Irregular working times and metabolic disorders among truck drivers: a review

Elaine C Marquezéa,*, Melissa A Ulhôa, Claudia R C Moreno

*Environmental Health Department, School of Public Health, University of São Paulo, Dr.Arnaldo Av, 715 Zip Code 01246-904, São Paulo, Brazil.

Abstract. A number of studies to better understand the complex physiological mechanism involved in regulating body weight have been conducted. More specifically, the hormones related to appetite, leptin and ghrelin, and their association to obesity have been a focus of investigation. Circadian patterns of these hormones are a new target of research. The behaviour of these hormones in individuals subject to atypical working times such as shiftwork remains unclear. Shiftwork is characterized by changes in biological rhythms and cumulative circadian phase changes, being associated with high rates of obesity and metabolic syndrome. Truck drivers, who work irregular shifts, frequently present a high prevalence of obesity, which might be associated with work-related factors and/or lifestyle. In this context, the aim of this paper was to discuss the relationship of body mass index, appetite-related hormones and sleep characteristics in truck drivers who work irregular shifts compared with day workers.

Keywords: Obesity, leptin, ghrelin, circadian rhythm, truck drivers.

1. Introduction

Driven by the current obesity epidemic, a number of studies to better understand the complex physiological mechanism involved in the regulation of body weight have been conducted. During the last two decades, appetite-related hormones, especially leptin and ghrelin, have been extensively studied in a bid to describe the pathophysiology of obesity. Both ghrelin and leptin act on the hypothalamus, controlling energy balance by increasing and decreasing food intake, respectively [44,119]. Thus, these hormones are considered essential elements in energy metabolism, but their mechanism of action remains unclear [68,89].

Energy metabolism becomes more complicated when circadian misalignment occurs. Notably, many biological processes are regulated by the circadian clock while shiftwork is usually associated with chronic desynchronization between internal and external timing [108]. Folkard [33] posited that few workers have fixed-night complete circadian adjustment (<3%), which reveals that the vast majority suffer from circadian misalignment.

In addition, shift work is associated to a high prevalence of a number of diseases including obesity as well as metabolic and sleep disorders [16]. In this context, truck drivers are subject to working irregular shifts to deliver goods on time and consequently are exposed to high risk for these diseases.

Thus, the aim of the present study was to shed light on this discussion. First, the paper covers the appetite-related hormones and obesity. Subsequently, topics on shiftwork and metabolic disorders in connection to truck drivers are addressed.

2. Leptin

Leptin is an anorectic peptide hormone comprising 167 amino acids, discovered in 1994 by Zhang et al [122]. The name is derived from the Greek word Leptos, which means Thin [4,5].

Leptin is synthesized primarily in adipose tissue [62], and is proportionately higher in subcutaneous...
tissue compared to visceral tissue [13,65]. Leptin is also synthesized in the placenta, gastrointestinal tract and mammary glands, as well as heart and bone cartilage [45,82,88,99].

Its main function is metabolic homeostasis, signaling nutritional status to the central nervous system and also to peripheral organs [1,37,38,56,61].

The secretion of leptin is pulsatile and circadian; with an average of 32 pulses per day with each pulse lasting about 30 minutes [3,25,37,40,56,67,68,88,72,94,96].

The leptin peak occurs at night and the nadir during the day [25]; regarding daily meals, leptin peaks post-prandially [58]. Larsson et al [62] stated that the concentration of leptin is more related to quantity of food intake than to diet content.

The serum concentration of leptin is partially related to the amount of adipose tissue [34,64], since its levels differ in individuals with the same body mass index [54]. There is also an effect of sex on its concentration. The same amount of body fat in women secretes up to twice the amount of leptin compared to men [36,65].

Several parameters can change leptin concentration. In the event of circadian misalignment, a decrease in leptin levels can be observed [26,94]. By contrast, high levels of triglycerides, insulin and cortisol increase its concentration [21,49,60,76].

At the time of its discovery, it was also postulated that leptin deficiency could lead to obesity. However, it was later observed that most obese individuals have high leptin levels [28,40,66,74,105]. Estimates show that the concentration of leptin in obese individuals is about five-fold that of normal-weight subjects. Less than 5% of obese individuals have low leptin concentrations [14].

A high concentration of leptin is a condition known as hyperleptinemia, and is due to changes in leptin receptors [5,9,14,61] and/or deficiency in leptin transport in cerebrospinal fluid [9,14,61]. Hyperleptinemia is rarely due to genetic mutations [9,11,104].

Somoza et al [100] showed that obesity caused by diet induces hyperleptinemia since signalling of the leptin’s receptor is impaired in the hypothalamus.

Weight loss may cause a decrease in leptin levels, suggesting that the individual is experiencing a drop in energy reserves. By contrast, weight gain may increase leptin levels, albeit not as significantly. In other words, gains in metabolic reserve might not necessarily result in an abrupt increase on leptin levels [12,46,71].

Regarding the effect of exercise on leptin levels, there is no consensus in the literature, since some studies have found no changes in levels [84,106,116,121,123] whereas others report a reduction [53,81,83,90,110]. A few studies have described increased levels of circulating leptin [21,60]. Morris et al [76] showed increased leptin in a laboratory study with simulated night work proceeded by exercise.

Langenberg et al [61] pointed out that population-based studies are needed to better understand the association between leptin and weight changes.

3. Ghrelin

Ghrelin was discovered later than leptin, in 1999, by Kojima et al [57] and is an orexigenic peptide hormone comprising 28 amino acids [80,105,113]. The term ghrelin is based on the word Ghre, in the Proto-Indo-European language, meaning Grow, plus the suffix Relin as in the Release [120,74].

The main organ synthesizing ghrelin is the stomach [41,78,95,113,120]. Smaller amounts of ghrelin are produced in the intestine, pancreas, kidneys, immune system, placenta, testicles, lung, pituitary and hypothalamus [57].

The most important function of ghrelin is the stimulation of appetite, being an endogenous regulator of energy homeostasis [39,56,78,113,120]. According to van der Lely et al [113], ghrelin also influences behaviour, control of gastric motility and acid secretion. Ghrelin participates in the modulation of pancreatic exocrine and endocrine function. It also has an effect on glucose metabolism, cardiac performance and vascular resistance, stimulation of the secretion of GH, PRL (prolactin), ACTH and AVP (arginine vasopressin), on modulation of the proliferation of neoplastic cells and influences the immune system [113].

Ghrelin also acts in the decline of fat oxidation [112] and in the suppression of core temperature [63]. Recently, ghrelin has been identified as a factor for promoting sleep in humans and also as a mediator in neuroendocrine and behavioural responses to stressors [115]. Thus, the stomach may play an endocrine role, not only in stimulating appetite, but also in the induction of anxiety [2,41].

Akin to leptin, ghrelin also has a circadian pattern and fluctuates throughout the day, peaking post-prandially and dipping post-prandially, supporting the concept of endogenous ghrelin as a regulator of energy homeostasis [3,8,18,19,20,41,52,61,78,113].
Cummings et al. [18] suggested that meals can be consumed voluntarily in the absence of environmental clues (time of day) due to ghrelin rhythms. In contrast to leptin levels, ghrelin levels are lower in obese compared to normal-weight subjects [39,41,73,91,105]. The mechanisms underlying this association remain unclear, although some authors have suggested several possible explanations. Van der Lely et al. [113], for instance, pointed out a similarity between this process and hyperleptinemia. Gale et al. [39] suggested that the high food intake among the obese leads to decreased ghrelin concentrations.

Ghrelin concentrations are also related to the sleep/wake cycle [3,111]. Some studies have shown that sleep deprivation and alterations in sleep schedules may influence ghrelin levels [27,98]. Spiegel et al. [102] found that restricting sleep to four hours for only two nights led to increased secretion of ghrelin and decreased leptin. Gauralet et al. [40] also showed the same results.

High ghrelin levels may lead to increased caloric intake and consequently to obesity. Obesity, in turn, can reduce ghrelin levels [40,41,74,101,105]. On the other hand, weight loss due to physical activity leads to increased ghrelin levels [35].

Morris et al. [76] found increased ghrelin levels after nocturnal physical exercise during simulated night work. However, levels are suppressed after diurnal exercise [6,7]. These data indicate that the time of day is an important factor to consider in the relationship between exercise and appetite-related hormones.

Langenberg et al. [61] concluded that longitudinal studies are needed to determine whether ghrelin is involved in the etiology of human obesity, since it is not yet clear if leptin and ghrelin influence long-term changes in weight and body mass index.

4. Obesity and shiftwork

Most of the world’s population is suffering negative health repercussions as a result of industrialization and computerization. One of these problems is a sedentary lifestyle, which contributes to overweight and obesity [10].

Obesity is a multifactorial syndrome (genetic, neuroendocrine, cultural and environmental), where disorders of energy balance due to desynchronization with temporal organization may play a key biological role in its genesis [29]. Gauralet et al. [40] called obesity a chronobiological disease.

There are around 1.6 billion overweight and 400 million obese individuals worldwide [52]. Brazil ranks high in the list of countries for obesity prevalence, and it has been estimated that by 2025 it will be fifth in the world rankings [92]. Within a few decades, obesity will overtake tobacco as the greatest health risk [39].

In industrialized countries, obesity and metabolic syndrome are major causes of morbidity and mortality, where industrialization is a major predisposing factor for positive energy balance [29].

Besides the well-known risk factors such as poor diet and sedentary lifestyle, shiftwork has been widely associated with weight gain [109]. In parallel, shorter sleep times and longer working hours have resulted from economic competitiveness and globalization [10].

Epidemiological studies have indicated a causal link among shorter sleep times, shiftwork and metabolic diseases [118].

Garaulet et al. [40] reported a 1.5 h decrease in sleep duration over the last century, with subsequent weight gain. However, it is noteworthy that circadian desynchronization is triggered not only by short sleep duration, but also by change in the timing of sleep, a factor favouring the development of obesity [29].

Ostry et al. [85] also showed a positive association between high work load, long working hours and body mass index. This confirms the influence of work organizational factors on the prevalence of overweight and obesity [30]. These aspects will be discussed later in the current paper.

5. Shiftwork and metabolic disorders

The association between shiftwork and obesity is likely explained by behavioural disruption and biological factors involved in energy balance, and desynchronization of biological rhythms [3,76,108]. It should be highlighted that shift and night workers represent about 20% of the workforce of the European community [3] and also of the United States [42]. Fischer [32] estimated that in Brazil, this percentage attains 15% of the workforce.

Since shiftwork is an independent risk factor for weight gain [17], these data demonstrate the relevance of this subject.

Aspects such as time of day, frequency and regularity of meals, and also the desynchronization of circadian rhythms, can affect energy metabolism and body weight regulation [29]. While there is a de-
crease in hunger during the night when satiety requires the intake of smaller portions of food [69], most food consumption among shift workers occurs at night. This is harmful to energy balance [47] since postprandial thermogenesis is lower [93] and the body is not designed for energy consumption at night [3].

Both content and quantity of food consumed can be influenced by shiftwork, as well as the disruption of traditional meals at home. Some studies have shown that shiftwork has little influence on eating habits [31] whereas other authors have shown that diet content is better among shift workers than day workers [17].

De Assis et al [22] found no difference in total energy intake and nutrient composition. Thus, it appears that the amount of energy intake is not greatly affected by shiftwork [87]. In contrast, Sudo and Ohtsuka [107] found a lower caloric intake among shift workers compared to day workers, along with lower intake of protein, fat and carbohydrate. These differences were attributed to a lower frequency of meals during the day and to the low nutrient composition of night-time meals among shift workers.

Indeed, the frequency of diurnal meals is usually reduced, whereas snack consumption during night shifts, with higher energy intake, is increased [3]. Further studies investigating chronobiological aspects of feeding behaviour are warranted, since night-time feeding also affects circadian rhythms [77]. Another point to be considered is that the eating habits of shift workers are specific to the type of work, work environment and food supply. The type and frequency of meals are influenced more by time limitations than by feelings of hunger [114].

Another important aspect is physical activity since sedentary habits are associated with a high prevalence of obesity. In general, shift work decreases opportunities for doing exercise. However there is no scientific evidence that exercise can reduce body mass index among shift workers [3].

Finally, the partial sleep deprivation in shift workers, besides problems of circadian desynchronization, with short sleeping times to increase opportunities and time for eating, leads to increased food intake. There is also a change in body thermoregulation and consequent decrease in expended energy, in turn leading to increased body weight [40].

Metabolic changes include elevated levels of cholesterol, triglycerides, insulin and glucose [15,30,42,50,51,79,118]. Shift work may also lead to lower levels of HDL and leptin, insulin resistance, higher waist-hip circumference, higher waist circumference, higher systolic blood pressure and obesity [3,15,23,24,30,42,48,50,51,55,59,70,77,79,86,94,96,118].

Studies have highlighted that blood glucose levels are lower in shift workers than in day workers [30]. Nevertheless, other studies failed to find differences between these groups [42,50,51]. In view of these findings, it appears that shiftwork has a strong association with metabolic disorders.

6. Truck drivers

Truck drivers work irregular hours due to workload demands. Long working hours, including night work, is the main characteristic of the job. Working at night may contribute to chronic sleep deprivation and obesity, which are commonly observed among these professionals [75].

Generally, truck drivers have a high prevalence of sedentary lifestyle, poor eating habits and obesity. Most are smokers and have high blood pressure [43,75]. These characteristics put this population at risk for a number of diseases such as cardiovascular, gastrointestinal and metabolic diseases. However, few studies have investigated the health status of professional drivers.

Regarding public transport drivers, Siedlecki [97] stated that several studies show that these professionals have a high risk for cardiovascular disease. Obesity, sedentary lifestyle and smoking number among the main risk factors for cardiovascular disease. Stoohs et al [103] showed a 16% prevalence of hypertension among truck drivers. It is important to note the high percentage of these individuals who were unaware they had the disease (75%).

In a cross-sectional survey involving 92 truck drivers, Whitfield-Jacobson et al [117] found that 85.9% of drivers were overweight and 56.5% were obese. By contrast, Moreno et al [75] found a lower prevalence (28.3%) of obese in a study of 4,878 drivers. In fact, both studies showed a high percentage, indicating that this job is associated with obesity.

The irregular working hours is one possible explanation for the high number of obese among these workers. Irregular working times contribute to unhealthy dietary habits [87], as well as fewer opportunities for regular physical activity.

Whitfield-Jacobson et al [117] suggested that the implementation of wellness programs for drivers could prevent several diseases, such as obesity. These programs could include educational activities and
support as well as provide nutritional guidance to truck-stop restaurants. The development of such prevention programs is justified not only for economic reasons, but mainly for the safety of drivers who travel the highways [97].

In summary, the category of truck drivers seems to have a high prevalence of obesity, which could be associated with factors such as shiftwork, lifestyle and diet habits. We emphasize the need for studies with greater control of variables to investigate the relationships among obesity, sleep and work organization.

7. Final remarks

The explanation for the negative effects of shiftwork on health is both complicated and complex. Moreover, its impact on metabolic risk factors is not yet completely understood. However, many studies indicate that shiftwork has a substantial negative influence on physiological functions, mediated by circadian misalignment.

As outlined above, epidemiological evidence shows that shiftwork, specifically the work schedule of truck drivers, is associated with increased rates of obesity and metabolic disorders. This association has been explained by inadequate work organization, which changes sleeping and eating times. Consequently, the majority of truck drivers suffer from circadian misalignment. There is an imbalance between energy consumption and energy expenditure in shift workers, probably due to the desynchronization of appetite-related hormones. In addition, constant changes in meal times can also affect this internal mechanism.

Despite the high prevalence of obesity among shift workers, its underlying mechanisms remain unclear. In general, factors such as unhealthy lifestyle, high frequency of snacks, and short sleep times, may contribute to circadian desynchronization.

Specifically for truck drivers, irregular working times seem to be a decisive factor in the prevalence of obesity. We emphasize that irregular working times not only reduce sleep duration, but also lead to a number of changes in truck drivers’ lives. Understanding the effects of these changes could provide key insights to the pathophysiology of obesity in this population.

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References


