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Frequency of obstructive sleep apnoea in Danish truck drivers

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ABSTRACT

INTRODUCTION: Obstructive sleep apnoea (OSA) is associated with excessive daytime sleepiness and therefore affects traffic safety. The risk factors for OSA are age and BMI, and therefore sedentary occupational groups are likely to have a high prevalence of OSA. Our aim was to investigate the prevalence and identify the risk factors for OSA and Type 2 diabetes (T2D) among occupational truck drivers in Denmark.

METHODS: Occupational truck drivers were recruited and their pulse oximetry and nasal respiratory flow were measured with the ApneaLink device. The Apnea-Hypopnea Index (AHI), defined as the average number of apnoeas and hypopnoeas per hour of sleep, was used to classify 1) non OSA (AHI < 5/h), 2) mild OSA (5/h ≤ AHI < 15/h), 3) moderate OSA (15/h ≤ AHI ≤ 30/h) and 4) severe OSA (AHI > 30/h). Risk factors for OSA and T2D were investigated by linear and logistic regressions.

RESULTS: A total of 57 of 97 drivers were included in the analysis, all of whom were men, and 56% had OSA. The linear regressions showed all of the evaluated risk factors to be positively associated (< 0.01) with the AHI score, supported by the estimated odds ratios of having above-recommended levels of the evaluated risk factors when classified as having OSA.

CONCLUSIONS: All the evaluated risk factors were significantly associated with AHI, and the prevalence of OSA was above mean levels in the population. Confirmation of these results is warranted in future studies.

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Increased risk of obstructive sleep apnoea (OSA) is characterised by recurrent apnoea episodes (interruption in airflow of ≥ 10 sec.) and/or hypopnoea (decrease in airflow for ≥ 10 sec. combined with a ≥ 3% desaturation compared with a pre-event baseline) during sleep [1]. The OSA syndrome is associated with excessive daytime sleepiness, fatigue and various

aspects of mental dysfunction [2]. Severe OSA is associated with an increased risk of cardiovascular disease risk [3] and Type 2 diabetes (T2D) [1, 2]. The relation between OSA and T2D is considered to be bidirectional because of the associations between fragmented sleep and abnormal glucose metabolism as well as the association of diabetic neuropathy with central control of respiration [1]. Having OSA is associated with higher rates of health-related contacts, medication use and unemployment, resulting in annual excess total direct and indirect costs of 3,860 € per OSA patient compared with non-OSA people [4] – even before diagnosis of OSA [5]. Also, traffic safety is affected by OSA due to the increased risk of road accidents [3].

Earlier studies of the general Danish adult population place the OSA prevalence in the 1-5% range in men and 1-2% range in women [6]. However, a higher prevalence of OSA may be expected among groups with high fractions of obesity and more advanced age, as age and BMI are risk factors for OSA [4, 5]. Such groups may be constituted by occupation; for example, occupational truck drivers in Denmark are predominantly above 50 years of age [7], and have an increased prevalence of obesity. The high prevalence of obesity may be explained by the combination of a sedentary occupation, lack of leisure time physical activity and an excessive caloric intake [6, 8]. Therefore, we aimed to investigate the prevalence and identify risk factors for OSA among occupational truck drivers in Denmark.

METHODS

The local ethical committee and data protection agency approved the project (H-15003477). Occupational truck drivers from a Danish brewery (Carlsberg) were recruited at information meetings at three Danish distribution sites. The Danish Council informed the drivers about the potential implications of sleepiness and road safety for safe traffic, and the researchers informed about OSA, T2D and the possibility of participation in the study. All participation was voluntarily and anonymised in accordance with the Helsinki Declaration. The drivers were asked to fill out questionnaires on daytime sleepiness, symptoms of OSA and interest in participating in the study at the information meeting. Also, drivers could sign up for more information about the study. A subsequent appointment for investigation was scheduled at the Carlsberg facilities during working hours and coordinated with the company.

The inclusion criteria were: written informed consent, age ≥ 18 years and employment as an occupational truck driver. The exclusion criteria were inability to use the device for measuring pulse oximetry and nasal respiratory flow.

The primary outcome in this study was OSA. However, since the population included is assumed to be at increased risk of T2D and as the relation between OSA and T2D is bidirectional, a cross-sectional investigation is unable to establish whether the high risk for

OSA is due to the T2D risk profile or not.

Obstructive sleep apnoea screening and classification

Pulse oximetry and nasal respiratory flow were measured with the ApneaLink device, previously validated for OSA screening [8]. Trained study personnel instructed the participants on how to mount and wear the ApneaLink at bedtime and during ≥ 4 h of sleep. If the recording was non-conclusive, the participants were offered to sleep one more night with the device.

Data were downloaded and analysed by ResMed ApneaLink, software version 9.20. The default settings of the ApneaLink for episodes of apnoea, hypopnea and desaturation were used. An episode of apnoea was defined as a decrease in airflow by 80% of the baseline flow for at least 10 sec., and hypopnea was defined as a decrease in airflow by 50% to 80% of the baseline flow for at least 10 sec.

The frequency of obstructive events was reported by the Apnea-Hypopnea Index (AHI), defined as the average number of apnoeas and hypopneas per hour of sleep. OSA severity was defined according to the American Academy of Sleep Medicine guidelines from 2009 [9] as non OSA (AHI < 5/h), mild OSA (5/h ≤ AHI < 15/h), moderate OSA (15/h ≤ AHI ≤ 30/h) and severe OSA (AHI > 30/h).

All drivers diagnosed with OSA (AHI ≥ 15/h or AHI ≥ 5/h with symptoms) with the ApneaLink were referred to local sleep clinics for final diagnosis and initiation of treatment.

Clinical measures at the subsequent appointment

Body weight and height were measured, and BMI calculated as bodyweight (kg)/(height (m) × height (m)). Blood pressure was measured twice by an oscillometric method with a semiautomatic device after the patient had been resting in a sitting position for ten minutes. The mean of the two measures was included in the analysis. Capillary blood samples were taken to determine blood glucose level and haemoglobin A_{1c} (HbA_{1c}). HbA_{1c} was measured by use of high-performance liquid chromatography from a capillary blood sample.

Questionnaires

Daytime sleepiness was measured by the Epworth Sleepiness Scale (ESS) [8]. The total score was calculated from eight questions rating the chances of dozing off or falling asleep in eight different situations commonly encountered in daily life. The total score falls in the 0-24 range. A score above ten is considered abnormal and indicates high sleepiness [8]. The ESS is commonly used for quantifying symptoms of sleepiness and the ESS score increases with severity of OSA [10].

Risk of OSA was estimated by the validated Berlin questionnaire [11]. This questionnaire addresses subjective symptoms of sleep apnoea; snoring (0-4 points), observed apnoeas (0-1

point), day-time sleepiness (0-3 points); and it combines the risk scores with presence of obesity (BMI > 30 kg/m^2) and/or self-reported hypertension (diagnosed by the patient's general practitioner). A high risk of OSA is determined by symptoms in at least two categories (> 4 points) in the absence of obesity/hypertension or at least two points in the presence of obesity or hypertension.

Furthermore, the drivers were asked to report the number of kilometres driven per year, how often they felt tired when driving, if they had ever been close to falling asleep while driving or had been involved in a traffic accident due to tiredness.

Statistical analyses

Data are presented as mean (± standard deviation) and range for normally distributed variables and frequency (%) for categorical variables. To present the descriptive variables across the population stratified by OSA and to investigate whether there were any differences between the two groups, t-test were applied to the normally distributed variables and Pearson's χ^2-test was applied to categorical variables. AHI was analysed both as categorical data based on clinically predefined cut-offs and as count data. Risk factors for OSA and T2D were investigated by linear and logistic regressions; linear regressions investigated AHI level in relation to BMI, HbA_{1c}, blood glucose and SBP in unadjusted and adjusted models. The logistic regression estimated the odds ratios (OR) of having OSA with higher BMI (≥ 30 kg/m^2), HbA_{1c} (≥ 48 mmol/mol), blood glucose (non-fasting > 7 mmol/l) and blood pressure (≥ 140/90 mmHg). All statistical analyses were performed in SAS 9.4, and the level of significance was set to 0.05.

Trial registration: none.

RESULTS

A total of 63 of 97 male drivers (62%) participated in the study. Six participants were excluded due to unsuccessful overnight measurement with the ApneaLink (**Figure S1**). The clinical characteristics are presented in **Table 1** for all of the 57 participants who completed the screening for OSA. The table also presents the groups stratified by OSA (non-OSA defined as AHI < 5/h, or OSA defined as AHI ≥ 5/h). The non-OSA and OSA groups significantly differed in frequency of snoring and prevalence of a high BMI (≥ 30 kg/m^2).

TABLE 1 / Descriptive information on the total and obstructive sleep apnoea-stratified population, and differences between the obstructive sleep apnoea-stratified groups.

	Total population (N = 57)		OSA: AHI ≥ 15/h or AHI ≥ 5/h with symptoms (n = 32)		Non-OSA: AHI < 5/h (n = 25)		
	mean ± SD (range)	n (%)	mean ± SD (range)	n (%)	mean ± SD (range)	n (%)	p-value[a]
Age							
Population, yrs	49.3 ± 7.8 (35.0-66.0)		51.0 ± 7.4 (35.0-65.0)		47.3 ± 7.9 (35.0-66.0)		0.50
≥ 50 yrs		29 (51)		15 (47)		14 (56)	0.50
Weight, kg	96.7 ± 15.0 (68.5-128.6)		101.5 ± 15.4 (68.5-128.6)		90.4 ± 12.2 (69.7-112.0)		0.27
Height, m	179.4 ± 6.4 (1.7-1.9)		1.8 ± 0.07 (1.7-1.9)		1.8 ± 0.06 (1.7-1.9)		0.82
BMI							
Population, kg/m^2	30.0 ± 4.5 (22.0-41.3)		31.3 ± 4.9 (22.1-41.3)		28.2 ± 3.3 (22.0 - 35.7)		0.06
≥ 30 kg/m^2		27 (47)		19 (59)		8 (32%)	0.04
Moderate-vigorous physical activity in leisure time		35 (61)		20 (63)		15 (60)	0.99
Blood pressure							
Systolic, mmHg	139.6 ± 17.3 (112.0-193.0)		143.0 ± 17.5 (112.0-189.0)		135.2 ± 16.3 (115.0-193.0)		0.50
Diastolic, mmHg	91.6 ± 10.9 (71.0-130.0)		93.1 ± 12.4 (71.0-130.0)		89.6 ± 8.4 (76.0-112.0)		0.16
≥ 140/90 mmHg		30 (53)		20 (63)		10 (40)	0.09
HbA_{1c} concentration							
Population, mmol/mol	36.7 ± 8.0 (27.0-68.0)		38.5 ± 9.2 (30.0-68.0)		34.5 ± 5.6 (27.0-56.0)		0.14
≥ 39-47 mmol/mol		6 (11)		4 (13)		2 (8)	0.42
≥ 48 mmol/mol		5 (9)		4 (13)		1 (4)	0.26
Blood glucose concentration, non-fasting							
Population, mmol/l	6.6 ± 1.7 (4.7-12.9)		6.9 ± 1.9 (4.7-12.9)		6.2 ± 1.2 (4.7-9.2)		0.11
> 7 mmol/l		19 (33)		13 (41)		6 (24)	0.22
Diabetes mellitus diagnosis		5 (9)		4 (13)		1 (4)	0.26
Epworth Sleepiness Scale[b] > 10		15 (26)		10 (31)		5 (20)	0.34
AHI, events/h	9.4 ± 12.1 (0.0-61.0)		15.5 ± 13.2 (5.0-61.0)		1.7 ± 1.3 (0.0-4.0)		< 0.01
Berlin questionnaire							
Snoring		42 (74)		29 (91)		13 (52)	0.01
Observed apnoeas		20 (35)		12 (38)		8 (32)	0.63
Daytime sleepiness		40 (70)		25 (78)		15 (60)	0.13

AHI = Apnea-Hypopnea Index; HbA_{1c} = glycated haemoglobin; OSA = obstructive sleep apnoea; SD = standard deviation.
a) Difference between OSA and non-OSA.
b) Range: 0-24.

Obstructive sleep apnoea

A total of 32 participants (56%) had OSA. Mild OSA was found in 20 participants, whereas nine drivers had moderate OSA and three participants had severe OSA (**Figure S2**). None of the participants had Cheyne-Stokes respiration or central apnoeas.

Most of the participants were asymptomatic and did not report more tiredness than drivers without OSA (ESS: 8 versus 8, p = 0.5). However, drivers with OSA more frequently reported snoring (91% versus 52%, p = 0.01) and tended to experience daytime sleepiness more frequently (78% versus 60%, p = 0.13), but did not have more observed apnoeas (38% versus 32%, p = 0.63) (Table 1).

Risk factors for diabetes and cardiovascular disease

Based on the definition of T2D as an HbA_{1c} above 48 mmol/mol [9, 12], five of the 57 participants (9%) had T2D, hereof three were detected by the study screening. Furthermore, six of the 57 participant (11%) had prediabetes, defined as a HbA_{1c} of 39-47 mmol/mol [9]. The frequency of prediabetes did not differ between the OSA groups (Table 1).

Furthermore, 33% of the population had a non-fasting level of glucoses above the recommended level (7 mmol/l) [12]. In the stratified groups, 41% of those with OSA and 24% of those without OSA had a level of non-fasting glucose above the recommended level.

More than half (53%) of the participants were hypertensive (resting blood pressure ≥ 140/90 mmHg) [10]. In the stratified groups, a tendency was seen (p = 0.09) among those with OSA towards being hypertensive more frequently (63% hypertensive among those with OSA versus 40% hypertensive among those who did not have OSA).

Moreover, 47% of the drivers had a high BMI (BMI ≥ 30 kg/m^2), and those with OSA had a higher frequency of obesity than those without OSA (59% versus 32%, p = 0.04) (Table 1).

The linear regressions showed that all of the evaluated risk factors were significantly (all < 0.01), positively associated with AHI score in the crude as well as the adjusted model. The estimates from the crude and adjusted model are of similar magnitude and thus indicate that the associations do not seem to be biased by either age or level of leisure time physical activity. Thus, for each point increase of the AHI scale, the BMI was estimated to increase by 0.17 kg/m^2 (95% confidence interval (CI): 0.08-0.26 kg/m^2); HbA_{1c} by 0.26 mmol/mol (95% CI: 0.10-0.42 mmol/mol); non-fasting blood glucose by 0.06 mmol/l (95% CI: 0.03-0.09 mmol/l); and systolic blood pressure by 0.49 mmHg (95% CI: 0.13-0.85 mmHg) (**Table 2**). These positive associations were supported by the estimated OR for having OSA when classified as having a high BMI (OR = 1.81, 95% CI: 1.03-3.30), but not when classified as having above recommended levels of blood pressure, HbA_{1c} or blood glucose (**Table 3**).

TABLE 2 / Associations between Apnea-Hypopnea Index (events/h) and risk factors for Type 2 diabetes and cardiovascular disease.

	Model 1		Model 2[a]	
	β (95% CI)	p-value	β (95% CI)	p-value
BMI, kg/m^2	0.17 (0.08-0.26)	< 0.001	0.17 (0.08-0.26)	< 0.001
HbA_{1c} concentration, mmol/mol	0.27 (0.11-0.44)	0.001	0.26 (0.10-0.42)	< 0.01
Blood glucose concentration, non-fasting, mmol/l	0.06 (0.03-0.10)	< 0.001	0.06 (0.03-0.09)	< 0.001
Systolic blood pressure, mmHg	0.52 (0.16-0.88)	< 0.01	0.49 (0.13-0.85)	< 0.001

CI = confidence interval; HbA_{1c} = glycated haemoglobin.
a) Adjusted for age and leisure time physical activity.

TABLE 3 / Odds ratios (95% confidence interval) of having obstructive sleep apnoea by being in the high-risk group of BMI, glycated haemoglobin (HbA_{1c}) concentration, blood glucose concentration, and blood pressure.

	Model 1	Model 2[a]
BMI ≥ 30 kg/m²	1.76 (1.03-3.11)	1.81 (1.03-3.30)
HbA_{1c} concentration ≥ 48 mmol/mol	1.85 (0.68-8.34)	1.83 (0.67-8.29)
Blood glucose concentration, non-fasting > 7 mmol/l	1.43 (0.81-2.63)	1.53 (0.81-3.06)
Blood pressure ≥ 140/90 mmHg	1.05 (0.61-1.81)	0.64 (0.36-1.10)

a) Adjusted for age and leisure time physical activity.

Obstructive sleep apnoea and relation to traffic safety

No association between the presence of OSA and the number of kilometres driven per year (linear regression p = 0.42) was seen. A χ^2 analysis indicated no differences between groups of severity of OSA and self-reported risk of "falling asleep during driving" or "daytime tiredness" (**Table 4**, **Figure S3** and **Figure S4**). Even so, three of the drivers (5%) with OSA reported nearby traffic accidents due to tiredness, and none of the drivers without OSA reported nearby traffic accidents due to tiredness, which indicates a potential traffic safety issue in relation to OSA.

TABLE 4 / Frequency of daytime tiredness and falling asleep during driving by obstructive sleep apnoea.

	Daytime tiredness		Falling asleep during driving	
OSA level	yes	no	yes	no
Non: AHI < 5/h	15	9	13	9
Mild: 5/h ≤ AHI < 15/h	14	5	14	5
Moderate: 15/h ≤ AHI ≤ 30/h	8	1	9	0
Severe: AHI > 30/h	3	0	1	2

AHI = Apnea-Hypopnea Index; OSA = obstructive sleep apnoea.

DISCUSSION

Study findings

This is the first study to investigate the prevalence of OSA among truck drivers in Denmark. It shows that more than half (56%) of the participating Danish truck drivers had OSA, thus exceeding the mean level observed in the general adult male population in Denmark (4%) [13]. Previously, the prevalence of OSA has been estimated to fall in the 3-28% range among commercial drivers in Northern America [11, 14] and to be 17.6% among truck drivers [15]. Furthermore, several studies have reported truck drivers to be at excessive risk for OSA [16, 17]. However, none of the previous studies reported a prevalence of OSA similar to the one reported in the present study, which may possibly be explained by the participants in this study being older and by the fact that a high BMI was prevalent. Nevertheless, there is a need for verification of the reported prevalence.

Surprisingly, these participants were asymptomatic in terms of daytime sleepiness and fatigue. This makes questionnaire-based OSA diagnosis challenging, which has also been shown in a previous study among patients with diabetes [18]. Self-reported sleepiness alone is therefore not useful in the diagnosis of OSA. Thus, a need for screening with a portable home-monitoring device is warranted, and it is questionable whether asymptomatic patients should be treated at all.

In accordance with previous studies [11, 14], the present analysis showed AHI to be associated positively with BMI, glucose, HbA_{1c} and blood pressure (Table 2). Also, this relation was reflected in the OR of having OSA in participants with a high BMI (OR = 1.81, 95% CI: 1.03-3.30), although the risk for OSA was not affected by the presence of hypertension or T2D (Table 3). In general, an increased risk for cardiovascular diseases and T2D would be expected based on the observed blood pressures [10] and HbA_{1c} [9] in participants with OSA (Table 1). Although the level of leisure time physical activity did not seem to bias the results in the present study, leisure time physical activity has been shown to protect from OSA [16] and to decrease the levels of the evaluated risk factors recorded in this study [19]. Therefore, prevention of OSA could be targeted through initiatives promoting increased levels of leisure time physical activity. However, these results are based on self-reported leisure time physical activity. This information may therefore be biased by lack of memory and by social desirability. Furthermore, it may be difficult to verify the precision of the estimates given on duration, frequency and intensity of the leisure time physical activity. Also, one would expect leisure time physical activity to mainly affect these variables (BMI, HbA_{1c}, blood glucose and blood pressure) by having a sufficient volume and especially intensity to be able to affect cardiorespiratory and metabolic fitness [19]. Whether this is the case may be hard to assess based on these self-reports of leisure time physical activity.

Relating the findings to traffic safety

No differences were seen across OSA groups in the prevalence of “falling asleep during

driving" or "daytime tiredness". However, traffic safety may still be affected by OSA by the indication of an increased prevalence of nearby traffic accidents due to tiredness reported by 5% of the drivers with OSA. However, none of the drivers without OSA reported nearby traffic accidents due to tiredness. This indication is in line with previous studies also reporting an increased risk of traffic accidents among OSA patients [3, 11, 20].

Methodological considerations

The strengths of the study include the dual classification of OSA by questionnaire and apnoea link monitor, as well as the dual classification of risk for diabetes by both glucose and HbA_{1c}. The size of the population (N = 57) and the fact that all of the participants were recruited from one company holds a potential selection bias. This combined with the assumption that companies who are willing to participate in research may have a better work environment than those not wanting to participate in research indicating that the participants may be healthier than the entire population of truck drivers in Denmark. Thus, the reported results may be conservative, as higher frequencies of OSA may possibly be expected among the population as a whole. The small study population and cross-sectional design are limitations. Thus, upscaling and verification of these results are needed, as are prospective studies evaluating OSA in relation to traffic safety.

Implications of the findings

This study provides new knowledge about the prevalence of OSA among occupational truck drivers and demonstrates that BMI, glycated haemoglobin, blood glucose and systolic blood pressure are associated with OSA. More information is essential for optimising the clinical and public health sectors as well as reducing the health and traffic safety consequences of untreated OSA. In addition, the results provide an overview of the general health among the included occupational truck drivers, indicating a moderate to high risk for cardiovascular as well as metabolic disease. Thus, it seems that occupational truck drivers would benefit from health screening in other aspects than sleep apnoea per se by earlier detection and recognition of risk factors for cardiovascular and metabolic diseases.

CONCLUSIONS

This study found a 56% prevalence of OSA among the participating male occupational truck drivers, which clearly exceeds the population mean of 4%. All the evaluated risk factors (BMI, glycated haemoglobin, blood glucose and

systolic blood pressure) were significantly associated with the level of AHI. However, confirmation of these results is warranted in future studies to guide initiatives for prevention and vocational rehabilitation of OSA.

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