Better Sleep for Long-Haul Truckers: A comparison of three conditions. Engine Idling, Engine Off, & in the Sleep Lab.

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ABSTRACT

Study objectives: To evaluate the sleep of Truck Drivers with full-attended Polysomnography on Truckers in their own trucks and on their own schedules (1) with their engine idling, (2) with their engine turned off, (3) in the Sleep Lab.

Design: Test/Retest pilot study with subjects serving as their own controls.

Subjects: 25 truck driver volunteers (22 male) tested under three conditions.

1. With their engines idling (EO); drivers currently must let their engines run while parked to obtain power for heating or cooling while they sleep in the truck cab.
2. With their engines turned off, using conditioned air provided by the Advanced Travel Center Electrification System of IdleAire (IA) Technologies Corporation.
3. In the Sleep Lab (Lab) with standard rooms.

Settings: Petro Truck Stop; Watt Road exit; Knoxville, TN.
East Tennessee Neurology Clinic; Sleep Lab; Knoxville, TN.

Results: Both objectively by polysomnography and subjectively by questionnaire, sleeping with the engine off (IA) was preferred by 84% of the drivers and provided significantly better (p=.0023) Sleep Efficiency (84.96% vs 77.73% EO & 72.89% Lab), and significantly fewer (p=.001) EKG arrhythmias (42.24 vs 57.92 Lab & 85.6 EO). SAO2 was significantly lower (p=.003) during EO (81.04% vs 85.39% IA & 86.4% Lab) but no significant difference was observed between IA and Lab.
Significant PLMS (> 10.0) was observed in 80% to 88% of all drivers under each test with a significantly higher index (p=.003) observed in the Lab.
Significant RDI (> 5.0) was observed in 52% to 64% of all drivers under each test. Indices were highest during Engine Idling (EO) but not significantly different.
100% of drivers were observed Snoring at least occasionally under each test.
100% of drivers were observed to have at least four Upper Airway Resistance Syndrome (UARS) events under each test (range 4-118).
64% of all drivers indicated poor sleep hygiene with highly variable Bed & Rise Times.
44% of all drivers scored 10 or higher on the Epworth Sleepiness Scale (ESS).
Mean Body Mass Index (BMI) =33.68 kg/m^2.

Conclusions: Truck Drivers who sleep with their engines turned off while receiving externally supplied filtered air for heating and air conditioning enjoy a significantly improved quality of sleep compared to those who sleep with their truck engines idling (to provide power for the truck's heating and air conditioning system). Truck Drivers are an "at risk" population more likely to be involved in crashes due to fatigue secondary to sleep disorders. Truckers face unique circumstances contributing to unhealthy lifestyles, increased mortality, and job dissatisfaction.

KeyWords: Truck Driver, Truck Stop, Engine Idling, IdleAire, Diesel Exhaust, Sleep.
Citation: Kabbani SA; Haring RA. Better Sleep for Long-Haul Truckers: A comparison of three conditions, Engine Idling, Engine Off, & in the Sleep Lab. (submission pending).

Introduction

Truck Driving is globally recognized as an unhealthy occupation in which the job itself contributes to poor health by promoting erratic schedules, lack of exercise, stress, weight gain, poor diet & poor sleep.[3-8] Exposure to diesel emissions alone have been linked to several types of cancer in this population including pancreatic[9], bladder[10, 11], laryngeal[12], lung[13-17], renal cell[18], gastric cadia[19], even TB[20] and infant leukemia[21].
Further, the lack of home amenities (bed, bathroom, TV, internet), inadequate health care, and social isolation on the road can have a profound psychological impact on drivers which contributes to the high driver turnover rate in the trucking industry[22-26] and can encourage risky health behaviors such as drug use [27-33], and prostitution[34-37].
Trucking is a rapidly growing industry that has gained significant attention recently, notably from the Department of Transportation's Federal Motor Carrier Safety Administrations (FMCSA) flip-flopping on the revised Hours-of-Service Rule[1].
Data was collected during this time (Mar-Aug, 2004).
A primary concern involves wrecks due to tired truckers. There are an estimated 2.5 million drivers in the trucking industry logging 10 billion miles per year in the US[40].
The National Highway Traffic Safety Administration's National Center for Statistics and Analysis (NHTSA/NCSA) states that in 2002 large trucks were involved in 434,000 traffic crashes in the U.S. killing 4,897 people[41, 41a] which cost an average of $51,000 per accident and $2.7 million per accident when fatalities were involved[42,56]. The National Transportation Safety Board (NTSB) reports that roughly 57% of these crashes are fatigue related[2]. A 2000 study reported that 47.1% of long-distance truck driver survey respondents had fallen asleep at the wheel, 25.4% having done so within the past year[43].
Crash rates are highest in the early morning hours correlating with highest sleep propensity[38,39]. Several studies including the most recent "Sleep Habits and Accident Risk Among Truck Drivers: A Cross-Sectional Study in Argentina" (Perez-Chada et al) appearing in *SLEEP* 2005[90] have shown that truck drivers routinely get fewer hours of sleep per night, have poor sleep hygiene, and are more prone to sleeping disorders. Other risk factors contributing to crashes include youth, inexperience, shift work, alcohol, and drug use[44-55]. Unfortunately, most of these studies have only utilized questionnaires with little or no correlating objective data having been collected.
This project was designed to determine whether engine idling is a factor in Truck Driver sleep by performing full-attended sleep studies following American Academy of Sleep Medicine (AASM) guidelines[59] at a truck stop in Knoxville, Tennessee with the drivers in their own trucks and on their own schedules. IdleAire* is a privately held company headquartered in Knoxville, TN. which is installing the first nationwide advanced truck stop electrification ("ATE") network. This service uses an external HVAC unit and externally supplied electrical power to provide filtered in-cab heating and air conditioning, electric shore power, communication, entertainment, and educational services to drivers of heavy-duty class 7 & 8 diesel, long haul trucks. The IdleAire system allows drivers to turn off their engines while they are parked and maintain a comfortable cab temperature. It is being installed in commercial travel centers and other parking facilities across the country where drivers park and idle their truck engines for extended periods thereby permitting Truckers to sleep with their engines turned off during rest periods.

Methods:
25 drivers (22 male) tested under three different conditions: Engine On (EO), Engine Off with IdleAire (IA), and in our Sleep Lab with conventional rooms (Lab).
Full attended Sleep Studies performed following AASM standards by monitoring EEG at C3, C4, A1, A2, O1, O2 of the International 10/20 system, EOG, Chin EMG, Nasal/Oral airflow & pressure transducer, Snore microphone, EKG, Chest/Abdominal belts, Leg EMG, pulse/oximetery, Audio/Video (camera/intercom) on portable XLTEK data acquisition units* (Ontario, Canada). Studies were scored blindly using R&K and AASM guidelines.[60]

Participants:
29 drivers originally took part but four dropped out after the first study and their data was not utilized except to note that two of these drivers had significant OSA (RDI of 42 and 66 –the later having a 1min SOL and multiple SAO2 desats into the 40's).
Driver volunteers were chosen on site based on willingness to participate and availability to be in Knoxville, TN on three mostly non-consecutive nights over a three-month period.
Drivers were paid $20 for EO, $20 for IA, and $60 for the Lab tests respectively.
Drivers were also given free use of IdleAire during that portion of testing.
Drivers were further promised anonymity to encourage honest answers.
Data was collected from March through August of 2004.
We had originally hoped to have all drivers spend the first night in the Lab as first night effect would be expected to be greatest[61] but this quickly proved impossible as drivers were extremely reluctant to leave their trucks unattended. We therefore counterbalanced first night effect by spreading it over treatment conditions.[62]
Of the 25 subjects 22 were males (88%) and 3 were females (12%).
Mean age 37.28 years (range 23-57).
Mean Ht 5'9.12 feet (range 5'0-6'2).
Mean Wt 228.2 lbs (range 120-362).
Mean BMI 33.68 (range 18.8-49.6)
12 drivers (48%) had used IA before and 13 (52%) had not.
Of the 12 who had used IA:
4 had 1st test on IA, 4 had 1st test with EO, and 4 had 1st test in Lab.
Of the 13 who had not used IA:
5 had 1st test on IA, 4 had 1st test with EO, and 4 had 1st test in Lab.
Participants were asked to fill out questionnaires and release forms prior to testing as well as post sleep questionnaires after each test. Questionnaires included our standard Sleep Lab Questionnaires, Driver Specific Questionnaire, The Epworth Sleepiness Scale, The Fatigue Scale, The Sleep Hygiene Inventory, and verbal questions during interview and hook-up. Sleep Diary was attempted but only 4 drivers (16%) correctly completed it.
CDL requirements vary from state to state but call for drivers to "be able to read and speak English well enough to understand traffic signs, prepare reports, & speak with law enforcement officials and the public".[63] Many drivers however had difficulty filling out the questionnaires.

Results:
-Sleep Efficiency was significantly better (p=.0023) with the engines turned off.
IA: 84.96% range 64.6%-98.9%, EO: 77.73% range 45.8%-94.0%, Lab: 72.89% range 25.9%-88.5%
-EKG arrhythmias (includes all premature and irregular beats/rhythms PVC, multifocal PVC, PVC couplets, PVC triplets, bi, tri, & quadgeminal PVCs, PAC, PJC, PAT, SA, SBT,etc) were significantly lower (p=.001) with the engines turned off.
IA: 42.24 range 0-271, EO: 85.68 range 0-516, Lab: 57.92 range 0-342.
We consider this finding most intriguing as it indicates a correlation to inhaled diesel emissions and their impact on the heart. Further supported by our findings in SAO2. Several articles show that truck drivers are more prone to heart attack[68-70] and heart disease[71]. Many smaller studies have even shown changes in heart rate and function while drivers were on the road[72-75]. This further correlates well with the Peters study which shows that being in traffic (or that particulate air pollution from traffic)[64] may trigger or raise the risk of Heart Attack almost three-fold.
Arrhythmias increased insignificantly during the Lab phase. We attribute this to driver stress associated with first night effect from being away from their rigs.[61]
-SAO2 (blood oxygen levels %) baseline & nadir (low%) averages were significantly lower (p=.003) during the EO phase but no findings were observed between IA & Lab.
-IA: 94.68%, -EO: 93.76%, -Lab: 94.76%
-IA low: 85.39%, -EO low: 81.04%, -Lab low: 86.4%
That SAO2 levels were consistent in both the Lab and IA phases suggests that the difference making SAO2 lowest on the EO phase would be attributable to inhaling increased diesel emissions while the engine was idling.
-Respiratory Disturbance Index (RDI) shows the highest number of respiratory events occurred under the Engine On (EO) treatment condition while indices remained consistent and lower, but not significantly so, for both IA and Lab phases. We attribute this to increased inhalation of diesel emissions during the EO phase.
IA: 12.62, EO: 16.2, Lab: 12.46.
-RDI > 5.0[77] # of drivers: IA: 16 (64%) range 0-76.9, EO: 16 (64%) range .2-95.8, Lab: 13 (52%) range .2-74.8.
>50% of all truck drivers tested had significant breathing impairment under each treatment condition compared to 2-4% in the general population[66].
-PLMS was significantly higher (p=.003) under the Lab portion of the test. No significant difference observed between EO and IA. Significant night to night variability is known to exist in PLMS[76,67]. The additional anxiety drivers experienced by having to leave their trucks and cargo while in the lab (most companies require drivers to remain at least within visual range of their trucks and loads)[63] may have been a factor. This does correlate with our finding of increased wake time seen in the Lab phase.
IA: 37.45, EO: 40.74, Lab: 50.02.
-PLMSI > 10.0[76] # of drivers: IA: 20 (80%) range 0-160.9, EO: 20 (80%) range 1.3-138.7, Lab: 22 (88%) range 0-222.
>80% of all drivers tested had significant limb movement disorder (PLMS) under each treatment condition compared to 5% of people between 30-50yrs and 29% of people over 50yrs[67].

-%Time Awake was significantly higher (p=.003) during the Lab phase compared to both EO and IA. Possibly due to increased first night effect from being away from their rigs.
-Arousals were significantly (p=.003) increased during the EO phase and lowest on the IA testing phase correlating to lowest PLMS and RDI indices, as sleep efficiency was highest relative to EO & Lab testing phases respectively. Differences were not statistically significant between IA and Lab.
-Stage 1 Sleep% was significantly lower (p=.0023) during the IA phase compared to both Lab and EO. This correlates with findings of better sleep efficiency seen during this test. No significant differences were observed in Stages 2, 3, 4, and REM percentages.
Total Sleep Time (mean =4hrs 46min. +/-3.52) was not significantly different across conditions although the changing Hours-of-Service Rule[1] encountered during the data collection process of this research may have played a factor.

-Driver Preference:
Drivers were asked to select their preferred sleep environment from the test.
16 drivers (64%) chose IdleAire (non-idling with externally supplied air).
5 drivers (20%) chose the Sleep Lab.
4 drivers (16%) chose Engine On idling.
21 drivers (84%) stated that if IdleAire were available, they would prefer to turn off their engines and use an external source of heating and air conditioning during rest periods rather than leaving their engines idling. A savings in fuel costs while using an external source vs idling played a role in the response of some drivers as an idling engine will consume approximately 1 gallon of fuel per hour[57].
All test subjects indicated they would prefer to sleep at home. However, many indicated that they need a night or two to adjust after being on the road. This may be due to the change in Engine noise, vibration, or environment.

-Other Driver Information:
20 drivers (80%) use Caffeine or OTC stimulants.
19 drivers (76%) had TST of less than six hours.
16 drivers (64%) have variable bedtimes/risetimes greater than three hours.
14 drivers (56%) report to get less than six hours of sleep routinely.
14 drivers (56%) Smoke.
12 drivers (48%) felt IdleAire/internet access could decrease Sexually Transmitted Diseases (STDs) a significant problem in the trucking industry[34-37].
11 drivers (44%) have an ESS score of greater than 10 (indicating excessive tiredness).
10 drivers (40%) report Depression.
10 drivers (40%) complain of Pain.
9 drivers (36%) take Naps.
7 drivers (28%) complain of Head Aches.
7 drivers (28%) complain of Stress.
6 drivers (24%) complain of Reflux or GERD.
4 drivers (16%) use Alcohol.
4 drivers (16%) use illicit drugs (methamphetamine, coke, pot, heroin, pain pills, other).
3 drivers (12%) report High Blood Pressure (blood pressure was not taken during tests).
3 drivers (12%) report Diabetes.
2 drivers (8%) report Asthma.

1 driver (4%) reports Hernia.
1 driver (4%) was observed to have Parasomnia (night terrors).
1 driver (4%) was observed to have seizure discharges.

Discussion:

Our findings confirm previous studies showing Truck Drivers to be a particularly unhealthy group. Significant RDIs were seen in > 50% of drivers compared to 2-4% in the general population[66] and significant PLMS was seen in > 80% of drivers compared to 5% of people 30-50yrs and 29% of people over 50yrs[67]. This is an "at risk" population with unique problems that the general public often cannot relate to, but frequently suffer the consequences from in the form of crashes. Truck drivers also have an increased risk of cancer, heart attack, musculoskeletal disorders[80,81], and other ailments[82-85].

Our data suggests that a non-idling sleep environment provides significant health benefits to drivers. Other countermeasures to driver fatigue have been tried without success. These include bright light[85], temperature variation[86], Circadian Alertness Simulator[87], fitness programs[88], and diet[89].

In personal interviews & on questionnaires drivers relate that while sleeping with the engine on, whenever the engine coughs or sputters, it causes an arousal with "Reefer Trucks" (refrigeration/freezer trucks) being the worst due to regulating cargo temp. Truck Drivers without an on-board source of electrical power are forced to park where they can and leave the engine running. Drivers state that having to park on an incline such as an On or Off Ramp, will effect sleep and comfort as the direction they park will roll them into or out of bed. "It's like sawing the legs off one side of your bed at home". Drivers also try to park where there is food, fuel, restrooms, & showers available, and where radio & TV reception is good as drivers often must spend days, weeks, and months on the road. At the truck stops, noise from other trucks, drivers, prostitutes & drug dealers (going truck to truck looking for business), etc, frequently disturbs sleep[68,69,78,79]. It was thought that the change from engine vibration to stillness might cause initial Sleep Onset delays but familiarity with the environment (truck cab) seemed to negate this making Sleep Efficiency and wake time poorest in the Lab.

Truck drivers are at greater risk for crash due to factors including decreased Total Sleep Time, increased OSA and PLMS, as well as poor sleep hygiene. Future research should look toward implementing treatment strategies for these patients and assessing their effectiveness and practicality on the road. A comparison between non-idling trucks parked with and without ATE systems would be interesting but not realistic as seasonal temperatures play a great role in both ATE and idling use. It should be noted that several states have enacted "no idling" laws[58]. Idling for over 5 minutes is a ticketable offense regardless of temperature unless a health condition or pet is present.

Disclosure & Acknowledgements: Study sponsored in part by East TN Neurology Clinic, & Sleep Incorporated. The authors each own small portions of IdleAire preferred stock of which some was issued in connection with this study. Special thanks to IdleAire and its employees, Petro Truck Stops, the truck drivers and their companies.

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