A STUDY OF THE ASSOCIATION BETWEEN WORK RELATED, INDIVIDUAL, AND ENVIRONMENTAL FACTORS ON SELF-REPORTED FATIGUE AMONG OFFICERS WORKING IN THE CANADIAN SHIPPING INDUSTRY

L. E. Critch [1], A. Loucks-Atkinson [1], S. N. MacKinnon[1], J. Parsons[2]
[1] School of Human Kinetics and Recreation, Memorial University of Newfoundland & Labrador, St. John's, NL, Canada
[2] Fisheries and Marine Institute of Memorial University of Newfoundland & Labrador, St. John's, NL, Canada

Abstract - **Limited research exists examining fatigue and its indicators among seafarers. The purpose of this research was to determine the influence of work specific, individual, and environmental factors on perceived fatigue among officers. Preliminary data were collected from 8 participants dispatched on 2 vessels in the Canadian offshore sector working a 6-on, 6-off watch system. A self-reported questionnaire method was employed to collect data on momentary subjective physical and mental fatigue for comparison with sleeping patterns, health related behaviours, occupational factors and environmental conditions while on a seagoing trip. Linear trend analyses reveal that problematic sleep sufficiency may be associated with perceived fatigue prior to watch, but overall perception of fatigue remains consistent throughout the 14-day tour. Differences among perceived fatigue between two watch shifts may exist. Participants may be using caffeine to mitigate fatigue symptoms as caffeine consumptions increased over the course of a watch.**

Keywords
Seafarer, fatigue, indicators

INTRODUCTION

Fatigue is a widespread phenomenon that has been found to be relatively common and linked to reduced performance, injury, and chronic health issues among the general working population (Wadsworth, Allen, McNamara & Smith, 2008). As a construct, fatigue is difficult to define due to its multidimensional nature which includes a number of physical, psychosocial and behavioural processes. Regardless of these processes, fatigue is still an experience that is most commonly measured through subjective measures (Fu, LeMone, McDaniel, & Bausler, 2001; Shen, Barbera, & Shapiro, 2006). Thus, fatigue may be defined as "a subjective, unpleasant symptom which incorporates total body feelings ranging from tiredness to exhaustion, creating an unrelenting overall condition which interferes with an individual's ability to function in their normal capacity" (Bridger, Brasher, & Dew, p.106, 2010). Gawron et al. (2001) discusses this concept by explaining that outcomes from fatigue affect not only the areas of performance, physiology, cognition and emotion, but combines with other states such as boredom.

Corresponding author
Name: Dr. Scott N. MacKinnon
Affiliation: Memorial University of Newfoundland
Address: School of Human Kinetics & Recreation
Memorial University of Newfoundland
St. John's, NL A1C 5S7
Canada
Email: smackinn@mun.ca
Phone: 1-709-864-6936

The interaction of these states is apparent when one considers the two main types of fatigue: physical and mental. Physical fatigue is considered a reduction in the ability to perform physical work as a result of previous physical effort (Gawron et al., 2001). Mental fatigue results in reduced performance on tasks that require attention and alertness with memory retrieval (Gawron et al., 2001). Within the marine industry, there are many unique employment challenges that may further exacerbate the effects of fatigue including sopite syndrome, a form of motion induced drowsiness commonly associated with motion sickness (Bridger et al., 2010), as well as the direct added energy requirements associated with working in a moving environment (Marais et al., 2010). Employment at sea often requires being miles offshore for extended periods of time; the work environment is also one's place of habitation and leisure 24-hours a day (Louie & Doolen, 2007). Seafarers face potential unanticipated changes in their work environment (e.g., work schedules, shipping routes and foul weather) which could result in reduced sleep,

extended work days, increased workload, poor dietary habits, inconsistent exercise, and social isolation. Coupled with the inherent danger of working in an unpredictable environment, fatigue could place the responsible seafarer, their co-workers or safe vessel operation at an increased risk of accident. These consequences of fatigue related accidents could result in environmental damage, economic loss, personal injury or even death. Seafarer fatigue contributes to an estimated 16% of critical vessel accidents and 33% of personal injuries (Raby & Lee, 2001).

There is limited research on seafarer fatigue and its precursors despite marine-specific fatigue research beginning in 1950's (Grech, Horberry, Koester, 2008; Smith et al., 2003). Age, experience, and perceived voyage difficulty have been found to contribute to an officer's perceived fatigue (Leung et al., 2006). Inconsistent sleep times and lack of sleep were identified by Louie and Doolen (2007) to contribute to officer of the watch fatigue. Yet unlike Leung et al. (2006) perceived fatigue levels were not found to vary as a function of watch schedule, age, or experience. The Cardiff Research Program is the most extensive study to explore the multi-dimensional nature of marine fatigue. Wadsworth et al. (2008) performed a cross-sectional study that covered all sectors of the British seafaring industry to address the lack of research aimed at determining levels of fatigue and associated risk factors at sea. The findings from this study demonstrated the multi-factorial nature of fatigue which consists of individual (age, smoking and sleeping patterns), psychosocial (job security, support and work stress) and work environment (shift length and physical hazards) factors all contributing to subjective reports of fatigue. It is recognized that while a number of factors may contribute to fatigue, there is a lack of consensus in terms of the multi-factorial interactions among fatigue indicators. This lack of association may be due to the specific context of samples in terms of differing shipping vessels, work conditions, and subject demographics (Wadsworth et al, 2008).
The current research presents preliminary linear trend analysis where subjective self-report questionnaires were collected to quantitatively assess the influence of work-related, individual and environmental factors on perceived fatigue among officers of the watch. In evaluating fatigue as a process, this is the initial step in identifying the indicators that may contribute to fatigue and also the subjective perception of fatigue by participants.

METHODOLOGY

Sampling and Data Collection

Preliminary data collection took place February to April, 2011 on two Canadian vessels that were selected in conjunction with company support and individual officer willingness to participate. Officers of the watch were recruited for this study. A member of the research team either met with the participant face to face or through telephone conversation to discuss the research protocol with participants. Data were collected during the duration of a 14-day seagoing trip with an average of one visit to port per trip. This study employed an Ecological Momentary Assessment (EMA) (Shiffan & Stone, 1998) method in combination with a survey method. EMA is a methodological approach that allowed for the examination of patterns of momentary fatigue. A subjective questionnaire was employed in order to explore the relation between these fatigue patterns and participants' demographics, work characteristics, and health and lifestyle behaviours. The data collection tools were adapted from Fatigue Offshore: Phase 2, the short Sea and Coastal Shipping Industry (Smith et al., 2003). Smith et al. (2003) reported that analysis of the content within the survey revealed that it provides good measure of job characteristics that may relate to fatigue and also takes into consideration the unique seafaring work context, vital to understanding the indicators of fatigue. Consultation with subject matter experts occurred while adapting the questionnaires for application in the current research. In the current study, participants were required to complete: a) "pre-voyage questionnaire" prior to a seagoing trip and b) two ESM diaries referred to as the "before shift questionnaire" and "after shift questionnaire" to coincide with their respective time for completion while at sea. The scheduled periods for questionnaire completion at sea were chosen so to not interfere or interrupt work activities. Ethical approval was obtained through Memorial University of Newfoundland and Labrador's Human Investigations Committee.

Fatigue was measured using two scales. A 6-item symptoms of fatigue scale (adapted from Smith et al., 2003) asked participants to rate the extent to which they experienced confusion, tiredness, poor sleep quality, depression, tension and loss of concentration in the pre-voyage questionnaire. A second fatigue measure was adapted from Pietrowsky and Lahl's (2008) Physical-Mental Fatigue Scale (PMFS) to assess physical and mental

indicators of fatigue in short intervals (such as hours). Once a participant boarded the vessel to go to work, s/he was instructed to complete a daily before- and after- shift diary ESM booklets for the full duration of the work trip. The participants was instructed to fill out the questionnaires as close to the beginning and immediate time after the watch shift as possible. The "before shift" diary examined individual sleeping patterns (i.e., bed time, waking time, sleep disruptions, and quality of sleep), eating behaviours, alcohol and caffeine consumption, medication use, smoking behaviours and momentary perceptions of fatigue before the watch shift. The "after shift" diary contained questions about breaks taken during the shift, eating behaviours, caffeine consumption, workload during the watch (physical/mental effort, physical/mental demand), perception of work related issues, the physical work environment (sea state, motion, noise, air temperature), and perceived fatigue after the watch. For both of these diaries, fatigue was measured using the adapted 10-item PMFS discussed above.

Participants

All of the recruited officers' work aboard vessels that operate in the Canadian offshore industry and all of were Canadian nationality. The average age of participants was 41.5 years (*SD* = 9.18 years, range: 28-53 years) with an average experience of 20.6 years at sea (*SD* = 10.89 years, range: 7-35 years). Rankings among the officers included two 1st Officers, three 2nd Officers and three 3rd Officers who were all under the 6-on, 6-off watch system.

Statistical Analysis

Linear trend analyses of the relationships between overall perceptions of fatigue during a seagoing trip and 5 trends-related variables were conducted. The variables selected included a) mental effort put into the watch b) sleep sufficiency c) caffeine consumption prior to and after the watch d) ship motion. Missing data were identified during the last day for 2 participants and the final 2 days for another.

RESULTS AND DISCUSSION

Mean composite scores of fatigue over the 14-day tour length were calculated for every watch (Figure 1). It appears that the mean overall perception of fatigue among participants was stable throughout the

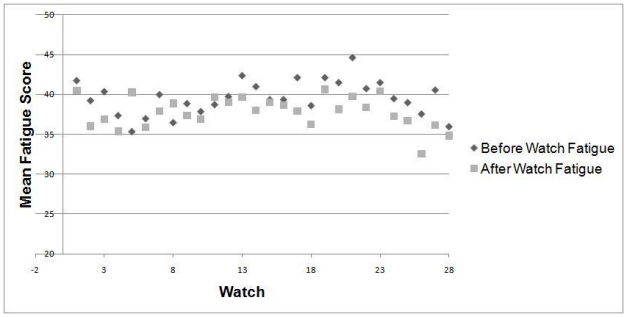

Figure 1. Comparison of Before and After Watch Mean Fatigue Scores

14-day trip duration. This is in contrast to the general assumption that individuals may be more vulnerable to the cumulative effects of fatigue as days-into- tour increases. However, there are inconsistencies regarding this issue reported in the literature. Smith et al. (2003) stated that extended tours (greater than 2 weeks) may be less detrimental to the effects of fatigue due to changes in the impact of work and the work environment as well as greater support resources for long tours. The current study was only a 2-week tour but there are factors observed in the current study that may support Smith et al.'s (2003) position including participant's having infrequent visits to port with an mean visit of .75 (*SD* = .46) trips into port per seagoing trip. Frequent port turnarounds disrupts turnarounds disrupt regular work routines and watch schedules (Louie & Doolen, 2007). Six hour watches were consistently reported in the current study. Thus, the fact that fatigue levels were fairly consistent may be due to limited port turnarounds.

Perceived mental effort (Figure 2) also appeared to decrease after the first few days at sea which may be attributed to the initial adjustment of work demands. As days-into- tour increased, habituation of the work routine may take place, decreasing the perception of mental workload and fatigue. While overall perceptions of fatigue appear to remain constant throughout a seagoing trip, the data revealed a trend that there may be differences in the mean fatigue between consecutive watch shifts; perceptions of fatigue were greater in the second watch shift of the day represent in the first and last day of the tour (Figure 3).

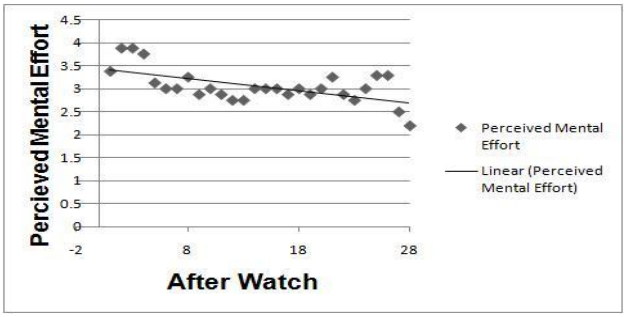

Figure 2. Perceived Mental Effort After Watch

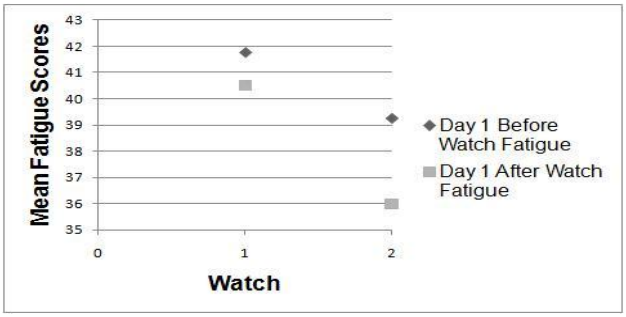

Figure 3. Day 1 Before and After Watch Mean Fatigue Scores

Preliminary analysis suggest a negative linear trend among reported sleep sufficiency and mean composite fatigue scores, suggesting that as sleep sufficiency becomes more problematic, subjective fatigue scores decrease, indicating higher perceived fatigue (Figure 4). It has been previously reported that individuals employed on the 6-on, 6-off watch system may have more sleep difficulties than other watch systems (Donderi, et al., 1995; Härmä et al., 2008**;** Lützhoft et al., 2010). Further analysis of this association may provide support that individuals on a 6-on, 6-off watch may have more sleep problems or shorter sleep episodes than other watch schedules.

Caffeine is recognized as an option for mitigating fatigue symptoms and thus increasing caffeine consumption can be viewed as a symptom of fatigue (Smith et al., 2003). These data suggest constant increases in caffeine consumption reported after the watch shift (Figures 5 & 6). There was a slight negative linear trend in after watch caffeine consumption and after watch reports of fatigue indicating that participant's may be increasing caffeine consumption during the watch to counter the symptoms of fatigue. Other fatigue

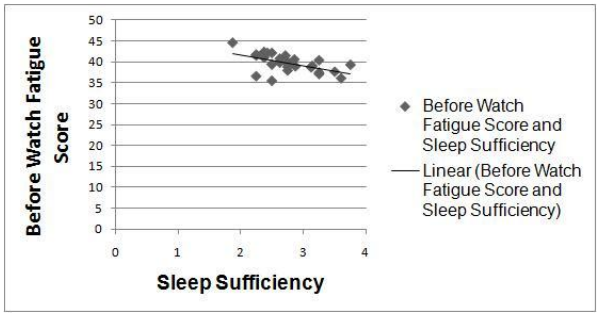

Figure 4. Comparison of Before Watch Mean Fatigue Scores and Sleep Sufficiency

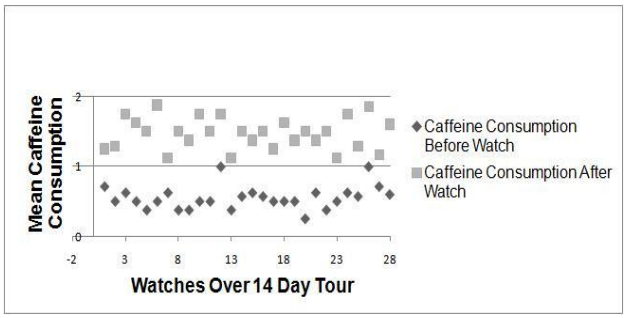

Figure 5. Caffeine Consumption Before and After Watch During 14-Day Tour

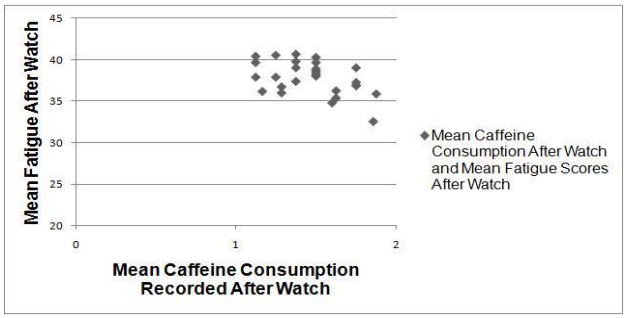

Figure 6. Comparison of After Watch Mean Fatigue and Caffeine Consumption Recorded After Watch

countermeasures such as strategic napping (Ferguson et al., 2008) were not utilized by participants in the current study.

Ship motion did not affect perceived fatigue in the current study. Data suggests that motion induced interruptions had minimal or no impact on fatigue. Increases in vessel motion have been reported to influence health outcomes at sea that may influence fatigue (Bridger et al., 2010). We feel that caution should be made in generalizing this trend in the current study. The fact that in the current study, vessel motion was assessed subjectively (i.e., participants reported their perceptions).

Limitations

Limitations in financial resources, equipment and time resulted in the absence of an objective measure in the current study. The observer effect on participants was not a concern; however unavailability of the research team to be onboard vessels during data collection presents potential issues with participant compliance. Acclimation of participant response to the dairies may have also occurred. As days-into-tour increased, participants may have become complacent in their responses; thus, it can only be assumed that participants followed the research protocol and completed the diaries accurately. Low participant numbers were a limitation of the present research, which reduces the generalizability of the current research. Current participants were all on the 6-on, 6-off watch making it impossible to make any judgements between fatigue and watch schedules.

ACKNOWLEDGEMENTS

The authors of the current would like to thank the Company of Master Mariners and the Maritime Awards Society of Canada for their support of this study.

REFERENCES

Bridger, R.S., Brasher, K., & Dew, A. (2010). Work demands and need for recovery from work in ageing seafarers. *Ergonomics, 53*(8), 1006-1015.

Donderi, D.C., Smiley, A., & Kawaja, K.M. (1995). *Shift schedule comparison for the Canadian coast guard.* (TP 12438E). Transport Development Centre Policy and Coordination: Transport Canada.

Ferguson, S.A., Lamond, N., Kandelaars, Jay, S.M., & Dawson, D. (2008). The impact of short, irregular sleep opportunities at sea on the alertness of marine pilots working extended hours. *Chronobiology International, 25(2&3)*, 399–411.

Gawron, V.J., French, J., & Funke, D. (2001). An overview of fatigue. In Hancock , P.A. & Desmond, P.A. (Eds.), *Stress, Workload, and Fatigue* (581-595). Mahwah ,NJ: Lawrence Erlbaum Associates.

Grech, M, Horberry, T, & Koester, T. (2008). *Human factors in the maritime domain.* Bosa Roca, Fla: Taylor & Francis.

Fu, M., LeMone, P., McDaniel, R.W., & Bausler, C. (2001). A multivariate validation of the defining characteristics of fatigue. Nursing Diagnosis, 12 (1), 15-27.

Härmä, M., Partinen, M., Repo, R., Sorsa, M., & Siivonen, P. (2008). *Effects of 6/6 and 4/8 watch systems on sleepiness among bridge officers. Chronobiology International, 25* (2&3), 413-423.

Leung, A.W.S., Chan, C. C.H, Ng, J.J. M., & Wong, P.C.C. (2006). Factors contributing to officer's fatigue in high-speed maritime craft operations. *Applied Ergonomics, 37,* 565-576.

Louie, V.W., & Doolen, T.L. (2007). A study of factors that contribute to Maritime Fatigue. *Marine Technology, 44*(2), 82-92.

Lützhoft, M., Dahlgren, A., Kircher, A., Thorslund, B., & Gillberg, M. (2010). Fatigue at sea in Swedish shipping: A field study. *American Journal of Industrial Medicine, 53*(7), 733-740.

Marais, J.F., Basset, F.A., Duncan, C.A. and MacKinnon, SN. (2010). Measurement of aerobic demands associated with moving platforms. *Proceedings of the 2010 Human Performance at Sea Conference,* June 16-18, 2010, Glasgow, Scotland.

Raby, M., Lee, J.D. (2001). Fatigue and workload in the maritime industry. In Hancock , P.A. & Desmond, P.A. (Eds.), *Stress, Workload, and Fatigue* (566-578). New Jersey: Lawrence Erlbaum Associates Inc.

Shen, J., Barber, J., & Shapiro, C.M. (2006). Distinguishing sleepiness and fatigue: focus on definition and measurement. *Sleep Medicine Reviews, 10*, 63-76.

Smith, A., Lane, T., Bloor, M., Allen, P., Burke, A., & Ellis, N. (2003). *Fatigue offshore: Phase 2. The short sea and coastal shipping industry*. Seafarers International Research Centre. (SIRC). ISBN: 1-900174-21-9.

Wadsworth, E.J.K., Allen, P.H., McNamara, R.L., & Smith, A.P. (2008). Fatigue and health in a seafaring population. *Occupational Medicine, 58*, 198-204.