

USEFUL FIELD OF VIEW IMPAIRMENTS IN DRIVERS WITH OBSTRUCTIVE SLEEP APNEA

Jon Tippin, JonDavid Sparks & Matthew Rizzo
University of Iowa and Veterans Administration Medical Center
Iowa City, Iowa, USA
Email: jon-tippin@uiowa.edu

Summary: As a group, drivers with obstructive sleep apnea (OSA) have an increased risk for motor vehicle crashes, but determining individual crash risk is difficult. We tested the hypothesis that drivers with OSA have impaired visual attention, as indexed by reduced useful field of view (UFOV), a predictor of high-risk driving. Forty-one drivers with untreated OSA and 50 comparison drivers were assessed by UFOV. OSA drivers performed significantly worse than controls on all UFOV subtests and had reduced UFOV as indicated by a higher mean total UFOV score ($p = 0.0017$). However, only 4 OSA and 2 control drivers had values indicative of high crash risk (UFOV reduction $>23\%$). Drivers with OSA have reduced UFOV compared to drivers without neurological or sleep disorders. However, as UFOV identifies few high-risk drivers, its role in assessing crash risk in an unselected population of drivers with OSA appears to be limited.

INTRODUCTION

Drivers with obstructive sleep apnea (OSA) have a crash risk that is more than twice that of the general population (Tregear et al., 2008). Sleepiness-related cognitive impairments, which reduce driver performance and increase the likelihood of driver errors that result in crashes, may play a key role. Sustained attention is often impaired in OSA patients (Aloia et al., 2004) and reduced visual attention, as indexed by the useful field of view (UFOV) task, has been shown to be associated with increased crash-risk in drivers with cognitive impairments (Ball et al., 1993; Clay et al., 2005; Owsley et al., 1998a; Rizzo, 2004; Uc et al., 2006).

In this study we tested the following hypotheses; 1) drivers with OSA have impaired performance on the UFOV task compared to normal drivers, and 2) OSA drivers have reduction in UFOV to levels shown to be associated with increased crash risk.

METHODS

Participants

Ninety-one legally licensed drivers participated in this study. These included 41 drivers with OSA and 50 comparison drivers. Participants with OSA were recruited from the Sleep Disorders Clinic in the Department of Neurology at the University of Iowa, and met accepted clinical criteria for the diagnosis (American Academy of Sleep Medicine, 2005). Diagnosis was confirmed by polysomnography (PSG), which showed an apnea-hypopnea index (AHI) greater than 5 events per hour (Kushida et al., 2005). Consecutive new patient referrals with a clinical suspicion of OSA were invited to participate in an attempt to minimize selection bias. None were

being treated with positive airway pressure (PAP) therapy. Comparison drivers were recruited from community dwelling individuals and were screened with the same procedures as the OSA patients, but did not undergo PSG. Potential comparison drivers were excluded if they had a history of neurological or sleep disorders, any symptoms of OSA (American Academy of Sleep Medicine, 2005), or an Epworth Sleepiness Scale (ESS) score greater than 10 (see self-reported sleepiness below). All potential subjects were excluded if they were no longer driving, were acutely ill, had active, confounding medical conditions such as other sleep disorders, chronic obstructive pulmonary disease, congestive heart failure, dementia, major psychiatric and vestibular diseases, alcoholism or other forms of drug addiction, or used the following medications: stimulants, antihistamines, antidepressants, narcotics, anxiolytics, anticonvulsants and other major psychoactive medications. Potential subjects were also excluded if they had an irregular sleep-wake pattern, or habitual sleep duration of < 6 or > 9 hours (Aeschbach et al., 2001). The study received prior approval by the University of Iowa Institutional Review Board and informed consent was obtained from each participant after full explanation of the study procedures. Subjects were compensated \$50 (US dollars) for their participation.

Self-reported sleepiness

Self-reported sleepiness was assessed by the Stanford Sleepiness Scale (SSS) (Hoddes et al., 1973) given just before the UFOV test, and by the Epworth Sleepiness Scale (ESS) (Johns, 1991) performed at recruitment.

Assessment of Visual Function

Individuals with diseases of the optic nerve, retina, or ocular media were excluded only if they had a corrected visual acuity of less than 20/50. Participants with visual field defects defined by Humphrey perimetry were also excluded. Contrast sensitivity (CS) was assessed using the Pelli-Robson chart (Rizzo et al., 2000). Best-corrected visual acuity (VA) was measured using the reduced Snellen chart, with results expressed as LogMAR (logarithm of the minimum angle of resolution) (Rizzo et al., 2000). For example, 0 represents an acuity of 20/20, whereas 0.30 = 20/10, 0.10 = 20/25, and 0.40 = 20/50.

Assessment of Useful Field of View

Visual attention was assessed by means of the personal desktop computer (PC) version of the useful field of view (UFOV) test (Visual Awareness, Inc., Chicago). The UFOV test consists of three subtests of increasing difficulty involving visually presented tasks; speed of processing (SP), divided attention (DA) and selective attention (SA). A fourth subtest is similar to the SA task but requires subjects to identify if targets at central fixation are the same or different as ones in peripheral locations (S-D). UFOV performance is summarized by combining the first three subtest scores, as deficits in each of these abilities have been shown to be additive in their effect on UFOV size (Oleske et al., 1995). Total score can also be expressed as a percentage reduction of the field of view (maximum radius of 35°) by using a conversion metric (Edwards et al., 2005). The UFOV task was performed at a fixed time in the afternoon (1 p.m.) in an attempt to mitigate the confounding effect of the circadian fluctuation in alertness (Carskadon and Dement, 1992).

Statistical analysis

Wilcoxon rank-sum tests were used to determine whether the OSA and control groups had significantly different distributions for any of the demographic variables or UFOV tests. In tests that determined the group differences on UFOV, linear regression models were used to adjust for age and CS, which could potentially confound the relationship between group status and UFOV.

RESULTS

Participants

Demographic information for the participants is shown in the Table 1. There were no statistically significant differences between OSA and comparison drivers in terms of age or gender, although there were somewhat more male comparison drivers and female OSA drivers. The OSA drivers had poorer CS, but there was no difference for VA. OSA drivers were also sleepier, as indexed by both ESS and SSS.

Useful field of view

OSA drivers performed significantly worse than controls on all UFOV subtests and had reduced UFOV as indicated by a higher mean total UFOV score (Table 1). The differences for subtests of selective attention (SA, S-D) and total UFOV remained significant after adjusting for age and CS, factors known to strongly influence UFOV performance (Edwards et al., 2006). Using the conversion metric (Edwards et al., 2005), mean scores for both groups correspond to <22.5% reduction in UFOV. 3 OSA and 2 control drivers had 23.0-39.5% reduction in UFOV, while only a single OSA driver had >40% reduction.

DISCUSSION

Our findings support the hypotheses that drivers with OSA have impaired visual attention, as indexed by reduced UFOV, compared to control drivers without neurological or sleep disorders. To our knowledge, this is the first report of reduced UFOV in this patient population.

Safe driving depends upon the continuous coordination of several cognitive processes, including information processing speed, working memory, visuoconstructive ability and visual attention (Rizzo, 2004). UFOV, which relies on visual speed of processing, and selective and divided attention, has been shown to be impaired in elderly drivers as well as those with a variety of visual and neurological disorders known to be associated with increased driving errors and crash risk (Clay et al., 2005; Coeckelbergh et al., 2002; Owsley et al., 1998a, 1998b; Uc et al., 2006). Attention and executive function (decision-making and implementation) are among the most commonly reported cognitive deficits in OSA (Aloia et al., 2004) and preferential impairment of attention to peripheral visual targets has been reported in this population (Tippin et al, in press). However, despite finding significantly worse UFOV performance in our OSA drivers, only a few subjects would be considered high-risk based upon previously published data. Ball et al (1993) found that a reduction in UFOV of >40% predicted drivers with a history of crashes in the preceding 5 years with a sensitivity of 89% and specificity of 81%. Owsley et al (1998b) showed

that the odds ratios for predicting injurious crashes with UFOV reductions of 23-40%, 41-60% and >60% compared to a reduction of <23% were 4.2, 13.6 and 17.2, respectively. As only 4 OSA and 2 control drivers in our study had >23% UFOV reduction (a single OSA driver had >40% reduction), UFOV detected few high-risk drivers in our unselected OSA population and failed to differentiate OSA and control groups in terms of the proportion of high-risk drivers.

Table 1. Comparison of OSA and Control drivers in terms of demographics, visual function, subjective sleepiness and UFOV. MEAN +/- SD (range). CS = contrast sensitivity (Log units), VA = visual acuity (LogMAR), ESS = Epworth Sleepiness Scale, SSS = Stanford Sleepiness Scale.

	OSA n = 41	Controls n = 50	p-value
Gender (M/F)	16/25	27/23	0.5035
Age, yrs	44.3 +/- 9.9 (24-65)	40.3 +/- 9.7 (23 - 61)	0.1034
CS	1.862 +/- 0.161 (1.35 - 2.1)	1.932 +/- 0.094 (1.65 - 2.1)	0.014
VA	0.039 +/- 0.066 (0 - 0.218)	0.02 +/- 0.056 (0 - 0.301)	0.0704
ESS	12.34 +/- 4.88 (1 - 22)	6.34 +/- 2.68 (0 - 10)	<0.0001
SSS	2.49 +/- 1.08 (1 - 6)	1.80 +/- 0.76 (1 - 3)	0.0014
UFOV: SP	17.561 +/- 5.282 (16-36)	16 +/- 0 (16)	0.0254
UFOV: DA	43.463 +/- 57.793 (16-290)	25.52 +/- 31.854 (16-226)	0.0218
UFOV: SA	130.024 +/- 72.21 (36-373)	86.9 +/- 53.053 (17-343)	0.0003
UFOV: S-D	269.195 +/- 114.058 (83-500)	211.18 +/- 76.736 (73-500)	0.0096
UFOV: Total	460.244 +/- 199.923 (192-1115)	339.6 +/- 144.774 (135-1085)	0.0017

A variety of methods have been proposed for screening sleepy drivers, including driving simulators (Orth et al., 2005) and off-road vigilance tests (George, 2003) but determining which predictor and outcome variables are useful for determining individual crash risk has met with limited success. Along similar lines, the UFOV scores in our OSA subjects rarely fell into the range generally considered to be associated with increased crash risk. Recently published guidelines for commercial drivers with OSA (Hartenbaum et al., 2006) stratify driving restrictions based upon adequacy of therapy, presence of sleepiness and disease severity. According to the currently available data, assessment of driver fitness for most OSA drivers should be based upon similar information. The potential role for tests such as UFOV in assisting in this determination remains to be determined.

ACKNOWLEDGEMENTS

Funding for this study was made possible by grants from the Center for Disease Control (CDC R49 CCR 721682) and the National Institute of Aging (NIA R01 AG017177). The authors would like to thank Malcolm Yeh, MD for his assistance in screening the participants used in this study.

REFERENCES

- Aeschbach, D., Postolache, T. T., Sher, L., Matthews, J. R., Jackson, M. A., Wehr, T. A. (2001). Evidence from the waking electroencephalogram that short sleepers live under higher homeostatic sleep pressure than long sleepers. *Neuroscience*, *102*, 493-502.
- Aloia, M. S., Arendt, J. T., Davis, J. D., Riggs, R. L., Byrd, D. (2004). Neuropsychological consequences of sleep apnea; A critical review. *Journal of the International Neuropsychological Society*, *10*, 772-785.
- American Academy of Sleep Medicine (AASM), (2005). *International Classification of Sleep Disorders, 2nd edition: Diagnostic and Coding Manual*. Westchester, Illinois: American Academy of Sleep Medicine; 51-55.
- Ball, K., Roenker, D. L., Bruni, J. R. (1990). Developmental changes in attention and visual search throughout adulthood. In: J. Enns, J. (Ed.), *Advances in Psychology*, Volume 69, Elsevier, North Holland, 489-508.
- Ball, K., Owsley, C., Sloane, M. E., Roenker, D. L., Bruni, J. R. (1993). Visual attention problems as a predictor of vehicle crashes in older drivers. *Investigative Ophthalmology and Visual Science*, *34*, 3110-3123.
- Carskadon, M. A., & Dement, W. C. (1992). MSLT's during the constant routine. *Sleep*, *15*, 396-399.
- Clay, O. J., Wadley, V. G., Edwards, J. D., Roth, D. L., Roenker, D. L. (2005). Cumulative meta-analysis of the relationship between useful field of view and driving performance in older adults: current and future implications. *Optometry and Vision Science* *82*, 724-731.
- Coeckelbergh, T. R. M., Brouwer, W. H., Cornelissen, F. W., van Woffelaar, P., Kooijman, A. C. (2002). The effects of visual field defects on driving performance: A driving simulator study. *Archives of Ophthalmology*, *120*, 1509-1516.
- Edwards, J. D., Vance, D. E., Wadley, V. G., Cissell, G. M., Roenker, D. L., Ball, K. K. (2005). Reliability and validity of useful field of view test scores as administered by personal computer. *Journal of Clinical and Experimental Neuropsychology*, *27*, 529-543.
- Edwards, J. D., Ross, L. A., Wadley, V. G., Clay, O. J., Crowe, M., Roenker, D. L., Ball, K. (2006). The useful field of view test: Normative data for older adults. *Archives of Clinical Neuropsychology*, *21*, 275-286.
- George, C.F.P. (2003). Driving simulators in clinical practice. *Sleep Medicine Review*, *7*, 311-320.
- Hartenbaum, N., Collop, N., Rosen, I., Phillips, B., George, C. F. P., Rowley, J. A., Freedman, N., Weaver, T. E., Gurubhagavatula, I., Strohl, K., Leaman, H. M., Moffitt, G. L. (2006).

- Sleep apnea and commercial motor vehicle operators: Statement from the Joint Task Force of the American College of Chest Physicians, the American College of Occupational and Environmental Medicine, and the National Sleep Foundation. *Chest*, 130, 902–905.
- Hoddes, E., Zarcone, V. P., Smythe, H. (1973). Quantification of sleepiness: A new approach. *Psychophysiology*, 10, 431-436.
- Johns, M.W. (1991). A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. *Sleep*, 14, 540-545.
- Kushida, C. A., Littner, M. R., Morgenthaler, T., Alessi, C. A., Bailey, D., Coleman, J., Friedman, L., Hirshkowitz, M., Kapen, S., Kramer, M., Lee-Chiong, T., Loubé, D. L., Owens, J., Pancer, J. P., Wise, M. (2005). Practice parameters for the Indications for Polysomnography and Related Procedures: An Update for 2005. *Sleep*, 28, 499-521.
- Oleske, D. M., Wilson, R. S., Bernard, B. A., Evans, D. A., Terman, E. W. (1995). Epidemiology of injury in people with Alzheimer's disease. *Journal of the American Geriatrics Society*, 43, 741-746.
- Orth, M., Duchna, H.-W., Leidag, M., Widdig, W., Rasche, K., Bauer, T. T., Walther, J. W., de Zeeuw, J., Malin, J.-P., Schultze-Werninghaus, G., Kotterba, S. (2005). Driving simulator and neuropsychological testing in OSAS before and under CPAP therapy. *European Respiratory Journal*, 26, 989-903.
- Owsley, C., Ball, K., McGwin, G., Sloane, M. E., Roenker, D. L., White, M. F., Overley, E. T. (1998a). Visual processing impairment and risk of motor vehicle crash among older adults. *JAMA*, 279, 1083-1088.
- Owsley, C., McGwin, G., Ball, K. (1998b). Vision impairment, eye disease, and injurious motor vehicle crashes in the elderly. *Ophthalmic Epidemiology*, 5(2), 101-113.
- Rizzo, M., Anderson, S. W., Dawson, J., Nawroot, M. (2000). Vision and cognition in Alzheimer's disease. *Neuropsychologia*, 38, 1157-1169.
- Rizzo, M. (2004). Safe and unsafe driving. In: M. Rizzo and P. J. Eslinger (Eds.), *Principles and Practice of Behavioral Neurology and Neuropsychology*, Philadelphia: W.B. Saunders, 197-222.
- Tippin, J., Sparks, J., Rizzo, M. (in press). Visual vigilance in drivers with obstructive sleep apnea. *Journal of Psychosomatic Research*.
- Tregear, S.J., Tiller, M., Greenberg, M.I., Rizzo, M., Hegmann, K.T., Phillips, B., et al. (2008). Sleep Apnea and Motor Vehicle Crashes – A Systemic Review and Meta-Analysis. *National Occupational Injury Research Symposium* (October). Pittsburg, PA, 13-21.
- Uc, E. Y., Rizzo, M., Anderson, S. W., Shi, Q., Dawson, J. D. (2006). Unsafe rear-end collision avoidance in Alzheimer's disease. *Journal of the Neurological Sciences*, 251, 35-43.