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Effects of irregular-shift work and physical activity on cardiovascular risk factors in truck drivers

Efeitos do turno irregular de trabalho e atividade física nos fatores de risco cardiovasculares em motoristas de caminhão

ABSTRACT

OBJECTIVE: To analyze the putative effect of type of shift and its interaction with leisure-time physical activity on cardiovascular risk factors in truck drivers.

METHODS: A cross-sectional study was undertaken on 57 male truck drivers working at a transportation company, of whom 31 worked irregular shifts and 26 worked on the day-shift. Participants recorded their physical activity using the International Physical Activity Questionnaire along with measurements of blood pressure, body mass index and waist-hip ratio. Participants also provided a fasting blood sample for analysis of lipid-related outcomes. Data were analyzed using a factorial model which was covariate-controlled for age, smoking, work demand, control at work and social support.

RESULTS: Most of the irregular-shift and day-shift workers worked more than 8 hours per day (67.7% and 73.1%, respectively). The mean duration of experience working the irregular schedule was 15.7 years. Day-shift workers had never engaged in irregular-shift work and had been working as a truck driver for 10.8 years on average. The irregular-shift drivers had lower work demand but less control compared to day-shift drivers ($p < 0.05$). Moderately-active irregular-shift workers had higher systolic and diastolic arterial pressures (143.7 and 93.2 mmHg, respectively) than moderately-active day-shift workers (116 and 73.3 mmHg, respectively) ($p < 0.05$) as well as higher total cholesterol concentrations (232.1 and 145 mg/dl, respectively) ($p = 0.01$). Irrespective of their physical activity, irregular-shift drivers had higher total cholesterol and LDL-cholesterol concentrations (211.8 and 135.7 mg/dl, respectively) than day-shift workers (161.9 and 96.7 mg/dl, respectively (ANCOVA, $p < 0.05$).

CONCLUSIONS: Truck drivers are exposed to cardiovascular risk factors due to the characteristics of the job, such as high work demand, long working hours and time in this profession, regardless of shift type or leisure-time physical activity.

DESCRIPTORS: Transportation. Risk Factors. Cardiovascular Diseases. Sedentary Exercise. Motor Activity. Shift Work. Work Hours. Occupational Health.

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RESUMO

OBJETIVO: Analisar o efeito presumido do turno de trabalho e sua interação com a atividade física no tempo de lazer nos fatores de risco cardiovasculares em motoristas de caminhão.

MÉTODOS: Um estudo transversal foi conduzido com 57 motoristas de caminhão do sexo masculino que trabalhavam em uma transportadora de cargas, dos quais 31 trabalhavam no turno irregular e 26 no turno diurno. Os participantes registraram sua atividade física por meio do questionário Internacional de atividade física; foi aferida a pressão arterial, calculado o índice de massa corporal e a relação cintura-quadril; e também forneceram uma amostra de sangue dos motoristas de caminhão, em jejum, para análise dos fatores lipídicos. Os dados foram avaliados utilizando modelo fatorial controlado pelas covariáveis: idade, tabagismo, demanda de trabalho, controle no trabalho e apoio social.

RESULTADOS: A maioria dos motoristas do turno irregular e do turno diurno trabalhava mais de oito horas por dia (67,7% e 73,1%, respectivamente). O tempo de experiência no trabalho no horário irregular foi de 15,7 anos. Trabalhadores diurnos nunca trabalharam no turno irregular e trabalhavam como motoristas de caminhão em média havia 10,8 anos. Os motoristas do turno irregular apresentaram menor demanda e controle no trabalho comparados aos motoristas do turno diurno ($p < 0,05$). Os motoristas do turno irregular, moderadamente ativos, apresentaram maiores pressões arteriais sistólica e diastólica (143,7 mmHg e 93,2 mmHg, respectivamente) do que os motoristas diurnos, moderadamente ativos (116 mmHg e 73,3 mmHg, respectivamente) ($p < 0,05$), assim como maior concentração de colesterol total que os motoristas diurnos moderadamente ativos (232,1 mg/dl e 145 mg/dl, respectivamente) ($p = 0,01$). Independentemente da prática de atividade física, motoristas irregulares apresentaram concentrações mais elevadas de colesterol total e LDL-colesterol (211,8 mg/dl e 135,7 mg/dl, respectivamente) do que os diurnos (161,9 mg/dl e 96,7 mg/dl, respectivamente) (ANCOVA, $p < 0,05$).

CONCLUSÕES: Motoristas de caminhão são expostos a fatores de risco cardiovasculares devido às características próprias de seu trabalho, com grande demanda, extensa jornada e tempo de trabalho na profissão, independentemente do turno de trabalho e da atividade física no tempo de lazer.

DESCRITORES: Transportes. Fatores de Risco. Doenças Cardiovasculares. Exercício. Atividade Motora. Trabalho em Turnos. Jornada de Trabalho. Saúde do Trabalhador.

INTRODUCTION

Night and shift-work have negative effects on health outcomes such as sleep quality, certain types of cancer, obesity, diabetes mellitus, gastrointestinal and mental health problems, female reproductive system disorders, metabolic disorders and cardiovascular diseases.[2,6,14] Boggild & Knutsson[4] reported that shift-workers have a 40% higher risk of cardiovascular disease compared with day-shift workers.

Circadian misalignment, caused by the reversal of working time, sleep and timing of meals, explains the association between shift work and cardiovascular disease.[14,15] Other factors may be related to this association, such as changes in meal content, social life, and social support at work. Lifestyle changes may also be involved such as smoking, low levels of physical activity and alcohol consumption.[3,4] In spite of over 20 years of research into the association between shift work and cardiovascular diseases, the underlying mechanisms for this link remain unclear. Metabolic disorders, sleep deprivation and stress are also associated with cardiovascular diseases.[4,6] The

contribution of each of the factors outlined should be further investigated.[2,11,14]

Truck drivers work at irregular times to accomplish their tasks, which may lead to sedentarism and other unhealthy habits.[18,19] Most studies available have employed only a single question to measure physical activity among shift workers. Such simplistic measurements fail to account for the complexities of the broad range of leisure-time physical activities, thus rendering conclusions on the relative contribution of this factor unclear.[2]

Considering the above-mentioned potential risk factors for cardiovascular diseases, and the lack of studies with reliable physical activity measurements, we aimed to analyze the putative effect of type of shift and its interaction with leisure-time physical activity on cardiovascular risk factors in truck drivers.

METHODS

A cross-sectional study was undertaken within a transportation company in Sao Paulo, Southeastern Brazil, between April and July 2009. The study population comprised 101 professional truck drivers, which included all workers at the company. Forty-four workers who had either acute or chronic active disease, had undergone some form of medical surgery in the last 12 months, took medication on a daily basis, had no formal contract with the company and/or who had other paid employment were excluded from the study. Workers not presenting these exclusion criteria were invited to participate in the next phase of the study which entailed completing questionnaires and having physiological parameters measured (n = 57).

A *t*-test comparison of excluded and selected participants revealed no statistically significant differences between the two groups (n = 44 *versus* n = 57) in relation to age or body mass index (BMI) ($p > 0.05$).

The truck drivers were classified according to their working hours:

- Irregular-shift: work was undertaken predominantly at night. Irregular-shift workers typically got to work at 20:30 h, waited for the truck to be loaded and started driving at around 22:30 h. Drivers finished duty in the morning at around 08:00 h although the exact time was unpredictable, depending on the distance between cities as well as traffic congestion. The irregular-shift workers sometimes worked morning or afternoon shifts in the same working week. These drivers also performed cargo transportation between the city of Sao Paulo (carrier branch) and different cities throughout Brazil (long-haul drivers).
- Day-shift: the working day was from 08:00 h to 18:00 h, with a two-hour lunch break. The drivers on the day-shift transported goods within the metropolitan area of Sao Paulo (short-haul drivers).

The working week was from Monday to Friday and occasionally included Saturday, according to work demands, in both short- and long-haul groups.

The truck drivers completed a self-administered questionnaire about socio-demographic factors (age, marital status, education, and family income), work (type of shift, length of working day, time in the profession), health and lifestyle (smoking, physical activity).

Drivers completed the International Physical Activity Questionnaire (IPAQ – long version), translated into Portuguese by Matsudo et al[16] for physical activity assessment. The long version of the IPAQ contains 27 questions related to physical activities performed in a typical week, with vigorous, moderate and mild intensities divided into four domains of physical activity (work-related physical activity, transport-related physical activity, domestic and gardening (yard) activities and leisure-time physical activity). Transport-related and leisure-time physical activity domains were used to categorize the level of physical activity along with established recommendations by the World Health Organization (WHO).[10] Participants were classified as being physically active if they performed at least 150 min of physical activity per week for transport, leisure-time or walking for transport or leisure. Participants who undertook 10 to 149 min of physical activity per week were classified as moderately active, while those practicing < 10 min per week were classified as insufficiently active.

Participants completed the Portuguese short version[1] of the job content questionnaire.[12] This questionnaire is composed of 17 questions, subdivided into three scales: six questions on job control (e.g., autonomy at work); six questions on social support (e.g., hostile supervisor and co-worker relations), with scores on both scales ranging from 6 to 24; and five questions on job demands (e.g., time pressure to do the job) scored from 5 to 20. High job demand, low job control and low social support were defined by median scores set at thresholds of 16, 14 and 18, respectively.

The workers were weighed on a calibrated analogue scale with a capacity of 150 kg and accurate to the nearest 100 g. Subjects were weighed barefoot and without heavy winter clothes; their pockets were emptied to ensure accuracy of body weight measurements. The height of each worker was measured by a wall-mounted stadiometer without baseboard. Workers were asked to stand up straight against the wall (heels, calves, hips, shoulders, and head touching the wall), with feet close together and head on the Frankfurt ground plane while looking straight ahead. The BMI was calculated and compared with the reference values established by the WHO, classified as

normal (18 to 24.9 k/m^2), overweight (25 to 29.9 k/m^2) and obese (≥ 30 k/m^2).[25]

Waist (between top edge of iliac crest and 12th rib – medial portion) and hip (at maximum extension of buttocks on anterior-posterior and lateral plane) circumferences were measured using a flexible anthropometric tape model Gulick brand Mabis with scale increments of 0.1 cm. Abdominal and hip circumferences were used to calculate waist-hip ratio (WHR).

Participants had resting blood pressure and heart rate measured three times at two-minute intervals. The mean value of these three measures was used for data analysis.

A blood sample was obtained after 12-hour fasting to determine physiological measures. Data were always obtained on Mondays at approximately 07:00 h. All drivers were instructed to rest at night-time, avoid exercise and refrain from drinking alcohol during the weekend prior to data collection.

Fasting blood samples were collected from the antecubital vein by a trained technician. The blood samples were placed in EDTA tubes, centrifuged for 15' at 3,500 rpm and immediately stored at -20°C. The blood samples were analyzed for plasma glucose, total cholesterol LDL-cholesterol, VLDL-cholesterol, HDL-cholesterol and triglycerides (enzymatic colorimetric method CHOP-PAP).

Serum levels were evaluated against the criteria of the European Society of Cardiology.[8] According to these criteria, risk factors for cardiovascular diseases are classified as follows: systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg, total cholesterol ≥ 190 mg/dl, LDL-cholesterol ≥ 115 mg/dl, glycemia ≥ 110 mg/dl, triglycerides ≥ 150 mg/dl and HDL-cholesterol < 40 mg/dl. Although the concentration of VLDL-cholesterol is not included as a criterion of the European Society of Cardiology,[8] it has been used as a predictor for cardiovascular diseases (values above ≥ 30 mg/dl)[9] and this cut-off was therefore adopted in this study.

The Chi-square test was applied to compare proportions of socio-demographic, work conditions, lifestyle and cardiovascular risk factors between day and irregular-shift workers. Analysis of covariance (ANCOVA) was used to analyze the putative effect of type of shift, and its interaction with leisure-time physical activity, on cardiovascular risk factors (anthropometric and physiological measures). Other variables recognized as confounding factors were used as covariates (age, smoking, job demands, job control and social support at work).[13] LSD multiple comparisons were selected to follow-up significant F-values.

All tests were considered statistically significant when $p < 0.05$. All data analysis was carried out with SPSS, version 17.0 and Stata, version 9.1 software packages.

The study was approved by the Research Ethics Committee of the *Faculdade de Saúde Pública, Universidade de São Paulo* (Protocol nº 1921) and in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all participants.

RESULTS

The average age of drivers surveyed was 39.8 years old (SD = 6.6 years) and ages ranged from 29.1 to 56.1. A large proportion of drivers were married or living with a partner (90.0%), had completed primary school (54.0%), and were the sole earners(58.0%).

Most irregular-shift and day-shift workers worked more than 8 hours per day (67.7% and 73.1%, respectively). The mean duration of experience working the irregular schedule was 15.7 years. Day-shift workers had never engaged in irregular-shift work and had been working as a truck driver for 10.8 years on average.

The percentage of truck drivers who smoke was low, with a slightly higher prevalence among irregular-shift workers, a difference not reaching statistical significance (Table 1).

Table 1. Sociodemographics, working conditions, and lifestyle of the study population. Sao Paulo, Southeastern Brazil, 2009.

Variables	Day-shift workers		Irregular-shift workers		χ^2
	n	%	n	%	p
Smoking					0.62[a]
No	23	88.5	26	83.9	
Yes	3	11.5	5	16.1	
Work demand					< 0.01
Low	9	34.6	24	77.4	
High	17	65.4	7	22.6	
Control at work					0.03
High	16	61.5	10	32.3	
Low	10	38.5	21	67.7	
Social support					0.83
High	11	42.3	14	45.2	
Low	15	57.7	17	54.8	
Leisure-time physical activity					0.01 [a]
Insufficiently active (< 10 min)	23	88.5	15	48.4	
Moderately active (10 to 149 min)	2	7.7	8	25.8	
Physically active (≥150 min)	1	3.8	8	25.8	

[a] Fisher's exact test

Day-shift workers had higher job demands than irregular-shift workers; however, irregular-shift workers had less job control compared to day-shift workers (Table 1). Social support was similar in both groups.

Irregular-shift workers were more physically active and moderately active during leisure time compared to day-shift workers (Table 1).

Irregular-shift workers were more active at moderate and vigorous physical activities than day-shift workers, although this difference was only significant for moderate activities ($p < 0.05$).

Day and irregular-shift workers had similar proportions of most risk factors for developing cardiovascular diseases. However, the prevalence of high levels of total cholesterol and LDL-cholesterol and high waist-hip ratio were higher among irregular-shift workers than day-shift workers (Table 2).

Although the proportion of BMI was not statistically different between groups, irregular-shift workers were 2 kg/m^2 higher than day-shift workers (28.4 ± 3.8 kg/m^2 *vs* 26.4 ± 3.6 kg/m^2, $p = 0.04$) in terms of BMI.

No putative effect of type of shift on mean arterial pressure (MAP), rate-pressure product (RPP), pulse pressure, VLDL-cholesterol, HDL-cholesterol, triglycerides or glycemia was found. No interaction effect between type of shift and leisure-time physical activity on these factors was observed ($p > 0.05$).

ANCOVA showed an interactive effect of shift and leisure-time physical activity on systolic blood pressure, diastolic blood pressure, total cholesterol, waist circumference, waist-hip ratio and body mass index. A significant isolated effect of type of shift on total cholesterol and LDL-cholesterol was observed where irregular-shift workers had higher total cholesterol and LDL-cholesterol levels than day-shift workers (Figure 1).

DISCUSSION

Truck drivers present risk factors for developing cardiovascular diseases. Although there was an interactive effect between leisure-time physical activity and type of shift, the risk factors of cardiovascular diseases seem to be independent of type of shift or practice of physical activity. The truck drivers showed high systolic and diastolic blood pressures, above-normal anthropometric characteristics and high levels of total cholesterol.

No differences were found between groups for sedentary workers. However, there was a significant difference between the groups on the moderately active category. The irregular-shift workers showed a significantly higher risk for cardiovascular diseases

Table 2. Cardiovascular risk factors of the study population. Sao Paulo, Southeastern Brazil, 2009.

Variables	Day-shift workers		Irregular-shift workers		χ^2
	n	%	n	%	p
Systolic blood pressure					0.91
< 140 mmHg	15	68.2	20	66.7	
≥ 140 mmHg	7	31.8	10	33.3	
Diastolic blood pressure					0.76
< 90 mmHg	13	59.1	19	63.3	
≥ 90 mmHg	9	40.9	11	36.7	
Mean arterial pressure – MAP					0.64
≤ 110 mmHg	18	72.0	24	77.4	
> 110 mmHg	7	28.0	7	22.6	
Rate-pressure product – RPP					0.47[a]
≤ 12,000	22	88.0	29	93.6	
> 12,000	3	12.0	2	6.5	
Pulse pressure (mmHg)					0.58
≤ 50 mmHg	16	64.0	22	71.0	
> 50 mmHg	9	36.0	9	29.0	
Cholesterol					< 0.01
< 190 mg/dl	18	78.3	9	30.0	
≥ 190 mg/dl	5	21.7	21	70.0	
LDL-Cholesterol					0.02
< 115 mg/dl	15	65.2	10	33.3	
≥ 115 mg/dl	8	34.8	20	66.7	

Continue

Continuation

VLDL-Cholesterol					0.15
< 30 mg/dl	16	69.6	15	50.0	
≥ 30 mg/dl	7	30.4	15	50.0	
HDL-Cholesterol					0.07
≥ 40 mg/dl	15	65.2	12	40.0	
< 40 mg/dl	8	34.8	18	60.0	
Triglycerides					0.15
< 150 mg/dl	16	69.6	15	50.0	
≥ 150 mg/dl	7	30.4	15	50.0	
Glycemia					0.78[a]
< 110 mg/dl	21	91.3	28	93.3	
≥ 110 mg/dl	2	8.7	2	6.7	
Waist circumference					0.03
< 90 cm	15	57.7	9	29.0	
≥ 90 cm	11	42.3	22	71.0	
Waist-hip ratio					0.06
Low risk (< 90 cm)	14	53.9	9	29.0	
High risk (≥ 90 cm)	12	46.1	22	71.0	
Body mass index					0.17[a]
Normal (18 to 24.9 k/m^2)	13	50.0	8	25.8	
Overweight (25 to 29.9 k/m^2)	9	34.6	16	51.6	
Obese (≥ 30 k/m^2)	4	15.4	7	22.6	

[a] Fisher's exact test

than day-workers within this category. A previous study suggested that even moderate physical activity could promote better health status among irregular-shift workers.[18] No significant difference was noted for physically active individuals. This might be due to the sample size, i.e., only one day-shift worker was classified as physically active. The sample size in this category represents a limitation of this study. On the other hand, the results observed regarding the moderately active category were significant, even in this small sample.

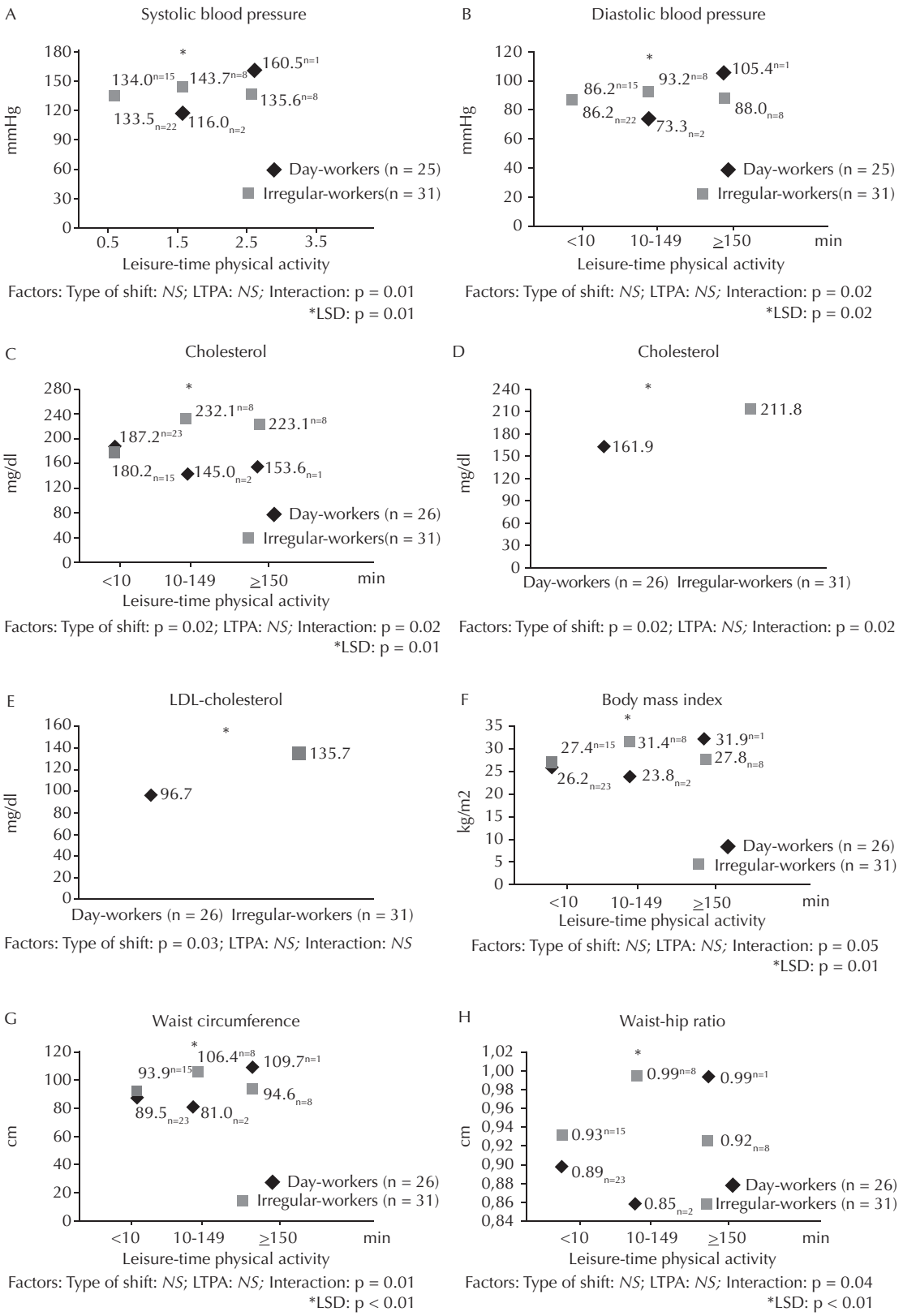
These results showed little or no positive effect of physical activity toward reducing risk factors for cardiovascular disease. This professional category could be considered a risk factor for health *per se*. This category has a high prevalence of sedentary lifestyle, poor eating habits and obesity; most are smokers and have high blood pressure.[19,22] These characteristics place this population at risk of a number of diseases such as cardiovascular, gastrointestinal and metabolic diseases. However, few studies have investigated the health status of professional drivers.[15] Working irregular shifts contributes to unhealthy eating habits,[21] such as high calorie intake during nighttime meals.

In a cross-sectional survey involving 92 truck drivers, Whitfield-Jacobson et al[24] found that 85.9% of drivers were overweight and 56.5% were obese. Moreno et al[19] found 28.3% obesity in a study of 4,878 drivers. Both these studies showed a high percentage of overweight, indicating that the job is associated with obesity.

Even truck drivers working day shifts may have a life style that can contribute to obesity. Irregular-shift workers are at higher risk of obesity than day-workers, although day-workers also have long working hours and this could lead to problems with inadequate diet and a sedentary life style.

This study was also conducted with truck drivers working irregular shifts, including night work. Several studies have found changes in lipid profile among shift workers. However, Atkinson et al[2] posit that these results are not entirely consistent on which non-specific lipid concentrations are altered. Ha and Park[11] and Biggi[3] also found that shift-workers have higher cholesterol levels than day-shift workers, whereas Ghiasvand et al[7] found elevated levels of LDL-cholesterol. Irregular-shift workers are at increased risk of developing cardiovascular diseases compared to day-shift workers.[11,14]

Although we found day-workers were at risk for developing cardiovascular disease, our results showed an isolated effect of shift type on serum total cholesterol and LDL-cholesterol concentrations, with irregular-shift workers exhibiting higher levels than day-shift workers.



Covariates: Age, Smoking, Work demands, Control at work and Social support.
*Post-hoc values for each risk factor statistically significant for both groups.

Figure. Cardiovascular risk factors according to interaction of shift and leisure-time, physical activity (A, B, C, F, G and H) and according to shift (D and E). Sao Paulo, Southeastern Brazil, 2009.

The elevated sera lipid concentrations seen among irregular-shift drivers may be associated to the timing of meals, typically consumed at nighttime and during the early hours. Greater nighttime carbohydrate consumption might also explain increased LDL-cholesterol levels.[17] A change in the timing of meals can also promote alterations in enzyme activity of certain plasma hormones affecting gastric emptying, such as insulin and glucagon, as well as in some metabolites such as ketone bodies, cholesterol and triglcerides.[17]

Shift workers are not totally adapted to the imposed social timing, including work timing, which may lead to an increased incidence of cardiovascular diseases. Atkinson et al[2] and Lowden et al[14] have suggested that cardiovascular diseases may be mediated by metabolic responses to inadequate nocturnal meals.

The percentage of smokers among respondents was low and no statistically significant difference in smoking status was found between the two shifts. Some studies have found an association between shift work and smoking,[3,20] while others have refuted this hypothesis.[6,11] Although some studies regard smoking as a risk factor for cardiovascular diseases,[5,22] smoking was deemed a confounding factor in the analysis of covariance in this study, since it is not known if this habit started before or after working irregular-shifts. Our decision is supported by the study of Nabe-Nielsen et al[20] advocating that smoking should not be treated only as a mediator of shift-work and cardiovascular diseases, but also as a confounding factor.

We found greater work demands among the day-shift workers compared to irregular-shift workers, whereas job control was lower among irregular-shift workers. These variables were considered confounding factors, since both are occupational stressors[23] and exert a negative effect on physical health, such as cardiovascular function.[26]

Since this was a cross-sectional study, there is no evidence of cause-effect available for the variables studied. On the other hand, this was a field study involving two populations within the same company and constitutes the first study to evaluate the effects of irregular-shifts and leisure-time physical activity on cardiovascular risk factors in truck drivers.

In conclusion, the nature of the job as a driver seems to be conducive to developing cardiovascular risk factors, an effect which appears to be independent of shift type or level of physical activity.

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