Sleep And Physical Activity: A Mixed Method Study In People With Chronic Pain

By

Fatanah Ramlee

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Psychology

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

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List Of Abbreviations

AEM	:	Avoidance-Endurance Model
AIC	:	Akiake Information Criterion
AOR	:	Adjusted Odds Ratio
BIC	:	Bayesian Information Criterion
BMI	:	Body Mass Index
BPI	:	Brief Pain Inventory
CBT	:	Cognitive Behaviour Therapy
CBT-I	:	Cognitive Behaviour Therapy for Insomnia
COREQ	:	Consolidated Criteria for Reporting Qualitative Research
CPM	:	Conditioned Pain Modulation
CPT	:	Cold Pressor Task
CSD	:	Consensus Sleep Diary
DBAS-16	:	Dysfunctional Beliefs and Attitude about Sleep-16
DSM-5	:	Diagnostic and Statistical Manual of Mental Disorders, 5th Edition
EEG	:	Electroencephalography
EMG	:	Electromyography
EOG	:	Electrooculography
ESS	:	Epworth Sleepiness Scale
FAM	:	Fear-Avoidance Model
HADS	:	Hospital Anxiety and Depression Scale
IASP	:	International Association for the Study of Pain
ICSD-3	:	International Classification of Sleep Disorders-3
ISI	:	Insomnia Severity Index
MCMC	:	Markov Chain Monte Carlo
MCMCP	:	Markov Chain Monte Carlo with People
MEQ	:	Morningness-Eveningness Questionnaire
MFI	:	Multidimensional Fatigue Inventory
OR	:	Odds Ratio
PAMSys	:	Physical Activity Monitoring System
PBAS	:	Pain-Related Beliefs and Attitudes about Sleep
POAM-P	:	Patterns of Activity Measure-Pain
PSG	:	Polysomnography

PSQI	:	Pittsburgh Sleep Quality Index
QALY	:	Quality-Adjusted Life-Year
RCT	:	Randomised Controlled Trial
REM	:	Rapid Eye Movement
SE	:	Sleep Efficiency
SOL	:	Sleep Onset Latency
SWS	:	Slow Wave Sleep
TIB	:	Time In Bed
TST	:	Total Sleep Time
TSK-11	:	Tampa Scale for Kinesophobia-11
WAKE	:	Number of Wake After Sleep Onset
WASO	:	Wake After Sleep Onset
WHO	:	World Health Organization

Declaration

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy in Psychology. It has been composed by myself and has not been submitted in any previous application for any degree. The work presented (including data generated and data analysis) was carried out entirely by the author.

Inclusion of Published Work

Part of this thesis has been published by the author:

Chapter 3 includes the following publication:

Ramlee, F., Afolalu, E. F., & Tang, N. K. Y. (2016). Do people with chronic pain judge their sleep differently? A qualitative study. *Behavioral Sleep Medicine*, 1-16.

Dr. Nicole Tang contributed to the planning and supervision of this research. All co-authors provided feedback on drafts of the manuscript.

Chapter 4 includes the following publication:

Ramlee, F., Sanborn, A. N., & Tang, N. K. Y. (2017). What sways people's judgement of sleep quality? A quantitative choice-making study with good and poor sleepers. *Sleep,* 40(7).

Dr. Nicole Tang contributed to the planning and supervision of this research. Dr. Adam Sanborn contributed to the planning, analysis and supervision of this research. All co-authors provided feedback on drafts of the manuscript.

Outputs Arising From This Thesis

Publications

Ramlee, F., Sanborn, A. N., & Tang, N. K. Y. (2017). What sways people's judgement of sleep quality? A quantitative choice-making study with good and poor sleepers. *Sleep,* 40(7).

Ramlee, F., Afolalu, E. F., & Tang, N. K. Y. (2016). Do people with chronic pain judge their sleep differently? A qualitative study. *Behavioral Sleep Medicine*, 1-16.

Poster Presentations

Ramlee, F., & Tang, N. K. Y. (2017, May). *Does a good night's sleep contribute to improving daytime physical activity? A daily process study in patients with chronic pain*. Poster presented at the British Pain Society's 50th Anniversary Annual Scientific Meeting, Birmingham, United Kingdom.

Ramlee, F., Sanborn, A. N., & Tang, N. K. Y. (2015, November). *What is a poor night's sleep? A quantitative approach to unravel the meaning of sleep quality*. Poster presented at the 7th World Congress of the World Sleep Federation (WSF 2015), Istanbul, Turkey.

Ramlee, F., Afolalu, E. F., & Tang, N. K. Y. (2015, September). *Do people with chronic pain judge their sleep differently? A qualitative study*. Poster presented at the 9th Congress of the European Pain Federation (EFIC 2015), Vienna, Austria.*

*****Award:* **The Best Poster Presentation on the Subject of Clinical Science**

Ramlee, F. & Tang, N. K. Y. (2014, June). *Exploring the essential ingredients of a good night's sleep: A qualitative study with people with fibromyalgia, back pain and healthy individuals without chronic pain.* Poster presented at Research Postgraduate Poster Showcase, University of Warwick, Coventry.

Ramlee, F. & Tang, N. K. Y. (2014, May). *Exploring the essential ingredients of a good night's sleep: A qualitative study with people with fibromyalgia, back pain and healthy individuals without chronic pain*. Poster presented at Psychology Postgraduate Research Day, University of Warwick, Coventry.

Oral Presentations

Ramlee, F., Sanborn, A. N., & Tang, N. K. Y. (2016, May). *What is a poor night's sleep? A quantitative choice making approach to unravel the parameters of sleep quality.* Oral presentation at Psychology Postgraduate Research Day (PGR 2016), University of Warwick, Coventry.

Ramlee, F. & Tang, N. K. Y. (2015, September). Sleep and daytime physical activity in people with chronic pain. Oral presentation at Rheumatology Department, University Hospital Coventry and Warwickshire, Coventry.

Additional Research Conducted With Warwick Sleep And Pain Laboratory

Publications

Afolalu, E. F., **Ramlee, F.**, & Tang, N. K. Y. (in press). Effect of sleep changes on pain-related health outcomes in the general population: A systematic review of longitudinal studies with exploratory meta-analysis. *Sleep Medicine Reviews.*

Afolalu, E. F., Moore, C., **Ramlee, F.**, Goodchild, C. & Tang, N. K. Y. (2016). Development of the Pain-Related Beliefs and Attitudes about Sleep (PBAS) scale for the assessment and treatment of insomnia comorbid with chronic pain. *Journal of Clinical Sleep Medicine*, 12(9), 1269-1277.

Book Chapter

Tang, N. K. Y., Afolalu, E. F., & **Ramlee, F.** (2018). Sleep and Pain. In F. P. Cappuccio, M. A. Miller, & S. W. Lockley (Eds.) *Sleep Health and Society – From Aetiology to Public Health*, 2nd Edition. Oxford, U.K.: Oxford University Press.

Poster Presentations

Afolalu, E. F., **Ramlee, F.**, & Tang, N. K. Y. (2017, May). *Reliability of conditioned pain modulation in a healthy population: investigating the influence of distraction, pain catastrophising and sleep.* Poster presented at the British Pain Society's 50th Anniversary Annual Scientific Meeting, Birmingham, United Kingdom.*

Award:* **The highly commended poster rosette

Afolalu, E. F., **Ramlee, F.**, & Tang, N. K. Y. (2017, May). *Effect of sleep changes on pain-related health outcomes in the general population: A systematic review of longitudinal studies with exploratory meta-analysis*. Poster presented at the British Pain Society's 50th Anniversary Annual Scientific Meeting, Birmingham, United Kingdom.

Afolalu, E. F., Moore, C., **Ramlee, F.**, Goodchild, C. E., & Tang, N. K. Y. (2015, November). *Development of the Pain-Related Beliefs and Attitudes about Sleep (PBAS) scale for the assessment and treatment of insomnia comorbid with chronic pain.* Poster presented at the 7th World Congress of the World Sleep Federation (WSF 2015), Istanbul, Turkey.

Abstract

This thesis investigates how people make judgements of their sleep quality and the temporal association between sleep and physical activity in people with and without chronic pain. In doing so, the thesis used a multi-methodological approach comprising qualitative (Chapter 3), experimental (Chapter 4) and daily process studies (Chapters 5 and 6). The qualitative study presented in Chapter 3 explored how people with and without chronic pain define their sleep quality and to what extent judgments of sleep quality differ with the presence of pain (*n*= 17). The experimental study presented in Chapter 4 quantitatively examined the relative importance of 17 parameters of sleep quality in good and poor sleepers (*n*= 100). This study conceptualised sleep quality as a decision-making process and used a choice-based conjoint analysis to identify parameters that shape people's judgement of sleep quality. Then the thesis shifts its focus to the relationship between sleep and physical activity in Chapters 5 and 6. Using self-reported measures, the daily process study presented in Chapter 5 investigated the temporal within-person association between sleep and physical activity in healthy young adults (*n*= 118). Using both self-reported and objective measures of sleep and physical activity, a follow-up daily process study was conducted in people with chronic pain (*n*= 51, Chapter 6). In addition, the study presented in Chapter 6 also explored the roles of pain and other psychological variables (e.g., mood) that may interact with sleep to affect the regulation of physical activity. The results across studies converge to suggest that sleep quality judgement is a retrospective decision-making process dependent on both daytime and nighttime processes and that subsequently influence daytime functioning such as physical activity and mood in chronic pain patients. Therefore, future investigations and interventions should consider the possibility of broadening the focus to addressing chronic pain patient's perception of sleep quality and the impact of poor sleep on daytime processes, for improving sleep quality, engagement in physical activity and the overall quality of life.

Chapter 1

General Introduction

1.1 The beginning of the research programme

Six years ago, I had the opportunity to carry out a research project for my Master's study at a haemodialysis centre. I found out that sleep was an important issue to patients undergoing haemodialysis. Although at that time, I did not have much knowledge about sleep, the experience of working with these patients has inspired me to explore sleep problems in people living with chronic medical conditions as part of my doctoral research. At Warwick, I was given the opportunity to study sleep in chronic pain and this thesis presents the work I have done here.

1.2 Prevalence of chronic pain, sleep disturbance and reduced physical activity

The prevalence of sleep disturbance is very high among people with chronic pain. Chronic pain is defined as pain that persists for more than three to six months, beyond the expected time of healing (IASP Task Force on Taxanomy, 1994; Treede et al., 2015). Chronic pain is a debilitating health condition and a major health problem worldwide. The prevalence of chronic pain for adults (≥18 years old) was 30.7% in the United States (Johannes, Le, Zhou, Johnston, & Dworkin, 2010) and 18.9% in Canada (Schopflocher, Taenzer, & Jovey, 2011). In the United Kingdom (UK), the estimated prevalence of chronic pain (lasting more than three months) is 43% (Fayaz, Croft, Langford, Donaldson, & Jones, 2016). A large-scale survey involving 46,394 adults in 15 European countries and Israel indicates that 19% of the respondents have chronic pain

that significantly affects their quality of life (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). Based on Breivik et al.'s survey (2006), individuals suffering from chronic pain indicated that they were no longer able or less able to work outside home (61%), lift (72%), exercise (73%), drive (47%), have sexual relations (43%), attend social activities (48%), carry out household chores (54%), sleep (65%), walk (47%), maintain an independent lifestyle (30%) and maintain relationships with family and friends (27%). Importantly, pain was the top cause of quality-adjusted life-year (QALY)[1] losses in primary health care, above mood disorder and anxiety as well as other chronic physical conditions such as cardiovascular disease and diabetes (Fernández et al., 2010).

At the societal level, chronic pain has an impact on economy. Pain has been cited as a primary reason of missed work (U.S. Department of Health and Human Services, 2017). Consequently, it causes an economic loss specifically in term of loss of productive working time in the workforce (Stewart, Ricci, Chee, Morganstein, & Lipton, 2003). Besides, in the UK, 25% of individuals with chronic pain lost their job as a result of pain (Breivik et al., 2006; Breivik, Eisenberg, & O'Brien, 2013). At the individual level, the impact of chronic pain is more devastating. The reported statistics are grim as chronic pain has a negative impact on daily activities, employment, psychological, physical and social functioning (Smith & Osborn, 2007; Widerstrom-Noga, Felipe-Cuervo, & Yezierski, 2001).

A number of surveys have also shown that sleep impairment is a common comorbidity of chronic pain. In a survey of five European countries (i.e., UK, Germany,

[1] QALY takes into account both quantity and quality of life. It is an indicator of life expectancy weighted by the quality of the remaining life years (Fernandez et al., 2010). For example, a year of life lived in perfect health is worth 1 QALY, half a year lived in perfect health is equivalent to 0.5 QALY and death is equivalent to 0.

Italy, Portugal and Spain), 23% of individuals with chronic painful physical condition reported at least one insomnia symptom in comparison to only 7.4% among individuals without chronic pain (Ohayon, 2005). A recent large-scale population-based study involving 6,205 older adults (≥65 years of age) in Sweden found that older adults with chronic pain had a high proportion of clinical insomnia (24.6%) compared to older adults with subacute pain (21.3%) and without pain (13%) (Dragioti, Levin, Bernfort, Larsson, & Gerdle, 2017). The prevalence of chronic pain comorbid with sleep disturbance in clinical populations is also high. Approximately 50-80% of patients with chronic pain seeking treatment at the pain clinics reported to have clinical insomnia (Mccracken, Williams, & Tang, 2011; Tang, Wright, & Salkovskis, 2007).

Insomnia refers to difficulty initiating sleep, difficulty maintaining sleep and/or early morning awakenings with inability to return to sleep and those difficulties occur despite adequate opportunity for sleep (The Diagnostic and Statistical Manual of Mental Disorders 5th Edition (DSM-5), American Psychiatric Association, 2013). Insomnia is predominantly a complaint of dissatisfaction with sleep quantity or quality causing significant distress in social, occupational or other areas of functioning such as cognition, mood, fatigue and daytime sleepiness (American Psychiatric Association, 2013; Fortier-Brochu, Beaulieu-Bonneau, Ivers, & Morin, 2012; Kyle, Morgan, & Espie, 2010; Ustinov et al., 2010). Ustinov et al. (2010) found that a report of insomnia was a significant predictor of poor daytime functioning in 734 adults with (n=235, mean age= 59 years) and without insomnia (n= 499, mean age= 51.3 years). Ustinov et al. (2010) included two types of participants in the study, which were those who reported a sleep

problem (i.e., trouble falling asleep or staying asleep) lasting at least 6 months and those who reported no sleep problem. Fortier-Brochu et al. (2012) carried out a meta-analysis to examine the magnitude differences in daytime cognitive functioning between individuals with primary insomnia and normal sleepers. Findings revealed that there were significant impairments of small to moderate magnitude in some aspects of daytime cognitive functions (i.e., episodic memory, problem solving, working memory) among individuals with primary insomnia compared to normal sleepers. Kyle et al. (2010) also reported that insomnia has a negative impact on various aspects of health-related quality of life (HRQoL). These aspects include vitality, energy, mental, social and physical functioning.

Insomnia is associated with significant economic and societal burden (Daley, Morin, LeBlanc, Grégoire, & Savard, 2009; Godet-Cayré et al., 2006; Ozminkowski, Wang, & Walsh, 2007). In the workplace, at least 50% of individuals with insomnia have one work absence compared to only 34% of good sleepers (Godet-Cayré et al., 2006). Findings from a retrospective cohort study in France showed that the mean extra cost of insomnia-related work absenteeism of the national health insurance system was € 77 per employee, per year (Godet-Cayré et al., 2006). The employer bore an extra cost of €233 for salary replacement and €1062 for loss of productivity. In the US, the direct costs of untreated insomnia (estimated from the medical claims data) for individuals with insomnia were approximately $1,143 higher than individuals without insomnia (Ozminkowski et al., 2007).

Reduced physical activity is a common consequence of chronic pain with more than 40% of individuals suffering from chronic pain being less able to exercise, walk and do household chores (Breivik et al., 2006). Studies have also indicated that people with chronic pain are generally less physically active than those without chronic pain (Griffin, Harmon, & Kennedy, 2012; Kop et al., 2005; McBeth, Nicholl, Cordingley, Davies, & MacFarlane, 2010; McLoughlin, Colbert, Stegner, & Cook, 2011; Ryan et al., 2009; van den Berg-Emons, Schasfoort, de Vos, Bussmann, & Stam, 2007; Verbunt et al., 2003). Griffin et al. (2012) conducted a systematic review to examine differences in the physical activity pattern between patients with chronic low back pain and healthy individuals. The systematic review used the electronic databases from the start of each database until the end of December 2009 (i.e., Embase, Medline, ISI Web of Knowledge, Cinahl, Sport Discus and Nursing and Allied Health). Of 1414 potentials citations retrieved, seven studies were included in the final review comprising four studies among adults aged 18-65 years, two studies among older adults aged ≥65 years and one study among adolescents aged <18 years. These studies used different physical activity measures, which ranged from self-report and activity monitoring to the use of pedometers. Griffin et al. (2012) found that patients with chronic low back pain showed an altered pattern of physical activity over the course of a day than healthy controls. Patients with chronic low back pain were significantly less active in the evening compared to healthy controls.

Other individual studies using accelerometer and clinical population also found that patients with chronic pain were physically less active than pain-free individuals

(e.g., Kop et al., 2005; van den Berg-Emons et al., 2007). van den Berg-Emons et al. (2007) compared activity level of patients with chronic pain (*n*= 18) with healthy individuals (*n*= 18) using an accelerometer. They found that patients with chronic pain exhibited lower overall levels of physical activity compared to the healthy control group. Kop et al. (2005) monitored activity levels of patients with fibromyalgia and/or chronic fatigue syndrome (*n*= 38) and age-matched healthy controls (*n*= 27) using actigraph accelerometer for 5 days. Activity levels comprised a cumulative count of activity units for every 5-minute period. Patients with fibromyalgia and/or chronic fatigue syndrome (mean= 8654 units) demonstrated lower peak activity levels than individuals in the control group (mean= 12913 units). Patients with fibromyalgia and/or fatigue syndrome also spent less time in high-level activities than individuals in the control group. Previous correlational studies in older adults have also shown that sleep disturbance is associated with physical activity such as walking speed, completion of sit-to-stand tasks and activities of daily living (Dam et al., 2008; Goldman et al., 2007).

Taken together, sleep and physical activity are the top concerns of people living with chronic pain. Specifically the survey from Brevik et al.'s (2006) study showed that more than half of people with chronic pain were "no longer able to" and "less able to" exercise, sleep or walk. However, despite the high prevalence of sleep disturbance and reduced physical activity in chronic pain, little is understood about the complex relationship between sleep and physical activity. Therefore, the overarching aim of this thesis is to investigate sleep quality and the pathway through which sleep influences engagement in daytime physical activity. Two different but complementary research

approaches were employed. The two approaches were qualitative and quantitative (i.e., experimental and daily process studies). A qualitative approach provides in-depth exploration of sleep experience and insights from participants' perspective. Meanwhile, a quantitative approach uses a more rigorous statistical method and larger sample sizes to examine the relationship between sleep and physical activity. These two approaches provide a holistic picture to fill a gap in the literature and meet the aims of the research programme.

1.3 Aims of the research programme

The overarching aim of this research programme is to investigate sleep quality and the pathway through which sleep influences engagement in physical activity. The first two studies presented in the thesis focus on exploring and refining the concept of sleep quality (Aims 1 and 2), whilst the next two studies focus on investigating the link between sleep and physical activity, as well as the possible roles of pain and other psychological variables (Aims 3 and 4).

1) To explore and compare the definition of sleep quality in people with and without chronic pain and to examine to what extent judgments of sleep quality differ with the presence of pain (See Chapter 3).
2) To quantitatively examine the relative importance of 17 parameters of sleep quality in good and poor sleepers (See Chapter 4).
3) To examine the temporal association between sleep and next day physical activity, and the temporal association between daytime physical activity and

subsequent sleep on a day-to-day basis in healthy young adults (See Chapter 5) and patients with chronic pain (See Chapter 6).

4) To investigate the possible role of the psychological variables in determining subsequent physical activity. These psychological variables were pain, mood, tiredness, sleepiness, energy level, body condition, motivation to accomplish tasks, confidence to get things done and management of pain right now and later (See Chapter 6).

1.4 Overview of the thesis

Chapter 2 presents a brief introduction to sleep and physical activity in the context of chronic pain. Specifically, this chapter provides a background on sleep, its functions and the physiological processes regulating sleep. This chapter also provides a brief background on assessment of sleep and physical activity ranging from self-reported measures to objective measures. Besides, this chapter discusses the nature of sleep disturbance in chronic pain and the relationship between pain and sleep. Next, this chapter focuses on physical activity and its relationship with sleep, the theoretical models of physical activity in people with chronic pain and, finally, this chapter provides a brief discussion on the possible roles of psychological variables in predicting physical activity.

Chapter 3 presents a qualitative study that explored the definition of sleep quality in people with and without a pain condition (Ramlee, Afolalu, & Tang, 2016). Apart from Harvey, Stinson, Whitaker, Moskovitz, and Virk (2008) and Kleinman et al.

(2013), there is a lack of research that explores the subjective meaning of sleep quality specifically in chronic pain population. The aim of this qualitative study was to offer an in-depth exploration of participants' mental representation of sleep quality using their own words (Pope & Mays, 1995). A thematic analysis was carried out on all interview transcripts to uncover potential factors that determine people's judgment of sleep quality (Braun & Clarke, 2006). Although the thematic analysis has the flexibility to generate unexpected insight from the data, interpretation of the data may have been influenced by personal beliefs and biases. Therefore, several measures were also taken to minimise the biases. These are also described in detail in Chapter 3.

Chapter 4 complements Chapter 3 by quantitatively investigating the relative importance of parameters of sleep quality cited by good and poor sleepers (Ramlee, Sanborn, & Tang, 2017). The quantitative approach complements the qualitative approach by allowing the data to be extracted from a larger sample under a controlled condition and analysed using a rigorous statistical method. In this experiment, sleep quality judgment was conceptualised as decision-making process. Using a choice-based conjoint analysis, participants were presented with a series of choices between options with different sleep quality parameters. Two sleep/wake scenarios encompassing possible sleep quality parameters that occur at different times of the day (i.e., day before, pre-sleep, during sleep, upon waking, day after) were presented to the participants. Participants were asked to choose one of the two scenarios and went through 48 trials. The advantage of this approach over other methods (e.g., qualitative) is being able to present all possible sleep quality parameters simultaneously and each

parameter was anchored to different options. Besides, this study can quantitatively examine the relative importance of these possible parameters as well as interactions with each other by using logistic regression. Together, both Chapters 3 and 4 will present multiple parameters of sleep quality and by clarifying what people mean when they explicitly said they have had a good (or poor) night's sleep has provided insight into people's judgment of their sleep experience. Having defined what is meant by sleep quality, the thesis shifts its focus to the link between sleep and physical activity in Chapters 5 and 6.

Chapter 5 presents a daily process study that was conducted in healthy young adults. The daily process study involved repeated monitoring of sleep and physical activity over certain period (i.e., 7 days in the present study) (Affleck, Urrows, Tennen, Higgins, & Abeles, 1996). Using self-reported measures of sleep and physical activity, this daily process study provided a preliminary examination of the relationship between sleep and physical activity in the participants' natural living and sleeping environment. This study recruited healthy young adults to minimise the influence of medical symptoms and use of medications on day-to-day sleep and physical activity. The advantage of this method is that it allowed an examination of temporal association between sleep and physical activity and an analysis of the within-person association on day-to-day basis. The data collected were time-specific in nature because participants were required to complete sleep diary in the morning and the physical activity diary at bedtime. Therefore, the data can be used to examine the temporal effect of sleep on next day physical activity and the effect of physical activity on the subsequent sleep.

Chapter 6 presents a follow-up daily process study that was conducted in people with chronic pain. Using both self-reported and objective measures of sleep and physical activity, the study adapted and extended the methods established in Chapter 5 to examine the bidirectional relationship between sleep and physical activity in the chronic pain patients' natural living and sleeping environment. In addition, Chapter 6 also investigated the possible roles of pain and other psychological variables that may interact with sleep to affect the regulation of daytime physical activity.

Chapter 7 presents the general discussion and conclusions that may be drawn from the studies presented in this thesis. The chapter begins with summary of the key findings, followed by discussion of overall findings, overall limitations of the research, and importantly implications and future directions.