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.
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, which are associated with an increased risk of developing diabetes mellitus type 2 and cardiovascular disease as well as increased mortality.

The increased prevalence of MetS worldwide has been attributed to changes in lifestyle, particularly with regard to new eating patterns and sedentarism. 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.

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. 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.
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 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, 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 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; >15 g/day for women and ≥30 g/day for men; heavy drinking: ≥15 g/day for women and ≥30 g/day for men);14 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 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.

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 using an inextensible tape measure with 1 mm accuracy.
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 vari-
ables 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 asso-
ciated 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 recom-
manded 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 behav-
ioral 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 prev-
alence 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 prev-
alence 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, consid-
ering 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 dura-
tion 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 compo-
nents of MetS were mostly associated with sociodemo-
graphic characteristics; however, only waist circumfer-
ence and blood pressure were associated with altered
behavioral characteristics.

The factors associated with the occurrence of altered
MetS components among workers in this study corrob-
orate 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 associ-
ated 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
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 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 | HDL | Blood pressure | TG | Fasting glucose |
|----------|---------------------|-----|----------------|----|----------------|
|          | Male ≥ 94 cm Female ≥ 80 cm | Male < 40 mg/dL Female < 50 mg/dL | ≥ 130/85 mmHg | ≥ 150 mg/dL | ≥ 100 mg/dL |
|          | % | 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 | < 0.001 | 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;54.4 | 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 | 28.3;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
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 |
| 2nd 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); 2nd level: 1st level + socioeconomic variables (education, income, work shift); 3rd level: 1st level and 2nd 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 al7 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. 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 circumference 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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Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

Research supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq – Process 477069/2009-6 and 470366/2011-6). Raquel Canuto received a scholarship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). Olinto MTA and Pattussi MP received research productivity grants from CNPq (Process 307257/2013-4 and 303424/2011-7).

The authors declare no conflict of interest.

Airline-based on the doctoral thesis of Raquel Canuto, titled: “Fatores associados aos distúrbios metabólicos em trabalhadores de turnos de um frigorífico do sul do Brasil,” submitted to the Postgraduate Program in Medical Sciences: Endocrinology of the Universidade Federal do Rio Grande do Sul, in 2012.

The authors declare no conflict of interest.

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