Towards a Definition of Liminal Fatigue in Nursing

Fatigue is typically categorized as either acute or chronic, with no classification for a transitional item. In particular, while acute and chronic fatigue have been studied extensively in nursing, there is a lack of studies on the buildup of fatigue beyond acute. Neither have studies researched the initial stages of chronic fatigue. This study reviews the literature to identify differences between acute and chronic fatigue in an attempt to identify or frame a transitional phase hereby called liminal fatigue. We present the finding from a narrative literature review to ground this new concept, which may aid future methods to identify and mitigate fatigue build-up contributing to burnout.

INTRODUCTION

The 3rd leading cause of death in the United states is medical error (Makary & Daniel, 2016) which encompasses nurses and doctors. Nurses have suffered from high stress (Riahi, 2011) and significant fatigue issues since at least the 1930's (Gilbreth, 1935). Fatigue and stress are interrelated (Iacovides, Fountoulakis, Kaprinis, & Kaprinis, 2003) and associated with burnout (Maslach, Schaufeli, & Leiter, 2001: Steege & Dykstra, 2016). Fatigue could be contributing to a nursing shortage by increasing burnout rates (McHugh et al., 2011) this has become a major problem in post-industrial countries (Leiter & Maslach, 2009). Which could lead to higher workloads (Huang, 2018) and additional stress as nurses taking sick leave, prolonged absence (sabbatical) or shifting to part time status can impact other nurses having to cover vacancies (Holmas, 2002; Schaar et al., 2012). Potentially impacting patient and worker safety as fatigue, stress and workload combined can impair cognitive and physical performance (Mock & Crumpton-Young, 2005: Hockey, 1997). Which correlates to hours per week, department, shifts, workload and patient to nurse ratio, (Malekpour et al., 2013) increased error rates could result in injury or death in a hospital setting.

Extreme healthcare environments and shiftwork further expose the personnel to stressors and limit the amounts and types of fatigue recovery (Sagherian, Clinton, Abu-Saad Huijer, & Geiger-Brown, 2016). Having to treat sick or injured people in pain (Nagy, 1998) or witnessing death can have impacts (Hill, 2012) such as Secondary Traumatic Stress (STS) (Beck, 2011; Samson & Shvartzman, 2016) which has Post Traumatic Stress Disorder (PTSD) type symptoms (Darves-Bornoz et al., 2008). Nurses are also required to interact with patient families while expressing empathy and maintaining a façade of emotional control (Mauno, Ruokolainen, Kinnunen, & De Bloom, 2015). These situations and psychosocial stressors for nurses are compounded by long work hours (Valente & Berry, 2015) and night shifts (Kurumatani et al., 1994) separating them from their social networks and negatively impacting work/life balance (Mullen, 2015) making even "Normal" human activities become stressful as scheduling activities with friends becomes difficult or impossible (Vezina, Derriennic, & Monfort, 2004). This can have a negative impact on cardiovascular disease (Johnson, Hall, & Theorell, 1989).

Finding time for meals such as lunch can be difficult (Witkoski & Dickson, 2010) during an 8- hour or 13-hour shift (Stewart-Knox, 2014) and nurses with early start times might skip breakfast due to morning time constraints (Yoshimura, Hatamoto, Yonekura, & Tanaka, 2017). Meal skipping combined with stress and long workdays can lead to overeating during late dinners (Suzuki, Sakurazawa, Fujita, & Akamatsu, 2016) which contributes to obesity (Takaki et al., 2010) possibly restricting sleep and contributing to increased fatigue (Jarosz et al., 2014) and hypertension.

Fatigue and burnout also effects people from many different occupations ranging from daycare workers to air traffic controllers (Martinussen and Richardsen, 2006; Maslach and Pines, 1977) with an estimated 37.9% of the workforce in the United States having some level of occupational fatigue build-up (Ricci, Chee, Lorandeau, & Berger, 2007). Fatigue contributes to almost 70% of industrial injuries and accidents (Golden & Jorgensen, 2002).

People "know" what fatigue is yet there is no single agreed upon formal definition. Fatigue is complex and multifaceted such that researchers create custom definitions to fit their specific cases (Phillips, 2015) but it is typically categorized as either acute or chronic (Mehta & Agnew, 2012: Mehta & Parasuraman, 2014). The perception of people is interesting as no unified definition exist for fatigue, one study viewed the difference between acute and chronic fatigue as healthy people having acute fatigue while ill people suffering from chronic fatigue (Aaronson, Pallikkathayil, & Crighton, 2003). Investigation of this varied and inter-related problem requires a holistic model that evaluates a wide range of contributors to fatigue, stress, and psychosocial factors. An aggregate fatigue model (Flores & Sasangohar, 2018) helps understanding the contributors to acute and chronic fatigue and promotes a more proactive approach to understand fatigue build up to "liminal" fatigue. This search to determine if fatigue is only acute or chronic or if there a transition area between them.

METHOD

A narrative review of literature was used to identify items which might affect acute or chronic fatigue differently or that produced different effects for acute and chronic. The review included Pubmed/Medline, Compendex, and Scopus limited to English language only and inclusion terms (Fatigue or Muscle Fatigue or Distress* or Fatigue* or Exhaust* or tired* or Stress and Physiological or Burnout) and (Professional or Occupation* or worker* or employee* or Occupational Exposure) while the terms used for exclusion range from chronic to diseases such as HIV or Cancer or PTSD or Chronic

Fatigue Syndrome and finally children and non-humans. There is no starting publication date cutoff to the search as there might have been historical articles which could be useful; however, the main focus was on the more recent articles, especially when dealing with technology. The term "Aggregate Fatigue" yielded no usable articles while the inclusion of aggregate identified excessive numbers of articles about mechanics of materials thus aggregate was not included in the search terms: however, it was not excluded.

The resulting 12,612 articles after removal of duplicates were screened by a single screener reviewing titles and abstracts of the 12,140 articles yielding in 647 articles. Full text screening of these resulted in 427 items. A final detailed review of the full articles resulted a reduction in subtopics and inclusion of only 176.

A second review for "chronic fatigue" was performed in Pubmed/Medline as it was inadvertently excluded in the initial review, and 2,489 English articles resulted after duplicates using similar exclusion criteria to the previous searches. Manual screening resulted in 108 articles included for synthesis. An additional search for "liminal fatigue" was performed in Google Scholar and Pubmed yielding no results. This change was due to renaming the concept as it was noted that acute and chronic fatigue could also be caused by several stressors aggregated which is the basis of the aggregate fatigue model. Liminal was chosen instead of the previous name aggregate fatigue which was then applied to the model.

RESULTS

The search results are grouped into three basic categories which showed changes between acute and chronic: Hippocampus Pituitary Adrenal (HPA) axis, cardiovascular system, and recovery.

Three articles illustrated a gap between acute and chronic fatigue caused by repeated or prolonged stress/overwork without sufficient recovery, which changes the behavior of the HPA axis relative to acute and chronic fatigue. (Ishii, Tanaka, & Watanabe, 2014; Tanaka, Ishii, & Watanabe, 2013; Tanaka et al., 2015) This change in the behavior of the HPA axis is illustrated in Figure 1 and does not occur instantaneously much like a learned response (Lenaert, Boddez, Vlaeyen, & van Heugten, 2018).

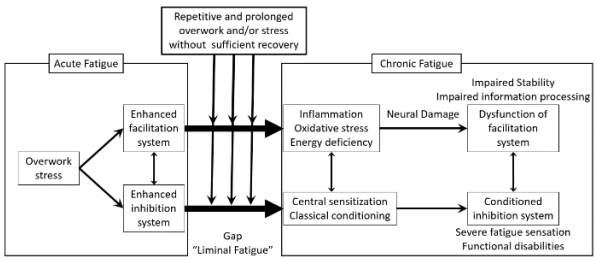

Figure 1: Illustration of the gap where liminal fatigue exists (adapted from Tanaka, Ishii, and Watanabe, 2013). The facilitation system for the HPA axis was enhanced for acute fatigue (left) and dysfunctional for chronic fatigue (right) while the inhibition system is enhanced for acute fatigue and conditioned for chronic fatigue.

This enhanced response to acute fatigue by the HPA axis in both the facilitation system and the inhibition system is natural until they are changed by repeated and/or prolonged stressors. The final result is dysfunction in the facilitation system and a conditioned response by the inhibition system in chronic fatigue.

There are also other physiological changes between normal stressed subjects and Chronic Fatigue Syndrome such as amino acid processing, nitrogen metabolism and energy metabolism dysfunction (Armstrong, McGregor, Butt, & Gooley, 2014) and deviant physiological responses to exercise (Twisk & Geraghty, 2015).

Hypertension can result from genetic and/or environmental stressors and typically takes years to develop; in addition, studies have shown that age is not a cause but that cultural norms may have an effect (Pickering, 1996). There appears to be a correlation with industrial societies/high stress where strain related differences for work hours affect systolic but not diastolic pressure with systolic BP being higher during work hours and mean BP being lower on off days than work days (Landsbergis, Dobson, Koutsouras, & Schnall, 2013; Theorell et al., 1988). A delay in lowering of resting blood pressure to its lowest level during the night also occurs (Rau, Georgiades, Fredrikson, Lemne, & de Faire, 2001). A correlation was also shown between masked hypertension and men having jobs with high demand and latitude or control (Trudel, Brisson, & Milot, 2010). This effect showed to be in effect 24 hours with the strongest relationship with diastolic not systolic BP (Theorell et al, 1991) in a men's only study. A similar effect to the men's study was shown for female white-collar workers with a university degree (Laflamme et al., 1998) while other female workers did not show a significant effect (Laflamme et al., 1998; Trudel, Brisson, & Milot, 2010). Diastolic blood pressure rise was shown to be related to intrinsic job stress in female hospital workers under 35 years old (Van Ameringen, Arsenault & Dolan, 1988). While a study of female nurses found changes in both blood pressure measurements to be associated with job strain, but this effect did not continue during sleep; notably, higher job control correlated to higher diastolic blood pressure (Riese, Van Doornen, Houtman, & De Geus,2004). Reactivity of BP to stress and exercise showed to be a factor in future hypertension in several studies (Mathews et al., 2004; Odahara, Irokawa, Karasawa, & Matsuda, 2010) while another study showed no effect caused by reactivity nor high job stress (Fauvel et al., 2003) but it showed all subjects progressing towards hypertension during the five-year study. A review article found a positive correlation between job strain and hypertension in studies with good methodological quality (Babu et al., 2014). One study between heat exposed and non-exposed men during stressful years showed a significant increase in systolic and diastolic blood pressure along with heart rate: however, while blood pressure eventually returned to normal years later, heart rate never returned to the previous baseline (Kjeldsen et al., 2006).

Sufficient recovery from stress appears as both remediation from fatigue and a mitigating factor in the progression from acute to chronic fatigue. Ensuring proper recovery seems prudent given acute fatigue is common and remediated by rest

or working at a slower pace (Bultmann et al., 2000) both for physical and cognitive work (Ackerman & Kanfer, 2009). Stressful events or working shifts could require more time to recover (Depue & Monroe, 1986) than the recovery time available man lead to carry over stress and fatigue. This is common and referred to as "recovery debt" (Geurts & Sonnentag, 2006) to go along with "sleep debt" (Sallinen, 2008). While researchers once claimed that stress and recuperation must balance during a day (Grandjean, 1979), this assumes the ideal situation, and lack of full recovery during the rest period could be a precursor for prolonged fatiguewhich can take month to complete recovery (Jansen, Kant, & van den Brant, 2002). The average recovery time for Chronic Fatigue Syndrome is 5 years in the USA, but in some cases symptoms can persist for 20 years (Reynolds, Vernon, Bouchery, & Reeves, 2004). While full recovery is rare it is better for chronic fatigue than for CFS (Cairns & Hotopf, 2005).

DISCUSSION

There is a stage in early chronic fatigue where the dysfunction in the HPA axis is not noticed but shows as severity increases (Van Houdenhove, Eede, & Luyten, 2008). This fits well with General Adaption Syndrome (GAS) and the definition of stress (Selye, 1955) and also the Generalized Unsafety Theory of Stress (GUTS) as the stress response eventually causes changes/damage to the organism (Brosschot, Verkuil, & Thayer, 2018).

The conditioning effect on the inhibition system shown in Figure 1 takes time and is almost like a learned effect. The posterior cingulate and insular cortices which are involved in fatigue sensation are also involved in neural mechanisms of the classical conditioning (Tanaka et al., 2015). This time dependence for the change shows that it is not an instantaneous change in state from acute to chronic; a transition zone exists. Based on the time-progressive aspects of fatigue, it is best to find a remediation early, to ensure that it prevents fatigue from proceeding to more serious levels (Hambly, 2004). This early stage is illustrated in Figure 1 which shows acute fatigue and chronic fatigue while comparing the physiological differences between them. This gap is the transition zone between acute and chronic. For this study, we are calling this liminal fatigue and attempting to identify the changes and characterize the effects on the individual.

Blood pressure (BP) and hypertension are not clear-cut as to the effects caused by stress and fatigue and there appear to be some gender differences as well as educational influences. The delayed reset in blood pressure and heart rate might show some potential to study. Especially since some of the effects become permanent over time while others take months to years to recover from. Some of the differences might also be individual such as the high reactors but that particular study also showed all individuals headed toward hypertension at about the same approximate rate as if it was inevitable.

In the event that complete recovery does not occur, a build-up of fatigue and stress may occur and allow the progression from acute to liminal then prolonged fatigue, burnout, and chronic fatigue (Figure 2). This conceptual timeline shows the estimated time periods required for fatigue to build. Time is important because Chronic Fatigue Syndrome (CFS) is defined by at least, a six-month duration of severe symptoms (Fukuda et al., 1994). Prolonged fatigue is disabling and has symptoms that last longer than one month (Elliott, 1999) and can overlap with burnout or occur in combination or separately (Leone, Huibers, Knottnerus, & Kant, 2007).

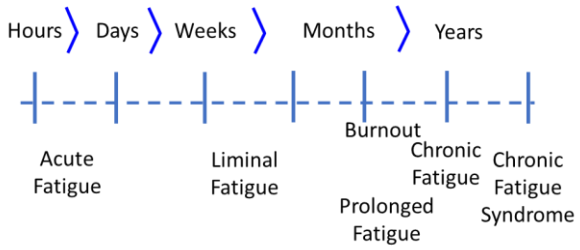

Figure 2: Timeline of fatigue buildup (adapted from Flores and Sasangohar, 2018)

Recovery time or is the only reasonable remediation for stress and fatigue available. Long working hours and commute time, in addition to other personal and social activities and even sleep can compete for time. Time at work is a major contributor to fatigue among nurses as shifts consume a large portion of daily activities thus the recommended 7 hours sleep is not always possible due to social and family commitments (Hirshkowitz et al., 2015) and sleep debt is common (Sallinen, 2008). Awake recovery time when the employee is not thinking about work is essential for recovery (Sonnentag & Bayer, 2005). Optimal recovery is extremely limited given other personal and social responsibilities and activities. The amount of sleep or time off required seems to be affected by the magnitude of stress and fatigue (Sonnentag and Bayer, 2005) carried over and can be referred to as "recovery debt" (Geurts and Sonnentag, 2006) which is much like "sleep debt" that can take several days to recover from a single acute event (Blasche, Baubock, & Haluza, 2017). Chronic fatigue can take years to recover from partially and there may never be full recovery to a nominal state.

CONCLUSIONS

Burnout and aggregated fatigues are affecting nurses in complex healthcare environments. In this short paper, we presented a "Liminal Fatigue" that is not acute nor chronic but is a unique transitional classification. The progressive nature of fatigue makes early detection and treatment desired recovery is more easily accomplished (Hambly, 2004). Time available for recovery cannot be ignored as fatigue buildup can reduce capacity to respond to severe events either physically, mentally, or emotionally (Van Bogaert et al., 2014). A longitudinal study is in progress to measure a wide range of contributors to estimate recovery time and to detect liminal fatigue at an early stage (pre-chronic) using a combination of self-reported surveys and physiological measures.

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