et al.*** [27]. Our finding agrees with **Moon *et al.*** [28] and **Burton *et al.*** [29] who detected higher prevalence of hypercholesterolemia among employees who had MetS and the difference was statistically significant, but it is different from **Ranasinghe *et al.*** [30]. A previous study by **Yu *et al.*** [21] arranged factors predisposing to MetS to be started by sleep factors as follows (1) short sleep duration (<5 h/day), (2) shift work, (3) insufficient number of days off work, (4) always eating until satiety, (5) not trying to take every opportunity to walk, (6) alcohol intake ≥60 g/day, and (7) smoking and physical exercise. Some of these factors were discussed in our study, which proved that sleep deprivation and lack of exercise are significant risk factors for MetS development. **Deng *et al.*** [6] commented that sleep is an essential factor for body functions homeostasis. So, shift work has been associated with many negative health outcomes and urologic complications. Correspondingly **Broussard *et al.*** [31] and **El Tayeb *et al.*** [32] explained that mechanism of action of sleep deprivation increases levels of neuropeptide promoting increased food intake, thus weight gain and development of obesity. Also, experimental studies have shown that sleep deprivation and disturbed sleep tend to decrease glucose tolerance and compromise insulin sensitivity[33].

Our results demonstrated that there was non-statistically significant difference between shift workers and day workers regarding smoking habit (Table 4). The same finding was detected by **Bae *et al.*** [34]. However, **Guo *et al.*** [7] explained increased trend for smoking generally between shift workers as a way to relieve stress and counter sleepiness and tiredness during the shift.

Shift rotation can disturb regular exercise activities and decrease the chance to do physical activities. This was confirmed in our study results by the statistically highly significant difference between both shift and day time workers (p=0.001) (Table 3). Similarly, **Barbadoro *et al.*** [31] detected highly statistical difference in physical activity between same comparable workers. Other studies proved insignificant relation between working schedule and performance of physical activities like studies of **Guo *et al.*** [7] and **Bae *et al.*** [34], which may differ with different communities' culture.

At the level of work, there is a question about performance and productivity of MetS-affected workers. The study investigated the relationship between affected workers and job engagement level, accident/injury incidence and unpaid absenteeism (Table 5). It showed that MetS affected workers who had significant lower job engagement scores as a result to affection of the overall lifestyle and health consequences.

Met S affection can aggravate liability for accidents because of irregular sleeping pattern and rhythmic functions especially if complicated by relevant diseases. This study showed that there were statistically significant differences between workers and day workers in occurrence of accident/injury. On the other hand, general economic state of Egyptian employees causes insignificant difference between the two comparative groups regarding frequency of unpaid absenteeism vacations (even illness-related absence days) because exhausted workers usually consume their off days to overcome symptoms for the favor of their salaries. This is different from the study of **Burton *et al.***

[29] who found that employees with metabolic syndrome were more likely to have illness-related absence.

CONCLUSION

This study concluded that, shift work significantly increases liability for MetS, which has many drawbacks and systemic affection on health. Lack of physical activity and poor sleep quality are significant risk factors for metabolic syndrome development among shift workers. Metabolic syndrome can decrease workers' engagement and increases the liability for work accidents among affected workers.

RECOMMENDATIONS

Working on a shift is certainly not for everyone. However, for those who can tolerate these hours, Regular exercise and balanced healthy food are essential measures to stay healthy whatever the shift. Getting enough sleep is mandatory. Adaptation of the body clock can be achieved through replacement of 12-hour and 24- hour shift by 8- h shift. Clockwise shift rotation (morning-evening-night). The best recommended schedule is 3 days morning shift, 3 days evening shift and 3 days night shift followed by 3 recuperative days off. By this schedule sleep loss can be rapidly recovered and internal body clock adapts, thus prevent fatigue and illness.

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