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# Shift Work and Metabolic Syndrome: Systematic Review

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**ABSTRACT**

**Introduction:** Compared to standard working hours, shift work is one of the most popular options. The disruption of circadian rhythms caused by shift work and the loss of circadian rhythms caused by sleep disturbances are considered to be major risk factors for the development of metabolic diseases.

**Objective:** This systematic review analyzed the relationship of shift work to the risk of metabolic syndrome

**Method:** Systematic searches using pubmed, scopus, proquest, science direct and google scholar were published within 2014 - 2024 using English and Indonesian. Reviews are displayed in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 and article quality assessment using the PICO framework (Patient/Population, Intervention, Comparator/Control, and Outcome).

**Result:** 9 out of 10 articles show that shift workers have a higher incidence of metabolic syndrome and most studies show the effect of shift work on several indicators of metabolic syndrome.

**Conclusion:** There is an association between shift work (night work or rotating shifts) and various metabolic syndrome disorders. Circadian misalignment due to night work activities can cause systemic metabolic dysfunction.

**Keywords:** Shift Work; Metabolic Syndrome; Occupational Health

## INTRODUCTION

A method of organizing working time in which workers substitute for each other in the workplace so that the enterprise can operate for longer than the working hours of individual workers" is defined as shift work (1). One of the most flexible types of working time arrangements that first began in the early 20th century, shift work allows companies to operate 24 hours per day and seven days per week (continuous operation) and also to accommodate changes in demand for their goods or services (2). There are two main types of shift systems: fixed shift systems, where a specific group of workers always work the same shift; and rotating shift systems, where workers are assigned to different shifts on a regular basis and "rotate" through time (3). While there is no comparable data on the prevalence of shift work worldwide, shift work is one of the most popular options compared to standard working hours (2)

A graph of work organization characteristics from the National Health Interview Survey (NHIS 2015) shows that about 26% of workers in the United States do night shifts, rotating shifts, or night shifts (4). Between 10% and 20% of workers in most countries do night work (19% in the EU, 16% in Turkey, 13% in the Republic of Korea, 11% in Argentina, and 30% in the US). In Uruguay, 28% work at night at least once a month. Similar proportions of work shifts (21% in Europe, 38% in the US, 11% in Turkey, 9% in the Republic of Korea, and 12% in Argentina). In the Republic of Korea, Europe and Turkey, the most common type of shift is alternating shifts, which is done by about half of shift workers. Some employees also said that they had unusual work schedules. In Turkey, 16% of workers and 11% reported working nights; 62% of them were rotating shifts and 31% permanent, while 7% reported other types of shifts. Men are twice as likely as women to work nights and shifts (5).

Health factors affecting labor market participation are an important aspect of research on the relationship between work and health, as there are two directions in this relationship, where one affects the other (5). Circadian rhythm disturbances are associated with shift work. Metabolic parameters can be affected by circadian misalignment between endogenous and behavioral cycles. Important changes such as morphology, glucose metabolism, cortisol release phase, and neurohumoral metabolism can lead to metabolic syndrome (6). Metabolic events such as type 2 diabetes mellitus, obesity, hypertension, dyslipidemia, and cardiovascular problems (7).

About 19.1 million people died from cardiovascular disease worldwide in 2020. There were 239.8 deaths per 100,000 population. In 2020, an estimated 244.1 million people worldwide were living with ischemic heart disease, with a prevalence of 141.0 million men and 103.1 million women, respectively. High low-density lipoprotein cholesterol caused 4.5 million deaths in 2020. Data collected in 2020 showed that 243.3 million men and 229.0 million women worldwide had diabetes. High BMI levels were associated with 2.40 million deaths worldwide in 2020 (8). The results of a case-control study in Sweden showed that shift work with metabolic syndrome affected men with shift work and lack of physical activity, and that shift work and high waist-hip ratio or elevated triglycerides affected women with risk factors for myocardial infarction. In addition, physical inactivity is more harmful to male shift workers compared to male day workers with associated risk factors for myocardial infarction (9).

Based on the description above, that work shifts have an influence related to the risk of metabolic syndrome. With the still high prevalence associated with metabolic syndrome and the work shift chart that is fairly dominant in several countries, so this study needs to be done to analyze the relationship between work shifts and metabolic syndrome and what impacts arise with regard to work shifts so that it can be considered in carrying out an effective and consistent combination of actions for the success of strategies and interventions.

## METHOD

This study is a systematic review of the results of article searches in pubmed, scopus, proquest, science direct and google scholar with inclusion criteria articles are original research published in 2014 - 2024 in English and Indonesian with full text availability (full access), research studies that report the prevalence of metabolic syndrome by mentioning the definition criteria of metabolic syndrome, research conducted in humans with age >18 years, research comparing participants of shift worker groups (rotating work) with standard daily worker groups, research with cross sectional, case control or cohort study designs and there is complete information for the results of the odds ratio (OR) or relative risk (RR). Exclusion criteria in this study are review articles, proceedings, theses, dissertations, comments, and books are not included and have cardiometabolic disease. To formulate the eligibility criteria in this study using the PICO framework (Patient/Population, Intervention, Comparator/Control, and Outcome). The PICO framework can appropriately develop research questions, increasing the power and relevance of research results across the spectrum of scientific inquiry (10)

**Table 1.** PICO (Patient/Population, Intervention, Comparator/Control, dan Outcome)

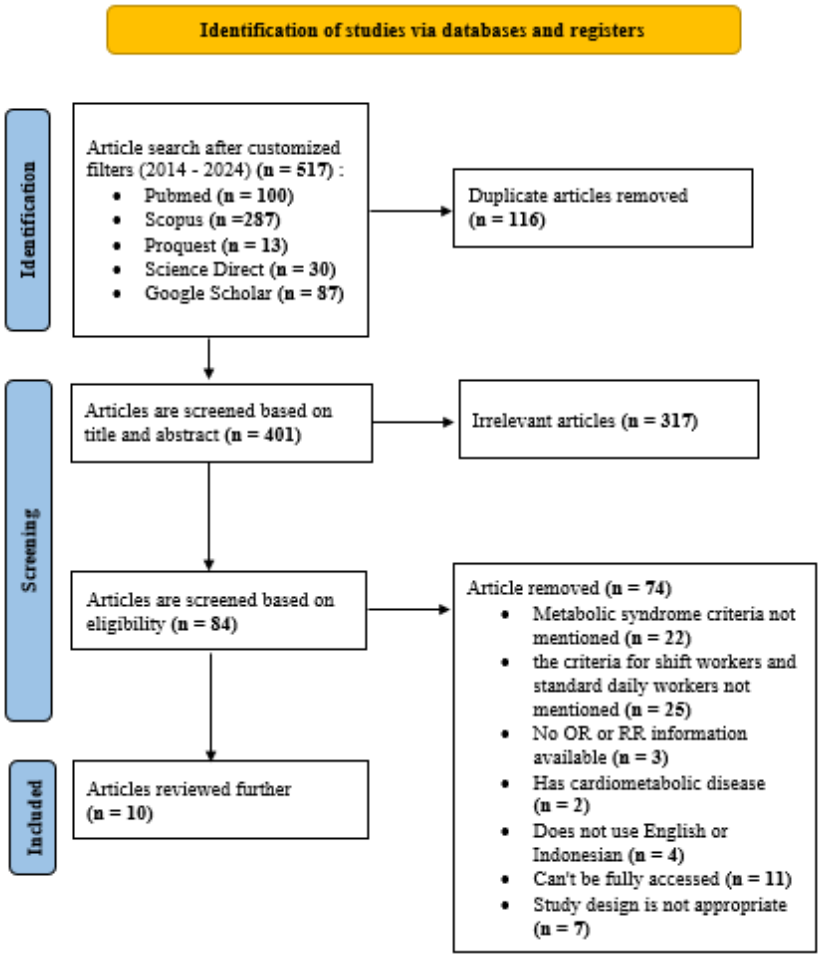
| Item | Information |
|---|---|
| Patient/Population | Male and female workers |
| Intervention | Shift work time (rotating work) |

| | |
|---|---|
| Comparator/Control | Standard daily working time |
| Outcome | Metabolic syndrome |

Research data from article searches are displayed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flowchart. This study included all types of jobs as research subjects and there were no exceptions related to job types and positions. The article search used the Boolean Operator OR/AND for all search engines with the main keywords and their synonyms. Synonym searches using the Medical Subject Headings (MeSH) feature for pubmed search engines included ("shift work" OR "shift work schedule" OR "night shift work" OR "night work" OR "rotating shift" OR "three shift system" OR "three shift work" OR "duty period" OR "split shift"), ("metabolic syndrome" OR "dysmetabolic syndrome" OR "metabolic syndrome X"), and ("worker" OR "staff" OR "employee"). The researcher selected article titles that fit the research theme, screened titles and abstracts using the PICO framework as well as inclusion criteria and exclusion criteria. After screening, the authors downloaded the articles in their entirety. Each selected outcome was extracted to create a complete dataset of all research findings (Table. 2).

## RESULTS

Based on the search with data search on 5 electronic databases resulted in 517 articles. Furthermore, 116 duplicate articles were deleted, 401 articles were filtered based on the title and abstract, resulting in 317 irrelevant articles. 84 articles were screened based on their eligibility by reading the entire content of the article and the resulting 74 articles were excluded based on consideration of research criteria. So there are 10 articles that will be reviewed. The flowchart (Figure 1.) was adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidance (11).




**Picture 1.** Flowchart of Systematic Review with PRISMA Method

## DISCUSSION

The variation in data is shown in table 3 as a result of the systematic review. Most of the studies suggest an association between shift work and the risk of metabolic syndrome.

### Shift Work

Working time was the subject of the first international labour standard, the Working Time (Industry) Convention, 1919 (No. 1), and continues to be at the core of the work of the International Labour Organization (ILO). In labor law, one of the oldest issues is the regulation of working time. It has long been recognized since the 19th century that excessive working hours can harm the health of employees. Shift work is a method of organizing working time in which workers replace each other in the workplace so that the company can operate longer than the working hours of individual workers at different hours of the day and night (12).

Shift work allows companies to extend the working hours of individual workers and meet peak demand periods. Competitive pressures and frequent purchasing practices lead to overtime and excessive working hours, thus becoming a major issue in global supply chains. While there are many types of shift systems, there are 2 main categories: fixed shift systems, where a specific group of workers always work the same shift; and rotating shift systems, where workers are assigned to different shifts on a regular basis, or rotate through time (for example, from morning shift to afternoon/evening shift to night shift). Fixed 3-shift (morning, afternoon, and evening) and 2-shift (morning, afternoon, and evening) systems are the most common systems (12).

**Metabolic Syndrome**

Metabolic syndrome is a combination of several chronic and inflammatory pathologies that, when present in an individual, increase the risk of insulin resistance (IR) and type 2 diabetes mellitus (T2DM) and its complications or atherosclerotic cardiovascular disease (ASCVD) (13). Metabolic syndrome was developed by a number of expert groups (Table 2.) including World Health Organization (WHO) (14); the National Cholesterol Education Program—Third Adult Treatment Panel (NCEP-ATP III) (15); the American Heart Association (AHA)/National Heart, Lung and Blood Institute (NHLBI) (16); the International Diabetes Federation (IDF) (17); and harmonized definition/Joint Interim Studies Consensus Statement (18).

**Table 2.** Definition and Criteria of Metabolic Syndrome

| Components | WHO (1999) | NCEP-ATP III (2001) | AHA/NHLBI (2005) | IDF (2006) | Harmonized (2009) |
|---|---|---|---|---|---|
| Fasting Blood Glucose | ≥6.1 mmol/L (110 mg/dL) | ≥6.1 mmol/L (110 mg/dL) | ≥5.6 mmol/L (100 mg/dL) | ≥5.6 mmol/L (100 mg/dL) | ≥5.6 mmol/L (100 mg/dL) o |
| Waist circumference | Men: : WHR > 0.9 Women: WHR > 0.85 | Men: WC > 102 cm Women: WC> 88 cm | Men: WC > 102 cm Women: WC> 88 cm | Men: WC > 94 cm Women: WC > 80 cm | Men: WC > 94 cm) Women: WC >80 cm) |
| Blood pressure | ≥140/90 mmHg or treatment | ≥130/85 mmHg or treatment | ≥130/85 mmHg or treatment | ≥130/85 mmHg or treatment | ≥130/85 mmHg or treatment |
| Triglycerides | ≥1.7 mmol/L or treatment | ≥1.7 mmol/L or treatment | ≥1.7 mmol/L or treatment | ≥1.7 mmol/L or treatment | ≥1.7 mmol/L or treatment |
| High-density lipoprotein cholesterol | Men: <0.9 mmol/L Women: <1.0 mmol/L or treatment | Men: <1.03 mmol/L Women: <1.3 mmol/L or treatment | Men: <1.03 mmol/L Women: <1.3 mmol/L or treatment | Men: <1.03 mmol/L Women: <1.3 mmol/L or treatment | Men: <1.03 mmol/L Women: <1.3 mmol/L or treatment |
| Definition | Insulin resistance plus ≥ additional risk factors | ≥3 of componen the following five risk factors | ≥3 of componen the following five risk factors | Central obesity plus ≥ 2 others components | ≥3 of componen the following five risk factors |

**The Relationship between Shift Work and Metabolic Syndrome**

Looking at the criteria for metabolic syndrome (19), The incidence rates of metabolic syndrome in daytime workers and night shift workers are 5.3 and 10.5 cases per 1000 person years, respectively (20). The 12-hour night shift group compared to the day shift group had a significantly higher risk of metabolic syndrome so (19) shift work is a potential risk factor for metabolic syndrome. Research (21) shows that night shift workers have lower levels of systolic blood pressure and fasting blood glucose. Diastolic blood pressure levels were higher in night shift workers than daytime workers. Similar to the results of research (22). Shift workers have high blood pressure both in systolic blood pressure and diastolic blood pressure and when compared to day workers, fasting glucose is higher in shift workers. Likewise, the results of research (23) day workers have a higher prevalence of increased blood pressure than night shift workers, high waist circumference and night shifts are significantly associated with high blood pressure.

The shift work group, mean blood glucose, systolic blood pressure, mean serum total cholesterol and waist circumference were significantly higher than day shift workers. Blood glucose levels were significantly higher, 17

mg/dl higher in individuals working night shifts (24). Diastolic blood pressure, although observed to be higher in night shift workers, the difference was not significant. average Waist Circumference in the night shift group, was significantly higher than the day shift. The results of the study (20) mentioned that there was a significant relationship higher in triglycerides and HDL. In contrast to Research (25) there was a tendency for higher blood glucose and blood pressure among shift workers compared to day workers, but this difference was not statistically significant. Similar to the results of (26) the prevalence of systemic hypertension, central obesity, obesity, increased triglycerides, and decreased HDL were not statistically different between shift and day workers.

In addition, aspects related to sleep quality are also one of the things that are considered. In research (27)the average score of The Pittsburg Sleep Quality Index (PSQI global) for night shift workers is significantly higher than that of non-night shift workers such as poorer sleep quality longer sleep latency, shorter sleep duration, sleep disturbances and daytime dysfunction. Research (26) also mentioned that the assessment of sleep quality is much better in daytime workers. Thus (25) concluded that sleep duration mediates the relationship between alternating day-night shift work patterns and metabolic syndrome. Shift workers sleep less than day workers. The results of the study (26) stated that smoking and alcohol habits were more prevalent in the shift work group, the daytime group had more vegetarians, 16 (20%) compared to shift workers. Similar to the results of research (19), (28) and (22) which also states that smoking and drinking alcohol habits are significantly higher in shift workers than day workers. Due to the possibility of higher oxidative stress in night shift workers. It was also explained that female subjects who worked rotating night shifts had lower metabolic risk, oxidative stress, and antioxidants than men who worked rotating night shifts (24).

**Circadian Disruption in Shift Workers**

The central and peripheral clocks create a regular circadian rhythm to maintain health. Metabolic stress or circadian misalignment caused by nighttime activities or jet lag can cause clock dysfunction leading to systemic metabolic dysfunction (29). Almost all functions, from gene expression to behavior, are influenced by the endogenous circadian timing system. Human physiological parameters include body temperature, heart rate variations, brain waves, and resting energy expenditure; biological processes including hormones, metabolites, clock genes, and protein expression; and behaviors, including sleep patterns and organization; and cognitive abilities and performance. Shift workers have to perform their duties and go to sleep at biologically inappropriate times due to misalignment of endogenous rhythms and changes in the sleep-wake cycle (30).

In addition, shift work disrupts feeding rhythms, which disrupts circadian and metabolism. During the biological day, the circadian system promotes wakefulness/eating and fasting, and during the biological night, it promotes sleeping/fasting. They will wake up and eat at night and sleep or fast during the day, leading to severe circadian disruption due to misalignment of endogenous rhythms. In the eating jetlag stage, the midpoint of the eating episode on weekdays is different from that on holidays, which causes slight circadian misalignment. In the social jetlag stage, the midpoint of sleep on weekdays is different from that on holidays, leading to slight circadian misalignment. It is thought that this circadian misalignment will lead to increased body weight and cardiometabolic risks due to disrupting the energy balance (31).

Circadian misalignment reduces energy expenditure over 24 hours by 3% (by 55 kcal per day), alters appetite hormone levels, and encourages unhealthy eating compared to the condition of adequate sleep. In addition, circadian misalignment can increase energy expenditure by 100 kcal but also increase energy intake by more than 250 kcal per day, which results in good energy balance and weight gain (32). The results of other studies support the hypothesis that employees who work in shifts tend to consume alcoholic beverages excessively, especially young employees, males, and those who work long and rotating hours (33).

**Table 3.** Literature Search Results

| Researcher, Year and Country | Research Title | Study Design | Type of Work and Sample | Work Shift Criteria |
|---|---|---|---|---|
| (Dong et al., 2022) China | The association between long term night shift work and metabolic syndrome: a cross sectional study of male railway workers in southwest China | Cross sectional | Male railway workers<br><br>Night shift workers (n = 3008) & Day workers (n = 8015) | Working throughout the evening and midnight hours (6 PM – 8 AM) was referred to as night shift work. |
| (Cheng et al., 2021) Taiwan | Night shift work and the risk of metabolic | Cohort | Hospital workers | The International Agency for Research on Cancer defines night shifts as three working hours |

| Researcher, Year and Country | Research Title | Study Design | Type of Work and Sample | Work Shift Criteria |
|---|---|---|---|---|
| | syndrome: Findings from an 8 year hospital cohort | | Night shift workers (n = 2109) & Day workers (n = 3666) | between 0 AM and 5 AM, with at least one night shift each month. |
| (Lim et al., 2018) Malaysia | Association between night shift work, sleep quality and metabolic syndrome | Cross sectional | Workers in the private sector<br><br>Night shift worker (n = 177) & Non night shift worker (n = 317) | For the purposes of this study, working night shifts required working for at least eight hours. |
| (Ye, 2023) Korea | Association between Shift work and Metabolic Syndrome: A 4 Year Retrospective Cohort Study | Cohort | Manufacturing workers<br><br>Shift workers (n = 701) & Day workers (n = 510) | There were two different kinds of shift work: 8-hour and 12-hour rotations. There were three shifts every day: morning, evening, and night. The hours rotated every eight hours. Day and night shifts were distinguished by rotating 12-hour shifts. The study's participating companies had shifts that alternated between eight and twelve hours.. |
| (Gowda et al., 2019) India | Association between metabolic risk, oxidative stress and rotating shift work in a tertiary health care facility | Cross sectional | Health staff<br><br>Rotating night shift (n = 61) & Day shift (n = 63) | Employees who reported working at least 5 pm (8 pm - 8 am estimated to work 12 hours/day) per month, for the past two years, are considered to be employed in rotational night shift work. |
| (Kumar et al., 2021) India | A Cross sectional study among Hospital Employees Metabolic Syndrome and Shift Work | Cross sectional | The hospital staff members<br><br>Shift worker (n = 80) & Day shift (n = 80) | the age (shift workers were younger), physical activity (shift workers were more active), sleep (shift workers had lower quality sleep), and nutrition (shift workers had more non-vegetarians) of the shift working and daytime working groups. |
| (Korsiak et al., 2017) Canada | Sleep duration as a mediator between an alternating day and night shift work schedule and metabolic syndrome among female hospital employees | Cross sectional | Female hospital employees<br><br>Shift worker (n = 142) & day worker (n = 152) | Shift work is defined as a rotating schedule of day and night. |
| (Oh & Yim, 2018) Korea | Association between rotation night shif work and metabolic syndrome in Korea workers: differences between 8 hour and 12 hour rotating shift work | Retrospective longitudinal | A tertiary hospital workers<br><br>2 shift worker (n = 645), 3 shift worker (n = 538) & daytime worker (n=907) | Either two 12-hour rotating shifts or three 8-hour rotating shifts made up a night shift. There were three shifts in a day: morning, evening, and night. The shift lasted eight hours. There was a day shift and a night shift during the 12-hour rotating shift |
| (Guo et al., 2015) China | Shift work and the relationship with metabolic syndrome in Chinese aged workers | Cross sectional | Retired workers<br><br>A total of 9,088 shift workers had been | Three different shift work options are available at Dong Feng Motor Company: two 12-hour shifts, three 8-hour shifts, and four 6-hour shifts. |

| Researcher, Year and Country | Research Title | Study Design | Type of Work and Sample | Work Shift Criteria |
|---|---|---|---|---|
| | | | working for more than one year. 76.2% of these workers worked in two shifts, 22.6% in three shifts, and 1.2% in four shifts. | Any kind of shift worker is required to work at night. Individuals who have been shift workers for a minimum of a year were designated as such. |
| (Khosravipour et al., 2019) Iran | The effects of rotating and extended night shift work on the prevalence of metabolic syndrome and its components | Cross sectional | in the three petrochemical industrials | two alternating shifts between day and night and set days. Each work shift lasts for twelve hours and is followed by three weeks off. Each subject is then given a 10-day respite. |

**Tabel 3.** Literature Search Results (continued)

| Researcher, Year and Country | Metabolic Syndrome Criteria | Result |
|---|---|---|
| (Dong et al., 2022) China | American Heart Association | In addition to having shorter tenure and a higher body mass index, night shift workers also tended to be younger and have longer hip circumferences. The metabolic syndrome and working nights did not significantly correlate (OR 1.03, 95% CI 0.94-1.12, p = 0.543). A waist circumference of 90 cm and a systolic blood pressure of 130 mmHg (OR 1.11, 95% CI 1.02-1.21, p < 0.001) were linked to working night shifts. |
| (Cheng et al., 2021) Taiwan | the guidelines of the National Heart, Lung, and Blood Institute and the American Heart Association | When compared to daytime work, working the night shift was linked to an increased risk of developing metabolic syndrome (OR 1.36, 95% CI 1.04 to 1.78) and a larger waist circumference (OR 1.27, 95% CI 1.07 to 1.78). Higher blood pressure was linked to more night shifts worked by night shift workers (OR 1.15, 95% CI 1.01 to 1.31). |
| (Lim et al., 2018) Malaysia | The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) | A 2-fold greater incidence of metabolic syndrome was found to be independently correlated with working night shifts (OR 1.92, 95% CI 1.24 to 2.97). Nonetheless, gender did not seem to have an impact on the link between metabolic syndrome and working night shifts |
| (Ye, 2023) Korea | The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) | Compared to day workers, shift workers had a greater incidence of metabolic syndrome (OR 1.093, 95% CI 1.137-2.233). The metabolic syndrome was linked to shift workers who had worked more than 20 years (OR 2.080, 95% CI 1.911-9.103), although there was no statistically significant dose-response connection. |
| (Gowda et al., 2019) India | The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) | Those who worked night shifts had 2.53 times (95% CI 1.2 to 5.2) greater risks of metabolic risk than those who worked day shifts. |
| (Kumar et al., 2021) India | International Diabetic Federation (IDF) | When it came to the prevalence of metabolic syndrome, there was no statistically significant difference between shift and day workers. |
| (Korsiak et al., 2017) Canada | the 2009 Joint Interim Studies Consensus Statement or harmonized definition | The metabolic syndrome and shift work had a strong connection (ORtotal 2.72, 95% CI 1.38 to 5.36). |
| (Oh & Yim, 2018) Korea | The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) | Two shift rotation was positively correlated with metabolic syndrome (OR 1.58, 95% CI 1.09, 2.29). |
| (Guo et al., 2015) China | The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) | When all other variables were taken into account, there was a correlation between long-term shift employment and metabolic syndrome. Male workers did not show any clear dose-response pattern; however, female workers did demonstrate a dose-response association, with each shift increase over a ten-year period associated with a 10% increase in the OR of metabolic syndrome (95% CI 1%-20%). |

| Researcher, Year and Country | Metabolic Syndrome Criteria | Result |
|---|---|---|
| (Khosravipour et al., 2019) Iran | The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) | The 12-hour night shift group was substantially more likely to develop metabolic syndrome than the fixed day shift group. One notable high risk factor for metabolic syndrome is elevated levels of HDL and triglycerid. |

## CONCLUSION AND SUGGESTION

Shift work seem to negatively impact workers' health, possibly due to their impact on sleep-wake cycles, eating habits. Night shift workers are more susceptible to metabolic syndrome because they spend more working time at night with repeated shifts. Night and rotating shift workers experience circadian cycle issues with metabolic risk factors, which can lead to metabolic syndrome, type 2 diabetes mellitus, cardiovascular disease and other illnesses. This suggests that lifestyle interventions for night shifts should be recommended, looking for ways to minimize the health burden of shift work, detecting health risks and paying special attention to employees who have worked more than 10 - 20 years with some internal factors to prevent further metabolic and cardiovascular problems.

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