Work organization, sleep and metabolic syndrome among long-haul truck drivers

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Lemke M, Apostolopoulos Y, Hege A, Wideman L and Sönmez S. 2017. Work organization, sleep and metabolic syndrome among long-haul truck drivers. *Occupational Medicine* 67(4): 274-281. PubMed PMCID: 28419354

Made available courtesy of Oxford University Press: https://doi.org/10.1093/occmed/kqx029

Abstract:

Background: The work organization of long-haul truck drivers in the USA contains factors that have been shown to degrade sleep. In combination, these factors generate elevated cardiometabolic risk by inducing components of the metabolic syndrome (MetS). However, the prevalence and severity of MetS and the degree to which such factors differentially influence MetS among these drivers are unknown.

Aims: To determine the prevalence and severity of MetS among US long-haul truck drivers and to determine the predictive value of demographic, work organization and sleep variables in MetS diagnosis and severity.

Methods: A non-experimental, descriptive, cross-sectional study, designed to collect survey, anthropometric and biometric data from US long-haul truck drivers. Descriptive analyses were performed for demographic, work organization, sleep and MetS measures. Logistic and linear regression analyses examined potential predictive relationships between demographic, work organization and sleep variables and MetS diagnosis and severity.

Results: The study population was 262. Nearly 60% of drivers met MetS diagnosis criteria. Over 80% had a waist circumference >102 cm, 50% had triglyceride levels of ≥150 mg/dl, 66% had an high-density lipoprotein of <40 mg/dl, 28% had a blood pressure of ≥135/80 mm Hg and 17% had a fasting glucose of ≥110 mg/dl. Driving experience and work day sleep quality were associated with MetS prevalence and severity.

Conclusions: The prevalence and severity of MetS among this sample of US long-haul truck drivers were high. Preventive efforts should focus on experienced drivers and work day sleep quality.

Keywords: Diabetes | driving | work environment | work-related cardiovascular diseases

Article:

Introduction

There are nearly 2 million heavy and tractor-trailer truck drivers in the USA, most of whom are considered long-haul truck drivers [1]. Long-haul truck drivers stay on the road for extended periods of time while enduring numerous risks endemic to the long-haul trucking profession [1,2]. These risks affect many entities beyond the drivers themselves, including transportation companies, health insurance companies and the public with whom they share the road [2]. The work organization of long-haul truck driving is defined by long work hours, shift work, irregular schedules, job strain, wage declines and lack of worksite resources [3–6]. These work organization characteristics have been shown to worsen sleep duration and quality among workers in various occupations, including long-haul truck driving [7–9]. Consequently, the transportation sector as a whole has a higher prevalence of personnel with insufficient sleep than other occupations [10].

Work organization and sleep factors contribute to elevated cardiometabolic disease (CMD) risk by inducing components of metabolic syndrome (MetS), which is defined as meeting three or more of the following five criteria: abdominal obesity, high triglycerides, low high-density lipoprotein (HDL) cholesterol, high blood pressure and high blood glucose [11]. MetS represents a cluster of clearly defined specific risk factors, which both independently and synergistically elevate CMD risk [12]. Workers in the 'transportation/material moving' sector, which includes long-haul truck drivers, are at the greatest risk for MetS due to work organization factors such as irregular scheduling and shiftwork, job strain and sleep issues [13]. However, the prevalence of MetS among US long-haul truck drivers, and the degree to which demographic, work organization and sleep factors differentially influence drivers' MetS, are unknown. Therefore, using survey, anthropometric and biometric data from a sample of US long-haul truck drivers, this study aimed to provide, for the first time, a comprehensive picture of the prevalence and severity of MetS and to determine the influence of demographic, work organization and sleep variables on MetS prevalence and severity.

Methods

The study procedures and cohort characteristics have been described in detail previously [3,8,14–16]. This study was approved by the Institutional Review Board (IRB) at the University of North Carolina at Greensboro. We employed a non-experimental, descriptive, cross-sectional design to collect survey and biometric data from US long-haul truck drivers at a large truckstop located in North Carolina. This location was considered representative of typical large US truckstops because of the volume of trucking activity at this site and the transient nature of the profession. We collected data on demographic, behavioural, workplace and work organization variables that could potentially be related to MetS, developing the Trucker Sleep Disorders Survey (TSLDS) using insights gained from other instruments, relevant literature and our previous work with US long-haul truck drivers [17,18]. Characteristics of this survey, including questions pertaining to subjects' demographic details, work organization and sleep quality and duration have been described in previous publications which used this dataset [3,8,14–16].

On collection blood samples were spun at 3000 rpm for 15 min and then transported on ice to the laboratory, where serum was divided into aliquots and stored at −80°C for future analysis. Blood samples were analysed in duplicate with appropriate quality controls at the University of North Carolina at Greensboro's Exercise Physiology Laboratory using commercially available ELISA systems and the EPOCH plate reader (BioTek, Winooski, VT). Lipid profiles were assayed using colorimetric reagents using protocols specified by the manufacturer (Wako USA, Richmond, VA). Glucose was assayed using a colorimetric assay (Kit #10009582; Caymen Chemical, Ann Arbor, MI). The range of assays were 2.5–25 mg/dl, and all serum samples were diluted 1:5 prior to analysis. Samples above the detection limit of 25 mg/dl were further diluted and re-analysed. Tolerance for duplicate sample variance was set at 15% and samples were re-analysed if the coefficient of variance for the duplicate was >15%.

We first performed descriptive analyses to assess for differences between participants who did not have blood taken versus those that did across demographic, work organization and sleep variables. This ensured that drivers declining to have blood taken were not doing so for a systematic reason, such as perceiving themselves as unhealthy and being wary of exposing this to the research team. We then performed descriptive analyses across MetS diagnostic criteria: abdominal obesity (waist circumference ≥102 cm), high triglycerides (≥150 mg/dl), low HDL cholesterol (<40 mg/dl), high blood pressure (≥130/85) and high glucose (≥100 mg/dl) [19]. Subjects with three or more of these characteristics were deemed to have MetS [11]. We also evaluated the distribution of MetS characteristics to ascertain the severity of symptoms in the sample. For multivariate analyses, we re-categorized the demographic, work organization and sleep variables based on our sample findings, the academic literature and clinical recommendations. Specifically, this included age (45 or younger, 46 or older), driving experience (≤10, 11–20, ≥21 years), race/ethnicity [White versus non-White (because we had very few subjects who were not White or African-American)], work hours (≤11 h daily versus more than 11 h daily, based on US Department of Transportation guidelines for commercial motor vehicle drivers), sleep quality (never or rarely = poor; almost always or always = good) and sleep duration (7–9 h = optimal; <7 or >9 h = too short or too long). We then conducted an ordinal logistic regression analysis to examine for possible predictive relationships between driving experience, work organ ization and sleep variables in relation to MetS diagnosis, while adjusting for age and race/ethnicity. Finally, we performed an ordinal logistic regression analysis to examine for possible predictive relationships with MetS severity, while again adjusting for age and race/ethnicity. We re-categorized the MetS characteristics according to the number of factors present (0–5). We controlled for the use of prescription medications in the descriptive and logistic regression analyses for MetS. All statistical analyses were conducted using SPSS 23.0 (IBM Corp., Armonk, NY).

Results

A total of 262 truck drivers participated: two were excluded from analyses due to missing data and 115 had blood samples taken. The mean age of the drivers was 46.6, with no statistically significant age difference between those giving a blood sample and those not doing so. The majority of the sample (57%) was White, with statistically significant differences in group proportions between those who gave a blood sample compared with those who did not ($P < 0.05$). Drivers reported an average of nearly 15 years' driving experience with no statistically significant difference between those who gave a blood sample and those who did not. The most common form of payment was 'by the mile', and drivers averaged 2813 miles of driving per week. Most of the drivers (83%) worked irregular schedules and >70% reported working >11 h daily. Sixty percentage of drivers reported taking prescribed medications, with statistically significant differences between those who gave blood compared with those who did not ($P < 0.05$). These demographic and work organization variables have been reported in previous publications based on this dataset [3,8,14–16]. Complete demographic and work organ ization characteristics are shown in Table 1.

Table 1. Demographic and work organization characteristics of total sample, no blood sample and blood sample subjects

	Total sample		**No blood sample given**		**Blood sample given**		
	Mean (SD)	***n*(%)**	**Mean (SD)**	***n*(%)**	**Mean (SD)**	***n* (%)**	***P*[a]**
Age	46.6 (10.5)		45.7 (11.1)		47.8 (9.7)		NS
Ethnicity							*
White		149 (57)		74 (51)		75 (65)	
Black/AA		84 (32)		56 (39)		28 (24)	
Hispanic		22 (8)		13 (9)		9 (8)	
Other		7 (3)		2 (1)		3 (3)	
Driving experience	14.9 (11.5)		15.4 (11.8)		14.4 (11.3)		NS
Compensation							NS
By the mile		183 (70)		103 (71)		80 (69)	
By the load		35 (14)		19 (13)		15 (13)	
% of revenue		38 (15)		21 (15)		18 (16)	
Other		4 (1)		2 (1)		2 (2)	
Driving miles per week							NS
<2500		66 (25)		31 (21)		35 (30)	
2500–3000		139 (54)		81 (56)		58 (51)	
>3000		55 (21)		33 (23)		22 (19)	
Daily work schedule							NS
Same every day		45 (17)		23 (16)		22 (19)	
Different every day		215 (83)		122 (84)		93 (81)	
Daily work hours							NS
≤11		77 (30)		43 (30)		34 (30)	
>11		182 (70)		101 (70)		81 (70)	
Prescribed medication (any)							*
Yes		156 (60)		79 (54)		77(67)	
Blood pressure		65 (25)		38 (26)		27 (24)	
Cardiovascular		34 (13)		19 (13)		15 (13)	

	Total sample		No blood sample given		Blood sample given		
	Mean (SD)	***n*(%)**	**Mean (SD)**	***n*(%)**	**Mean (SD)**	***n* (%)**	***P*[a]**
Cholesterol		18 (7)		10 (7)		8 (7)	
Diabetes		12 (5)		6 (4)		6 (5)	
No		105 (40)		67 (46)		38 (33)	

AA, African-American; NS, not significant.
[a]Significant values pertain to comparisons between the non-blood sample and blood sample subjects.
*$P < 0.05$.

Drivers reported an average of 6.9 h of sleep on work days and 8.3 h on non-work days. There was no significant difference in workday sleep duration between those giving a blood sample and those not doing so. However, there was a significant difference in non-work day sleep duration between those who gave a blood sample and those who did not ($M = 7.95$ and $M = 8.52$, respect ively; $P < 0.05$). Regarding sleep quality, 38% reported never or rarely getting a good quality of sleep on work days, while 17% did so on non-work days. There were no significant differences in sleep quality between giving a blood sample and those not doing so. Findings related to sleep have been reported in a previous publication which using the same dataset [8]. Complete sleep characteristics are shown in Table 2.

Table 2. Sleep characteristics of total sample, no blood sample and blood sample subjects

	Total sample		No blood sample given		Blood sample given		
	Mean (SD)	***n*(%)**	**Mean (SD)**	***n*(%)**	**Mean (SD)**	***n*(%)**	***P*[a]**
Sleep duration (workdays)	6.92 (1.7)		6.97 (1.8)		6.86 (1.5)		NS
Short		119 (45)		64 (44)		44 (48)	
Optimal		117 (45)		64 (44)		53 (46)	
Long		25 (10)		18 (12)		7 (6)	
Sleep duration (non-workdays)	8.27 (2.1)		8.52 (2.2)		7.95 (2.0)		*
Short		57 (22)		30 (21)		27 (24)	
Optimal		115 (44)		58 (39)		57 (49)	
Long		90 (34)		59 (40)		31 (27)	
Sleep quality (workdays)							NS
Poor		98 (38)		57 (40)		41 (36)	
Good		159 (62)		85 (60)		74 (64)	
Sleep quality (workdays)							NS
Poor		39 (17)		24 (18)		15 (15)	
Good		194 (83)		108 (82)		86 (85)	

NS, not significant.
[a]Significant values pertain to comparisons between the non-blood sample and blood sample subjects.
*$P < 0.05$.

Due to data requirements for assessing MetS components, only the 115 drivers who gave a blood sample were included in subsequent MetS analyses (Tables 3–6). The means of the MetS measures for these drivers were 115 cm for waist circumference, 164 mg/dl for triglycerides, 35 mg/dl for HDL, 129 mm Hg for systolic blood pressure, 83 mm Hg for diastolic blood pressure and 92 mg/dl for fasting glucose. These means have been reported in previous publications based on this dataset [14,16]. Among these drivers, 79% had a waist circumference >102 cm, 50% had triglyceride levels of ≥150 mg/dl, 66% had an HDL of <40 mg/dl, 28% had a blood pressure of ≥135/80 mm Hg and 17% had a fasting glucose of ≥110 mg/dl. Over half (58%) of drivers who had blood sampled met the criteria for having MetS. Complete MetS characteristics are shown in Table 3.

Table 3. MetS measures[a]

	Mean (SD)	**Total, *n* (%)**
Waist circumference	115.0 (16.2)	
≤102 cm		24 (21)
>102 cm		91 (79)
Triglycerides	164.1 (91.8)	
<150 mg/dl		57 (50)
≥150 mg/dl		58 (50)
HDL	35.1 (10.7)	
≥40 mg/dl		38 (34)
<40 mg/dl		75 (66)
Systolic blood pressure	129.3 (19.3)	
<130 mm Hg		65 (57)
≥130 mm Hg		50 (43)
Diastolic blood pressure	82.8 (11.4)	
<85 mm Hg		74 (64)
≥85 mm Hg		41 (36)
Total blood pressure		
<130/85 mm Hg		83 (72)
≥130/85 mm Hg		32 (28)
Glucose	92.1 (26.3)	
<110 mg/dl		95 (83)
≥110 mg/dl		20 (17)
MetS[b]		
No		47 (42)
Yes		66 (58)

[a]Includes only those drivers who gave a blood sample.
[b]Drivers with three or more of the characteristics of MetS.

Table 4. Distribution of MetS measures[a]

No. of MetS criteria met	**Totals, *n* (%)**
0	0 (0)
1	19 (17)
2	28 (25)
3	30 (26)
4	33 (29)
5	3 (3)

[a]Includes only those drivers who gave a blood sample.

Table 5. Associations between driving experience, work organization, sleep and meeting characteristics for MetS (adjusted for age and race/ethnicity)[a]

	OR	95% CI	*P*
Model[b]			**
Age (reference: 46 and older versus 45 and younger)	0.62	0.21, 1.83	NS
Driving experience (reference: ≥21 years)	1	–	–
≤10 years	0.19	0.05, 0.70	**
11–20 years	0.94	0.25, 3.54	NS
Race/ethnicity (reference: non-White versus White)	2.81	0.92, 8.57	NS
Work hours (reference: >11 h daily versus ≤11 h)	1.55	0.52, 4.58	NS
Workday sleep quality (reference: good versus poor)	0.19	0.05, 0.74	*
Non-workday sleep quality (reference: good versus poor)	2.10	0.38, 11.72	NS
Workday sleep duration (reference: optimal versus too short or too long)	0.75	0.27, 2.05	NS
Non-workday sleep duration (reference: optimal versus too short or too long)	0.55	0.20, 1.51	NS

CI, confidence interval; NS, not significant; OR, odds ratio.
[a]Includes only those drivers who gave a blood sample.
[b]$\chi^2 = 21.31$; $R^2 = 0.21$ (Cox and Snell) and 0.28 (Nagelkerke).
*$P < 0.05$.
**$P < 0.01$.

Table 6. Associations between driving experience, work organization, sleep and MetS severity (adjusted for age and race/ethnicity)[a]

	OR	95% CI	*P*
Model[b]			**
Age (reference: 46 and older versus 45 and younger)	0.91	0.39, 2.15	NS
Driving experience (reference: ≥21 years)	1	–	–
≤10 years	0.15	0.05, 0.44	**
11–20 years	0.48	0.16, 1.43	NS
Race/ethnicity (reference: non-White versus White)	2.41	1.00, 5.84	*
Work hours (reference: >11 h daily versus ≤11 h)	1.68	0.71, 3.97	NS
Workday sleep quality (reference: good versus poor)	0.32	0.12, 0.91	*
Non-workday sleep quality (reference: good versus poor)	1.33	0.35, 5.05	NS
Workday sleep duration (reference: optimal versus too short or too long)	1.01	0.44, 2.31	NS
Non-workday sleep duration (reference: optimal versus too short or too long)	0.84	0.37, 1.91	NS

CI, confidence interval; NS, not significant; OR, odds ratio.
[a]Includes only those drivers who gave a blood sample.
[b]$\chi^2 = 23.46$; $R^2 = 0.23$ (Cox and Snell) and 0.24 (Nagelkerke).
*$P < 0.05$.
**$P < 0.01$.

Every driver met the diagnostic criteria for at least one MetS measure. The vast majority of the sample (80%) met the diagnostic criteria for between two and four of the MetS measures. Only three drivers (3%) met the criteria across all five MetS measures, the most prevalent category being for four measures, indicating the relative severity of MetS measures in this sample. The distribution of MetS measures is shown in Table 4.

We performed an ordinal logistic regression, with Boolean MetS diagnosis as the dependent variable and demographics, work organization and sleep duration and quality as potential predictor variables. We also adjusted for age and race/ethnicity. Significant predictors in the model included driving experience of ≤10 years [odds ratio (OR) = 0.19] and a good work day sleep quality (OR = 0.17). Logistic regression results are given in Table 5.

We next performed an ordinal logistic regression analysis to further examine associations between the predictor variables from the binary logistic regression analysis and MetS severity. We again adjusted for age and race/ethnicity in the ordinal logistic regression due to the fact that they are well-described risk factors or effect modifiers for MetS. A driving experience of ≤10 years (OR = 0.15) was again a statistically significant predictor, as was good work day sleep quality (OR = 0.32); however, when examining MetS severity, race/ethnicity also became a significant predictor (OR = 2.41). The full regression results are given in Table 6.

Discussion

One of the key findings of the study is the detailed profile of MetS among US long-haul truck drivers. The combination of anthropometric and biometric data collection permitted MetS diagnosis, as well as providing insight into the individual MetS components. Nearly 60% of the sample met the diagnostic criteria for MetS [11], with every driver meeting the criteria for at least one MetS measure. While we are unaware of similar studies among US long-haul truck drivers, our findings are very similar to those of truck drivers in Brazil (58% MetS prevalence) but higher than among truck drivers in Iran (36% MetS prevalence) [20,21]. A literature review of US long-haul truck drivers similarly indicated that abdominal obesity was the most prevalent MetS component, which corresponds with our findings regarding waist circumference [21,22]. With only three drivers (3%) meeting the criteria across all five MetS measures, it is possible that there is a ceiling effect, as drivers with particularly severe MetS may leave the profession. However, because the sample mode met criteria for four MetS measures, any ceiling effect appears to be somewhat muted. These findings suggest strengths and weaknesses in current policies aimed at ensuring the health and fitness of US long-haul truck drivers. For example, patterns of blood pressure and blood glucose, both of which are less problematic within this sample, are likely to be influenced by medical requirements of the US Federal Motor Carrier Safety Administration, which has strict criteria pertaining to both, violations of which can result in the loss of driving privileges [23]. This highlights the potential of macro-level, policy-based solutions.

The combination of survey, anthropometric and bio metric data provided insight into factors that may influence MetS. Significant associations with driving experience suggest the influence of exposure to this occupational milieu as a factor in MetS manifestation, with much higher odds beginning after roughly a decade in the profession. This may indicate a possible MetS ‘tipping point’ which reflects time-delayed effects of the various occupational risk exposures which then induce MetS onset. Surprisingly, among the work organization variables, work day sleep quality was the only significant predictor of MetS, with good work day sleep quality representing a potential protective factor. Along with numerous other factors, such as poor nutrition, poor sleep quality has been associated with MetS diagnosis, as well as with hyperglycemia, high triglycerides, low HDL cholesterol and greater abdominal obesity [24,25]. However, while many other studies have implicated both short and long sleep duration in MetS risk [24,26], neither work day nor non-work day sleep duration were significant predictors of MetS in this study.

With the majority of the sample being paid by the mile, which is associated with lower wages and is strictly performance-based [6], drivers reported a large number of driving miles per week and long daily work hours. However, while other studies have shown associations between long working hours and higher prevalence of MetS components among truck drivers and other working populations, this was not the case in our sample [27,28]. Similarly, shift work was commonplace in our sample, with >80% of drivers reporting their work schedules were different every day. While shift work has been shown to be associated with a higher prevalence of MetS in other studies [29], this was not the case in our sample. The lack of associations between work hours and shift work with MetS may be explained by the relatively small number of drivers who gave a blood sample.

While several studies of US long-haul truck drivers exist, none have similarly combined survey, anthropometric and biometric data collection to provide a rich picture of MetS. The sampling procedures used appear to be a strength of this study. The long-haul truck drivers who gave a blood sample did not differ markedly from those who did not, and the sample as a whole is representative of US long-haul truck drivers in respect of age and driving experience, although not of ethnicity [30].

There are four primary limitations of the study. Firstly, the overall sample size is relatively small. Secondly, across several key work organization variables (e.g. schedule regularity and payment system), there was little variance in participants' responses. This may have resulted in the inability of our analyses to identify important MetS factors. Thirdly, the potential for selection bias exists, as drivers may have refused to participate for many reasons. Finally, we employed a sampling technique that involved blood sampling in the actual workplace. Although this minimized the barriers to participation, it also limited the amount of time drivers were able to fast prior to blood sampling. While these shorter fasting times may have altered our blood values slightly, they are representative of the normal schedules maintained by these individuals. These limitations have been discussed in previous studies using this dataset [14,16].

Future research should include a larger sample size. Also, a longitudinal research design, to supplement the current study which is cross-sectional and represents a 'snapshot' in time, may provide additional insight into MetS risk and outcome dynamics over time within a cohort of drivers. Such a study would facilitate understanding of the unique interplay of MetS risk and outcomes within the context of long-haul trucking. As stated earlier, it is possible that ceiling effects may exist for MetS outcomes due to US federal medical examination requirements [30]. As the accumulation of MetS risk factors manifests as disease states, long-haul truck drivers are medically disqualified from the profession and thus leave this occupation. Should this be the case, our sample, consisting of medically qualified long-haul truck drivers, may not have captured those drivers who were severely affected by MetS and left the profession.

The prevalence and severity of MetS among US long-haul truck drivers is high, with MetS criteria related to abdominal obesity and blood lipids (high triglycerides and low HDL cholesterol levels) especially prevalent. With longer work experience and work day sleep quality representing significant predictors of MetS diagnosis and severity, future research and preventive efforts should focus on these elements to mitigate long-haul truck drivers' MetS risks.

Key points

- The prevalence of metabolic syndrome among US long-haul truck drivers was high in this study.
- Among metabolic syndrome components, abdominal obesity and blood lipids (high triglyceride and low high-density lipoprotein cholesterol levels) were especially frequent.
- Longer work experience and work day sleep quality were significantly associated with metabolic syndrome diagnosis and severity.

Funding

This paper is part of a commercial driver sleep study conducted with research funds awarded by the University of North Carolina-Greensboro's (UNCG) Office of Research and Economic Development. Additional funds were provided by UNCG's School of Health and Human Sciences, Bryan School of Business and Economics, Department of Public Health Education and Department of Kinesiology.

Conflicts of interest

None declared.

Acknowledgements

We would like to thank Mr Tom Liutkus, Vice President of Marketing and Public Relations for Travel Centers of America (TA) and Mr Jerald Brisson, General Manager of the Whitsett, NC TA truckstop and his staff for their instrumental support for our project and data collection efforts. We also thank the long-haul truck drivers who participated in this study, our graduate student Kiki Hatzudis for her invaluable assistance in various phases of data collection and Sagir Muhammad for his assistance with this manuscript.

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