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Nutritional composition of meals at work and its relationship with manufacturing workers' anthropometric profile and energy expenditure

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Abstract
The objective of this study was to verify whether the energy content and nutritional composition of meals consumed at work (lunch) correlated with the energy expenditure and nutritional status of workers from different sectors (administration and production) of different industries. The sample consisted of 292 workers. Many anthropometric dimensions were assessed, such as physical activity energy expenditure, and daily energy expenditure (DEE). Food intake was measured directly for five days. The study comprised an assessment of the correlation between sectors and gender, a qualitative assessment between obesity indicators, and a principal component analysis (PCA). Overweight workers prevailed, and DEE differed by gender and work sector ($p<0.05$). PCA showed that the majority of the individuals with high energy expenditure and high energy and fats consumption levels were males.

Keywords: meals, worker, nutrition, energy expenditure.

La alimentación de los trabajadores en la industria y su relación con los datos antropométricos y el gasto energético

Resumen
Este estudio tuvo como objetivo verificar la correlación entre la composición energética y nutricional de la comida consumida en el ambiente de trabajo (almuerzo), el gasto energético y el estado nutricional de trabajadores de diferentes sectores (administración y producción) en diferentes industrias. La muestra comprendió 292 trabajadores. Han sido evaluados diversos índices antropométricos, gasto energético en la actividad física y gasto energético diario (GED). El consumo alimenticio fue mensurado por observación directa, durante cinco días. El studio consistió en una evaluación de la correlación entre los sectores y género; una evaluación cualitativa entre los indicadores de obesidad y una Análisis de componentes principales (PCA). Se encontró prevalencia de trabajadores con sobrepeso y diferencia estadística del GED en función del género y sector de trabajo ($p<0,05$). En la PCA, fue posible determinar que pertenece al sexo masculino la gran mayoría de los individuos que presentaron un mayor gasto energético, mayores tenores de consumo de energía y lípidos.

Palabras clave: alimentación; trabajador; nutrición; gasto energético.

1. Introduction

Scientific and technological progress have increased people's life expectancy; changed their behavior, for example, by encouraging them to adopt a more energy-dense diet; and reduced physical activity. Notoriously, people have developed health problems related to these changes, such as overweight and obesity, both with a high global incidence [1-3].

In the study context, obesity may be related to higher absenteeism, occupational diseases, lower productivity, and higher health care costs [4-6]. Janssen et al. [7] studied these relationships and concluded that obese workers are more likely to report occupational accidents, especially those aged 40 or over who are less physically active. Barringto et al. [8] examined the association between perceived stress, eating behavior, physical activity (PA), and body mass index (BMI) in 621 healthy workers from the construction industry. Those authors concluded that high levels of perceived stress were

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associated with poor diets and low level of PA.

Based on the supposition that adults spend half of their waking hours at work, quality food and encouragement for more physical activity at work in order to ensure full health and benefit the workers' professional practice and life as a whole, may promote, for example, a normal weight [5,9,10].

Workers' meals must meet workers' energy and nutritional requirements in order to benefit their health, for example, by controlling weight and other risks that facilitate the development of degenerative diseases [11]. Much evidence regarding the habitual intake of unhealthy foods has been documented by studies that investigated workers' diets, especially the low intake of fruits and non-starchy vegetables, and the high intake of high-sugar and high-fat foods [12-14]. To ensure that workers have a proper diet, especially low-income workers, in 1976, Brazil implemented a food and nutrition policy called Worker's Food Program (WFP). This program aimed to ensure that workers' nutritional requirements are met at work and to promote education in nutrition-related topics. Its guidelines have been changed to adapt to the changes seen in the nutritional profile of active adults [15].

Health status and performance in daily physical activities, including work, depend, among other things, on the balance between energy requirement and the intake of energy nutrients. The balance between energy requirement and intake may be neutral, negative, or positive. A positive energy balance results in the accumulation of excess adipose tissue, leading to obesity [16]. In this context, a gap was identified in the literature regarding the nutritional composition of workers' food intake with respect to their nutritional requirements, taking into account specific characteristics, such as gender and type of work. Hence, the goal of the current study was to verify whether the energy content and nutritional composition of meals consumed at work (lunch) are correlated with the energy expenditure and nutritional status of workers from different sectors (administration and production) of different industries.

2. Materials and Methods

2.1. Design and sampling

This cross-sectional study included workers from many industries, such as logging, chemical, metal-mechanic, foundry, and food in the city of Ponta Grossa, in the central region of the state of Paraná, Brazil. Data were collected from companies from five different industries (metal-mechanic, chemical, logging, food, and casting) because of easy access. The inclusion criteria for the companies were: belonging to different industries, being of different sizes based on the number of employees, enrolled in the Workers' Food Program (WFP), and having in-house food services.

The sample size was calculated with a confidence interval of 95% (95%CI) and 0.05 error margin for estimating the mean – finite population, using Equation 1 below [17] (n=sample size; N=population size; population standard deviation (SD); E=error margin for estimating a population parameter; $Z_{\alpha/2}$ =critical value related to the degree of confidence used for normal distribution).

$$n=\frac{N.\sigma^2.(Z_{\alpha/2})^2}{(N\text{-}1)E^2+\sigma^2.(Z_{\alpha/2})^2} \quad (1)$$

The sample size was calculated based on the following data: total number of factory workers in the studied region (18.439); mean BMI SD of 4.25; and maximum error margin of 0.5 based on the results of a pilot study (n=40), totaling 274 individuals. The study effectively assessed 292 workers, 70.2% from the production sector (factory floor, laboratory, general services, and maintenance), and 30.0% from the administrative sector (administrative, management, and commercial jobs).

The data were separated into classes to stratify the results by gender (male/female), administrative sector (administrative, management, and commercial jobs), and production sector (factory floor, general services, laboratory, and maintenance). The inclusion criteria were: males and females aged 18 to 55 years, enrolled in WFP, a minimum education level of 5 years of elementary school, working during the day shift at one of the studied companies, and having lunch at the company's food service restaurant. The study was approved by the Research Ethics Committee of the Federal Technological University of Paraná (UTFPR) - CAAE 14331813.0.0000.5547 – under protocol number 361.283.

A structured questionnaire was applied to collect sociodemographic data, namely age, gender, marital status, education level, work sector, and salary.

2.2. Assessment of anthropometric data, energy expenditure, and nutritional composition

Anthropometric data, such as indicators of nutritional status, were collected individually by trained personnel in a closed room as recommended by Onis et al. [18]. The individuals were weighed barefoot with a digital electronic platform scale (W835A-Wiso) with a maximum capacity of 150 kg and accuracy of 100 g, and the weight of the uniform was subtracted. Height was measured by a portable stadiometer mounted on the wall. The individuals were measured barefoot, looking straight ahead, holding the legs together, and letting the arms hang down each side of the body. Waist circumference (WC) was measured at the smallest circumference between the iliac crest and the last rib. Hip circumference (HC) was measured at the widest point of the buttocks seen laterally. The body mass index (BMI=mass/height^2), waist-to-hip ratio (WHR=WC/HC), and waist-to-height ratio (WHeR=WC/height) were then computed. Nutritional status was classified as follows: underweight (BMI < 18.5kg/m^2); normal weight (18.5 kg/m^2 ≤ BMI ≤24.9kg/m^2); overweight (25.0kg/m^2 ≤ BMI ≤ 29.9kg/m^2), and obese (BMI ≥30.0kg/m^2) [19].

Abdominal obesity was assessed by the following indices: WC, WHR, and WHeR, and classified as follows: males with waist circumference (WC) of between 94 and 102 cm and females with WC of between 80 and 88 cm had abdominal obesity grade I; males with WC ≥ 102 cm and females with WC ≥ 88 cm had abdominal obesity grade II. Regarding WHR, males with WHR > 0.92 and females with WHR > 0.83 were considered abdominally obese. Regarding WHeR, males and females with WHeR > 0.5 were considered abdominally obese [20,21].

The daily energy expenditure (DEE) was given by a predictive equation recommended by the World Health Organization [22] taking into account the basal metabolic rate (BMR). The BMR was calculated taking gender, age, and body mass into consideration. The ideal body weight was used for calculating the BMR of underweight, overweight, or obese individuals according to BMI to avoid under- or overestimation. Formulas for predicting the BMR are a good option for clinical and epidemiological studies because of their usefulness and low cost [23]. Physical activity energy expenditure (PAEE) was monitored using a pedometer (Yamax Gigi Walker SW – 700) on five consecutive days [24].

Food intake during lunch at work was measured directly on five consecutive days when workers helped themselves, taking into account the preparations and respective standard weights or volumes in cooking units. The food was weighed three times using an electronic scale with accuracy of 0.01g. Volumes were measured using a 500mL beaker. After the meal, the leftovers on the plate were recorded and the amounts consumed were calculated in grams or milliliters. The DietWin software was used to calculate the energy content and nutrient composition (proteins, carbohydrates, total fats, saturated fats, and sodium) of the meal. The results were compared with WFP's recommendations and with the estimated energy expenditure, considering that lunch should provide 30-40% of the workers' requirements. The study considered that the following amounts [15] should be consumed during the main meal (lunch): carbohydrates: 83-268g; proteins: 15-30g; lipids: 10-27g; saturated fats: <9g; fibers: >7.5g, and sodium: <960mg.

2.3. Statistical treatment

The software used for the descriptive analysis and statistical tests was Statistica for Windows 5.0 (Statsoft®). Data normality was assessed using the Kolmogorov-Smirnov (n>100) test, rejecting the null hypothesis when $p \geq 0.05$. Pearson's test was used to assess the correlation between the two variables, work sector (administrative and production) and gender (female and male), with normal distribution, and the Spearman test was used to assess the asymmetric data.

Statistical inference (percentage of individuals) qualitatively assessed the obesity indicators (BMI, WC, WHR, and WHeR) with 95% CI and error margin of ±2%.

The Pirouette software (Infometrix®) was applied to run the principal component analysis (PCA), which correlated body weight, BMI, energy expenditure, and lipid content. The significance level was set at 5% ($p<0.05$) for all tests. Data values highly incompatible with the dataset were considered outliers and removed from the dataset. The principal component (PC) loadings and scores were graphed. A labeling system based on gender and work sector was proposed as a pattern recognition technique.

3. Results and discussion

The volunteers consisted of workers from the following industries: metal-mechanic (n=67, 22.9%); chemical (n=30, 10.3%), logging (n=30, 10.3%), food (n=83, 28.4%), and casting (n=82, 28.1%). The sample included 87 administrative workers (29.8%) and 205 production workers (70.20%). The mean ages of the males (n=224) and females (n=68) were 33.7±8.84 years and 31.5±8.84 years, respectively.

3.1. Anthropometric results

The BMI of the workers did not differ by gender or by work sector ($p>0.05$). The sample's average BMI (26.40±4.67kg/m^2) indicated a prevalence of overweight. Indeed, 16.0% and 19.0% of the females and males, respectively, were obese, and 31.0% and 42.0% of the females and males, respectively, were overweight (Fig. 1; Tables 1 and 2). Other studies with workers reported similar findings [1,13].

Regarding WC, 64.7% (n=189) of the participants were not abdominally obese, 21.2% (n=62) had abdominal obesity grade I, and 14.1% (n=41) had abdominal obesity grade II, not differing by gender ($p>0.05$). Regarding WHR, 20.2% (n=59) of the participants were abdominally obese, most of whom were males and/or production workers ($p<0.05$). Workers with low education level (less than eight years of formal education) had significantly higher WHR than those with higher education ($p<0.05$). This fact is corroborated by a study that found that type of work (as a function of education level) and gender (greater in males) influence the incidence of abdominal obesity [25,26].

Regarding WHeR, 42.1% of the participants were abdominally obese, most of whom were also males and/or production workers ($p>0.05$). According to Bauman et al. [25], being male correlates with obesity but is not a determinant of it.

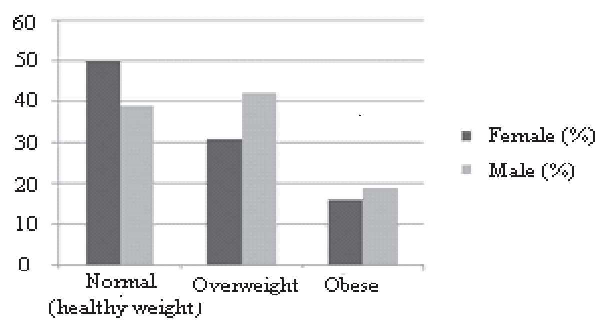

Figure 1. Prevalences of overweight and obesity (%) in a population of factory workers by gender.
Source: Bortolozo et al.

Table 1.
Anthropometric data of the manufacturing-plant workers by gender (mean ± standard deviation).

Variables	All	Women (n=68)	Men (n=224)
BMI (kg/m²)	26.40 (±4.67)	25.61 (±5.25)	26.61 (±4.85)
WC (cm)	87.110 (±12.02)	70.06 (±10.58)	89.54 (±11.50)
WHR* (cm)	0.85 (±0.08)	0.77 (±0.07)	0.88 (± 0.07)
WHeR* (cm)	0.51 (±0.07)	0.50 (± 0.06)	0.52 (±0.70)

Note: BMI: body mass index; WC: waist circumference; WHR: waist-to-hip ratio; WHeR: waist-to-height relationship; *lines with statistical differences.
Source: Bortolozo et al.

Table 2.
Anthropometric data of the manufacturing-plant workers by work sector (mean ± standard deviation).

Variables	Administrative (n=87)	Production (n=205)
BMI (kg/m²)	26.37 (±4.89)	26.45 (±4.35)
WC (cm)	83.33 (±12.26)	88.26 (±11.38)
RHR * (cm)	0.80 (±0.07)	0.86 (±0.07)
WHeR * (cm)	0.49 (±0.06)	0.52 (±0.06)

Note: BMI: body mass index; WC: waist circumference; WHR: waist-to-hip ratio; WHeR: waist-to-height relationship; *lines with statistical differences.
Source: Bortolozo et al.

Table 3.
Basal metabolic rate, physical activity energy expenditure, and daily energy expenditure of factory workers.

	BMR (Kcal)	PAEE (Kcal)	DEE (Kcal)
General (n=292)	1629.64(±155)	530.10 (±340)	2182.20 (447.00)
Women (n=68)	1483.04*(±126)	305.47* (±185)	1718.10* (±242)
Men (n=224)	1669.95*(±155)	598.98* (±347)	2331.28* (±379)
Administrative (n=87)		365.36* (±237)	1972.41* (±349)
Production (n=205)		618.02* (±354)	2302.78* (±436)

Note: BMR: basal metabolic rate; PAEE: physical activity energy expenditure; DEE: daily energy expenditure. *statistically different ($p<0.05$)
Source: Bortolozo et al.

The statistical interference test (error margin of ±2%) showed that obesity indices based on BMI were strongly correlated with WC and WHeR. On the other hand, the frequencies of obesity and overweight classified by BMI were weakly correlated with WHR. Although BMI is a widely used as an obesity indicator, alone it may not be an accurate indicator of body fat [27].

3.2. Energy expenditure

Table 3 shows the sample's BMR, PAEE, and DEE.

Taking the sample's characteristics (gender, mass, height, and age) into account, the mean BMR (kcal) was 1657.88 kcal (± 178). This value is close to that estimated by Frankenfield et al. [28] in a study of adults (1701.0 kcal). The BMR of males (1727.4) was higher than that of females (1405.0 kcal) ($p<0.05$). The mean PAEE was 530.10±340 kcal, differing significantly by gender and work sector. Males and production workers had higher PAEE than women and administrative workers, respectively.

Other studies have also found that administrative workers are more sedentary than those with supposedly more active jobs (production sector) [1,25,29]. This result was expected since PAEE is the component with more variability in energy expenditure [30].

The estimated daily energy requirement based on DEE not stratified by gender and work sector was close to the recommended value of the 2000 kcal ($p>0.05$) [15]. Therefore, the energy values differed significantly by gender and work sector (production or administrative). The significant differences in the energy requirements of workers with different characteristics have been considered by the WFP guidelines, which recommend that the menu should be adapted to the work activities undertaken [15]. According to the Dietary Reference Intakes (DRIs) guidelines, the energy requirement or Estimated Energy Requirement (EER) is defined as a mean daily amount of energy that promotes the energy balance of healthy individuals, which can vary by gender and level of physical activity [31]. However, studies about meals at work that verify menu adaptation were not found.

Regarding PAEE, it was verified that a number of other factors, namely education level and income, also showed different results ($p<0.05$). Workers with higher education levels (complete or incomplete) and higher income (more than 10 times the minimum salary) had lower PAEE than those with lower education levels and lower incomes. This result may have been influenced by the higher concentration of production workers with lower education levels, who are statistically more active. Hence, work activities may directly impact workers' daily level of physical activity, especially that of administrative workers.

3.3. Nutritional composition of lunch

Diet is an important environmental risk factor for obesity and other chronic noncommunicable diseases. The issue that requires determination is whether meals at work are promoting energy balance.

The menus of the study's in-house food services contain the following preparations on a daily basis: rice, beans, high-protein preparation (meat or meat-based product), side dish (pasta or legumes), salad (three or more options), dessert (fruit or sweet), juice (natural or artificial), and bread. Salt soybean oil, and other condiments for the salads are readily available. The amount of main dish or animal-protein preparation available for each worker is limited and distributed by the food service employees. The workers may eat as much of the other preparations as they please.

Fig. 2 shows the energy values recommended by the WFP, as well as the daily energy requirement of all workers, workers by gender, and workers by work sector. The energy requirement at lunch was based on the recommendation that 30-40% of the daily energy requirement (DER) should be provided by the main meal (lunch or supper) [15]. The mean energy content of this meal corresponded to 654.66-872.88 kcal, 515.40-687.20 kcal for females, 699.30-932.40 kcal for males, 591.72-788.96 kcal for administrative workers, and 690.83-921.11 kcal for production workers. The maximum recommended energy values (800 kcal) differed by gender and work sector. This is probably because the values recommended by the WFP for the main meal are based on a daily energy requirement of 2000 kcal, while the DEE of males and production workers was close to 2400 kcal/day, and of women and administrative workers, it was less than 2000 kcal/day.

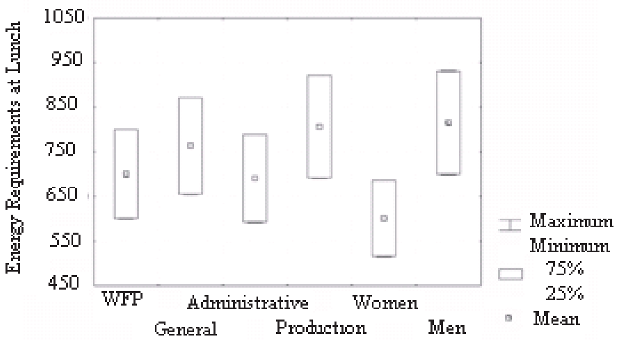

Figure 2. Energy content of lunch recommended by the Worker Food Program estimated by a study with factory workers.
Note: energy requirement in kcal; WFP: Worker Food Program [15].
Source: Bortolozo et al.

These differences can be considered in menu planning or by the educational approach directed at workers. Bauce [29] studied Venezuelan workers and established daily energy values for the main meal (lunch) by gender: 863.5 kcal for females and 1239.2 kcal for males. An energy intake that is in balance with one's energy requirement is a factor that promotes health and improves workers' performance in daily activities [16].

Table 4 presents the nutritional composition of lunch, taking into account the individual intake of the study sample.

Energy, protein, carbohydrate, and fiber intakes differed by gender and work sector ($p<0.05$), and were higher in males and production workers who had higher energy and lipid intakes. These differences may demonstrate some food intake adaptation based on individual requirements, even when the food services do not adapt the menus or the workers do not receive counseling.

Table 4.
Mean (standard deviation) food intake during lunch by a sample of factory workers.

Nutrients	Total	Women (n=68)	Men (n=224)	Adm. (n=87)	Prod. (n=205)
Energy (kcal)	776.13 (± 201)	644.02[a] (±164)	816.24[a] (±194)	672.36[b] (±191)	831.00[b] (±170)
Protein (g)	50.58 (±11)	45.08[a] (±13)	52.25[a] (±10)	47.32[b] (±11)	52.29[b] (±11)
Carbohydrate (g)	108.92 (±40)	85.51[a] (±27)	116.32[a] (±40)	87.89[b](±31)	120.03[b] (±39)
Total fat (g)	16.98 (±5.8)	16.51 (±6.3)	17.13 (±5.6)	16.97 (±6.2)	16.99 (±5.49)
Saturated fat (g)	5.37 (±2.3)	5.26 (±2.4)	5.41 (±2.2)	5.37 (±2.4)	5.38 (±2.14)
Fiber (g)	14.06 (±5.6)	10.76[a] (±4.9)	15.05[a] (±5.4)	11.27[b] (±5.2)	15.53[b] (±5.3)
Sodium (mg)	1689 (±540)	1625.73 (±606)	1707.83 (±531)	1670.54 (±570)	1698.32 (±536)

Note: Adm.: administrative workers; Prod.: production workers; [a] differed significantly by gender and [b] by work sector ($p<0.05$). Recommended values [15]: protein: 15-30g; total fat; 10-27g; saturated fat < 9g; fiber > 7.5g; sodium < 960mg.
Source: Bortolozo et al.

Likewise, the National Health and Nutrition Examination Survey (NHANES) found that adult male Americans have a higher energy intake, compared to females [32]. Other studies of adults reported similar findings [33,34].

Regarding nutrients, the carbohydrate, lipid, and saturated fat contents are within the WFP recommendations. However, the protein, fiber, and sodium contents exceed the recommended values. A positive fact about the food consumed at work was its high fiber content mainly due to the availability of three types of salad and fruit-based desserts at least three times a week. It is very important to ensure the intake of fruits and non-starchy vegetables at work, since adults usually consume few servings of these food groups in their regular diets [34]. In the case of proteins, the estimated values differed ($p<0.05$) from the values recommended for the main meal (15-20g) [15]. The main dish (meat), legumes, and dairy desserts contributed to a high protein intake.

The mean sodium intake was much higher than the recommended levels (<960 mg), especially because table salt was available for seasoning the salads. Excessive sodium intake is an important risk factor for chronic noncommunicable diseases (NCDs), especially high blood pressure [36]. Mishra & Mohanty [12] assessed the foods consumed at work by Asian Indian factory workers and found that their intakes of energy, protein, fat, some minerals, and some vitamins were too high.

Significant correlations ($p<0.01$) were found between body weight and BMI ($r = 0.84$), weight and DEE ($r = 0.52$), BMI and DEE ($r = 0.27$), energy and DEE ($r = 0.38$), and energy and fats ($r = 0.50$). All correlations were positive, indicating that an increase in one variable promotes an increase in the other variable.

Principal component analysis (PCA) was used on the data of 288 workers after outlier exclusion.

In PCA, two groups or relationships between the variables already contain much of the statistical information of the dataset. The first principal component (PC1) explained 44.96% of the total data variance, and PC2 explained 30.93%, totaling 75.89%. The results obtained from the loadings showed that the following factors contributed most to the separation in decreasing order of variance: for PC1, the differences observed in LPA (0.6372) and DEE (0.6826); for PC2, age (0.6395) and BMI (0.6688).

PCA showed that most individuals with high energy expenditure and high energy and fat intakes were males, many of whom were production workers. Hence, the influence of gender and type of work on energy intake and expenditure is confirmed, a finding also corroborated by Allman-Farinelli et al. [26]. Moreover, males also had the highest BMI and weights, regardless of their work sectors.

It is also important to acknowledge some limitations of the current study, which included, for example, the lack of control over some variables as exclusion criteria, such as body weight or nutritional status, because they were precisely the objects of analysis. Other variables such as race, age limit, different work shifts, and differences between companies were also ignored.

4. Conclusions

The current study investigated the energy content and nutrient composition of the main meal (lunch) consumed at work, by associating these variables with the energy expenditure and anthropometric data of industrial workers.

The study results show a prevalence of overweight, especially in males regarding abdominal obesity, and that energy intake varies by gender and type of work.

The mean energy values of the meals provided by the studied companies met the estimated requirements. However, the energy content estimated for gender and work sector differ from the energy content recommended by the WFP.

The nutritional composition of the lunch consumed at work complies with the recommended values for carbohydrates, fats, and saturated fats. However, protein and sodium contents were high. Sodium intake was the main problem found for this meal as it far exceeded the recommended levels. The high availability of salads resulted in a high fiber content.

The study results provide valuable information for professionals who work in the workers' health field and intend to implement nutrition and physical activity programs that will not only impact the work environment but quality of life as a whole. For the food service managers, it was possible to confirm the importance of assessing the specific characteristics of the workers involved, taking into account the different energy requirements and nutritional statuses.

Other risk factors for chronic noncommunicable diseases, such as hypertension, should be investigated, considering the high sodium content of the meals provided by the studied companies. Analyzing the worker's behavior away from work to better understand free-time activities could better clarify the high incidence of overweight workers, including production workers. Investigation of the same variables in workers working night shifts and in companies not enrolled in the WFP could also constitute an important study focus.

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