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# Metabolic syndrome in fixed-shift workers

# Síndrome metabólica em trabalhadores de turnos fixos

## ABSTRACT

**OBJECTIVE:** To analyze if metabolic syndrome and its altered components are associated with demographic, socioeconomic and behavioral factors in fixed-shift workers.

**METHODS:** A cross-sectional study was conducted on a sample of 902 shift workers of both sexes in a poultry processing plant in Southern Brazil in 2010. The diagnosis of metabolic syndrome was determined according to the recommendations from Harmonizing the Metabolic Syndrome. Its frequency was evaluated according to the demographic (sex, skin color, age and marital status), socioeconomic (educational level, income and work shift), and behavioral characteristics (smoking, alcohol intake, leisure time physical activity, number of meals and sleep duration) of the sample. The multivariate analysis followed a theoretical framework for identifying metabolic syndrome in fixed-shift workers.

**RESULTS:** The prevalence of metabolic syndrome in the sample was 9.3% (95%CI 7.4;11.2). The most frequently altered component was waist circumference (PR 48.4%; 95%CI 45.5;51.2), followed by high-density lipoprotein. Work shift was not associated with metabolic syndrome and its altered components. After adjustment, the prevalence of metabolic syndrome was positively associated with women (PR 2.16; 95%CI 1.28;3.64), workers aged over 40 years (PR 3.90; 95%CI 1.78;8.93) and those who reported sleeping five hours or less per day (PR 1.70; 95%CI 1.09;2.24). On the other hand, metabolic syndrome was inversely associated with educational level and having more than three meals per day (PR 0.43; 95%CI 0.26;0.73).

**CONCLUSIONS:** Being female, older and deprived of sleep are probable risk factors for metabolic syndrome, whereas higher educational level and higher number of meals per day are protective factors for metabolic syndrome in fixed-shift workers.

**DESCRIPTORS: Metabolic Syndrome X, epidemiology. Risk Factors. Life Style. Shift Work. Sleep Disorders, Circadian Rhythm. Work Schedule Tolerance. Socioeconomic Factors. Cross-Sectional Studies.**

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## RESUMO

**OBJETIVO:** Analisar se síndrome metabólica e seus componentes alterados estão associados a fatores demográficos, socioeconômicos e comportamentais em trabalhadores de turnos fixos.

**MÉTODOS:** Estudo transversal com amostra de 902 trabalhadores de turnos, de ambos os sexos, de um frigorífico de frango do sul do Brasil, em 2010. O diagnóstico da síndrome metabólica foi determinado pelas recomendações do *Harmonizing the Metabolic Syndrome;* e sua frequência foi avaliada segundo características demográficas (sexo, cor de pele, idade e estado civil), socioeconômicas (escolaridade, renda e turno de trabalho) e comportamentais (tabagismo, consumo de álcool, atividade física de lazer, número de refeições/dia e duração do sono). A análise multivariada seguiu um modelo conceitual de determinação da síndrome metabólica em trabalhadores de turnos fixos.

**RESULTADOS:** A prevalência de síndrome metabólica foi 9,3% (IC95% 7,4;11,2). O componente mais frequentemente alterado foi a circunferência da cintura (RP 48,4%; IC95% 45,5;51,2), seguido pela lipoproteína de alta densidade. O turno de trabalho não esteve associado à síndrome metabólica e aos seus componentes alterados. Após ajustes, a prevalência da síndrome metabólica foi positivamente associada ao sexo feminino (RP 2,16; IC95% 1,28;3,64), a trabalhadores com 40 anos ou mais (RP 3,90; IC95% 1,78;8.93) e àqueles que reportaram dormir cinco horas ou menos por dia (RP 1,70; IC95% 1,09;2,24). Por outro lado, a síndrome metabólica esteve negativamente relacionada à escolaridade e a fazer mais do que três refeições por dia (RP 0,43 IC95% 0,26;0,73).

**CONCLUSÕES:** Ser mulher, possuir idade mais avançada e ter privação de sono mostraram-se potenciais fatores de risco para síndrome metabólica, enquanto ter maior escolaridade e realizar maior número de refeições/dia foram fatores de proteção para síndrome metabólica em trabalhadores de turnos fixos.


**DESCRITORES: Síndrome X Metabólica, epidemiologia. Fatores de Risco. Estilo de Vida. Trabalho em Turnos. Transtornos do Sono do Ritmo Circadiano. Tolerância ao Trabalho Programado. Fatores Socioeconômicos. Estudos Transversais.**

## INTRODUCTION

Metabolic syndrome (MetS) describes a group of metabolic abnormalities including blood glucose changes, increased blood pressure, high triglycerides, reduced high-density lipoprotein and abdominal obesity,[1] which are associated with an increased risk of developing diabetes mellitus type 2 and cardiovascular disease as well as increased mortality.[26]

The increased prevalence of MetS worldwide has been attributed to changes in lifestyle, particularly with regard to new eating patterns and sedentarism.[3,13] However, modern life has also brought changes to the work environment. Working hours that once occurred during the daytime were extended in the last decades for a large number of services and production areas. Moreover, it is estimated that in some European countries up to 30.0% of workers are exposed to shifts.[21]

Over the last decade, several studies have investigated the relationship between shift work and MetS, reporting a fivefold increase in the risk of developing MetS in shift workers compared with day-shift workers.[19] A recent systematic review of observational studies on the topic concluded that there is insufficient evidence of the relationship between shift work and MetS. The authors also emphasized the importance of studying other risk factors that may be involved in the complex causal chain linking shift work to MetS.[5]

The aim of this study was to analyze if MetS and its altered components are associated with demographic, socioeconomic and behavioral factors in fixed-shift workers.

## METHODS

This cross-sectional study was conducted with workers from the production area of a poultry processing plant located in Southern Brazil that operates 24h a day. The workers were of both sexes and aged 18 to 50 years. Those who had worked at the company for less than six months, pregnant women and workers who were on a leave for more than 10 days were excluded from the sample.

The company employs 2,645 workers who live in the city where the company is located and in six neighboring cities. For logistical reasons, such as distance and urban area, all of the employees living in the municipality of the headquarters (n = 710) and in the two closest municipalities (n = 192) were included, summing to a sample size of 902 workers. The initial sample size was estimated for the obesity outcome and for exposure to shift work. Thus an *a posteriori* estimation of power was performed. Considering 80.0% power and a significance level of 5%, this sample had the power to show differences of 75.0% in the MetS prevalence between day and night shift workers.

MetS was diagnosed according to the recommendations outlined in the document Harmonising the Metabolic Syndrome.[1] Workers who had at least three of the following were classified as patients with MetS: waist circumference ≥ 94 cm in men and ≥ 80 cm in women (these cut-off points were used because of the high proportion of German ancestry among the population); blood pressure (systolic pressure/diastolic pressure) ≥ 130/85 mmHg or hypertension diagnosed by a physician and confirmed by medication use; high-density lipoprotein (HDL) concentration < 40 mg/dL in men and < 50 mg/dL in women; triglycerides (TG) ≥ 150 mg/dL; and fasting blood glucose ≥ 100 mg/dL or diabetes mellitus type 2 (DM2) diagnosed by a physician and confirmed by medication use. Additionally, each component was classified using these cut-off points, and their distributions in the sample were investigated.

Waist circumference measurement was performed at the midpoint between the last rib and the iliac crest using an inextensible tape measure with 1 mm accuracy. It was performed twice, with subsequent estimation of the mean. Blood pressure was measured twice with the aid of a digital automatic device (OMRON model HEM 711 ACINT), also with subsequent estimation of the mean. HDL, TG and fasting glucose were measured in blood samples obtained from the median cubital vein of the forearm after a 12h fast; blood analysis was performed in a biochemical analysis laboratory located in the region where the workers lived.

Information on the work shifts was collected at the company and confirmed by the workers during an interview, and shifts were categorized into day and night. Workers who performed more than 90.0% of their workday in the night/dawn shift, i.e., who started working at 5 pm, were considered night workers, and those who began their workday at 6 am were considered day workers. The company's work schedule was 44 h/week, and workers had one day off, either Saturday or Sunday.

A structured, standardized and pre-coded questionnaire was used to collect demographic, socioeconomic and behavioral data; workers were interviewed at home by trained interviewers. The following sociodemographic variables were analyzed: sex (female; male), skin color (white; other), marital status (without partner; with partner) and age, which was collected in completed years and categorized into quintiles. The socioeconomic variables investigated were the following: education (1st to 4th grade of elementary education; 5th to 8th grade of elementary education; incomplete secondary education; complete secondary education or more) and income, which was referred to as household income and categorized into quartiles of income *per capita*. The behavioral variables measured were the following: practice of leisure time physical activity, categorized as active (≥ 150 min/week) and inactive (< 150 min/week); smoking (never smoked; ex-smoker; smoker); alcohol intake, which was collected as quantity and type of beverage consumed and categorized according to daily alcohol consumption (no drinking; mild to moderate drinking: < 15 g/day for women and < 30 g/day for men; heavy drinking: ≥ 15 g/day for women and ≥ 30 g/day for men);[18] and number of meals per day (≤ 3 meals/day; > 3 meals/day). To determine the number of hours of sleep per night (< 5h; ≥ 5h), workers were asked at what time they usually went to sleep and when did they wake up.

In bivariate, stratified by shift (night/day), and multivariate analysis, Poisson regression with robust variance was used to estimate the prevalence proportions and their respective 95% confidence intervals (95%CI). Variables with a significance level greater than 20% in crude analysis were considered potential confounders, and were included in the multivariate analysis, which followed a conceptual model defined *a priori*.[23] In this model, the decision on the variables to be included in the analysis followed the probable hierarchy between the variables in the causal chain of MetS identification among fixed-shift workers. The variables were entered into the multivariate model according to determination level (distal, intermediate and proximal). Those at the distal level were the first to be included in the model because they would affect the outcome but would not be determined by variables that were intermediate and proximal to the outcome. Every variable that had a significance level of $p \leq 0.20$ was kept in the model and considered a potential confounder for variables of the next determination level. Thus, demographic variables were included in the first level. In the next level (2nd level), socioeconomic variables were included, in addition to those variables that were significant to the top level (1st level). In the 3rd level, behavioral variables and those potential confounders from the upper levels (i.e., intermediate and distal) were included. Finally, those variables that showed $p \leq 0.05$ after adjustment in the multivariate model were considered to be associated with MetS. Additionally, possible interactions between the shift worked and behavioral variables were investigated.

The current study was conducted in compliance with all ethical standards for research with human beings and was approved by the Research Ethics Committee of Universidade do Vale do Rio dos Sinos, as recommended by Resolution 196/96.

## RESULTS

The mean age of the workers was 31 years (SD = 8.7). The majority of the sample consisted of women (65.9%) and night workers (63.0%), and 48.0% of the workers were in the level of complete secondary education or more. The average time working for the company was 68 months (SD = 58.0).

The prevalence of MetS in the sample was 9.3% (95%CI 7.4;11.2), and the most frequently altered component was waist circumference, followed by HDL. Table 1 shows the frequency of altered MetS components according to sociodemographic and behavioral characteristics. Female workers showed a higher frequency of increased waist circumference and low HDL levels than male workers, who showed a higher frequency of altered fasting glucose. Younger workers, aged 18 to 22 years, had the highest proportion of low HDL. Conversely, older workers showed the highest proportion of high waist circumference, blood pressure and TG. This was also observed in workers with less education. Altered fasting glucose was more frequent among workers in the second income quartile. Finally, behavioral characteristics, such as fewer meals and less sleep, were associated with a higher prevalence of high waist circumference, blood pressure and TG. Work shift was not associated with the altered MetS components.

Table 2 shows the prevalence of MetS according to sample characteristics and crude and adjusted prevalence ratios. We found a higher prevalence of MetS in workers aged ≥ 40 years (18.0%) and in the lower levels of education (16.0%). After adjustment at the three multivariate model levels, women, workers aged ≥ 40 years and workers who reported sleeping five or fewer hours per day were more likely to have MetS. Conversely, workers with a higher education level who had more than three meals per day showed a lower prevalence of MetS. We did not find any interaction with the number of meals and sleep duration in the homogeneity test. We performed a stratified analysis by work shift (day and night) and found results for night shift workers similar to those of the total sample; however, considering the stratus of day shift workers, we found a higher prevalence ratio for 40-year-old workers (PR = 9.83; 95%CI 1.20;80.18).

The relationship between work shift and sleep duration was also investigated. All employees (100%) who reported sleeping five or fewer hours per night were night shift workers.

## DISCUSSION

In this study, the occurrence of MetS was associated with sex, age, educational level, dietary habits and sleep duration. When studied separately, the altered components of MetS were mostly associated with sociodemographic characteristics; however, only waist circumference and blood pressure were associated with altered behavioral characteristics.

The factors associated with the occurrence of altered MetS components among workers in this study corroborate the findings of other population-based studies,[9,10] except for the levels of HDL and fasting glucose. Traditionally, HDL levels below the reference value have been associated with increasing age, especially among women.[2] However, in the present study, we found a higher prevalence of low HDL among younger workers (18 to 22 years). One could conclude that older workers have a healthier diet than younger workers.[4]

Regarding fasting glucose, we found the most altered values among men and workers aged 32 to 39 years. However, a greater frequency of altered fasting glucose levels would be expected among workers aged over 40 years, as the literature indicates that increased levels of blood glucose are associated with increasing age.[12,22] Thus, one hypothesis is that younger workers (32 to 39 years) might be less alert to blood glucose alterations than workers aged over 40 years, and older workers possibly do more routine tests.

This study also aimed to investigate factors associated with MetS in fixed-shift workers. In this regard, some authors have recently noted the importance of controlling possible confounders and effect modifiers in studies investigating the relationship between shift

**Table 1.** Prevalence of altered MetS components according to sociodemographic and behavioral characteristics among fixed-shift workers in Southern Brazil, 2010. (N = 902)

| Variable | Waist circumference Male ≥ 94 cm Female ≥ 80 cm | | HDL Male < 40 mg/dL Female < 50 mg/dL | | Blood pressure ≥ 130/85 mmHg | | TG ≥ 150 mg/dL | | Fasting glucose ≥ 100 mg/dL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | % | 95%CI | % | 95%CI | % | 95%CI | % | 95%CI | % | 95%CI |
| Total | 48.4 | 45.5;51.2 | 33.8 | 30.7;36.9 | 12.8 | 10.9;14.7 | 8.7 | 6.9;10.5 | 4.2 | 2.9;5.5 |
| Sex | < 0.001 | | < 0.001 | | 0.061 | | 0.943 | | < 0.001 | |
| Male | 26.9 | 22.6;31.2 | 12.4 | 8.6;16.1 | 10.3 | 7.4;13.2 | 8.8 | 5.6;11.9 | 6.1 | 3.4;8.9 |
| Female | 59.9 | 56.4;63.3 | 44.8 | 40.8;48.7 | 14.1 | 11.6;16.5 | 8.6 | 6.3;10.9 | 1.5 | 0.5;2.5 |
| Age (quintiles) | < 0.001 | | 0.017 | | < 0.001 | | < 0.001 | | 0.003 | |
| 18 to 22 years | 32.7 | 26.8;38.5 | 44.8 | 37.2;52.5 | 2.4 | 0.5;4.3 | 5.4 | 1.9;8.9 | 0.6 | 0.0;1.8 |
| 23 to 26 years | 34.5 | 28.6;40.3 | 34.0 | 27.2;40.8 | 7.5 | 4.2;10.7 | 6.3 | 2.8;9.7 | 3.1 | 0.6;5.6 |
| 27 to 31 years | 49.1 | 42.4;55.8 | 28.9 | 21.8;36.0 | 10.6 | 6.5;14.7 | 6.9 | 2.9;10.9 | 0.1 | 0.0;1.8 |
| 32 to 39 years | 56.7 | 50.5;62.9 | 31.7 | 25.3;38.1 | 18.0 | 2.5;13.2 | 5.8 | 2.6;9.1 | 6.8 | 3.3;10.3 |
| ≥ 40 years | 71.2 | 65.4;77.1 | 30.3 | 23.6;36.9 | 26.2 | 20.5;31.9 | 18.6 | 13.0;24.2 | 3.2 | 0.6;5.7 |
| Education | < 0.001 | | 0.864 | | < 0.001 | | 0.012 | | 0.691 | |
| 1st to 4th grade of elementary | 63.2 | 56.7;69.7 | 34.1 | 26.8;41.4 | 20.3 | 14.2;25.7 | 15.0 | 9.5;20.4 | 4.2 | 1.1;7.2 |
| 5th to 8th grade of elementary | 56.9 | 51.4;62.4 | 34.3 | 28.1;40.5 | 16.3 | 12.1;20.4 | 8.7 | 5.0;12.3 | 3.0 | 0.8;5.2 |
| Incomplete secondary | 36.5 | 27.1;45.9 | 37.5 | 26.4;48.9 | 7.7 | 2.5;12.9 | 5.5 | 2.7;11.0 | 4.2 | 0.0;8.9 |
| ≥ complete secondary | 40.4 | 36.4;44.4 | 32.6 | 28.2;37.0 | 9.1 | 6.7;11.4 | 6.8 | 4.5;9.2 | 2.5 | 1.0;3.9 |
| Income (quartiles) | 0.278 | | 0.885 | | 0.402 | | 0.809 | | 0.001 | |
| I | 49.5 | 42.6;56.4 | 31.5 | 25.1;37.9 | 12.1 | 7.6;16.6 | 7.3 | 3.7;10.8 | 1.0 | 0.0;2.3 |
| II | 45.9 | 38.9;52.1 | 35.1 | 28.8;41.4 | 13.0 | 8.6;17.5 | 9.0 | 5.9;13.9 | 6.7 | 3.4;10.0 |
| III | 51.3 | 44.8;57.7 | 33.3 | 27.2;39.4 | 16.6 | 11.8;21.4 | 8.9 | 5.3;12.6 | 1.3 | 0.7;5.1 |
| IV | 54.6 | 48.1;61.1 | 27.8 | 27.9;40.2 | 16.6 | 11.7;21.4 | 9.2 | 5.4;12.9 | 3.0 | 0.0;2.8 |
| Work shift | 0.641 | | 0.249 | | 0.467 | | 0.723 | | 0.434 | |
| Day | 49.9 | 43.6;54.5 | 35.9 | 30.6;41.1 | 13.5 | 9.7;17.2 | 9.20 | 6.0;12.3 | 4.9 | 2.5;7.2 |
| Night | 50.7 | 46.6;54.8 | 32.1 | 28.3;35.9 | 15.3 | 12.3;18.2 | 8.51 | 6.2;10.8 | 3.8 | 2.2;5.4 |
| Meals/day | 0.003 | | 0.794 | | 0.029 | | 0.054 | | 0.718 | |
| ≤ 3 meals | 51.4 | 47.9;54.8 | 34.1 | 30.3;37.8 | 14.3 | 11.8;16.7 | 9.9 | 7.6;12.3 | 2.9 | 1.6;4.3 |
| > 3 meals | 42.4 | 37.5;47.3 | 33.2 | 2.8;38.6 | 9.8 | 6.8;12.7 | 6.1 | 3.3;8.8 | 3.4 | 1.3;5.4 |
| Sleep duration | 0.026 | | 0.535 | | 0.018 | | 0.163 | | 0.235 | |
| > 5h | 46.8 | 43.7;50.0 | 33.3 | 29.9;36.7 | 11.6 | 9.6;13.7 | 8.0 | 6.1;10.0 | 3.4 | 2.9;4.7 |
| ≤ 5h | 54.7 | 48.4;61.1 | 35.8 | 28.6;42.9 | 17.4 | 12.5;22.2 | 11.4 | 6.6;16.1 | 1.7 | 0.0;3.6 |

HDL: high-density lipoprotein; TG: triglycerides

work and chronic noncommunicable diseases such as MetS.[5,6] Therefore, here we proposed a conceptual model defined *a priori* that considered distal, intermediate and proximal variables related to outcome. The variables entered in each determination level were controlled for the variables on the same level and, when appropriate, for the variables on upper levels. Thus, the influence of potential confounding factors, such as demographic, socioeconomic and behavioral characteristics, was controlled when necessary. In addition, we performed statistical interaction tests to detect possible effect modifying variables.

A higher prevalence of MetS was found in older and less educated workers. Two previous studies on shift workers also reported that age was directly associated with MetS.[7,11,18] However, this study is the first to investigate sociodemographic variables and MetS in shift

**Table 2.** Prevalence and crude and adjusted prevalence ratios for metabolic syndrome according to demographic, socioeconomic and behavioral characteristics among fixed-shift workers in Southern Brazil, 2010. (N = 902)

| Variable | Prevalence | | | Crude Analysis | | | Adjusted Analysis | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | % | 95%CI | PR | 95%CI | p | PR | 95%CI | p |
| 1st Level | | | | | | | | | |
| Sex | | | | | | | | | |
| Male | 307 | 5.2 | 2.7;7.7 | 1 | | 0.004 | 1 | | 0.003 |
| Female | 595 | 11.4 | 8.8;14.0 | 2.20 | 1.30;3.71 | | 2.16 | 1.28;3.64 | |
| Marital status | | | | | | | | | |
| Without partner | 625 | 10.9 | 8.4;13.3 | 1.80 | 1.11;3.19 | | 1.35 | 0.80;2.30 | |
| With partner | 277 | 5.7 | 3.0;8.5 | 1 | | 0.018 | 1 | | 0.297 |
| Skin color | | | | | | | | | |
| White | 772 | 9.3 | 7.2;11.4 | 1 | | 0.986 | | – | |
| Other | 281 | 9.4 | 4.2;14.5 | 1.01 | 0.56;1.80 | | | | |
| Age (quintiles) | | | | | | | | | |
| 18 to 22 years | 188 | 4.2 | 1.1;7.4 | 1 | | < 0.001 | 1 | | < 0.001 |
| 23 to 26 years | 189 | 5.3 | 2.1;8.5 | 1.24 | 0.4;3.2 | | 1.21 | 0.47;3.15 | |
| 27 to 31 years | 159 | 6.9 | 2.9;10.9 | 1.62 | 0.6;4.1 | | 1.57 | 0.62;4.02 | |
| 32 to 39 years | 202 | 10.4 | 6.1;14.6 | 2.40 | 1.1;5.6 | | 2.28 | 1.00;5.27 | |
| ≥ 40 years | 164 | 18.0 | 13.0;24.2 | 4.40 | 2.0;9.5 | | 3.90 | 1.78;8.93 | |
| 2st Level | | | | | | | | | |
| Education | | | | | | | | | |
| 1st to 4th grade of elementary | 167 | 16.2 | 10.5;21.8 | 1 | | < 0.001 | 1 | | 0.047 |
| 5th to 8th grade of elementary | 228 | 12.7 | 8.4;17.1 | 0.78 | 0.48;1.27 | | 0.89 | 0.54;1.48 | |
| Incomplete secondary | 72 | 4.2 | 0.0;8.9 | 0.25 | 0.08;0.82 | | 0.46 | 0.13;1.57 | |
| ≥ complete secondary | 434 | 5.7 | 3.5;8.1 | 0.35 | 0.21;0.59 | | 0.55 | 0.29;1.06 | |
| Income (quartiles) | | | | | | | | | |
| I | 206 | 7.28 | 3.70;10.85 | 1 | | 0.080 | 1 | | 0.053 |
| II | 222 | 8.56 | 4.85;12.23 | 1.17 | 0.61;2.25 | | 1.13 | 0.60;2.12 | |
| III | 234 | 9.40 | 5.63;13.17 | 1.29 | 0.68;2.13 | | 1.25 | 0.68;2.34 | |
| IV | 229 | 12.22 | 7.95;16.50 | 1.67 | 0.92;3.06 | | 1.73 | 0.96;3.14 | |
| Work shift | | | | | | | | | |
| Day | 326 | 8.5 | 5.5;11.6 | 1 | | 0.575 | | – | |
| Night | 576 | 9.7 | 7.3;12. 1 | 1.13 | 0.73;1.74 | | | | |
| 3rd Level | | | | | | | | | |
| Physical activity | | | | | | | | | |
| Inactive | 582 | 9.4 | 7.0;11.9 | 1 | | 0.848 | | – | |
| Active | 320 | 9.1 | 5.9;12.2 | 0.96 | 0.62;1.47 | | | | |
| Smoking | | | | | | | | | |
| Never smoked | 785 | 8.9 | 6.9;10. 9 | 1 | | 0.449 | | – | |
| Ex-smoker | 80 | 12.5 | 5.1;19.9 | 1.40 | 0.75;2.6 | | | | |
| Smoker | 36 | 11.1 | 0.3;21.8 | 1.24 | 0.48;3.2 | | | | |
| Meals/day | | | | | | | | | |
| ≤ 3 meals | 610 | 11.1 | 8.6;13.6 | 1 | | 0.008 | 1 | | 0.002 |
| > 3 meals | 292 | 5.5 | 2.8;8.1 | 0.49 | 0.29;0.83 | | 0.43 | 0.26;0.73 | |
| Alcohol intake | | | | | | | | | |
| No drinking | 321 | 10.9 | 7.5;14.3 | 1 | | 0.213 | | – | |
| Mild to moderate drinking | 552 | 8.5 | 6.1;10.8 | 0.78 | 0.51;1.18 | | | | |
| Heavy drinking | 29 | 6.9 | 0.0;16.7 | 0.63 | 0.16;2.5 | | | | |
| Sleep duration | | | | | | | | | |
| > 5h | 730 | 8.3 | 6.3;10.3 | 1 | | 0.041 | 1 | | 0.017 |
| ≤ 5h | 172 | 13.4 | 8.2;18.5 | 1.60 | 1.02;2.51 | | 1.70 | 1.09;2.24 | |

1st level: demographic variables (sex, skin color, marital status, age); 2st level: 1st level + socioeconomic variables (education, income, work shift); 3rd level: 1st level and 2st level + behavioral variables (smoking, physical activity, alcohol intake, number of meals/day and sleep duration) workers. Studies on this topic have been conducted only in the general population and have found a similar higher prevalence of MetS among women with lower educational levels.[16,18]

The development of MetS is also strongly influenced by the individual's behavioral characteristics. Among the behavioral factors investigated in this study, the number of meals during the day and the duration of sleep were related to MetS. Workers who had a higher number of meals showed a lower prevalence of MetS. The statistical interaction between the number of meals and work shift was tested, but no association was found. Esquirol et al[7] conducted a similar investigation among shift workers in France and found similar results. Workers who had breakfast, an afternoon snack and an evening snack in addition to lunch and dinner had a lower prevalence of MetS compared with those who had fewer meals. Having meals more often leads to better appetite control, greater effect of postprandial thermogenesis, largest mobilization of lipids due to repeated stimulation of the sympathetic nervous system, lower elevation in plasma glucose and less variation in insulin levels and C-peptide,[14] all of which could possibly explain this difference.

The association between sleep duration, shift work and metabolic disorders has been the object of several observational studies in the last decade. However, because most studies do not include sleep in their analysis models, it is impossible to determine if sleep is a confounder, an effect modifier variable or a mediator in the causal pathway that connects shift work to MetS.[5] Three studies that investigated this relationship by treating sleep as a confounding factor obtained controversial results: one found a negative association between the presence of shift work and MetS,[12] and the other two found a positive association between night shift work and MetS.[15,24] In this study, workers who slept five or fewer hours per day had a higher prevalence of MetS and were all night shift workers. Thus, it seems that night shift work leads these workers to sleep deprivation, suggesting that sleep may be a mediating factor in the relationship between night shift work and MetS.

The hormonal regulation that occurs during sleep and its multiple peripheral effects depend on sleep duration and quality, indicating that sleep deprivation has deleterious health effects. Thus, observational and experimental studies have documented shortening of sleep as an independent risk factor in the occurrence of MetS.[14] Wu et al demonstrated that reduced sleep time (< 6 h/day) was positively associated with MetS.[25] Additionally, decreased sleep duration has been linked to several metabolic disorders, such as glucose intolerance, insulin resistance, dyslipidemia, hypertension and systemic inflammatory processes.[9,17,20]

Our findings should be interpreted considering three aspects. First, the study uses a cross-sectional design, which is inadequate to establish a temporal relationship between the events or variables of interest. Second, knowing their altered metabolic parameters might have led the workers to change their lifestyle, including work shift changes – reverse causality. For example, our findings show that, among daytime workers, the prevalence of MetS was approximately nine times higher in older individuals than in younger ones. It is possible that, after developing metabolic disorders and other chronic diseases, older shift workers are transferred to the day shift. Third, this survey was conducted among fixed-shift workers, and the survey findings cannot be extrapolated to rotating-shift workers. Finally, this study was conducted with a population of workers and, as a consequence, was susceptible to the healthy worker effect. It may have caused a lower exposure of individuals to risky behaviors, which is consistent with the low prevalence of smoking and alcohol consumption found in this sample.

We believe that our study provides important contributions to the understanding of how fixed-shift workers may be more exposed to the development of metabolic disorders compared with the general population. We found that higher educational level and number of meals per day were protective factors for MetS in fixed-shift workers, whereas being of the female sex, of older age and deprived of sleep are risk factors for MetS. Night shift work was not associated with MetS, but sleep deprivation appeared to be a linking factor between night shift work and MetS. Additionally, altered MetS components were mostly associated with sociodemographic characteristics, and high waist circunference and blood pressure were associated with sociodemographic and behavioural characteristics. To better elucidate the role of each of the independent variables in determining MetS in shift workers, future longitudinal studies that include all possible risk factors for MetS determination, including duration and quality of sleep, should be conducted.

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