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Fatigue differences between Asian and Western populations in prolonged mentally demanding work-tasks

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ABSTRACT

Introduction: With an increase in the number of mentally demanding jobs, as well as the increase in work performed while sedentary, there is a growing imbalance in the use of body resources. This often results in an increase in fatigue in the working population. The diversity of the workforce is also increasing, whereas physiological differences based on culture are important to consider. The objective of this study was to identify the differences in the levels of fatigue in the workplace experienced by Asian and Western workers in mentally demanding jobs.
Method: Eight Asian and eight Western participants completed an observation-based study. Each participant was observed for four hours in their workplace while they were working on highly mentally demanding work-tasks either computer programming or mathematical simulations. To balance the effect of time, half of the participants from each ethnic group were observed in the morning session and the other half in the afternoon session. Perceived fatigue was measured every 30 min using the single dimensional Borg and multidimensional SOFI scales. Workload was measured using NASA-TLX, and as a change in resting heart rate.
Result: Ethnicity and time interacted to significantly affect the perceived fatigue measured by Borg ($F(9,126) = 2.03$, $p = 0.0412$) and SOFI ($F(9,126) = 3.28$, $p = 0.0013$) scales. Asian participants reported significantly higher workload measured by NASA-TLX scores ($F(1, 14) = 3.68$, $p = 0.0024$) and change in resting heart rate ($F(1, 14) = 7.77$, $p = 0.0145$) was measured higher compared to Western participants. Unlike fatigue, no significant interactions were observed between time and ethnicity to affect either NASA-TLX scores or change in resting heart rate. Post-hoc analyses show that the rate of fatigue was higher for Asian participants. Correlations between the dependent variables were significant ($p < 0.0001$), with a stronger correlation identified for Asian participants.
Conclusion: As compared to the Western participants, Asian participants reported higher values in all dependent measures, including fatigue in both scales, NASA-TLX scores, and change in resting heart rate.
Relevance to industry: The significant growth in white-collar as well as mentally demanding jobs requires more cognitive resources, while reducing physical activities. The consequences of the imbalances in the use of body resources have yet to be studied. This study has been designed to investigate the issues of imbalance in the workplace.

1. Introduction

The experience of fatigue in the workplace has significantly increased in recent decades (van der Ploeg et al., 2013). During the same period, the negative health consequences of fatigue have also increased (van der Ploeg Hp, 2012). However, there is no clear

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Abbreviations

Ex	weekly exercise frequency
Sl	daily sleep in hours
DR	rest after work in hours
W	weekly working hours in primary occupation
TW	total weekly working hours in all of occupations
EDF	fatigue perceived at the end of a regular working day
Borg	one dimensional fatigue measured in Borg CR-10 scale
SOFI	multidimensional fatigue measured in Swedish Occupational Fatigue Inventory
ΔHR	change in resting heart rate
NASA	workload measured in NASA-TLX
Eth	ethnicity
I (or Asian)	study participants from first-generation Asian population
W (or Western)	study participants from Western population, excluding the 2nd or 3rd generation Asian.
T	experimental clock time or assessment point
ANOVA	analysis of variance using repeated measure design
F	F-value from appropriate F-statistics
p	P-value associated with corresponding analysis
r	correlation coefficient
A	afternoon shift between 1:00p.m. and 5:00p.m.
M	morning shift between 8:00a.m. and 12:00p.m.
Sh	working shift, either afternoon or morning

understanding of fatigue in the workplace (DeLuca, 2005). Significant effort has been made toward understanding localized fatigue, such as muscle fatigue, resulting in a significant reduction in injuries associated with those types of fatigue. As physical workload has apparently decreased due to technological advances, the mental workload has increased (Cenedella, 2010). Mentally demanding jobs, mostly performed in sedentary positions, create an imbalance in the use of body resources, resulting in a higher level of perceived fatigue (Ahmed, 2013). Whether the perception of fatigue results solely from the mental, physical or both from a combination is unknown (DeLuca, 2005).

Objective 1: *Therefore, the primary objective of this study is to study fatigue in the workplace developed due to mentally demanding work-tasks.*

According to the Population Reference Bureau (PRB), the Asian population in the United States holds a much higher portion (14 percent) of jobs in science and engineering than do the white (5.3 percent), Black (2.7 percent), and Hispanic (2 percent) populations (Lee and Mather, 2008). A study conducted by the U. S. National Science Foundation (NSF) has observed that among graduate students in science and engineering fields, international graduate students comprise 28 percent of the total population (NSF, 2014). The vast majority of those graduate students are Asian. In the United States, the Asian population is contributing significantly to mentally demanding jobs in the workplace.

Objective 2: *Therefore, to further understand fatigue in the context of the working populations, the second objective of the study is to compare the Asian population living in the United States and the Western population.*

1.1. Fatigue in the workplace due to mentally demanding work-tasks

1.1.1. Change in work-task paradigm and fatigue

In the United States, in the 48 years between 1960 and 2008, approximately 30 percent of jobs shifted from work requiring moderate physical activity to sedentary jobs (U.S. Bureau of Labor Statistics, 2013). In the same period, task-dependent energy consumption decreased 140 calories for men and 124 calories for women per day (U.S. Bureau of Labor Statistics, 2013), which has been suggested as the primary cause of mean weight gain in the U.S. population (Church et al., 2011). In the Netherlands, a 4.7 h per week increase in sedentary work-tasks was observed between 1975 and 2005; however, the non-occupational sedentary period was observed to be unchanged (van der Ploeg et al., 2013).

Cenedella shows that white collar jobs, which are primarily mentally demanding and performed sedentarily, increased 18 percent to 60 percent of the workforce during the 20th century (Cenedella, 2010). Despite the consistent growth in mentally demanding jobs, few studies have been performed on how these stressful jobs could increase fatigue in this population. While physically demanding jobs cause physical fatigue and injury, mentally demanding jobs impose a high level of stress that may result in fatigue if conditions persist for a prolonged period (BLS, 1999). The change in paradigm of the jobs does not necessarily reduce the demand on the personnel; instead it could introduce some unknown consequences if not properly understood.

1.1.2. Etiology of fatigue

In general, fatigue in the workplace can be explained by the amount of work relative to time, and the workload from various sources, including, lifestyle, workstyle, health conditions, organizational structure, work environment, and the work itself. Fatigue has been reported at the end of a regular working day, and fatigue increases over time (Santos et al., 2015). Duration of work-tasks or number of hours spent in occupation at the workplace is one of the primary factors that significantly affects fatigue (El Falou et al., 2003; Jensen, 2003; Østensvik et al., 2009). In addition to the duration of the work-tasks, workload has been proven to be one of the primary causes of fatigue in working populations (Boksem et al., 2006; Dorrian et al., 2011; Finkelman, 1994; Guastello et al., 2013; MacDonald, 2003). Moreover, a recent study shows that a significant interaction-only hyperbolic-mathematical relationship exists between time and load (anything that affects or causes fatigue) to explain fatigue in the workplace (Ahmed et al., 2014). For this reason, including the duration of the work-tasks in a fatigue study is imperative because of not just the main effect of time, but also the interaction with the fatigue load or workload (Ahmed et al., 2014).

Most mentally demanding work-tasks are designed to be performed in sitting positions, which makes the jobs even more sedentary. Prolonged sitting multiplies the odds for mortality irrespective of other physical activity (van der Ploeg Hp, 2012). Lack of physical activity either in the occupation or in non-occupation activities, boosts the risk for bad health consequences (Mork et al., 2010; Taylor and Dorn, 2006). For example, a sedentary job with low physical demands significantly contributes to central and total obesity (Choi et al., 2010), which has been considered the etiology of many life-threatening diseases (Bray, 2004; Gilson et al., 2011). Moreover, prolonged sitting has also been observed as the