

Dr. Martin Moore-Ede
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Education

Ph.D. Physiology, Harvard University, 1974
M.B., B.S. Guy's Hospital Medical School, (M.D. equiv.) University of London, 1970
MRCS, LRCP. Royal Colleges of Surgeons and Physicians, England, 1970
B.Sc. Physiology, University of London, England (1st Class Honors), 1967

Employment Information

1998 to present	Circadian Expert Services, Inc.	Scientific Director
1983 to present	Circadian Technologies, Inc.	Chairman & Chief Executive Officer
2010 to present	Circadian Light Research Center	Director
2022 to 2023	Korrus	Chief Medical Advisor
2011 to 2022	Circadian ZircLight, Inc.	Chairman & CEO
1988 – 1997	Institute for Circadian Physiology	Director & President
1981 – 1998	Harvard Medical School	Associate Professor of Physiology
1975 – 1981	Harvard Medical School	Assistant Professor of Physiology
1982 – 1988	Brigham and Women's Hospital	Associate Staff-Surgery (Physiology)
1974 – 1982	Brigham and Women's Hospital	Consultant in Surgery (Physiology)
1971 – 1974	Harvard Medical School	Research Fellow in Surgery
1970 – 1971	Toronto East General Hospital	Intern (Surgery & Medicine)
1970	Guy's Hospital Medical School	Instructor in Physiology
1968	NASA Ames Research Center	Research Associate

Professional Work Experience

For the past 40 years Dr. Moore-Ede has been an internationally-recognized leader in the field of human circadian, alertness and sleep physiology, human performance impairment, and the applications of this science to technologies and management practices which reduce the risks, costs and liabilities of employees in extended hours operations, where employees are required to work outside conventional daytime hours. This has included basic research as head of Harvard Medical School's Laboratory for Circadian Physiology, applied research as Director of the Institute for Circadian Physiology, and more recently as Director of the Circadian Light Research Center, and industrial applications, serving over 300 clients in a wide variety of transportation and non-transportation industries, as Chairman and CEO of Circadian Technologies, Inc. He is the recipient of numerous awards including the Bowditch Lectureship of the American Physiological Society, and has served as the chairman of various international and national committees including Chairman, International Union of Physiological Sciences (IUPS) Commission on Circadian Rhythms and Sleep Physiology, and Chairman, Panel on General Strategies for Space Research, National Academy of Sciences, Space Biology and Medicine Committee, and has served on the U.S. National Committee for the International Union of Physiological Sciences. He has also been an Associate Editor, American Journal of Physiology: Regulatory, Integrative and Comparative Physiology.

In his scientific career Dr. Moore-Ede has:

- Led over 100 research studies and 300 consulting projects conducting research and applications consulting in human factors as it relates to alertness, fatigue and human performance impairment in round-the-clock operational environments. Developed new technologies, software products and operational methodologies to minimize fatigue in 24-hour operations. Directed and supervised human factors, scientific research, operational consulting, engineering and change management teams.
- Headed a research team focused on human fatigue, drowsiness, microsleeps and impaired performance in commercial and non-commercial drivers and the testing and development of methods to reduce the risk of drowsy driving. Conducted studies on driving simulators and with vehicles (including trucks, buses, automobiles, trains, and mining vehicles) driven in real-world revenue producing operations. Independently evaluated third-party equipment for monitoring and correcting driver drowsiness. Developed and patented neural network systems for detecting microsleeps and triggering countermeasures to prevent accidents.
- Directed the Canalert '95 study of alertness, fatigue, sleep and performance in Canadian railway locomotive engineers. Developed the scientific and operational plan of how to introduce fatigue countermeasures for the first time into the railroad industry. Consulted with the senior management of Canada's three largest railways (Canadian National, Canadian Pacific and Via Rail) and the leadership of the major unions (BLE, UTU) and steered these adversarial organizations to a common consensus on how to proceed. Made presentations at the Ministerial level in the Canadian government to obtain waivers of regulations, and a freeze on proposed new regulations. Designed a major study to prove the effectiveness of fatigue countermeasures in locomotive engineers. Directed human factors and physiological research teams which collected 18-24 hour continuous EEG/EOG/EMG recordings for over 500 train trips through the demanding terrain of the Canadian Rockies, and on high speed operations in the Montreal-Quebec City corridor. Supervised the collection of extensive survey, sleep log, wrist-activity monitoring, trip log alertness scales, pupillometry, and other performance data before, during and after trips, and during rest and sleep periods. As a result of this program innovative fatigue countermeasure methods were developed, evaluated and implemented including crew scheduling, napping, auditory stimulation, rest facility enhancement, and lifestyle training. The net results were substantially improved alertness and safety, and reduced absenteeism. As a result of this program Transport Canada shelved plans to introduce more restrictive hours of work and rest regulations in the Canadian railway industry.
- Directed studies of human alertness, fatigue and performance in different employee groups (locomotive engineers, conductors, track crews and others) in numerous other freight and passenger railroads in Canada, USA and the United Kingdom. Designed new fatigue countermeasures, and studies to test their validity. Developed consensus between senior management (including CEO and Senior Vice-President Operations) and middle management and union leadership on how to fundamentally revise the crew scheduling procedures. Undertaken cost-benefit analyses of risks, cost and

liabilities of human fatigue. Supervised human factors engineering team in design of crew scheduling software, and train flow analysis systems. Developed innovative operational practices to improve human alertness and sleep with crew calling, train dispatch, labor relations, terminal management and rank and file employees. Supervised human factors and physiological research teams obtaining fatigue measurements included sleep logs, performance tests, wrist-activity monitoring, and alertness and performance assessment. Reported on results to Congressional Committees, Government regulators (e.g., FRA, NTSB), CEOs of Class I railroads, National and International Union leadership, and other management and employee groups. Achieved 4% operational cost-savings, transitioned freight railroads from 0% to 95-98% crew schedule predictability, obtained 60% reduction in lay-off absenteeism, improved safety (accidents per million train miles) to record-breaking levels in the industry, increased crew alertness, improved sleep, and significantly improved labor relations, and employee morale. Developed new performance benchmark for railroad industry.

- Pioneered the introduction of alertness/fatigue management into the transit industry. Analyzed the risks and costs of fatigue in multiple British rail train operating companies. Developed and implemented an Alertness Advantage Program in commuter rail in the UK. Undertaken the first studies of a new circadian sleep disorder in split shifts in GO Transit commuter rail operations and led seminars and workshops to identify fatigue root causes, and developed countermeasures.
- Conceived and supervised the development of advance software tools for human factors simulation of physiological alertness and fatigue risk. Developed and patented Circadian Alertness Simulator (CAS). Tested CAS in a wide-variety of real world operating scenarios. Published results and validation studies in peer-reviewed scientific journals. Supervised research teams on major studies of system wide fatigue including an assessment of pilot fatigue in the world-wide air operations of United Parcel Service (UPS) which analyzed every flight and determined minute by minute fatigue risk. Directed teams in reconstruction of fatigue contribution in major accidents (Exxon Valdez, Quantum Chemical Plant explosion, Carnival Cruise line collision, and numerous railroad accidents). Provided expert reports, deposition and trial testimony on results on some of these analyses in legal proceedings.
- Designed and supervised construction of a Control Room Simulator with accompanying residential apartments for the continuous study of round-the-clock shiftwork operations. Installed Foxboro process control simulator and developed human factors testing procedures for assessing operator performance. Conducted continuous day-night studies sponsored by the Nuclear Regulatory Commission (NRC) on the alertness/fatigue occurring on 8-hour versus 12-hour shifts. Supervised numerous other studies on fatigue countermeasures (light, sound, napping, etc.) in the Control Room Simulator sponsored by a panel of 27 major corporations (Exxon, Shell, Boston Edison, Liberty Mutual, Monsanto, etc.).
- Directed a study of vibration in the truck cab and its impact on alertness and driving performance sponsored by the Motor Vehicle Manufacturers Association (MVMA) and Navistar. Directed human factors and physiological research team in design of

project and its implementation. Advised on set-up of Truck Simulator and the design of smooth versus bumpy road protocols. Supervised researchers in collecting EEG/EOG/EMG data from truck driver subjects. Overseen data analysis of microsleep events and driver performance indicators. Presented data and conclusions to industry clients and sponsors. Evaluated suspension systems that remove road vibration on driver alertness in overnight highway driving.

- Developed the original concept of biocompatible shift scheduling in industrial shiftwork operations. Supervised the first industrial field test of shift schedules based on the principles of human circadian physiology in heavy equipment operators in the Great Salt Lake Minerals and Chemicals mining facility. Recorded with surveys and sleep logs the sleep-wake patterns, and alertness levels of employees. Devised the operational measures and conducted the analysis showing 22% improved productivity. Developed the first shift schedule training programs for shift workers.
- Directed human factors and research teams in the study of shift patterns in a wide variety of occupational environments including coal mines, nuclear power facilities, metal smelting foundries, using questionnaires, alertness, and performance assessments. Supervised project teams in over 300 shiftwork consulting projects over the past 15 years. Devised corporate shiftwork management/fatigue management strategies in consultation with senior management, union leaders and employees. Developed and supervised human factors research teams testing the efficacy of various fatigue countermeasures. Demonstrated 5% to 22% improvements in productivity, reduced accident rates, reduced absenteeism, improved sleep and quality of life.
- Led numerous consulting teams assisting corporations in managing crew reduction/downsizing risk. Developed staffing analyses based on circadian alertness physiology to determine optimal (cost-reduction/safety balance) employee staffing/crew size. Developed shift/crew scheduling routines that minimize absenteeism, and unsafe overtime to improve staffing utilization and reduce fatigue risk.
- As the Director of Harvard Medical School's Laboratory of Circadian Physiology, supervised and directed research teams on extensive studies of human and animal circadian physiology. Supervised and undertaken the collection and analysis of multiple endocrine (cortisol, melatonin, growth hormone, etc.) and metabolic variables in biological samples from human and other species as part of over 100 scientific studies over the past 25 years. Undertaken analysis of statistical data and interpretation of results from these studies. Accomplishments in this role included the first identification of the location of the human biological clock (suprachiasmatic nuclei), design of the first temporal isolation facility in the USA for the study of circadian rhythms, and the definition of the multi-oscillator circadian timing system.
- Conducted studies that identified and reported for the first time Shift Maladaptation Syndrome as an occupational risk in round-the-clock workers. Developed assessments of the fatigue-related health costs of 24-hour operations. Identified an increased incidence of Obstructive Sleep Apnea in shift workers. Developed effective

screening programs to confidentially identify and treat individuals in safety-sensitive jobs, with high compliance rates.

- Served as Principal Investigator and Co-investigator in multiple NASA missions. Designed experiments for NASA Space Shuttle and Soviet Soyuz missions to study circadian function in the space environment. Directed research teams. Devised methods and procedures for physiological data collection in space. Served on numerous NASA panels and advisory committees.
- Led the research team that identified how light synchronizes human circadian rhythms based on the human eye's spectral sensitivity to blue (440-495 nm) wavelengths, and led the engineering team that developed and patented the first evidence-based healthy circadian lighting for workplaces

Publications and Technical Reports

Dr. Moore-Ede has published more than 10 books and over 160 scientific papers in the scientific literature on circadian sleep and alertness physiology and its industrial and transportation applications. A list of selected publications is attached.

A. SELECTED PUBLISHED PAPERS

1. Czeisler, C.A., Weitzman, E.D., Moore-Ede, M., Zimmerman, J.C., Knauer, R.S. (1980) Human sleep: Its duration and organization depend on its circadian phase. *Science* 210: 1264-1267
2. Lydic, R., Schoene, W.C., Czeisler, C.A., Moore-Ede, M. (1980). Suprachiasmatic region of the human hypothalamus: Homolog to the primate circadian pacemaker? *Sleep* 2 (3): 355-361
3. Czeisler, C.A., Moore-Ede, M., Coleman, R.M. (1982) Rotating shift work schedules that disrupt sleep are improved by applying circadian principles. *Science* 217: 460-463
4. Moore-Ede, M., Czeisler, C.A., Richardson, G.S. (1983) Circadian timekeeping in health and disease. Part 1: Basic properties of circadian pacemakers. *NEJM* 309 (8): 469-476
5. Moore-Ede, M., Czeisler, C.A., Richardson, G.S. (1983) Circadian timekeeping in health and disease. Part 2: Clinical implications of circadian rhythmicity. *NEJM* 309 (9): 530-536.
6. Guttkuhn, R., Trutschel, U., Heitmann, A., Aguirre, A., Moore-Ede, M. (1998) Automatic microsleep detection by artificial neural networks and fuzzy context interpretation. *J. Sleep Res.* 7: Suppl. 2, p. 110
7. Trutschel U., Guttkuhn R., Ramstaller C., Golz M., Moore-Ede, M. (1998) Method for the Automatic Detection of Microsleeps Using a Neuro-Fuzzy Hybrid System Proc 6th Europ Congr Intellig Techn Soft Comput (EUFIT98), Vol 3, 1762-66, Aachen, Germany.
8. Moore-Ede, M., Guttkuhn, R., Heitmann, A., Trutschel, U., Lahoud, J., Cleveland, D., Norloff, P. (1999). Automatic Detection of Microsleep Events Using Neural Fuzzy Hybrid System. U.S. Department of Transportation, Federal Highway Administration. Report # FHWA-MC-99-136. pp. 98-107.
9. Chyten, J., Aguirre, A., Simonds, L., Moore-Ede, M. Sleep apnea screening and treatment program for shift workers. In: Sonia Hornberger, Peter Knauth, Giovanni Costa, Simon Folkard (eds.): *Shiftwork in the 21st Century. Challenges for research and practice.* Peter Lang, Frankfurt, Berlin, Bern, New York, Paris, Vienna, 2000
10. Aguirre, A., Heitmann, A., Imrie, A., Sirois, W., Moore-Ede, M. Conversion from an 8-h to a 12-h shift schedule. In: Sonia Hornberger, Peter Knauth, Giovanni Costa, Simon Folkard (eds.): *Shiftwork in the 21st Century. Challenges for research and practice.* Peter Lang, Frankfurt, Berlin, Bern, New York, Paris, Vienna, 2000
11. Coburn, E., and Moore-Ede, M. Keeping the Night Shift Alert. *Journal of Workers Compensation.* 10: 22-35, 2001

12. Sommer, D., Golz, M., Trutschel, U., Ramsthaler, C., Moore-Ede, M. Characterization of the Electroencephalogram of Microsleep Using Self-Organized Feature Maps. Advanced Computing in Biomedicine. To be presented at the ICSC Conference, Bangor, United Kingdom, June 2001
13. Golz, M., Sommer, D., Seyfarth, A., Trutschel, U., Moore-Ede, M. Application of Vector-Based Neural Networks for the Recognition of Beginning Microsleep Episodes with an Eyetracking System. Advanced Computing in Biomedicine. Presented at the ICS Conference, Bangor, United Kingdom, June 2001
14. Moore-Ede, M., Heitmann, A., Guttkuhn, R., Aguirre, A., Trutschel, U., Technologies for the Monitoring and Prevention of Driver Fatigue. Presented at “Human Factors in Driver Assessment, Training and Vehicle Design,” Aspen, CO USA, August 2001
15. Heitmann, A., Guttkuhn, R., Trutschel, U., Aguirre, A., Mitchell, D., Moore-Ede, M. Computerized Fatigue Analysis for Work Schedule Evaluation. Presented at XVth International Symposium on Night and Shiftwork, Hayama, Japan, September 2001
16. Moore-Ede, M. Fatigue in Transportation Operations. Clin. Occup. Environ. Med 2: 11-27, 2002
17. Moore-Ede, M., Heitmann, A., Croke, D., Guttkuhn, R., Aguirre, A., Trutschel, U. Truck Accident Frequency & Severity Reduction using Driver Fatigue Risk Assessment with Circadian Alertness Simulator.
18. Moore-Ede, M., Heitmann, A., Croke, D., Guttkuhn, R., Aguirre, A., Trutschel, U. Circadian Alertness Simulator for Fatigue Risk Assessment in Transportation: Application to Reduce Frequency and Severity of Truck Accidents. Aerospace Environ Med. 75: A107-A118, March 2004
19. Trutschel, U., Guttkuhn, R., Heitmann, A., Aguirre, A., Moore-Ede, M. Expert System for Simulating and Predicting Sleep and Alertness Patterns. Proceedings of the Seventh International Conference on Knowledge-based Intelligent Information & Engineering Systems, Oxford, UK, Sept 2003
20. Guttkuhn, R., Trutschel, U., Heitmann, A., Aguirre, A., Moore-Ede, M. Human Fatigue Risk Simulations in 24/7 Operations. Proceedings of the Winter Simulation Conference, New Orleans, December 2003
21. Moore-Ede, M., Schlesinger, B. Scientific Basis for Challenges to Work-Rest & Hours-of-Service Regulations. Journal of Transportation Law, Logistics and Policy 71: 262-279, Spring 2004
22. Moore-Ede, M., Heitmann, A., Dawson, T., and Guttkuhn, R. Truckload Driver Accident, Injury and Turnover Rates Reduced by Fatigue Risk-Informed Performance-Based

Program. 2005 Fatigue Management in Transportation Operations International Conference, Seattle, WA.

23. Sirois, W., Dawson, T., Moore-Ede, M., Aguirre, A., Trutschel, U. Assessing Driver Fatigue as a Factor in Road Accidents. Proceedings of the Fourth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design. 2007
24. Moore-Ede, M., Trutschel, U., Guttkuhn, R., Aguirre, A., and Heitmann, A. Fatigue Countermeasure Rebound: Temporary Alertness Gain from Caffeinated Chewing Gum Repaid as Excessive Sleepiness after Countermeasure Cessation. 2009 Fatigue Management in Transportation Operations International Conference, Boston, MA.
25. Moore-Ede, M. Fatigue Modeling: Opportunities and Challenges of the Transition into Everyday Use by Government Regulators and Industry Risk Managers. 2009 Fatigue Management in Transportation Operations International Conference, Boston, MA.
26. Moore-Ede, M., Miller, M., Trutschel, U., Guttkuhn, R., Aguirre, A., and Fassler, I. Relationship between Marine Pilot Complement and Pilot Fatigue Risk during Tanker Vessel Movements: Optimizing Staffing Efficiency and Safety. 2009 Fatigue Management in Transportation Operations International Conference, Boston, MA.
27. Sirois, B., Trutschel, U., Guttkuhn, R., Aguirre, A., Dawson, T., Moore-Ede, M. Fatigue Accident/Incident Causation Testing System (FACTS). 2009 Fatigue Management in Transportation Operations International Conference, Boston, MA.
28. Dawson, T., Trutschel, U., Sirois, B., Aguirre, A., Sommer, D., Golz, M., Moore-Ede, M. Shiftwork Adaptation Testing System (SATS). 2009 Fatigue Management in Transportation Operations International Conference, Boston, MA.
29. Lerman, S., Eskin, E., Flower, D., George, E., Gerson, B., Hartenbaum, N., Hursh, S., Moore-Ede, M. Fatigue Risk Management in the Workplace. Journal of Occupational and Environmental Medicine; 54(2): pp. 231-258. 2012
30. Moore-Ede, M., Heitmann, A., Guttkuhn, R. Circadian Potency Spectrum with Extended Exposure to Polychromatic White LED Light Under Workplace Conditions J. Biol Rhythms 35: 405-415 2020