Impacts of Psychosocial Stress on Physiology and Psychology Substantially Based on Effort Reward Imbalance Model: A Comprehensive Review

By

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A thesis submitted to the Department of Pharmacy in partial fulfillment of the requirements for the degree of
Bachelor of Pharmacy (Hons.)

Department of Pharmacy

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Declaration

It is hereby declared that

1. The thesis submitted is my own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I have acknowledged all main sources of help.

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Approval

The project titled "Impacts of Psychosocial Stress on Physiology and Psychology Substantially Based on Effort Reward Imbalance Model: A Comprehensive Review" submitted by M. An. Nayem Jahan (16146001) of Spring, 2016 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Pharmacy on 5th January, 2021.

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Ethics Statement

This study comprises no human or animal trial.

Abstract

Occupational stress is a common phenomenon all over the world and researchers found ways to identify and measure job stress and stressors which included some very popular models. In this article, we had focused on effort reward imbalance largely to measure psychosocial stress. This study was intended to identify the effects of job stress on human physiological and psychological aspects after reviewing several articles. Necessary articles were collected and classified based on their type of impacts on human life. The study finding was that psychosocial stress had several impacts on human physiology (e.g., cardiovascular problem, renal problem, diabetes etc.) and psychology (e.g., insomnia, anxiety, depression etc.). The study discussed about these aspects with supporting graphs, data and tables. Finally, we suggested increment of reward, salary, boosting job esteem, keeping resting period, stress management program and counselling to cope up with these stress condition to minimize the impacts.

Keywords: Psychosocial stress; Effort reward imbalance; Measurement of job stress; Effects of psychosocial stress; Management of stress.

Dedication

I would like to dedicate this work to all the healthcare professionals throughout the world including doctors, nurses, pharmacists, technicians who are working frontlines by risking their lives in this pandemic situation of COVID-19 virus.

Acknowledgement

All the praises and thanks be to almighty Allah the entirely merciful, the creator, the source of our life, strength, knowledge, wisdom and blessings.

Later, I would like to express my deepest gratitude to my supervisor, **Easin Uddin Syed**, Lecturer, Department of Pharmacy, Brac University for his expert guidance and suggestions and for giving me all kinds of support, encouragement and motivation at any moment I needed. I believe his words and advices helped me a lot to finalize the project and will help me in the future both academically and non-academically. It was truly a pleasure to find him as a mentor and to work with him.

Also, I would like to take this opportunity to express my gratitude to our honorable chairperson, **Dr. Eva Rahman Kabir** (Chairperson, Department of Pharmacy, Brac University) and all the respected faculty members who taught and help me out throughout my journey.

Last but not the least, I would like to express my greatest regards to my parents for their co-operation, continuous support, unconditional love throughout my life.

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List of Acronyms

ERI	Effort Reward Imbalance
JDC	Job Demand Control
OC	Over-commitment
OIJ	Organizational Injustice
CHD	Coronary Heart Disease
MI	Myocardial Infarction
CVD	Cardiovascular Disease
BMI	Body Mass Index
LF	Low Frequency
HF	High Frequency
HR	Heart Rate
HRV	Heart Rate Variability
BP	Blood Pressure
IHD	Ischemic Heart Disease
HDL	High Density Lipoprotein
LDL	Low Density Lipoprotein
OR	Odds Ratio
SD	Standard Deviation
RR	Relative Risk

Chapter 1

Introduction

1.1 Introduction

“If you work without love, you are working like a slave. When you work with love, you work like an emperor. Your work is your joy.” -Rajneesh Osho.

Acharya Rajneesh Osho a famous mystic leader and philosopher of the late 20th century quoted this regarding the importance of working with love which was very popular and well appreciated among working-class people all over the world. In his quotation, he meant that by working without liking it makes people feel like a slave who is bound to do his task. Moreover, slaves do their task for the sake of their duty which only serves the demand as far as the task is concerned. On the other hand, he compared the worker who does his work with passion and love with an emperor who is self-motivated for his duties and task. In this manner, he is always ready to bring his work to the next level with his creativity and thought. In addition to that, an emperor enjoys his responsibility and largely happy about his work and responsibility.

Moreover, from an employer’s perspective, several studies have shown that firm that consists of self-motivated workers who do their job with passion, love and courage has higher productivity than the firm which does not have. From an employee’s perspective, doing work with love and favorable condition reduces employee’s job stress in a significant amount and avoids several mental and physical health hazards that can be created from working in forceful and stressful conditions.

But can people love their work? Is it solely depend on that individual or the work type itself? If so, then which reasons and conditions are responsible for the workers' love towards their work or job?

Considering these measures, people tried to understand the psychology and reality beneath this to create a productive environment for the firm and ensure favorable working conditions for the firm's workers at the same time. Then the question arose how exactly these job conditions and environment should be evaluated under which circumstances and parameters and how it should be done for different job class including white-collar and blue-collar workers. White-collar workers can be classified as the administrative desk workers with superior social class and wage. Blue-collar workers on the contrary, do the dirty works with physical labor having paid less wage and getting social recognition. However, later on several scientists and analysts had come up with various methods regarding the analysis of job conditions and the environment in an attempt to solve these questions. Different methods had different advantages and limitations for which these were not adopted and accepted vastly later on. However, some of the models were accepted and adopted throughout the world for their convenience, accuracy and integrity. Among these models, some of the most common and well appreciated throughout the world were the Job demand control model (JDC model), Effort reward imbalance model (ERI model), Over commitment (OC model) and Organizational Injustice (OIJ model).

The JDC model is an environmentally based stress determinant model that correlates two dimensions include job-related decision-making capability (Job control) and workload (job demand). Decision making capability has further two sub-dimensions classified as decision authority and skill discretion. According to this model, job strain has occurred when job demand is high and decision-making latitude is low. In job decision latitude diverge 'A' where demands stay greater than decision latitude predicts 'mental strain'.

The job is defined as ‘active’ when job demand and decision latitude both are high that causes the development of behavioral patterns. On the contrary, the job with low demand having low decision latitude is defined as ‘passive job’ which declines overall activity. Moreover, a job with high demand and low decision making latitude is explained as “high job strain” while job with low demand and high decision latitude as “low strain job”. (Karasek & Theorell, 1990; Karasek Robert, 1979)

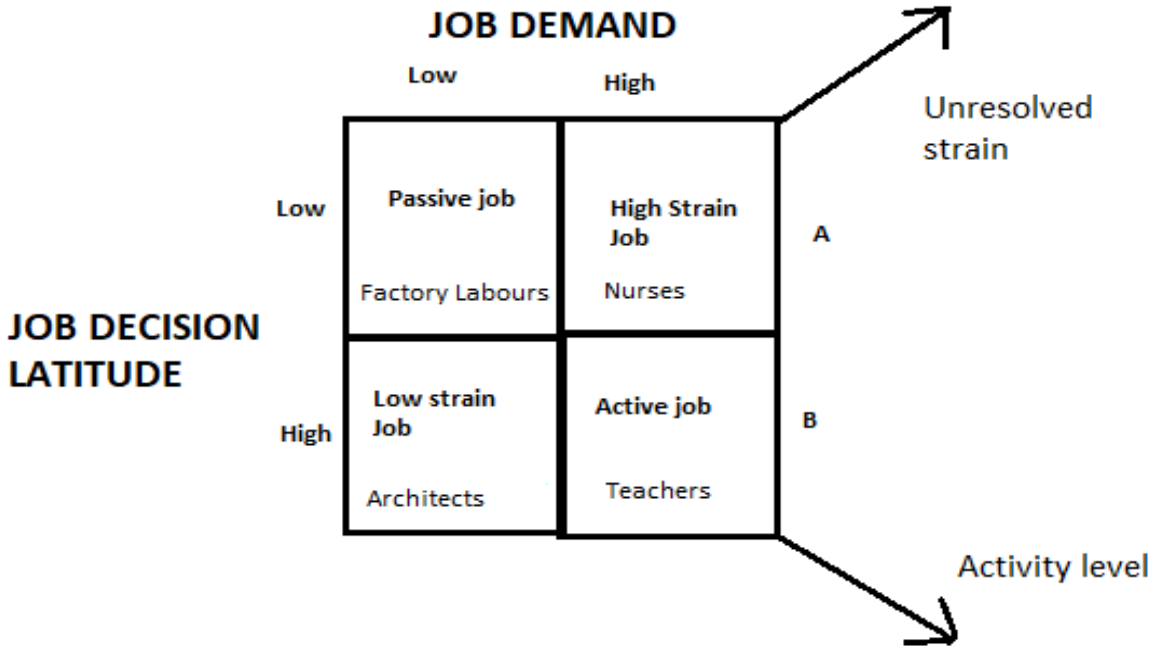

Figure 1: Job strain Model (adopted and modified from Karasek Robert A., 1979)

The organizational injustice model is another effective tool for determining the stress level that focuses on the extent of unfairness that is prevailed in an organization towards its workers. The model was first proposed by Greenberg considering employee’s judgement towards his organization and the resulting perception, attitude and behavior based on the judgement later on. Fairness or justice can be termed as an act or decision that is morally right, unbiased and

easily defined based on law, equity, ethics and religion. An employee is highly influenced by the actions and decisions taken by the organization on daily. The model is originated from equity theory and described by 3 sub-concepts: procedural justice, relational justice and distributive justice. Procedural justice deals with the decision-making process which is rational and democratic and reflects the employee's opinion. Relational justice is concerned with the fact that the employer respects the employees and provide the necessary information. Distributive justice makes sure the resources of the organization are well distributed in a balanced and fair manner considering the responsibility, skill and experience of the employees. When these justices are not met properly, there is a feeling of unfairness that further leads to perceived discrimination. This perceived discrimination changes the attitude and behavior of employees. (Greenberg et al., 1987; Harris et al., 2004; Lee et al., 2019; Warkentin et al., 2011)

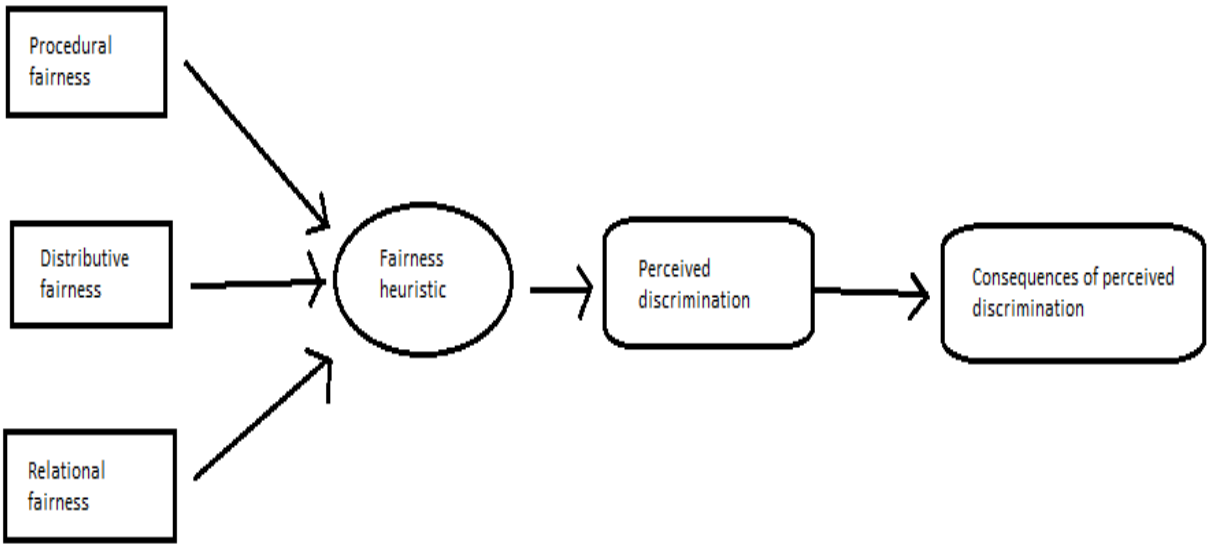

Figure 2: Organizational Injustice model (Adopted and modified from Harris, Lievens, & Van Hoye, 2004).

The ERI model was proposed by Siegrist that explains the imbalance between the given efforts of workers and received the reward. It is a ratio where effort is implied as demands, obligations and rewards are implied as money, esteem, security and opportunities. There is a set of questionnaires for both effort and reward. Additionally, there are some sets of questions to measure the over-commitment level. Though over commitment was presented as one of the sources of high effort at work previously, it is now considered as a psychosocial risk factor of its own and influences the perception of both effort and reward. (Peter & Siegrist, 1999; Siegrist et al., 2004).

An imbalance characterized by high effort with low reward conditions is considered as highly stressed situation and hence those subjects are prone to stress-related disorder. Individuals with high over commitment scores are also characterized as stressed individuals and at risk of several diseases. People co-manifested by both conditions (high effort-low reward, overcommitted) are at the highest risk for stress-related diseases. This model has been explained more in later segments (Godin et al., 2005; Van Vegchel et al., 2005).

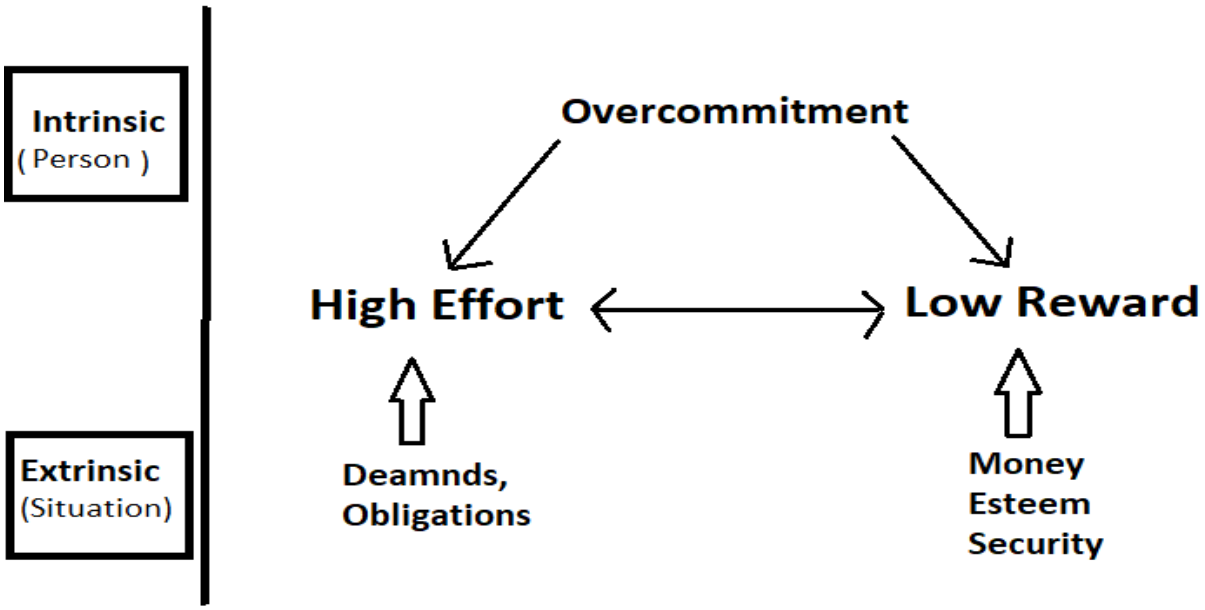

Figure 3: Effort-reward imbalance model (Van Vegchel et al., 2005).

According to these models, an optimum balance is required to get the best efficiency and productivity for the firm and the wellbeing of the worker. Excessive stress decreases productivity and hampers the well-being of the workers vastly. On the other hand, job stress below an optimum balanced level hampers efficiency and productivity in an expected manner both for the firm and the worker.

In this review, we have mainly focused on the 'Effort reward imbalance' model (ERI model) to indicate job stress level and by doing so we tried to relate job stress conditions with several mental and physiological states of humans. The relation between several health hazards with job stress was assumed and claimed long before. However, there was no theoretical or scientific evidence supporting the assumption. In modern times, several studies have carried out to identify and measure the extent of these health hazards more scientifically to evaluate the impact of job stress on creating the condition. Additionally, these studies have enabled us to

predict the extent to which these health hazards can reach upon continuous exposure to excessive job stress. In the case of the physical aspect, ERI related stressors affects the human cardiovascular system, digestive system, body weight, liver and immunity according to several studies and evidences. Moreover, fatigue, diabetes, biological aging, several types of pain, headache, loss of physical function and work ability has also been reported. Some studies have found to cause renal problem, liver problem and metabolic dysfunctions. Furthermore, these stressors can affect blood content, salivary content, hair cortisol level, urine content and DNA as well. Apart from that there is evidence of affecting the normal menstrual cycle and in inflammation progression to the individuals. Then in the case of the mental aspect, it is evident through studies that ERI related stressors directly affects mental health by causing anxiety, depression and insomnia. That further leads to a mental problem, increased anger and social problems. This may affect certain behavioral prospects as well as increasing alcohol consumption, smoking and increased internet addiction as well. In persistent severe stressing conditions, these may lead to accidents and can even grow suicidal tendencies in some cases according to scientific study and evidence.

1.2 Rationale

In the modern era, 'Job demand control' model and the 'Effort reward imbalance' model are most developed and practiced. The JDC model has been used in a large number of cases and has an impressive explanatory power of its single components. However, there are several negative findings reported as well within this period. On the other hand, the ERI model has been developed and tested even more recently with the rapid elevation of role explicating adverse health conditions. Moreover, this model has specified the structural conditions of 'high cost/ low gain' conditions. Apart from that, the model has also focused on individual differences in evaluating effort reward imbalance which is characterized by 'over-commitment' an excessive work-related commitment that made the model for independent and increased accuracy. (Siegrist et al., 2004).

Studies suggested having the more explanatory ability of the ERI model for different cases that make it more favorable to work with. The model is well adapted for diverse situations and can be easily interpreted for different situations compared to other popular models. (Li et al., 2006).

In addition to that, as a resident of a third world country where there is a consistent scarcity of employment, parameters like job control and organizational justice comes secondary in reality. Thus, the integrity of these parameters may deviate in a great amount considering the thinking process of people and workers here comparing to the developed regions where most of the study had done on these aspects. On the other hand, cheap labor and low cost per working hour for employees are well known all over the world in these regions. As we have a plan to extend our study further in this aspect in our country, ERI seemed the appropriate model for us to study. Thus, we decided to explore this model selectively.

1.3 Aim

The study aims to investigate and recognize the effects of psychosocial stress on human physiology and psychology just as to measure and anticipate the impacts on how much extent the effect can be observed.

1.4 Objectives

- To identify and address psychosocial stress and stressors.
- To be able to know psychosocial stress through different popular work-stress models and how they function.
- To identify different components of work stress models in physiology and psychology.
- To address the severity and frequency of different stress-related problems in the human body and mind.
- To seek for responsive measures that can be taken to counter the impacts.

1.5 Methodology

The review is done based on the most relevant articles from high impact factor journals in different parts of the world. The data and information gathered for this paper have been collected by searching journal articles from Google Scholar, PubMed database, The British Medical Journal, AHA Journals, etc. While searching articles from these sites the keywords that were used included “Effort-reward imbalance”, “Components of ERI”, “Psychosocial stress”, “Job stress”, “Effects of ERI”, “Effects of psychosocial job stress”, “Physiological impacts of ERI”, “Psychological impacts of ERI” etc. After searching by these key words,

thousands of articles were shown from which my articles of interest were downloaded after skimming through the abstracts of some of those articles depending on their title. At that point, around 250 articles were downloaded and read through to find necessary information. Finally, around 90 most relevant and informative articles were finalized to prepare the paper. These papers were later classified according to the type of information present and documented accordingly. However, further necessary articles were looked out which were linked to a particular article according to the necessity of the work.

1.6 ERI and its Components

The effort reward imbalance model is a tool to measure psychosocial job stress developed by Siegrist and his colleagues by measuring effort and reward level individually. Effort can be termed as the demands of the job or the obligations the worker has towards the job. On the other hand, rewards are composed of three components consisting of money, esteem and career opportunity or stability. In addition to this, another component has a noticeable impact on the relationship termed as ‘over commitment’. It is a personal coping characteristic of an individual that has specific cognitive, emotional and motivational elements that vary from person to person. Along with that, it implies an internally driven tendency upon excessive effort followed by a desire for approval and esteem. It often underestimates challenges and over estimates coping resources that result in emotional exhaustion and further increases the negative effects of ERI.

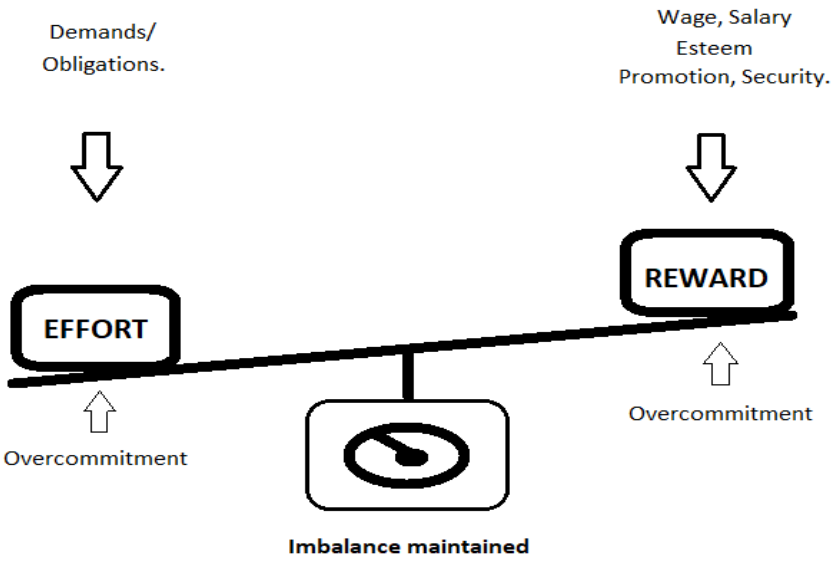

Figure 4: Effort-reward imbalance model (Derived and modified from Siegrist, 1996).

There are different versions of questionnaires with a different combination of question items. However, the most common and popular version of the questionnaire has 17 items among which 6 items are dedicated to the quantified effort and 11 items for the quantified reward. In the case of measuring overcommitment, there are 6 items of additional questions as well. Perceived stress is then determined as the ratio of effort to reward. Generally, the subject is classified as low ERI condition if the ratio of the effort to reward score remains below 1.0 while classified as high with a score exceeding 1.0 which is weighted for the numbers of items. However, the scores can vary considering the working environment of a certain region. There should always be an optimum balance between effort and reward to maintain proper working condition for both employees and employers with maximum productivity. (Peter & Siegrist, 1999; Siegrist, 1996)

1.7 ERI and Stress

Effort reward imbalance is the measure of stress. Several studies have shown a correlation between ERI and psychosocial stress. (Dragano et al., 2008; Hintsanen et al., 2007; Solis-soto et al., 2019)

Hintsanen et al. had found the low vagal tone and low parasympathetic activity in their study population women with higher effort reward imbalance. This was characterized by RMSSD, PNN50 and HF score. Moreover, they had found higher sympathetic activation as well by considering LF/HF and HR values. Law parasympathetic activation followed by high sympathetic activation indicates the presence of chronic stress conditions. (Hintsanen et al., 2007; Myrtek et al., 1996; Rozanskiet al., 2005).

Solis-soto et al. reported an association between ERI and mental stress (1.9; 95% CI 1.2 to 3.1). They had found that rural teachers had higher effort reward imbalance compared to the urban school teachers. They had also found higher evidence of poor self-rated health and mental distress conditions among rural school teachers that indicated effort reward imbalance was playing a role prolonged mental stress conditions. (Solis-soto, 2019)

Chapter 2

Physiological Impacts of ERI Related Stress

2.1 Problems Related to Cardiovascular System

Several studies had shown the association between high effort reward imbalance related stress and cardiovascular problem. (Chandola et al., 2005; Eller et al., 2011; Mika Kivimäki et al., 2002, 2018; Kuper et al., 2002; Siegrist, 1996; Siegrist & Peter, 1994; Siegrist et al., 1990; Van Vegchel et al., 2005)

Previously there was a study done by Vegchel et al. where they had analyzed 45 ERI related research articles among which 8 studies had reported direct cardiovascular diseases and 17 papers reported CVD symptoms and risk factors including higher cholesterol level, hypertension. They had also found that increased ERI imbalance rose the risk of CVD incidence over 1 to 9 times high compared to low ERI. (Van Vegchel et al., 2005).

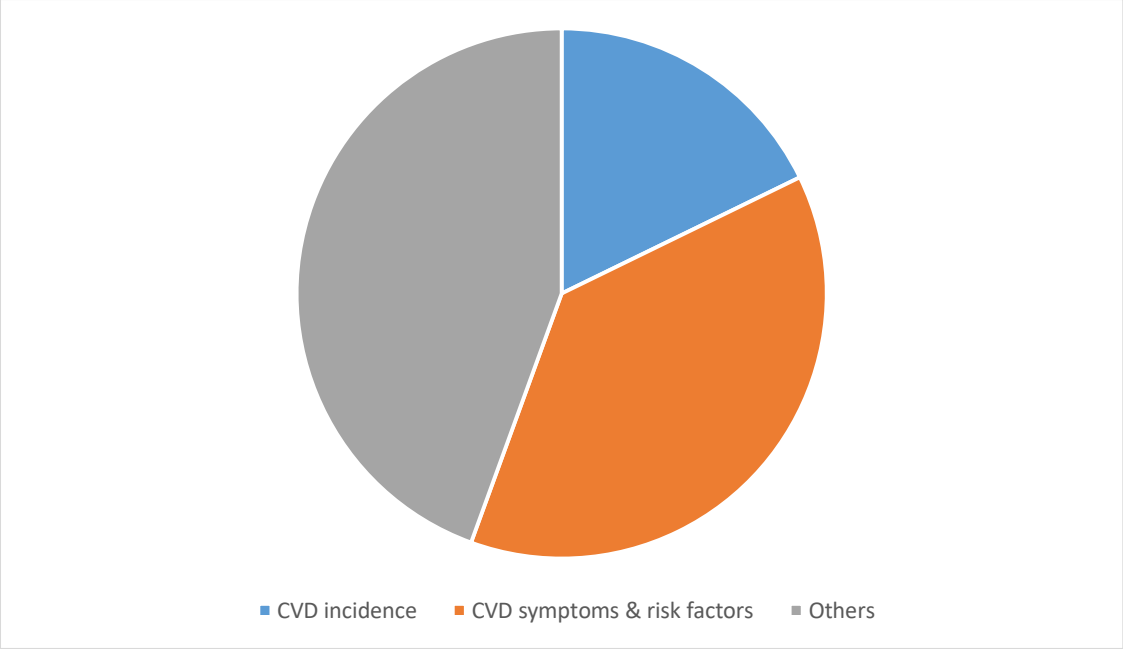

Figure 5: Percentage of studies reporting CVD incidence & risk from 1998 to 2003 (Van Vegchel et al., 2005).

In the initial stage, the study carried out by Siegrist and peter on 263 blue-collar men showed there was an increased probability of cardiovascular disturbance for the population with ERI related stress. People with low-status control (job insecurity, status inconsistency, low promotion prospect) and limited individual coping (work pressure, sleep disturbance, immersion) had a higher prevalence of clinical and sub-clinical ischemic heart disease occurrence compared to other groups. Moreover, people suffering from IHD were subjected to higher systolic and diastolic blood pressure, higher total cholesterol and LDL level. In the figure 'series 1' implies "no psychosocial risk condition" with balanced ERI, 'series 2' indicates "either low or high effort", 'series 3' indicates "low reward and high effort simultaneously". Categories are referring to bio-behavioral risk factors like age, BMI, BP, LDL level. The data clearly showed the increased probability of IHD for low reward and high effort groups in series 3. The table showed there is the least percentage of non-cases (3.8%) in low status and critical coping group. Population groups with "neither low status nor critical coping" had the highest percentage (63.3%) of non-cases in the basis of IHD occurrence. (Siegrist & Peter, 1994)

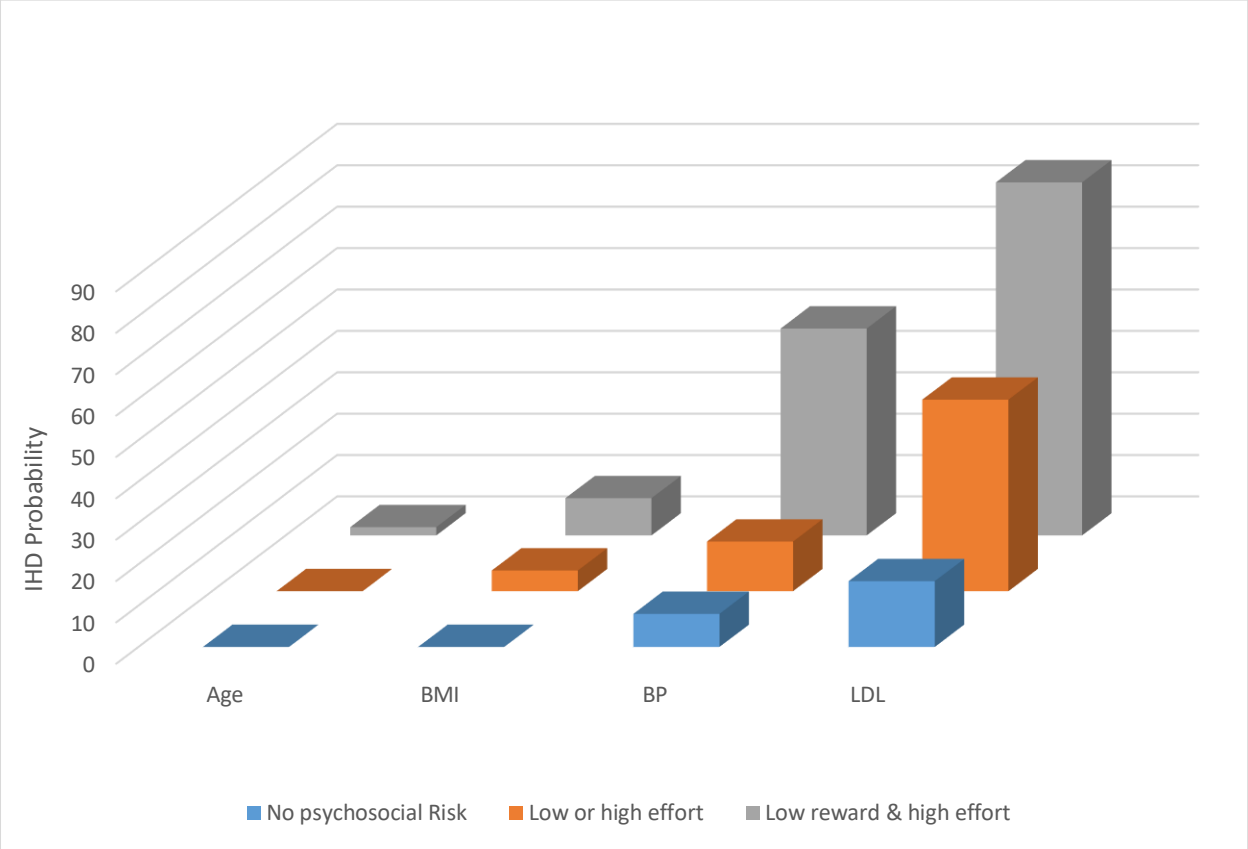

Figure 6: The expected probability of IHD incidence (5-6) years) in a logistic regression model using medical and psychological variables (Siegrist & Peter, 1994).

Variable	Cases (n=42)	Non-cases (n=287)
Age	45.0±9.2	41.6±9.9
Systolic BP (mmHg)	145.3±17.6	137.2±15.5
Diastolic BP (mmHg)	91.6±8.6	89.0±9.7
LDL (mg/dl)	157.0±25.2	154.1±31.4
Neither low-status control nor critical coping	40.4%	63.8%
Low-status control or critical coping	42.9%	32.4%
Low-status control and critical coping	16.7%	3.8%

Table 1: Coronary risk factors in men with IHD and free from IHD (Siegrist & Peter, 1994).

Hintsanen et al. had found a higher effort reward imbalance among women who were found to have low heart rate variability (HRV). Subjects were young adults with a mean age of 32.3.

Moreover, they had found a higher heart rate (HR) incorporated with lower reward among the same sub-class(women). However, in the case of men there were no significant correlations found with Heart rate or Heart rate variability to ERI or its components. The study is significant

in this aspect that it had been done on a large population sample compiled both men and women representing diverse occupations. (Hintsanen et al., 2007)

Eller et al. had also found that the ERI ratio affected heart rate and LF/HF ratio positively during their study on 231 public sector employees. However, according to their study the effect was more pronounced on women and was identified as vagal withdrawal. (Eller et al., 2011)

Heart rate and Heart variability on cardiovascular disease:

Studies identified that, low heart rate variability (HRV) is correlated with cardiovascular diseases (CHD) in general people. (Jacqueline et al., 2000)(Tsuji et al., 1996). In the case of postmenopausal women, a high reduction of HRV through acute stress increase the risk of atherosclerosis. (Gianaros et al., 2005). Moreover, low HRV causes poor prognosis towards cardiac disease patients. (Bigger, Fleiss, Rolnitzky, & Steinman, 1993). High effort reward imbalance is found to be associated with low HRV on ERI based study previously. (Vrijkotte et al., 2000). On the other hand, Heart rate is an assertion of the whole autonomic nervous system combined both parasympathetic and sympathetic systems. (Jennings, 2000). Additionally, an increased heart rate is solely a dominant risk determinant of a cardiovascular problem. (Palatini & Julius, 2004; Perret-Guillaume et al., 2009) Apart from these, it has been one of the major determinant of cardiovascular disease related death. (Habib, 1997). In addition to that studies suggested that higher heart rate directly contribute to the formation of atherosclerotic plaque that further contributes to severe cardiac complexity. (Palatini & Julius, 2004; Perret-Guillaume et al., 2009).

Variable	Women (n=457)	Men (n=406)	p
Age (24-39)	32.3±4.9	32.2±4.8	0.734
Social support (1-5)	4 39±0.69	4.02±0.82	<0.001
BMI (kg/m^2)	24.3±4.1	25.3±3.8	<0.001
SBP (mm/Hg)	113.3±12.4	121.5±12.3	<0.001
DBP (mm/Hg)	69.4±10.1	72.6±10.9	<0.001
Effort (1-5)	2.89±0.67	2.84±0.63	0.272
Reward (1-5)	3.79±0.70	3.85±0.68	0.240
Effort-Reward Imbalance (0.27-3.33)	0.80±0.31	0.77±0.28	0.141
HR (bpm)	70.0±10.7	65.7±10.4	<0.001
RMSSD (ms)	1.60±0.28	1.59±0.25	0.352
pNN50 (%)	25.27±24.45	22.75±21.35	0.106
HF (ms^2)	2.77±0.52	2.66±0.47	0.001
LF/HF	1.60±0.42	1.92±0.40	<.001

RMSSD: square root of mean squared differences of successive normal to normal [NN] intervals; pNN50: number of NN intervals that differed by more than 50 ms from adjacent interval, divided by the total number of all NN intervals.

Table 2 : Study characteristics for men and women (Hintsanen et al., 2007).

In another study, it had shown that there was a significant risk of mortality for a cardio metabolic diseased patient with job strain. Conventional risk factors, treatment or measured life-style did not eliminate or reduce the death risk for those populations associated with job strain. The study included 105284 people among whom 102663 participants had extensive cardio-metabolic disease. Over that, ERI imbalance increased the risk of mortality (6.6 per 10,000 people) for men without cardiometabolic disease. In that study, 102633 individuals were identified among 1423753 person-years at risk (13.9 years mean follow-up), 3441 individuals had an extensive cardio metabolic disease and 3841 had reported dead during the follow-up process. In the male cardio-metabolic diseased population, the mortality rate based on age was significantly greater in high job strain compared to the people who did not have (mortality difference found 52.1 greater per 10,000 person-year; HR ratio was found 1.68). However, comparative risk assessed for the people without cardio metabolic disease related to work-stress mortality was not notable. (Mika Kivimäki et al., 2018).

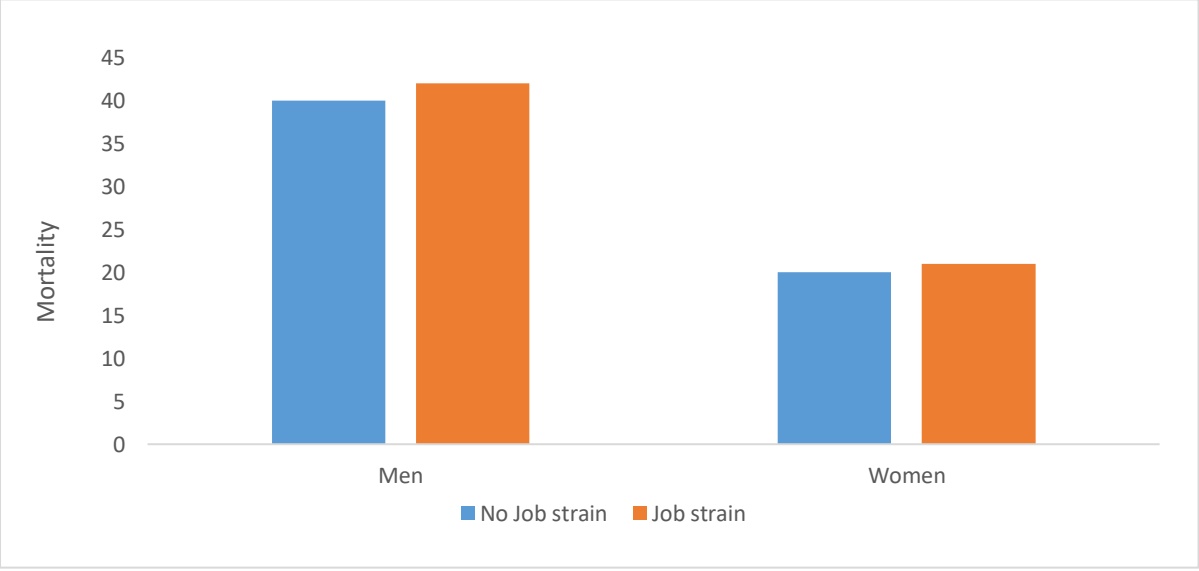

Figure 7: Participants without the cardio metabolic disease (Mika Kivimäki et al., 2018).

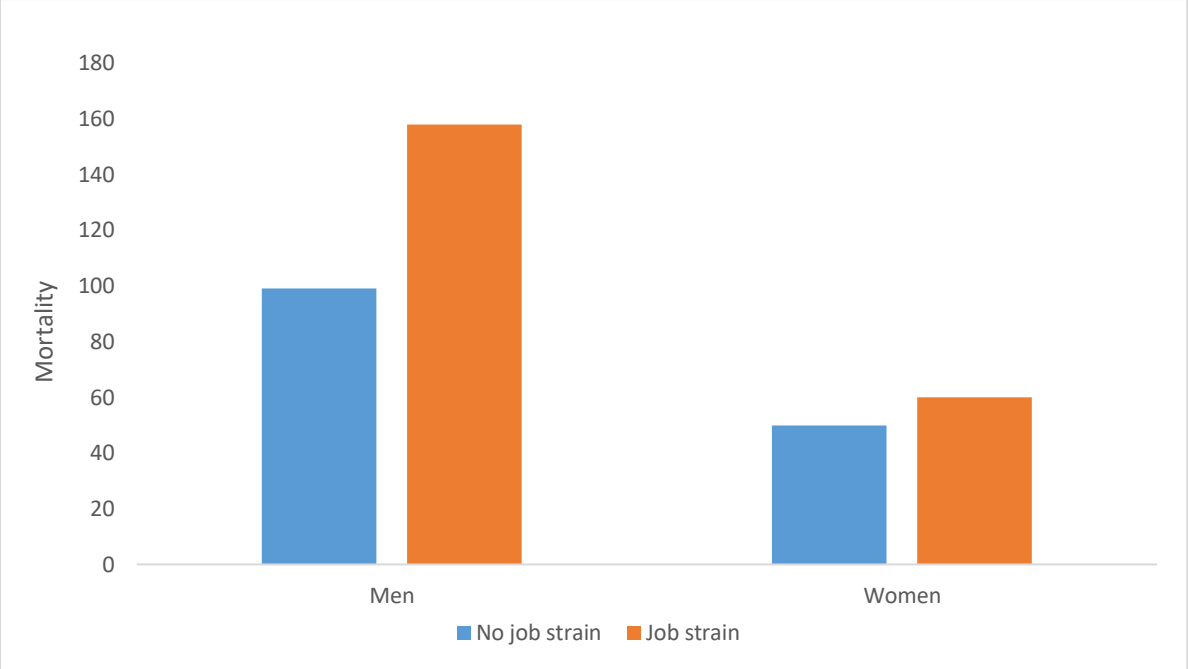

Figure 8: Participant with cardio metabolic disease (Mika Kivimäki et al., 2018).

Kivimaki et al. reported 2.4 folds of cardiovascular mortality risk among employees with high ERI compared to their colleagues with lower ERI value among Finland employees. Moreover, the study found an association of increment of cholesterol level with ERI at 5 years follow-up. The study showed the death hazard ratio had increased on low reward and high ERI imbalance case significantly with hazard ratio 2.04 and 2.36 respectively. (Mika Kivimäki et al., 2002).

Characteristic	No. of participants (No. of deaths)	Hazard Ratio (95% CI)
Effort		
Low	263(15)	1.00
Intermediate	277(24)	1.54
High	272(32)	1.63
Reward		
Low	280(27)	2.04
Intermediate	252(14)	0.79
High	280(32)	1.00
Effort-Reward Imbalance		
Low	269(15)	1.00
Intermediate	272(29)	2.21
High	271(29)	2.36

Table 3: Death occurrence and hazard ratio for cardiovascular mortality based on ERI components (Mika Kivimäki et al., 2002)

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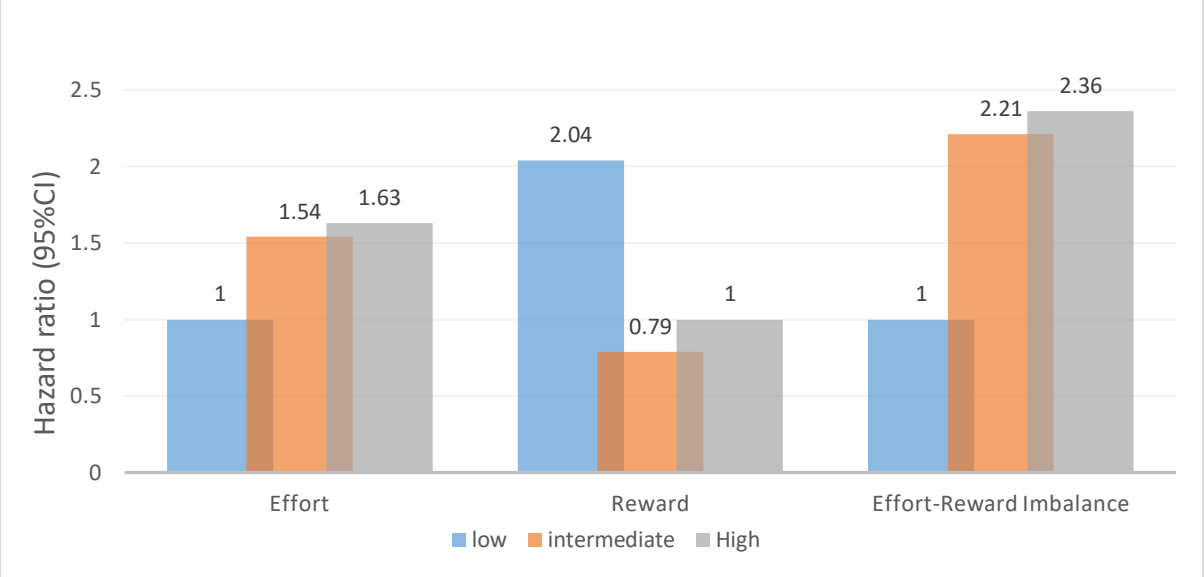

Figure 9: Hazard ratio for cardiovascular mortality based on ERI components (Mika Kivimäki et al., 2002).

Kuper et al. reported a higher risk of coronary heart disease and myocardial infarction (MI) for a high ERI ratio with an HR value of 1.36 and 1.28 respectively. Moreover, they found people with greater extrinsic effort are prone to these problems as well. However, lower-grade employees with a lack of social support were found to be at most risk of CHD among their population groups. (Kuper et al., 2002)

Studies suggest a reduction in effort reward imbalance through a change in structural and behavioral working conditions can eventually reduce the incidence of coronary heart diseases and provide a healthy working condition to the workers. (Chandola et al., 2005; Siegrist & Peter, 1994).

2.2 Correlation With Diabetes

Xu et al. had found correlations between ERI related job stress and diabetes mellitus identified by glycosylated hemoglobin (HBA1c) level in the Chinese population. They found that effort and ERI were positively associated with HBA1c level (r=0.22, p=0.003; r=0.21, p=0.006) where the reward was negatively associated with HBA1c for women. However, they had not found significant evidence for men in this study. (Xu et al., 2012)

Variable	Magnitude	n (number of subjects)	HBA1c
Effort	Low	64	5.12
	Intermediate	76	5.29
	High	75	5.41
Reward	Low	75	5.32
	Intermediate	70	5.21
	High	70	5.30
ERI	Low	47	5.07
	Intermediate	97	5.30
	High	71	5.39

Table 4: Comparison of HBA1c level based on different magnitude groups of ERI components among Chinese women (Adopted from Xu et al., 2012).

Furthermore, the positive relation between over commitment an important element of the ERI model was addressed with the HDL/LDL ratio, glucose and insulin. Moreover the study suggested that exhaustive coping style at work disrupts fibrinolytic capacity for chronic stress on insulin resistance. (Vrijkotte, Van Doornen, & De Geus, 1999).

Parameters	**Low over commitment**		**High over commitment**	
	Low imbalance	High imbalance	Low imbalance	High imbalance
Imbalance	0.63± 0.14	1.19 ±0.19	0.72± 0.13	1.24± 0.27
Over commitment	8.54± 2.64	9.54± 2.67	16.48± 3.55	17.33 ± 4.05
HDL/LDL ratio	3.23± 1.19	3.35 ± 1.30	3.62± 1.43	3.85± 1.83
Glucose(mmol/liter)	5.71± 0.46	5.62 ± 0.35	5.87 ± 0.50	5.91± 0.44
Insulin (mU/liter) [b]	6.21	6.44	7.60	6.92

Table 5: Work stress (over commitment) relating to HDL/LDL ratio, Glucose and Insulin (Vrijkotte et al., 1999).

In addition to that, Mutamdudzi et al had found a higher risk of diabetes (HR=1.33, 95% CI=1.04-1.69) for workers with higher stress levels at work in the US compared to those with low ERI after adjusting adult onset diabetes incidents. (Mutambudzi, Siegrist, Meyer, & Li, 2018)

Kumari et al. had found a higher risk of diabetes incidence for lower grade employees comparing to the higher-grade employees. They also found a profound relation of effort reward imbalance with type-2 diabetes. (Kumari et al., 2004).

Moreover, Hintsanen et al. in their study had found a higher effort reward imbalance in their study population with higher LF/HF and heart rate indicating higher sympathetic activation (Hintsanen et al., 2007). This increased sympathetic tone can contribute to hyperinsulinemia, insulin resistance and obesity that can further trigger diabetic conditions. (Palatini & Julius, 2004). In addition to that high heart rate increases triglycerides, glycemia and total cholesterol levels. (Perret-Guillaume et al., 2009).

2.3 Weight Gain and Obesity

Studies had found positive associations between high effort reward imbalance and increment of weight gain. (Mika Kivimäki et al., 2002; Kouvonen et al., 2005; Nyberg et al., 2012; Takaki et al., 2010)**.** According to Kivimaki et al. work stress increased body weight only for people with higher BMI. On the contrary, for people with low BMI, work stress decreased body weight further. (M. Kivimäki et al., 2006). Along with that Takaki et al. reported there was a strong association of over eating for men with higher BMI in stressful conditions. However, they did not find any evidence of this in women in the same study. Other studies had reported both weight gain and weight loss upon exposure to stressful working conditions. (Nyberg et al., 2012). While, studies suggested over weight could contribute to higher ERI conversely. Wang et al. had found there was 14% higher ERI scores for the higher BMI subject compared to those with a healthy one. (Wang et al., 2018). ERI related stress was reported to be associated with waist circumference, higher BMI, waist-hip ratio in men. In the case of women, only higher BMI was observed. (Hanson et al., 2017).

2.4 Effects on Blood and Urine

Studies suggested job-related stress can increase the fibrinogen level of blood (Clays et al., 2005; Kittel et al., 2002; Tsutsumi et al., 1999). Moreover, this could increase blood lipid parameters, white blood cell count compared to the one who does not have. Additionally a lower level of high density lipoprotein cholesterol was reported for a man having ERI related stress (Hanson et al., 2017).

Moreover, over commitment an important component of the ERI model was associated with the blood HDL/LDL ratio, triglycerides level, blood glucose level and insulin (Vrijkotte et al., 1999).

Kivimaki et al. reported there was an increasement of total serum cholesterol concentration with a greater imbalance of ERI in their study after collecting 5 and 10 years of follow-up reading measurement (Mika Kivimäki et al., 2002).

2.5 Effects on Immunity

Several studies had found an association between ERI and its components with immune function (Bellingrath et al., 2010; Bosch et al., 2009; Eddy et al., 2016).

Bellingrath et al. reported high levels of ERI and over commitment were associated with lower natural killer (NK) cell numbers and higher over commitment was associated with a lower increase in T-helper cells (CD4+). Moreover, individuals with higher ERI showed overall pro-inflammatory action with higher TNF-a production and increased pre-stress IL-6 production. Furthermore, higher IL-2 production was associated with over commitment post-stress. Overall, the study suggested reduced innate immunity defense resembling lower NK killer cell count along with boosted pro-inflammatory activity upon high ERI and OC (Bellingrath et al., 2010).

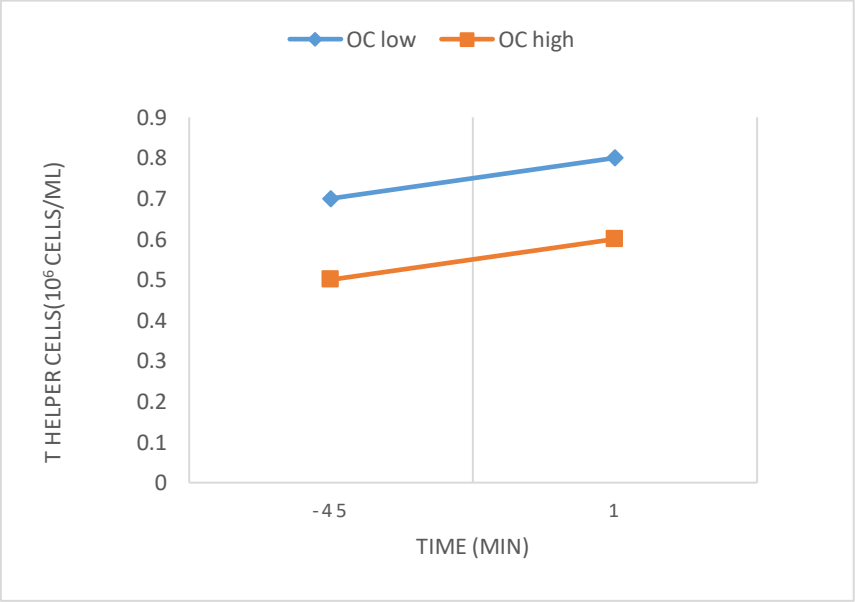

Figure 10: Count of T helper cells upon High vs Low ERI. (Modified from Bellingrath et al., 2010)

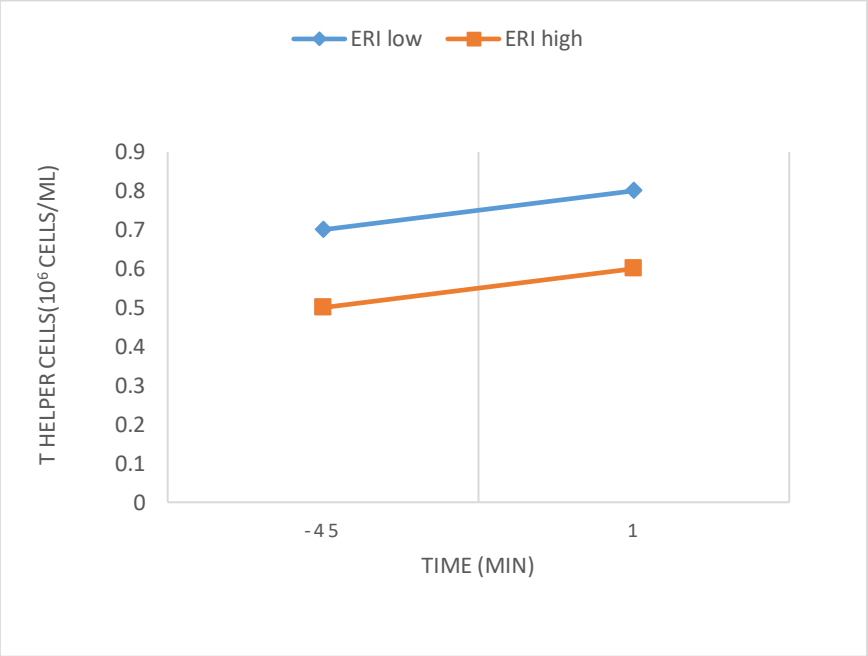

Figure 11: Count of T helper cells upon High vs Low OC. (Modified from Bellingrath et al., 2010)

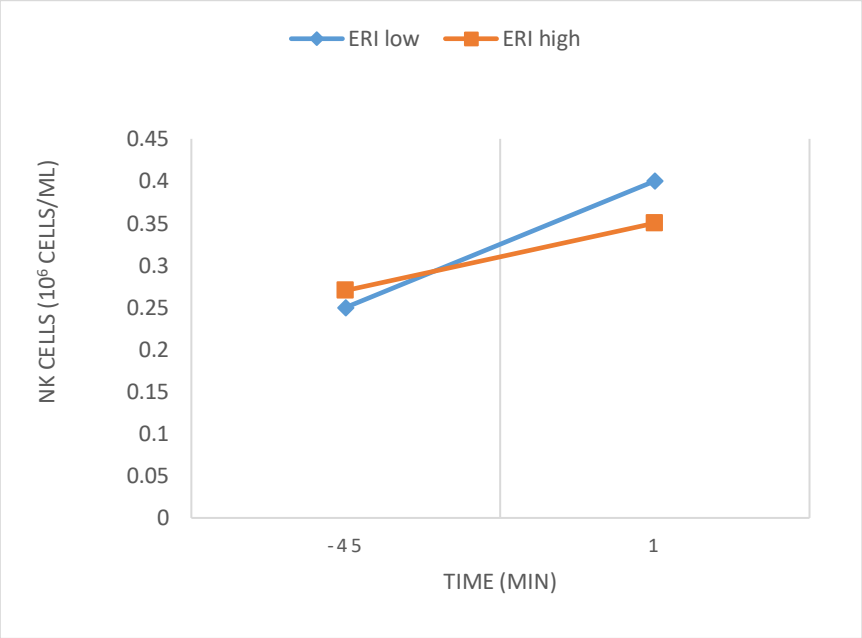

Figure 12: Count NK cells upon High vs Low ERI. (Modified from Bellingrath et al., 2010)

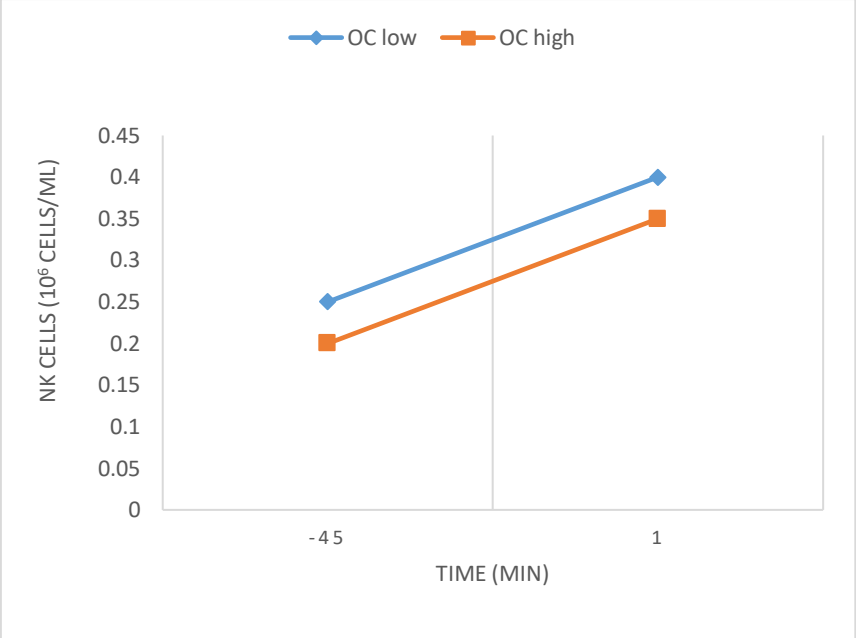

Figure 13: Count of NK cells upon High vs Low OC. (Modified from Bellingrath et al., 2010)

Moreover, study results suggested that physiological stress contributed to immunological aging. High level of job stress having a low reward, high ERI value with low social support at work was associated with a significant reduction of CD4:CD8 ratio. Employees classified with higher stress quartile had 30% to 50% higher CD27-CD28-CTLs number.(Bosch et al., 2009).

Another study carried out by Eddy et al. confirmed the association of ERI related to stress to lowering of immunity. Subgroup analysis stated to have stronger effect on mucosal immunity (r=-0.33, CI -0.47 to -0.18) than trends between both cytokine (r=-0.04, CI -0.07, -0.01) and leukocyte sub-groups 9r= -0.02 CI -0.04,0.01) respectively (k=7, N=9952). They also found the association of over commitment with lowered immunity (r= -0.05, CI -0.09, 0.01, p=0.014); sub-group (leukocytes, cytokines, mucosal immunity) associations and were homogenous. (Eddy et al., 2016)

Hanson et al. had reported increased white blood cell content in men who were exposed to ERI related stress. They also identified systemic inflammation condition for the same sub-class of the population. However, no association was identified in the case of women. (Hanson et al., 2017)

2.6 Correlation With Inflammation

Hanson et al. had reported increased white blood cell content in men who were exposed to ERI related stress. They also identified systemic inflammation condition for the same sub-class of the population. However, no association was identified in the case of women (Hanson et al., 2017).

Apart from that, Bellingrath et al suggested reduced innate immunity defense resembling lower NK killer cell count along with boosted pro-inflammatory activity upon high effort reward imbalance ration and over commitment score (Bellingrath et al., 2010).

2.7 Correlation With Hepatic System

Studies identified that ERI related stress caused harm to the liver function and to the liver itself (Hanson et al., 2017). Hanson et al. had reported there was an increased level of alanine transaminase associated with increased ERI for men that are a major indicator of liver damage. Along with that, the metabolic profile was reported to be altered as well (Hanson et al., 2017).

2.8 Body, Muscle Pain, Headache and Physical Function

Mäki et al. suggested a high effort reward imbalance increased the risk of migraine with an odds ratio of 1.23 (95% confidence interval 1.04, 1.45) and identified as a risk factor for new-onset migraine events. The proportion was 6.2% for new migraine cases having higher ERI value. Among 19,469 women, the number of newly diagnosed migraine cases were reported 1,281 after 2 years follow-up. The case was more common for young subjects with depression. Moreover, lower non-manual workers had a lower risk than those of higher non-manual workers (Mäki et al., 2008).

Låftman et al. reported that low reward and high over commitment were responsible to cause somatic pain and low worse-rated health among school students aged 14-16. The study was done on 403 Swedish students during the 2010 period. Moreover, higher ERI condition promoted the risk of somatic pain (Låftman., 2015).

Besides, Gillen et al. had found, lower socio economic status and higher effort reward imbalance both are associated with work related musculoskeletal disorders upon a study carried out on hospital workers (M. Gillen et al., 2010).

Moreover, he suggested ERI as a significant predictor in the case of neck and upper extremity (OR 1.5; 95% CI, 1.1-1.9) and all other injuries. The study identified specific psychosocial and physical job-related factors more strongly influenced work-related musculoskeletal disorders than socioeconomic factors (Marion Gillen et al., 2007).

Furthermore, Solis-soto et al. had reported increased incidence of lower back pain among teachers of sixty schools from the rural and urban areas chosen randomly (2.3; 95% CI 1.3 to 4.1) (Solis-soto et al., 2019).

In addition to that, ERI was responsible for neck-shoulder pain and low back pain with a relative risk of 1.51% and 1.21% respectively. They also suggested that, the onset of neck-shoulder pain further increased the risk of effort reward imbalance with a relative risk of 1.36% (Halonen et al., 2018).

Another study reported by Kouvonen et al. work stress increment was related to physical inactivity within an individual among the Finish population. It had been seen that the individuals were insufficiently active who were exposed to repeated low job control and low rewards compared to the ones who did not face these stressors with odd ratio ranged from 1.11 to 1.21 (Kouvonen et al., 2013).

2.9 Correlation With DNA damage

Inoue et al. reported that job distress was associated with urinary concentration of 8-hydroxy-2'-deoxyguanosine (8-OHdG) biomarker which is responsible for oxidative DNA damage. To illustrate, the distress among male workers who had greater job commitment, had higher 8-OHdG levels compared to the female workers. However, the study result supported in case of 'interactional justice' a component of organizational justice. In the case of the ERI model, they had not found these associations (Inoue et al., 2009).

2.10 Biological Aging

Work related stress was associated with biological aging along with other health-related determinants. According to a study consisted of 371 subjects of different occupational groups were analyzed to identify a discrepancy between Calendar age and Biological age depending on work and health-related predictors. Mental attitudes and resources towards work, occupational reward and body fat percentage were considered as relevant predictors for discrepancy value. Greatest discrepancy value was found for the subgroup of managers with 9 years, followed by teachers with 5 years. Managers also showed the best result in an effort reward imbalance value of 0.5±0.1 which was lowest among all. (Freude et al., 2009)

Sub-groups	Discrepancy (CA-BA)	ERI value
Management personnel	9	0.5±0.1
Teachers (female)	5	0.7±0.2
Nursery school teachers	2	0.5±0.1
Teachers (male)	2	0.7±0.3
Office workers (female)	1	0.6±0.2

Table 6: Relation of ERI with Biological age discrepancy (Freude et al., 2009).

2.11 Effects on Menstruation

Effort reward imbalance and over commitment were found to be associated with increased risk of menstrual pain (OR [95% CI]: 1.42 [1.03 to 1.94] and 1.07 [1.02 to 1.13] respectively) in the study consist of 821 pre-menopausal and not pregnant working women. Among 821 women, women having menstrual pain with limiting working function were 165 of whom ERI and over commitment value was presented as 0.82 and 14.19 respectively. On the other hand, women having menstrual pain without limiting working function were 656 of whom both ERI and over commitment values were found lower (László et al., 2009).

Variables	With Limiting Menstrual Pain (n=165)	Without Limiting Menstrual Pain (n=656)
Effort	7.14	6.70
Reward	20.59	21.97
Effort-Reward Imbalance	0.82	0.69
Over commitment	14.19	13.29

Table 7: Different variables for women with and without menstrual pain (László et al., 2009).

2.12 Correlation With Pulmonary System

Hanson et al. had reported that there was no factor involved in lung function with imbalance related stress. They had found 9.6% SD and 11.5% SD for men with no work stress and stressed work condition respectively whereas for women the SD percentage was 9.5% and 10.8% (Hanson et al., 2017)**.**

Chapter 3

Psychological Impacts of ERI Related Stress

3.1 Depression

Several scientific studies suggested that there was a significant occurrence of depressive symptoms with work stress. Marie et al. have carried out a study in 2019 in Brazil by analyzing data from the ELSA-Brasil-Brazilian Longitudinal study of adult health. They carried out the study on public sector workers that included professors, researchers, clerks, secretaries, nurses, medical and laboratory tacticians, repair workers and others. The total population of the study was 10,034 who were active workers with a similar ratio concerning gender along with ideal ration of specific age group and occupational diversity to set a wide socio-economic gradient. In this study, occupational stressors were measured through the effort reward imbalance (ERI) model. Mental stress assessment was done by the Clinical Interview Schedule-Revised (CIS-R) method. Data for effort, reward and over commitment were taken and assessed separately and the ERI ratio was obtained. Their study suggested that each model element (high effort, low reward and over-commitment) is related to extended prevalence ratios (PR) of depressive episodes. Occurrence ratios of depressive episodes related to the ratio of effort and reward are greater than incidence ratios with the single model component effort or reward respectively. Over-commitment moderated the affiliation of the effort-reward ratio with depressive episodes. In their result, there was increased prevalence ration of depression in quartile 4 with a prevalence ratio of 1.62 (1.27-2.06; 95% CI) in model 1 (adjusted by age) and 1.85 (1.44-2.37; 95% CI) in model 2 (adjusted with age, gender and education). Additionally, over commitment value was also high for the 4^{th} quartile with scoring 3.05 in model one and 3.62 in model two. E-R ratio was highest as well with a score of 2.27 and 2.47 in model 1 and model 2 respectively.

Scales	Quartile	Model 1		Model 2	
		PR	**95% Cl**	**PR**	**95% Cl**
Effort	Quartile 1	1.00		1.00	
	Quartile 2	1.21	093-1.57	1.22	0.94-1.59
	Quartile 3	1.27	1.01-1.61	1.36	1.08-1.73
	Quartile 4	1.62	1.27-2.06	1.85	1.44-2.37
Reward	Quartile 1	3.67	1.0-2.17	3.44	2.55-4.64
	Quartile 2	1.71	1.21-2.47	1.64	1.16-2.31
	Quartile 3	1.53	2.72-4.95	1.51	1.06-2.13
	Quartile 4	1.00		1.00	
Over-commitment	Quartile 1	1.00		1.00	
	Quartile 2	1.10	0.82-1.49	1.17	0.87-1.59
	Quartile 3	1.86	1.40-2.49	2.14	1.59-2.88
	Quartile 4	3.05	2.37-3.92	3.62	2.80-4.70
E-R ratio	Quartile 1	1.00		1.00	
	Quartile 2	0.94	0.93-1.27	0.99	0.73-1.33
	Quartile 3	1.08	0.92-1.27	1.17	0.88-1.57
	Quartile 4	2.27	1.63-2.14	2.47	1.92-3.17

Table 8: Association between 'effort-reward' imbalance and depressive episodes. (de Araújo et al., 2019).

In the following table, it could be seen that the prevalence of combined exposure (P= 8.25%) was lower than the prevalence group (10.79%) by 2.54%. Moreover, the combined effect of high E-R ratio and high over-commitment' was higher compared to estimated additive effects. Thereby the excess risk due to interaction (RERI) value gives the result of 0.95 which is a positive number that indicates the relationship of 'over-commitment' in depressive symptoms. (de Araújo et al., 2019).

Variable	Prev. (%)	PR*	95% CI	Excess of Prevalence	Measure	95% CI
E-R ratio=0 **Over-commitment=0**	3.29	1.00	-	-		
E-R ratio=1 **Over-commitment=0**	5.65	1.71	1.29-2.25	2.36		
E-R ratio=0 **Over-commitment=1**	5.89	1.79	1.53-2.68	2.60.		
E-R ratio=1 **Over-commitment=1**	10.79	3.28	2.97-4.56	7.50		
RERI					0.945	0.81-1.80
AP					0.256	0.04-0.46
S					1.543	1.00-2.39

Table 9: E-R ratio and over commitment interaction (adopted and modified from de Araújo et al., 2019).

In a study done by Siegrist et al. deriving data from a French cohort study among 24,327 employed individuals aged 45-60 years, ERI scales revealed consistent relation with depressive events. However, the study was based on a short version of the questionnaire (Siegrist et al., 2019).

Moreover, De Araújoet al. had reported an association of higher risk of depressive episodes with extrinsic (effort, reward) and intrinsic (over-commitment) components of the ERI model individually as well as the combination of both. The study was carried out through cross-sectional data from the ELSA-Brasil study which consisted of 10,034 workers from public sectors. Association of highest effort (PR=1.85; 1.44-2.37), 'lowest reward' (PR= 3.44; 2.55-4.64), highest 'over-commitment' (PR=3.62; 2.80-4.70) were confirmed to be related to depressive episodes. Apart from that, an additive correlation was marked between over-commitment and effort-reward ratio in that study further (de Araújo et al., 2019).

3.2 Anxiety

High effort, low reward, high over-commitment and high ERI-ratio were solely found to be responsible for anxiety symptoms with an odds ratio of ≥2.43 among German students from the NuPhA study. Those findings largely supported both medical and non-medical students further. However, ERI components had a more pronounced effect on medical students (Hilger-Kolb et al., 2018).

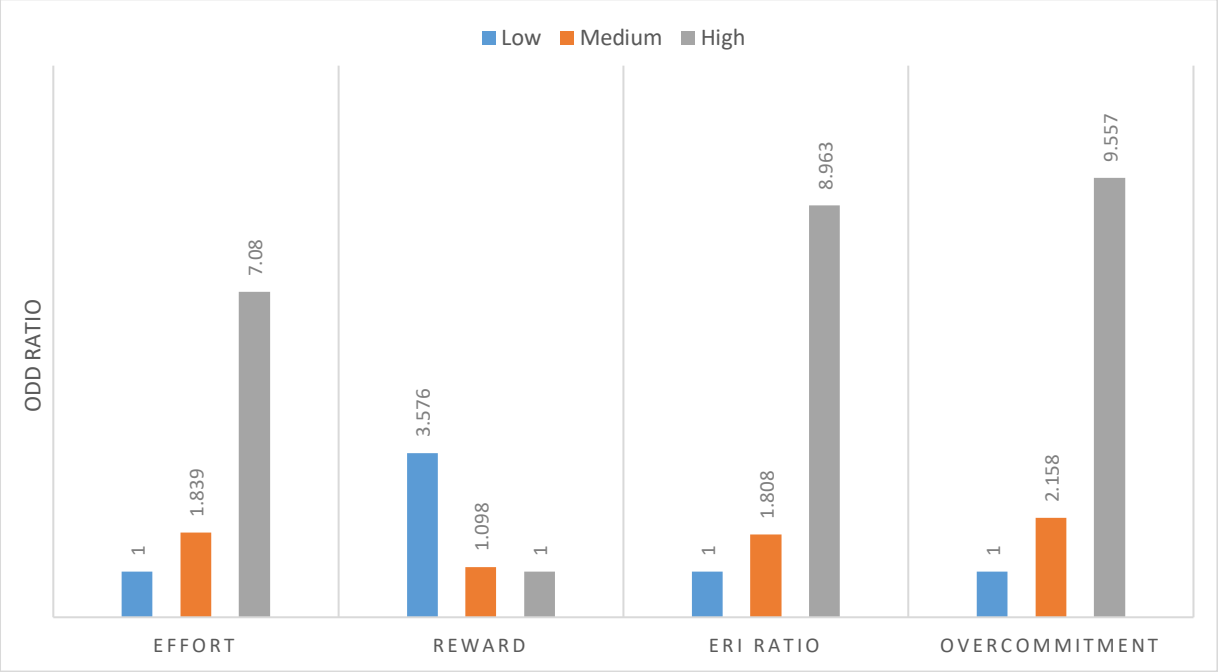

Figure 14: Relation of ERI components with anxiety (Hilger-Kolb et al., 2018).

Another study confirmed occasions of anxiety in case of increased effort and over-commitment situation among radiologists. On the other hand, control and support exerted a protective impact (Magnavita et al., 2014). According to another study, greater ministry satisfaction and greater status control were largely related to anxiety. However, lowered financial stress was found to decrease anxiety events (Proeschold-Bell et al., 2013).

3.3 Sleeping disorder

Several studies had found a link between sleeping disorder with ERI related stress conditions (Fahlén et al., 2006; Hanson et al., 2017). Fahlen et al. had seen the association of sleep disturbances for men and women both in case of higher effort reward ratio conditions. However, for women high effort was solely contributing to a sleeping disturbance with a PR value of 4.04, CI 1.53-10.7. (Fahlén et al., 2006) . In addition, Hanson et al had reported sleep disturbance problems caused by ERI with 29.8% SD and 40.9% SD score for men and women respectively. The trend was more common in the case of women compared to the man (Hanson et al., 2017).

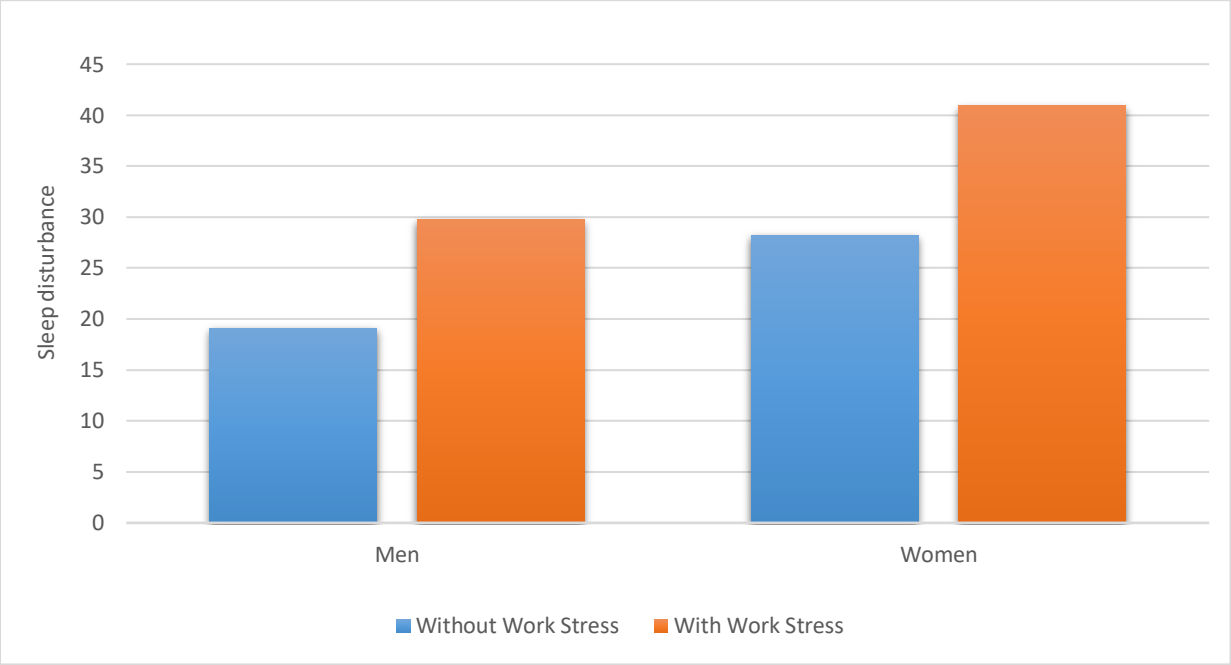

Figure 15: Work stress and Sleeping disturbance among men and women (Hanson et al., 2017)

3.4 Generalized Mental Health

Several studies had shown negative mental health impact causing by effort reward imbalance. Kuper et al had reported people exposed to high effort and low reward condition faces mental health problem compared to those who did not. Odds ratio was recorded 2.24, (95% CI) (Kuper et al., 2002). Moreover, Kolb et al. had confirmed the association between ERI components and self-rated mental health. Among these components, high effort, over commitment, ERI ratio and low reward were vastly responsible (Hilger-Kolb et al., 2018).

3.5 Alcohol, Smoking and Internet Addiction

Kuper et al. had reported higher drinking patterns with greater effort reward imbalance at work although they had not found any significant relation with cigarette smoking in this case (Kuper et al., 2002).

Hanson et al. had reported a correlation between ERI related stress with smoking and alcohol consumption. The study suggested men with higher social positions had a higher rate of smoking and risky alcohol consumption rate compared to women. The main reasons for poor liver function for people with high ERI have increased alcohol consumption. This means this alcohol consumption is further hampering their liver function (Hanson et al., 2017).

Furthermore, Work stress was associated with internet addiction. After a follow-up period of 6.2 months, 14.0% of subjects were identified as problematic internet users and 4.1% were identified as pathological internet users. Specifically, higher ERI ratio and higher over commitment were directly involved with internet addiction having an odds ratio of 1.61 and

1.68 respectively. Moreover, high work social support was found to be reducing internet addiction (OR=0.62) (Chen et al., 2014).

3.6 Accident

Hoggan et al. had reported there were direct and immense correlations between ERI imbalance with driving anger. Moreover, the case is found more prominent in case of a higher over commitment situation (a key component of ERI regulation). According to their findings, the perceived disproportion of effort and low reward in the workplace gradually develops overcommitment and general anger through which individual tend to experience intense anger during driving (Hoggan & Dollard, 2007).

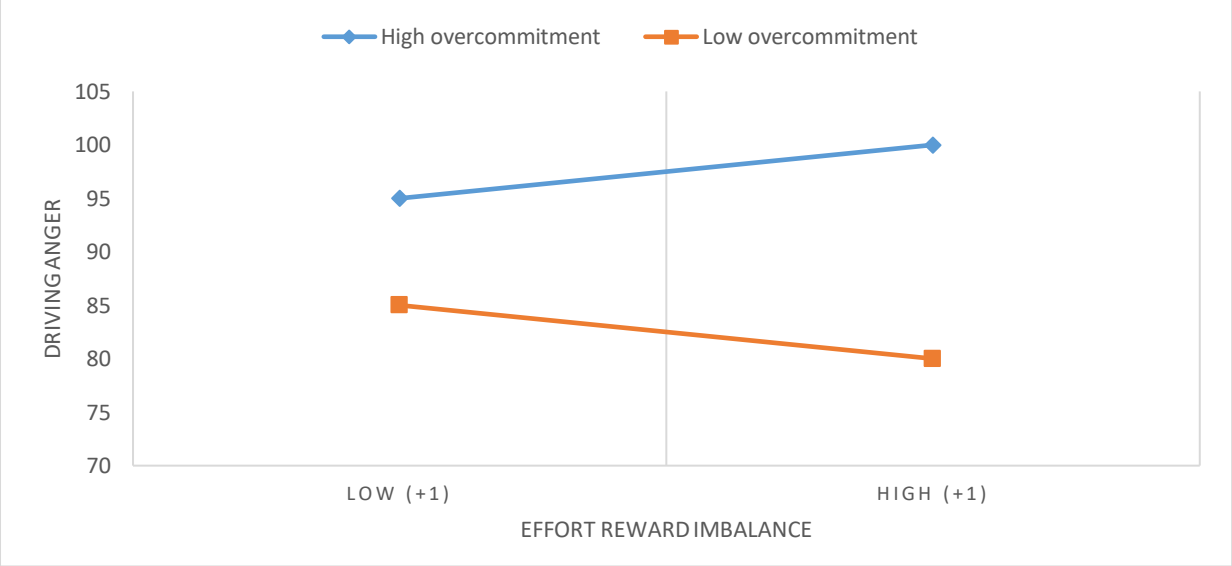

Figure 16: The interaction effect of ERI and over commitment on driving anger (Hoggan & Dollard, 2007).

3.7 Suicidal Tendency

Different studies had ensured that job stress creates suicidal tendencies among highly stressed people of different groups (Loerbroks et al., 2016; Zhuo et al., 2020).

Zhuo et al. had found that suicidal ideation was involved with high effort and low reward conditions individually with an HR score of 1.51 and 1.42, respectively. Moreover, even a higher risk of suicidal tendencies was found with a higher effort reward imbalance score with HR=1.96. However, the association was been varied by gender, education, region and household income (Zhuo et al., 2020).

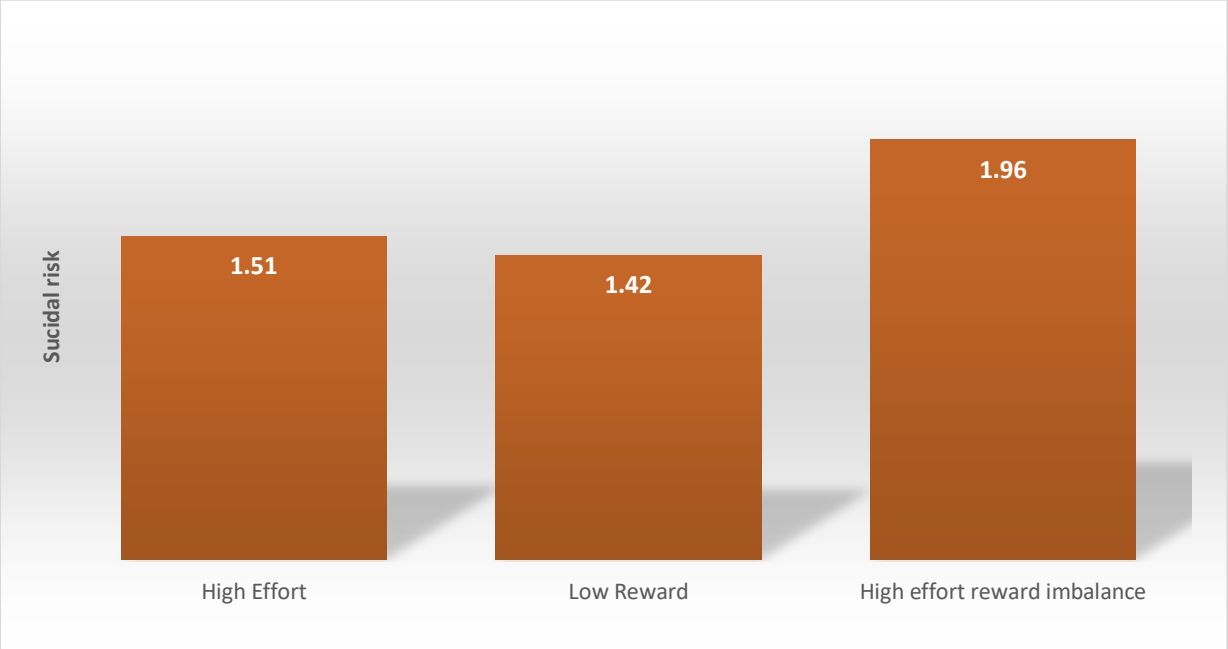

Figure 17: HR value for Suicidal Risk in Different working situation. (Modified from Zhuo et al., 2020).

Moreover, another study done by Leorbroks et al. involving three stress models done on 12,422 individuals assured the significant association of work stress with suicidal ideation where odd ratio varied around 2 (Loerbroks et al., 2016).

Chapter 4

The Suggested Solutions to Counter ERI Related Stress

Increment of rewards (wage, salary, esteem, promotion) visibly put weight in the reward which balances out increased effort situations. However, though increased reward balances out the efforts, the stress of increased efforts is still there. In these situations, people may face stress related health hazards having a balanced ERI ratio. However, several studies reported that increased rewards are beneficial to counter ERI related stress and effects in most of the case. Roelen et al reported a reduction of sickness related absence with increased job rewards where rewards were characterized by job esteem and job perspective for men; while for women the rewards were characterized by satisfaction with income. (Roelen et al., 2009). Prolonged stress was found to be related to the recovery process during non- working and resting periods during a year longitudinal study. It was also found that prolonged work stress caused a consistent decrement of HF and LF ability. Thus prolonged stress should be avoided to facilitate the recovery process. (Borchini et al., 2018). Moreover, the negative effect of ERI had shown more on the lowest employment grades with low social support. Therefore, increasing social support levels would be beneficial to counter ERI related impacts. (Kuper et al., 2002). Freude et al. suggested health promotion by a healthy diet and physical activities along with improving working conditions by stress prevention, social support and increment of job satisfaction in case of improving the biological aging process related to job stress. (Freude et al., 2009). Dragano et al. had reported ERI is directly associated with work related symptoms (poor self-rated health) for both men and women. However, the study found there was a far higher occurrence of these work-related symptoms with the individuals who were exposed to both downsizing and work-related stress. There was seen a synergistic effect to 21% men and 31% women with a far greater odds ratio of 4.41 and 5.37 in men and women respectively. This evidence suggests that health hazard caused by ERI related stress increases its magnitude with

job downsizing. Therefore, avoiding these two factors at once can decrease the effect largely in creating favorable working conditions (Dragano et al., 2005). Wang et al. suggested to enhancing psychosocial resources to boost up self-esteem among employees that would resulted in improved psychosocial health conditions (Z. Wang et al., 2017). Furthermore, Lehr et al., reported that a lack of esteem by supervisors and colleagues contributed to more ERI related depression compared to salary and job security. The study suggested appreciating the work environment to facilitate an ideal working environment for employees from both supervisors and colleagues (Lehr etal., 2009). Tsutsumi et al. reported that there was an existence of avoidable error in ERI scale as rated raw-scores did not reflect hypothesized sequence of stress level from lowest to highest level. They suggested to modify rating procedures to improve measurement accuracy (Tsutsumi et al., 2008). Mino et al. reported that stress management program focusing cognitive behavioral aspects improved depressive symptoms in a highly stressful work place. Stress management program contained lectures on stress perception, suggested measures cope up, recording sheets and counseling through email and the employee of stress management program showed improved psychological state compared to control group after 3 months (Mino et al., 2006).

Chapter 5 Future Aspects and Conclusion

We have seen several effects of ERI related stress on our general physiology and psychology. However, the mechanism through which this ERI related stress is affecting our body is not clear in all aspects. Moreover, some studies are contradictory to one another as well. Therefore, further studies needed to be carried out to find an explicit mechanism through which it is affecting us.

Most of the studies have been done individually on different models to identify and measure job stress. In this process, sometimes the real scenario of stress is not come out due to the shortcomings and limitations of individual models. For this reason, studies suggest employing several models at once to get the best possible result. Therefore, in the future, we can carry out these studies by using multiple accepted job stress measurement models and compare those results with former ones.

To add, though ERI is one of the most used and trusted measuring methods of psychosocial job stress in the work place, still, there was not much work done on this in our country (Bangladesh). However, it is essential to understand the real scenario of working conditions in a particular country to regulate and plan several functions including setting terms and conditions, determining acceptable and fair wages, preserving labor rights and maintaining an ideal environment for productivity of the companies as well. Moreover, these studies enable people (employees, employers, investors) to understand local market conditions, job market conditions and compare them to the global situation. In this regard, there is much more work to do related to this aspect of our country.

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