Job Strain and Neck Symptoms in Work-related Musculoskeletal Disorders

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ABSTRACT

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Work-related musculoskeletal disorders (WMDs) are a major public health problem in terms of the considerable amount of disability, impairment, and associated economic cost. Among these disorders, the occurrence of WMD symptoms of the neck is prevalent and has been associated with significant disability, long periods of sick leave and loss of productivity in occupational settings. Risk factors for WMDs are multifactorial, and studies have typically focused on ergonomic factors. Psychosocial factors in the work environment have been recently considered; however, findings across these studies have not been consistent. Despite the evidence associated with ergonomic factors on the occurrence of WMDs, widespread prevention and treatment efforts have not been successfully implemented. Psychosocial factors such as high psychological demands, low decision latitude and low social support may play a role in WMD occurrence.

The demand-control-support model has been widely used to predict job strain. Particularly for disorders of the neck, job strain seems to play a strong role in their

occurrence. The psychosocial work environment and WMDs are listed as research priorities of the National Occupational Research Agenda developed by the National Institute for Occupational Safety and Health.

This cross-sectional study looked at job strain and neck symptoms, while controlling for confounders. This project was carried out on a group of semiconductor manufacturing workers.

The prevalence of neck symptoms was measured by a self-administered questionnaire. A Chinese version of the Job Content Questionnaire was included to assess psychosocial factors and to test the demand-control-support model. An observational checklist was developed and used to assess ergonomic exposures on individual workers' jobs.

The participation rate was 86.5%. The final sample of semiconductor workers consisted of 373 female participants. Their mean age was 28.4 years ranging from 18 to 41 years. The mean length of employment was 4.3 years. The prevalence of symptoms of neck disorders in the semiconductor manufacturing population was 23.9%.

It was concluded that the prevalence rates of neck symptoms of WMDs in this study were high, especially given the very conservative outcome definition that was used. The study findings partially supported the job strain model, showing an increase in

prevalence of neck symptoms with psychological and physical job demands; however, association with decision latitude and social support were not supported. Further studies with more comprehensive measurements of work-related psychosocial factors are implicated and effective prevention strategies for neck symptoms of WMDs are suggested.

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CHAPTER 1

INTRODUCTION

1.1 General Overview

Work-related musculoskeletal disorders (WMDs) refer to the injuries that are caused from stressors over time at work. They primarily affect soft tissues such as tendons and tendon sheaths, muscles and myofascial tissue, nerves, and vasculature at various sites of the body and thus may manifest a wide array of symptoms. These disorders include carpal tunnel syndrome (CTS), tendonitis, tension neck syndrome, DeQuervain's syndrome, thoracic outlet syndrome, rotator cuff tendonitis, cumulative trauma disorders, repetitive strain injuries, occupational overuse syndromes, occupational cervicobrachial disorders, repetitive trauma disorders, and repetitive motion syndromes (1). The variety of body sites and conditions involved among these disorders reflects the difficulty in their differential diagnosis, therapeutic management, control and prevention.

WMDs are an important public health issue in industrialized countries and account for human suffering as well as economic cost associated with considerable amount of disability, sick leave, compensation days, and loss of productivity (2-8). Both work-related physical and psychosocial factors involved in the performance of work contribute significantly to the development, exacerbation, or acceleration of these multifactorial disorders, which may significantly impair working capacity (9).

WMD rates are expected to continue rising with the following trends of work-related ecology in Taiwan: aging of the workforce, the reduction in worker turnover, the increase in service and high-tech jobs, and the increase in work pace (10). Since the 1980s these trends, also seen in Europe, North America, and Australia, have generated an increasing interest in WMDs. However, to date, identification of the risk factors for WMDs, especially among East Asian working populations, is incomplete.

Among the various body sites involved in these disorders, neck symptoms show high prevalence rates in some working populations. The reported prevalence rates have differed across studies, ranging from 51 to 75% (11-14). National Occupational Research Agenda developed by the National Institute for Occupational Safety and Health (NIOSH) identified neck and upper extremity symptoms in WMDs as one of its research priorities within the “disease and injuries” category (15).

Factors such as neck and arm postures, repetitive work, and static workload have been identified as important risk factors for neck symptoms (1, 12, 16). In addition to the ergonomic factors, work-related psychosocial factors have received some attention in terms of possible etiology of these disorders and were considered most problematic. One of the widely used model to assess these work-related psychosocial factors is the job strain model which consists of two dimensions: psychological demands (including quantity of work, intellectual load, conflicting demands, and time constraints) and decision latitude (including skill discretion factors: learning new things, skill development, skill requirement, task variety, repetition, creativity requirement and decision latitude factors: freedom of making decisions, choice of ways to perform work). By the levels of these two dimensions, jobs may fall into one of four work environments: high strain jobs (high demands and low decision latitude), active jobs (high demands and high decision latitude), passive jobs (low demands and low decision latitude), and low strain jobs (low demands and high decision latitude). Figure 1.1 shows the different cells that are formed from different combinations of job demands and decision latitude (17).

Figure 1.1 Demand-Control Job Strain Model

		Job Demands	
		Low	High
Decision Latitude	Low	Passive Job	High Strain Job
	High	Low Strain Job	Active Job

Social support was the third factor later added to this model. The job strain model of psychological demands, decision latitude and social support (18, 19) has been used to predict various adverse health outcomes from high strain work environments (20). These conditions constitute the “Job Strain” model and affect a range of health outcomes, including coronary heart disease and depression (21, 22).

Figure 1.2 Demand-Control-Support Job Strain Model

				Psychological Demand	
				Low	High
Social Support	Low	Decision Latitude	Low		High strain
			High		
	High		Low		
			High	Low strain	

However, the relationship between these job strain factors and the prevalence of WMDs, particularly those of the neck have yet to be fully examined. Applying the demand-control-support model to neck symptoms in WMDs, one would predict an increase in neck symptoms in WMDs among individuals in high strain jobs (high psychological demands, low decision latitude, and low social support) as compared to individuals in low strain jobs (low psychological demands, high decision latitude, and high social support).

Specific Objectives

This study was performed among a group of semiconductor manufacturing workers in Hsin-Chu, Taiwan, whose work involved stressors on the neck and other sites of the body. The population is believed to be predominantly female and young with ages among twenties and thirties. It was expected to be a population with characteristics of cooperativeness with the authorities and conflict between gender equity from education and traditional female family duties and values among the Eastern Asian culture. Since the identification of the risk factors for WMDs and particularly the psychosocial risk factors for the neck symptoms had been incomplete, this study investigated the association of neck symptoms in WMDs and the work-related psychosocial factors.

The specific aims of this study are to:

1- to determine the prevalence of neck symptoms in WMDs

2- to assess the work-related psychosocial risk factors

3- to test the association between work-related psychosocial factors and the occurrence of neck symptoms in WMDs, controlling potential confounding factors including ergonomic factors and individual factors

4- to test the construct validity of the demand-control-support model of job strain on neck symptoms in WMDs

in a semiconductor manufacturing worker population in Hsin-Chu, Taiwan.

1.2 Hypotheses

This study examined the main effects of the elements in the job strain model on neck symptoms in WMDs and therefore reached the following hypothesis: the occurrence of neck symptoms in WMDs would increase as psychological demands increase, decision latitude decreases, and social support decreases. It is also hypothesized that the occurrence of neck symptoms in WMDs would be affected under two-way and three-way interaction of the elements in the job strain model.

1.3 Overview of Dissertation Layout

This dissertation proposal is composed of 5 chapters:

Chapter 1- Introduction: This chapter outlines the problems to be addressed in the dissertation.

Chapter 2- Review of Literature: This chapter reviews the literature on the risk factors, both work and non-work related, with a special focus on the psychosocial factors and neck symptoms in WMDs. It presents summary of the studies performed and a section covering of the relationship between the work-related psychosocial factors and the occurrence of neck symptoms in WMDs.

Chapter 3- Design and Methods: This chapter provides a description of the study population and the study design along with the methods for data collection, coding and analyses. The primary dependent and independent variables of interest are also specified and described.

Chapter 4- Results: This chapter presents tables and figures and summarizes the findings.

Chapter 5- Discussion: This chapter discusses the findings and possible explanations.

Comparison of the results with other literature and methodological issues are also explored here. The chapter also discusses the implications of the study for future research.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Review of Outcome Variable: Neck Symptoms in WMDs

2.1.1 Work-related Musculoskeletal Disorders (WMDs)

WMDs have become a major occupational health issue in the industrialized countries(23). In the United States, the Bureau of Labor Statistics's (BLS) 1996 annual survey found a total of 281,000 cases (64%) in repeated trauma category, which included WMDs, among all 439,000 injuries and illnesses reported in private industry (24). In addition to the considerable case number, the estimated costs were reported to have increased over time (25). The mean cost per case of upper extremity WMDs in 1999 was reported to reach $8,070 (26). Although short of similar studies, WMDs has also become a major occupational health concern in Taiwan, as the society went through modernization within the last decades. The direct costs of productivity loss and medical expenses as well as the indirect costs of presenteeism (27) and human suffering have resulted in increasing recognition and efforts in the control and prevention of WMDs.

Although interest has increased in the studies associated with WMDs, some uncertainty and unsolved problems in the identification of risk factors of these disorders remain. The paucity of studies on the neck symptoms in WMDs necessitates further exploration in this field to reach a better understanding of the risk factors associated with them.

2.1.2 Risk Factors for WMDs

Risk factors for WMDs involve both occupational and non-occupational origins. Personal, ergonomic, and psychosocial factors have been identified (28, 29). It is worth noting that the majority of these risk factors have been identified either from studies on Carpal Tunnel Syndrome (CTS) or from studies that involved combining WMDs of all the different body sites, thus precluding the identification of those risk factors that may be specific to neck symptoms in WMDs, which is the trend noted by recent quality of life (30) and the main outcome in our study.

2.1.2a Individual risk factors

Though some studies have reported that WMDs are positively associated with age (31), others have found no such association (32). Findings across studies have not shown consistent associations between Body Mass Index (BMI, defined as weight in kilograms over the square of the height in meters) and WMDs. While WMDs have been reported in some studies to occur more frequently in women than in men (33), there are conflicting explanations as to whether the susceptibility to these disorders is gender-specific, or merely due to the excess of females in high risk occupations for WMDs (34). Still, other studies do not report gender as a risk factor (32).

Therefore, it is important to examine the role of such factors as age, gender, and BMI in studies on neck symptoms in WMDs in order to assess potential confounding and control for it accordingly.

2.1.2b Ergonomic risk factors

Most commonly reported biomechanical or ergonomic risk factors for WMDs include forceful exertions, elevated levels of task repetition, awkward postures, vibration and contact stressors (14, 35-37). Additional ergonomic risk factors that have been associated with WMDs, particularly those with neck pain, include monotonous work tasks (38) and static work postures (39). The work-relatedness of these factors is supported by some studies (17, 40) although there have been criticisms (2) regarding the association between WMDs and work-related mechanical loads. Work-related and nonwork-related factors of WMDs were explored in a study of neck ailments among 173 female industrial workers (41). It was found the domestic tasks such as laundry, cleaning, cooking and, to a greater extent, responsibility for the children contributed to the prevalence of neck and shoulder ailments. The influence of factors related to family life such as the number of children living at home, or the care given to children, the elderly, or a disabled relative and factors related to leisure time such as cooking, playing a sport, and reading may also contribute to the association and thus need to be explored.

2.1.2c Work-related psychosocial risk factor

The work-related psychosocial work environment, proposed in the National Occupational Research Agenda developed by NIOSH as a priority research area within the "work environment and workforce" category (13), is another area that has been recently explored in relation to WMD occurrence. Among the more commonly studied among these psychosocial job characteristics are psychological demands, decision latitude and social support. These are discussed in greater detail in section 2.3.

2.1.3 Neck Symptoms in WMDs

Anatomically, the human neck is a complex structure made up of bony, ligamentous, muscular, vascular and neural components (42) and functionally is the most mobile section of the spine. Common neck diagnoses include the tension neck syndrome and the thoracic outlet syndrome (42). Other cervical spine disorders with neck pain include cervical sprain, cervical facet disease, cervical stenosis, cervical radiculopathy, and non-specific neck pain.

Neck pain is the most commonly reported complaint after the occurrence of a strain of the soft tissue structures and the cervical spine (43). Muscular and ligamentous tears and sprains are the most common causes of neck pain. In addition, pathological processes in other areas may also cause neck pain. Common disorders of the cervical spinal area causing neck pain include gouty and rheumatoid arthritis, osteoarthritis, spinal cord compression, ankylosing spondylitis, cervical disc infections and traumatic injury.

Among occupational settings, thoracic outlet syndrome has been associated with carrying heavy loads, prolonged restricted posture of upper body, and reaching overhead, while carrying heavy loads, prolonged restricted posture of upper body have been associated with tension neck syndrome (41). Psychosocial factors such as occupational stress were also reported to be responsible for neck pain through either rapid movement and poor posture due to time pressure or increased muscle tone and muscle fatigue due to exceeded muscle energy requirement (12).

Among various body sites involving WMDs, neck symptoms were reported to cause disability in office and industrial workers (6). A number of studies looking at the psychosocial work environment and neck, shoulder and upper extremities symptoms among telecommunication office workers, data process operators and general community workers have shown positive associations (44-46). A review of studies on WMDs by the National Institute for Occupational Safety and Health (NIOSH) (47) concluded in the chapter of WMDs and psychosocial factors that there appears to be stronger evidence for the relationship between psychosocial factors and neck symptoms in WMDs than for other disorders such as those of the hand/wrist.

2.1.4 Risk Factors for Neck Symptoms in WMDs

It has been found in a meta-analysis (48) including 21 studies with shoulder and neck diagnoses by physical or laboratory examination as outcome variables that increased number of work-related neck and shoulder disorders are associated with ergonomic factors such as constrained work postures and possibly head posture, static contractions, and highly repetitive muscle contractions. In addition, other risk factors such as exposures to driving should be considered. A study on 1,449 transit vehicle operators (34) reported driving to be independently associated with neck pain or back pain.

A population-based study (49) that included a random sample of 10,000 Norwegian aged 18 to 67 with the response rate at 77 percent revealed that the prevalence of neck pain increased with age and the prevalence is significantly greater among women than men. In the study, neck pain was assessed through questions on whether or not they had experienced troublesome neck pain within the last year, and the duration of pain in a questionnaire that was mainly concerned with sleep habits. The overall frequency of neck pain was 34%. Neck pain lasting six months or longer was found to be higher among women than men (17% vs. 10%). The authors also found that age was positively associated with neck pain for all pain durations, which was compatible with another population-based study (50) in Finland including 8,000 adults with the prevalence of 13.5% in women and 9.5% in men.

A 24-year follow-up study examined leisure time as a risk factor for neck and upper limb disorders (51). Assessment of leisure time was performed by frequency of social contacts with friends or relatives, satisfaction with leisure time, and additional domestic workload such as having responsibility for children and household. The results showed that overtime work, high mental workload, and unsatisfactory leisure time were associated with disorders in the neck-shoulder region. Significant interaction was also found between high mental workload and unsatisfactory leisure time among women. The mechanism to explain the association between the presence of children and neck symptoms may be due to the physical workload from actual carrying of children or due to the psychosocial burden from the added responsibility

2.2 Review of Exposure Variable: the Work-related Psychosocial Factors

2.2.1 Conceptual Framework

The idea of the psychosocial work environment to explain the behavioral and health effects of work has developed from ‘psychosocial epidemiology’ (52). Frankenhaeuser showed an increase in ‘stress hormones’ such as catecholamines and cortisol with some work-related environmental factors such as repetitiveness and isolation (53). To understand the epistemology behind psychosocial work environment, two major traditions established during this century in social psychology must be noted (54, 55). The first is sociological tradition and its aim is to study the effects of social structure on individual behavior or personality. Sociological social psychology contemplates the possibility of “downward causation”, that is, what happens at the sociological level can determine what occurs at the psychological level (e.g. a surge in unemployment during an economic recession can determine an increase in depression and alcohol use among individual workers having to work harder for longer hours and lower wages to keep their jobs). The second is psychological tradition and its aim is to study the behavior of individuals in social context. In contrast to sociological social psychology, psychological social psychology situates itself primarily in psychological level (e.g. the performance of high paced monotonous work for long hours causes depression or worsens smoking habit among individual workers).

The points of entry in terms of psychosocial work environment are therefore different. The point of entry for the sociological tradition is sociological concept or mechanisms such as the labor process (56, 57) and class structure (58-60). In contrast, the psychological tradition focuses more on psychological level or behavioral context such as the interaction at the workplace between individual workers and job characteristics or work environment.

In accordance with the psychological tradition, the Person-Environment fit model states that strain develops when there is a discrepancy between the motives of the person and the supplies of the environment (job) or between the demands of the job such as work load and job complexity and the abilities of the person to meet those demands. Motives include factors such as income, participation, and self-utilization. Demands include workload and job complexity. The model focuses on self-perceptions and perceptions of the environment. A difficulty with the P-E fit model is that it has little utility for predicting what work conditions are likely to result in stress. The model states that stress may result form a misfit between the person and the environment.

The job strain model of psychosocial work environment used in this study constitutes an attempt in sociological tradition to explain the relationship between psychological characteristics of the work environment and health outcomes. Despite the model's reliance on psychological level of analysis, it assumes a sociological causality because its applied aim is to change work organizations and not individual behavior (e.g. subject's coping resources). This conceptual emphasis on the structural impact of work organization distinguishes it from the more psychological person-environment fit model (52). Ideally job redesign would take place at the level of work organization to produce a downward effect at the task level (e.g. by increasing decision latitude) and ultimately on worker's health.

It is difficult to compare the models directly because the job strain model focuses on objective features of the work environment that can trigger disease, but fails to assess individual needs or values; while in the PE fit model focuses on the interaction between the individual and the environment but measures neither need for control nor the controllability of stress (61). But it appears that the PE fit model may support the job strain model's interpretation of low decision latitude as a stressor and a modifier of demands. While emphasizing the fit (interaction) between the person and environment, investigators testing the PE fit model did examine interactions between environmental stressors in predicting strain (61). The most significant interaction was between workload and job complexity fit. The impact of workload on strain was greatest among occupations with misfit on job complexity. Also, workers in jobs with low complexity had higher levels of strain than others, at every level of workload fit. Thus, low job complexity both modifies (exacerbates) the impact of workload on strain and acts as an independent stressor. In addition, it was found that greater participation in decision making reduced the association between workload and strain. Taken together, the direct effects on strain of low job complexity, underutilization of abilities, and low participation, as well as the interaction effects of job complexity and participation on workload, suggest support for job strain model's hypothesized effect of decision latitude. The PE Fit model does not explicitly evaluate control; it mixes the concept in with other factors that are measured. Consequently, the PE fit model captures some of the effect of low decision latitude, but the full effect is obscured due to the mixing of discrete factors.

The study using the PE fit model evaluated psychological strain, health –related behavior such as smoking, physiological strain, and illness such as cardiovascular disease and peptic ulcer in 23 occupations (61). Some of the stressors and PE fit measures were associated with psychological strain. There were no consistent relationships between the stressors and physiological strain. No association with disease was found. Other studies using the PE fit model have reported similar results. Baker commented in a review article about occupational stress that the percentage of variance that PE fit theory can explain in strain must be increased if the theory is to deserve further attention in stress research (62).

In contrast, investigators using the job strain model have found significant associations between the job demands and decision latitude measures and adverse physiological and psychological outcomes. Low decision latitude is associated with job dissatisfaction and boredom (18, 19). The combination of low decision latitude and high demands is associated with psychological strain (depression and somatic complaints) and coronary heart disease morbidity and mortality (18, 19). Passive jobs with both low demands and low decision latitude are associated with passive behavior at home and nonparticipation in community affairs (18, 19).

To compare the use of these two models in health-related studies, Baker evaluated the evidence for these two models and concluded that the job strain model has greater predictive power in the association between stress and adverse physiological and psychological outcomes than the P-E fit model (63). Many subsequent studies have used and tested the job strain model. This model provides an integrative framework for the study of occupational stress and its use contributed significantly to the empirical foundation supporting the relationship between work stress and health. Moreover, its widespread use provides a comparative basis across studies between work stress and health (55).

Overall, it appears that the job strain model is more powerful than the PE fit model in its ability to predict adverse health outcomes. The primary difference between the models is in their grouping and interpretation of factors relating to lack of control in the work environment. The PE fit model focuses on individual perceptions and does not assess control as a discrete variable. The interaction between person and environment captures some additional variance in the prediction of strain, but the absence of decision latitude measure critically weakens the model (63). The contrasting strength of the job strain model seems to validate the hypothesis that the key determinants of stress are to be found in the characteristics of the work environment —specifically, the separate and interactive effects of job demands and decision latitude.

2.2.2 The Job Strain Model

One of the psychosocial models that has been widely used to assess the work stress in relation to physical illness and psychological strain is the Job Strain Model (19). The model postulates that the primary source of stress lies within the characteristics of work itself. For most occupations today, individual workers are physically and intellectually capable of performing the required activities. Even considering the variability among individuals, demands within the workplace rarely exceed the capabilities of most workers. Thus the source of stress is to be found in work that simultaneously presents demands and restricts the options of workers for responding the those demands. These work environments will be stressful for virtually all workers. These work characteristics typically are found in occupations with a high division of labor and deskilling of individual tasks. This work does not allow the workers to use his or her abilities to develop creative responses to the demands of the job. Thus, the demand-control model presents a clear prediction of the work conditions that will be associated with psychosocial strain. According to this model, psychological strain, which may be in the form of anxiety, depression, fatigue or physical illness, occurs with high levels of demands and low levels of decision latitude (19).

A “social support” component was later added to this model and suggesting that job strain results from the interaction of three components: high psychological demands, low decision latitude, and low social support (20). Social support at work refers to positive, or helpful, social interaction available from superiors, management and co-workers in the workplace (19). The inclusion of social support in the job strain model is based on the growing body of evidence in several studies of coronary artery diseases (CHD) as the result of psychosocial strain, as well as psychological distress outcomes demonstrating the positive effects of social support in the workplace.

Workplace social support has been added to the job strain model as a third major job characteristic in several studies of CVD (64-66), all-cause mortality (67, 68), smoking and sedentary behavior (69), and ambulatory blood pressure (70) as well as a number of studies of psychological strain outcomes (71, 72).

The main effect of low social support on CVD was examined, with positive associations (68, 73), as well as the interaction between social support and job strain (67, 68, 73). Social support was as an effect modifier in the Swedish study of retired men (68) (increased job strain-mortality risk ratios for those with low social support), in the Swedish factory worker study (67) (reduced high latitude-mortality risk ratios for those with high workplace social support), and in a Swedish national study (74) (increased high demand-low latitude-CVD prevalence ratios with greater workplace social isolation).

Further study of social support and its effect on stress and health is indicated not only by the job strain studies cited above, but also by the extensive literature of the beneficial effects of both workplace and non-work based social support on cardiovascular and psychological health (75,76).

Greater social integration is associated with lower mortality (77) in various population based prospective studies. Negative associations between social support and CHD were found in Alameda County, California (78), eastern Finland (79), Sweden (80, 81), Denmark (82) and Tecumseh county, Michigan (83). A nonsupportive boss was associated with CHD among female clerical workers in Framingham (84). Emotional support has also been associated with lower mortality following a myocardial infarction (85, 86). In laboratory reactivity studies, social support has been found to buffer the effect of stress on diastolic blood pressure responses (87, 88).

With the demand-control-support as the model of choice for the assessment of psychosocial work environment in this study (20, 89), modification was made to include variables such as factors in caring for children, aged or disabled relatives, which may involve ergonomic effects in the physical posture or exertion in the care-giving process and psychological effects in the responsibility of home duties.

2.3 Review of Association of Interest: Neck Symptoms in WMDs and the Work-related Psychosocial Factors

2.3.1 Rationale for the Role of Psychosocial Factors in the Occurrence of WMDs

Recent literatures have noted the role of psychosocial factors in the occurrence of WMDs in different occupational groups (90-92). In a review article of 39 studies exploring psychosocial and behavioral factors in neck and shoulder pain (93), Linton concluded psychological factors are pertinent in the etiology, maintenance, treatment and prevention of neck and shoulder pain problems, especially among chronic symptoms, which are common in the occupational medicine settings. The application of cognitive-behavioral approaches was suggested, other than ergonomic approaches, to enhance the outcomes of the prevention and treatment of the neck and shoulder pain. Table 2.1 summarizes the literatures selected with the criteria of work-related symptoms of the neck and psychosocial factors in job strain model.

Figure 2.1 Comparison of occupational studies that looked at disorders of the neck and job strain

First author, year	Reference	Population	Outcome Definition	Results
Linton, 1989	9	Secretaries at a Swedish Hospital	Neck pain discomfort anytime during the last year (2 discomfort scales: 6-point frequency scale and Nordic Musculoskeletal Pain Questionnaire)	Prevalence: 73.1 % Poor as opposed to good psychosocial work environment: OR=2.85; 95%CI=1.28-6.32
Ohlsson, 1989	94	Assembly workers	Neck pain in the last 7 days and 12 months, Nordic Musculoskeletal Questionnaire	148 female assembly workers as opposed to 60 age-adjusted referents: OR=1.9; 95% CI=0.9-3.7 (12 months) OR=1.6; 95%CI=0.98-3.6(7days)
Blader, 1991	11	Sewing machine operators	For neck and shoulder pain: Symptoms over the last 7 days and 12 months, Nordic Musculoskeletal Questionnaire; Clinical examination	Prevalence 75% (12 months) Prevalence 51% (7days) from questionnaire
Andersen, 1993	10	Sewing machine operator	Continuous pain that lasted for a month or more after starting work; number of days of pain within the last year	Sewing machine operators as opposed to internal reference group of auxiliary nurses and home helpers: PPR=3.88; 95%CI=1.94-9.67
Krause, 1997	34	Urban Public Transit Operator	Current non-disabling back or neck pain (self-administered questionnaire)	Prevalence 14.7% High as opposed to low job strain: OR= 1.50; 95%CI=0.98-2.30
Josephson, 1997	12	Nursing personnel	For at lease one of the body regions of neck, shoulder or back: “had any symptoms in the past 12 months y/n”, ”have ongoing symptoms” on a 10-point scale (Nordic Musculoskeletal Pain Questionnaire)	Prevalence 53% for neck pain (y/n) Prevalence 40% for neck pain (scale, 2-9) High as opposed to low job strain: RR=2.3; 95%CI=1.4-3.6

OR=Odds Ratio;
PPR=Prevalence proportion Ratio
RR=Rate Ratio
CI=confidence Interval

Possible mechanisms have been suggested in a review on 44 cross-sectional studies and 15 longitudinal studies (37). First, work-related psychosocial factors may directly affect the mechanical load by changing posture, movements or forces. An example was that time pressure may increase rapid movements and poor posture. Another mechanism would involve individual characteristics, such as the psychosomatic response under stress, which may either: 1) increase muscle tone, or 2) influence the relationship between mechanical load and muscle fatigue when individual capacity is exceeded by muscle energy requirement. Therefore, stress may either directly lead to an increase in pain or to an increase in perception of symptoms due to other risk factors.

2.3.2 Neck Symptoms in WMDs and Work-related Psychosocial Factors

Psychological Demands

One of the factors most consistently associated with neck symptoms in WMDs has been the perception of an intensified work demand, as measured by indices of perceived time pressure (not enough to time to finish or working under deadline), workload (work amount beyond capability), and workload variability (surges in workload).

High level of perceived time pressure was found to be associated with the reporting of neck and shoulder musculoskeletal complaints in a cross-sectional study of 222 visual display unit (VDU) operators (95) and in a longitudinal study of female bank cashiers (96). Theorell et al. (97), however, in a sample of some 206 workers from six occupations, found that perceived time pressure was not significantly correlated with neck or shoulder symptoms.

Positive associations with neck symptoms in WMDs have also been found in studies using measures of perceived workload. High levels of perceived workload were found to be positively associated with musculoskeletal symptoms in the neck and shoulder regions in a six-occupation study (94), VDU operators (95), 224 employees in an engineering firm (98), the Swedish white collar labor union federation (99), newspaper employees (100) and telecommunication workers (101). Likewise, neck and shoulder symptoms of pain are also found to be associated with high levels of workload as well as demands for attention in 248 VDT users (102), having to push themselves in 143 data processors (103), rushed work pace in 109 workers (44) and in 5865 workers in Netherlands (104). However, Dehlin and Berg found no relationship between reports of high perceived physical and psychological demands and reports of ever having pain in the cervical region (105).

Variability in workload has also been linked to upper extremity disorders. The studies by Hales et al. (101) of 553 telecommunication workers and Hoekstra et al. (106) of some 108 teleservice representatives, found perceived workload variability to be associated with elbow (OR 1.2) and neck (OR 1.2) disorders, but not with shoulder or hand disorders.

Monotonous work has been positively linked to the prevalence of neck symptoms in various studies. Neck symptoms were found to be associated with “being bored most of the time” in 143 data processors (103), with monotonous work in 22,200 Swedish workers (107) and in

224 employees in a engineering firm, with "low quality work" (lacking stimulation and variation) in 109 workers (44), and with high levels of boredom in 280 clerical workers (108).

A number of studies, including those of Ryan and Bamptom (103), Karasek et al. (99), and Ekberg et al. (44), have shown positive associations between reports of role ambiguity (uncertainty about job expectations) and upper extremity disorders (particularly neck disorders). Similarly, uncertainty regarding job future was found to be predictive of neck and shoulder discomfort (102) and elbow, neck, and hand/wrist symptoms(101).

Decision Latitude

Numerous studies have reported positive associations between limited job control or autonomy at work and neck problems. These include neck symptoms (102, 104), neck/back/shoulder symptoms (97, 102), musculoskeletal aches (99), and muscle/joint symptoms (104, 108). The study by Pot et al. (95), however, failed to support this relationship.

Social Support

Limited social support from supervisors and coworkers has been found to be positively associated with a variety of neck symptoms. The studies by Pot et al. (95), Kompier (109), Hopkins (108), Sauter et al. (102), and Hales et al. (101), all support a positive association. Linton (107) reported a positive association between neck symptoms and limited support from supervisors. Ryan and Bampton (103) reported an effect of limited support from coworkers (OR

6.7), but not supervisors, on neck symptoms, while Kvarnstrom and Halden (98) reported an effect of limited support from supervisors, but not coworkers, on sick leave due to shoulder muscle symptoms. Dehlin and Berg (105), however, found no effect of social support on neck/shouldersymptoms, while Theorell et al. (97) found no effect of social support at work on neck and shoulder symptoms or symptoms of the other joints (with or without adjustment for physical load). Likewise, Karasek et al. (99) found no significant association between musculoskeletal aches and social support at work.

Overall, the epidemiologic studies of upper extremity disorders suggest that certain psychosocial factors (including intensified workload, monotonous work, and low levels of social support) have a positive association with these disorders. Lack of control over the job also appears to be positively associated with neck symptoms in WMDs.

The evidence for the relationship between psychosocial factors and upper extremity disorders appears to be stronger for neck/shoulder disorders or musculoskeletal symptoms in general than for hand/wrist disorders (47). This stronger association for neck/shoulder disorders may be due to the following reasons: the large number of studies performed in the Nordic countries which have focused more on the neck/shoulder WMD health outcome than a hand/wrist outcome; many of the neck/shoulder studies included numerous psychosocial variables in their models, whereas studies of hand/wrist WMDs have not, as a rule, included as extensive psychosocial variable testing (therefore the variables are absent from the risk factor models); and the fact that most of the studies with extensive psychosocial scales were in office settings, where physical factors may be less important than psychosocial factors in their relationship with WMDs. This finding can be contrasted with studies in heavy industrial settings, where higher exposure to physical factors may have played a greater role than psychosocial factors in the development of WMDs. Also, pathophysiologic processes resulting from adverse psychosocial and work organization factors may exert a greater effect on the neck musculature to produce increased muscle tension and strain than on the hand/wrist region.

2.4 Neck Symptoms in WMDs among Semiconductor Manufacturing Workers

The semiconductor manufacturing workforce may be at special risk for musculoskeletal disease because of the ergonomic characteristics of the manufacturing process. High-volume production demands and exacting repetitive work may increase risk for musculoskeletal conditions resulting from cumulative trauma. In 1990, cumulative trauma disorders were reported in 38 of every 10,000 employees in electronic component manufacturing, a six fold increase compared with 1984 (110,111). A 1989 review of reportable occupational conditions at the Semiconductor Health Study showed that musculoskeletal disorders accounted for approximately one-third of the cases of occupational injuries and over half of lost workdays (112).

The present study focuses on the assessment of neck symptoms as the outcome variable of interest and is based on a group of semiconductor manufacturing workers, which has been related to an increased risk of WMDs (113). Among their possible ergonomic exposures during semiconductor manufacturing (113), static postures and static loads are considered to be strongly correlated with neck symptoms (38). However, the extent of the psychosocial factors' influence on the occurrence of neck symptoms in WMDs in this population is yet to be determined.

CHAPTER 3

DESIGN, POPULATION AND METHODS

3.1 Study Design

This was a cross-sectional study designed to find the prevalence of neck symptoms and to examine their association with work-related psychosocial factors as well as ergonomic factors in the study population. Data on the dependent, independent variables, and potential confounders were collected through a self-administered questionnaire in 2002, which asked the experience of immediate past (last 12 months) and also through an observational checklist, which assessed the ergonomic factors.

3.2 Measurement: Exposure/Outcome Assessments

In studies involving physical exposures, the assessment methods generally include direct measurements, observations, questionnaires, interviews and diaries. Direct measurements such as electromyography recordings, movement and posture recordings and the use of other devices, are expensive and time-consuming. However, they have the advantage of providing quantitative information and are highly reliable (114, 115). In contrast, questionnaires are of low cost, and have been the more frequently used method of assessment. The use of questionnaires or interviews allows the assessment of cumulative exposures over time of certain variables that may not be otherwise present at the time of direct measurements. Such methods, however, may involve recall bias, which results from selective recall or inability to recall past exposures. Though the use of interviews has been said to have higher validity than questionnaires, these methods have their inherent limitations, such as those associated with the interviewer bias and with the subjectivity of the information obtained. Observations allow for assessment of the exposure profile by task, which cannot be otherwise analyzed by direct measurements. Observation methods may be less expensive than interviews or use of questionnaires, but also have biases of their own. Biases related to the observers and the workers, e.g. inter-observers/workers and intra- observer/worker biases need to be taken into consideration, and proper training and standardization of the methods need to be done. Kilbom explored the method issues of the assessment of physical exposure in relation to WMDs in a review article (114) and concluded that systematic observations that are accompanied by a questionnaire or interview would provide a fairly good task representation and yield sound assessment of physical exposures. These methods will allow for a more detailed description regarding the physical workload instead of relying on a crude measure such as job title (115).

The present study used an observational checklist carried out by two observers and a self-administered questionnaire. The observation is designed to provide valuable information on the posture and body movements that would otherwise be missed by reliance on only the questionnaire. A self-administered questionnaire was also used to assess the outcome: neck symptoms. The outcome definition for this study was “pain, aching, stiffness or limited movement in the neck, which either interfered with work at home or work on the job as experienced by the worker during the last 12 months.” The use of the worker’s experience of “pain” is considered to be an important indicator of the potential for WMDs (116). Thus, the outcome definition in this study is based on symptoms of neck pain. This method, which allows for the identification of those workers who have symptoms, has been recommended as a suitable approach in studying these disorders. It was thought to provide meaningful information for preventive efforts (17). Also, relying on symptoms to assess the outcome provides a sensitive measure of assessment (117). Including a measure of functional status in the outcome definition by asking about interference with work at home or on the job provides an indication of the nature and severity of these symptoms. A better description of the outcome would therefore be feasible to be accomplished by using such a definition. Also, a measure of disability of neck symptoms was assessed in this study using a modified version of a disability index previously used by Jordan and colleagues (118). Therefore, including questions on the interference of neck symptoms with such activities as managing daily activities and reducing reading activity would provide a better picture of the type of neck symptoms reported in this study.

Measurement of work-related psychosocial factors was based on the three dimensions of the job strain model for the psychosocial work environment: psychological demands, decision latitude and social support. Categorical method of the 4-point Likert scale was used to assess the level of self-perception in the statements among each of the three dimensions. To conform to the categorical methodology of other literatures of the same measurement for future comparison reasons, these dimensions were then each divided into high and low levels according to the median value of the collective scores from the statements. The expected finding would be to observe the highest prevalence rate of neck symptoms in the high strain group with high psychological demands, low decision latitude, and low social support as well as the lowest prevalence rate in the low strain group with low psychological demands, high decision latitude, and high social support.

Comparisons were made among groups with different work-related psychosocial profiles for the occurrence of neck symptoms with the low strain group as the reference despite the fact that the reference would not be totally free of exposures. Further comparisons were also attempted to examine the effect of ergonomic and personal factors to look for any possible patterns and trends as well as better understanding of the associations observed.

3.3 Study Population

This study population was a group of workers in a semiconductor-manufacturing plant, located in Hsin-Chu County, Taiwan, one of 15 similar plants in the Science-based Industrial

Park in the county. There were a total of 525 employees at this plant. The semiconductor-manufacturing workers made up a total of 486 and were predominantly Taiwanese women with a median age in the twenties, and with Mandarin as their first language.

Of the 486 semiconductor-manufacturing workers, 21 workers such as trainees, workers for whom the turnover rate was known to be high and workers who had worked at the plant for less than one year were excluded to eliminate unrepresentative workers. The remaining of 465 workers were invited and given the questionnaire.

3.3a Participation Rate

Of the 465 questionnaires distributed, a total of 402 were returned resulting in a participation rate of 86.5%.

This high participation rate of 86.5% was anticipated because of the close relations that we formed with the workers, union, and management. In addition, previous studies on semiconductor manufacturing workers in Taiwan have shown relatively high participation rates, such as the 86.0% rate reported by Du (119).

3.3b Selection of the Final Sample

Out of a total of 402 questionnaires returned, 11 were found to be incomplete. Of the 391 participants for whom there were usable questionnaires, there were only 18 men who were then subsequently excluded in the final analyses, resulting in a final sample of 373 female semiconductor manufacturing workers (Table 4.1). The reasons for excluding the few men present were related to their small number which did not allow for stratified analyses to be performed. Furthermore, men worked at certain jobs in the plant such as maintenance work, and thus differed in certain ergonomic factors. For example, men were more likely to perform jobs while standing in comparison to the more commonly observed seated position of the female workers.

Table 3.1 Questionnaire administration leading to final sample

Questionnaire Status	N	% of Total Sample
Distributed	465	100.0
Returned	402	86.5
Usable	391	84.1
* Final sample in study	373	80.2

* After excluding the men

Out of the 373 participants with usable questionnaires, 335 were observed for physical exposures. Some of the reasons for observation not conducted include leaving employment, evening shift, sick leave and unidentified reasons.

3.3c Characteristics of the Work Schedule

A regular workday at the plant is eight hours. There are two paid rest breaks of twenty minutes each (one in the morning and one in the afternoon), plus a thirty-minute unpaid lunch break. The break times differ by section so that at any one single time, some section of the plant is in operation.

3.3d Informed Consent

Participation in the study was voluntary, and a signed informed consent form from each participant was obtained. A copy of the consent form was given back to each participant for his or her records. The consent form was approved by the Committee on Human Research at the Taipei Medical University, School of Public Health and the study protocol was approved by IRB at Columbia University Medical Center.

3.4 Data Collection

3.4a Questionnaire

A self-administered questionnaire (appendix) was distributed to each participant, who was given 4 days to complete it in his or her own time. The completed questionnaire was returned to the investigator team in a sealed, plain envelope. The principle investigator removed all personal identifying data and assigned a random code number for linkage with exposure data from observation.

The questionnaire covered personal factors, such as sociodemographic information, health history (medications, current and previous diseases, previous fracture/injuries), home duties (child care, number of children and their ages, caring for the aged and disabled), and leisure time activities; work history, such as length of employment, time on primary job operation, work station, and work shifts; assessment of neck symptoms in WMDs; ergonomic factors, such as exposure to repetitive tasks, forceful exertions, awkward postures; and work-related psychosocial factors, such as psychological demands, decision latitude, and social support. The questions were asked on a 4-point Likert scale ranging from “strongly agree” to “strongly disagree”.

3.4b Observational Checklist

An observational checklist (appendix) previously constructed for assessing the ergonomic exposure and neck pain among garment workers (120) was used to assess ergonomic exposures. Direct observation on the primary job operation was carried out by one of two observers. Evaluations of the workers’ posture as well as hand and body movements were observed for a short time (30 seconds per item) and were then recorded. A checklist for each worker was completed and returned by the observers and was then given the same code number as the questionnaire. Observations were made among some of the workers by the two observers simultaneously for the purpose of evaluating standardization and inter- and intra-observer reliability, which will be presented in section 4.3.

The observational checklist included the following:

- Working position: sitting versus standing
- Section of the plant
- Time of complete work cycle

- Neck posture (neck flexion, neck rotation)

- Forward lean

- Arm forward/lateral reach

- Workstation layout (position of work- adequate height, high, or low)

- Lifting

3.5 Independent Variables

The work-related psychosocial factors were the primary exposure of interest in the study; while other factors such personal factors and ergonomic factors were also considered.

3.5a Work-related Psychosocial Factors

Work-related psychosocial risk factors were the primary independent variables assessed, which included psychological demands, decision latitude and social support.

Measures of these dimensions are taken from the Job Content Questionnaire (JCQ) developed by Karasek and colleagues (121).

Psychological demands measure the participant's subjective perception on speed, intensity and interruption on the job including the following 9 statements.

a. My job requires working very fast

b. My job requires working very hard

c. My job is very hectic

d. My job requires long periods of intense concentration on the task

e. Waiting on work from other people or sections often slows me down on my job

f. My tasks are often interrupted before they can be completed, requiring attention at a later time

g. I am not asked to do an excessive amount of work (reverse coded)

h. I have enough time to get the job done (reverse coded)

i. I am free from conflicting demands that others make (reverse coded)

Decision latitude refers to the degree of freedom on the job and the extent of learning new things including the following 6 statements about skill discretion and 3 statements about decision authority.

Skill discretion

a. My job requires that I learn new things

b. My job requires me to be creative

c. My job requires a high level of skill

d. I get to do a variety of different things on my job

e. On my job, I have an opportunity to develop my own special abilities

f. My job involves a lot of repetitive work

Decision authority

a. My job allows me to make a lot of decisions on my own

b. I have a lot to say about what happens on my job

c. On my job I have very little freedom to decide how I do my work

Social support measures the degree of attention, concern, and assistance received on the job including the following 4 statements about coworker support and 4 statements about supervisor support.

Coworker support

a. People I work with are competent in doing their jobs

b. People I work with take personal interest in me

c. People I work with are friendly

d. People I work with are helpful in getting the job done

Supervisor support

a. My supervisor is concerned about the welfare of those under her/him

b. My supervisor pays attention to what I am saying

c. My supervisor is helpful in getting the job done

d. My supervisor is successful in getting people to work together

3.5b Personal Factors

Data were collected in the questionnaire on age, gender, height, weight, highest level of education completed, marital status, home duties and leisure time activities.

The Body Mass Index (BMI) was then computed using the following formula:

BMI= (weight in kilogram)/(height in meter)2 (122).

Also, a section on health history asked about medication, current and previous physician diagnosed physical disorders such as osteoarthritis, rheumatoid arthritis, cervical disc, gout, and traumatic injury to the neck. Income, education and arthritis of neck were selected for testing of Spearman's correlation due to study interest.

3.5c Ergonomic Factors

Direct observation of workers in their primary job operations included assessments of neck flexion (≧ 20 degrees), neck rotation (> 2 times per minute), forward lean, sitting versus standing during the primary job operation, frequency of arm reaching (≧ 10 times per minute), and lifting (> 5 kilograms per task). Physical demand factors were assessed in the questionnaire using the scale previously developed by Karasek in the JCQ (121) including the following 2 statements about physical isometric load and 3 statements about physical exertion.

Physical Isometric Loads

a. I am required to work for long periods with my head or arms in physically awkward positions

b. I am often required to work for long periods with my body in physically awkward positions

Physical Exertion

a. I am often required to move or lift heavy loads on my job

b. My work requires rapid and continuous physical activity

c. My job requires lots of physical effort

Questions on work history included hours worked per week, length of employment, and time on primary job operation.

The information regarding commuting time (total time spent in commute to and from work), information on caring for children ($<$ 6 years old), elderly, and disabled persons was also collected as nonwork-related exposures.

3.6 Dependent Variables

The primary dependent variable is the occurrence of WMD symptoms of neck pain and a disability scale.

3.6a WMD Symptoms of Neck Pain

The definition for WMD symptoms of neck pain was based on the following criteria as reported by the worker for the last twelve months:

(1) * Symptoms of any pain or aching, or stiffness, or limited movement in the neck (yes/no),

and

(2) * Absence of acute trauma in the neck (yes/no),

and

(3) * Interference with work on the job or work at home (yes/no).

3.6b Neck Disability Scale

A modified version of the Copenhagen Neck Functional Disability Scale, previously tested to have good validity and reliability (118), was used to assess the extent of disability for the reported symptoms of neck pain and to further characterize the nature of it. These questions, with a yes/no response option, are as followings:

Did this problem with your neck interfere with:

a. Managing your daily activities?

b. Putting on your clothes in the morning?

c. Brushing your teeth without getting neck pain?

d. Lifting objects weighing 2-5 kilograms?

e. Reducing your reading activity?

f. Reducing your ability to concentrate?

g. Participating in your usual leisure time activities?

h. Influencing your emotional relationship with your closest family members?

i. Staying away from other people during the past 2 weeks?

j. Being bothered by headaches during the time that you have had neck pain?

k. Feeling that neck pain will influence your future?

These questions were scored by yes=1 and no=0, with the maximum of 11 indicating extreme neck disability. The information was also be assessed by dividing the respondents into two groups: less disabled and more disabled according to the median of the scale score.

3.7 Pilot Test

The questionnaire was pilot tested on a group of supervisors and volunteer workers. The principal investigator gave a briefing on the goal of the study and the instruction for filling out questionnaire. The participants were encouraged to write comments on the questionnaire for the approximate time to complete the questionnaire, and whether the wording was unclear or offensive, and then to return the completed questionnaire in 4 days. The observational checklist was also pilot tested on workers in another department of the plant. Refinement was made for clarity and accuracy.

3.8 Sample Size

The sample size needed was estimated to detect a difference in proportion of neck symptoms between two groups (the exposed and the unexposed) in consideration of the following:

(1) The total number of eligible semiconductor manufacture workers in this plant was 465, all of whom were invited to participate.

(2) We anticipated a high participation rate ranging between 80% and 90% and thus leading to sample sizes of 372 and 419 respectively. This participation rate was anticipated from previous worksite questionnaire study in Taiwan: 86% Du and colleagues (119); 78% Su and colleagues (123). Also, a friendly relation cultivated with the workers, the union, and the management was thought to be helpful in promoting the participation rate.

(3) An alpha level (α) of 0.05 was set for the probability of making a Type Ⅰ error (rejecting Ho when it is true).

(4) A beta level (β) of 0.2 was set for the probability of making a Type Ⅱ error (failing to reject Ho when it is false) yielding eighty percent power.

(5) The proportion of outcome in the exposed group (Pe) was set to be thirty percent and the proportion of outcome in the reference population (Pu) was set to be twelve percent according to a similar study looking at the associations between WMD symptoms of neck pain and the work-related psychosocial factors (9). The reported WMD symptoms of neck pain were estimated to be 30% among the exposed group (poor environment) and 12 % for the reference population or the unexposed group

(good environment).

The sample size was then calculated to be 134 per group based on comparing proportions of health outcomes between two groups according to Fleiss (124).

3.9 Data Coding and Entry

All data from the questionnaire and the observational checklist were checked and proved to the original and confirmed where edited to ensure the accuracy of entry.

In constructing scale scores for independent variables, missing values of the independent variables were substituted by the mean value of the other items from that scale, given that the missing values are not more than half the total number of items. If more than half of the items were missing, then the scale score was coded as missing.

3.10 Statistical Analyses

In the univariate stage, examination of the data for possible outliers and descriptive analyses were performed among all variables with exploratory data analyses (data plotting, frequencies), measures of central tendency (mean, median, mode) and measures of variability (standard deviation, range).

In the bivariate stage, associations of independent variables with the WMD symptoms of neck pain were tested. For the assessment of nominal independent and dependent variables, contingency tables were constructed with chi-square values and p-values calculated. For the assessment of continuous independent variables with nominal dependent variables, means were compared using t-test. Prevalence odds of neck symptoms by ergonomic factors and work-related psychosocial factors were compared. Evaluation of confounding variables was also performed.

In the multivariate stage, logistic regression analyses were used to test the association of the log odds of symptom prevalence with exposures while controlling for confounding variables. A forward stepwise logistic regression analysis was used as an exploratory analysis, while maintaining the work-related psychosocial factors always in the model. The presence of effect modification was tested between psychosocial and other variables in relation to neck symptoms. A forward stepwise regression step was used to determine which added interaction terms to the variables of interest in the regression model were significant and should be kept in the model. Odds ratios were calculated from regression coefficients and ninety-five percent confidence intervals were obtained.

All statistical analyses were performed by SPSS 8.0 for Windows.

CHAPTER 4

RESULTS

4.1 Assessment of the instruments

The level of agreement between items on the observational checklist was evaluated for both inter-rater and intra-rater agreement. The former was assessed for a total of 40 duplicate observations completed by the two observers on the same workers at the same time over 15 minutes each. The intra-rater agreement was evaluated with a total of 8 observations by one observer and 6 observations by the second observer of the same workers in the morning and the afternoon. The validity and reliability of the Job Content Questionnaire (JCQ) scales were also assessed by evaluation of psychometric properties.

4.1a Agreement between Items on Observational Checklist

4.1a1 Inter-rater Agreement

The level of agreement between the observers was evaluated by calculating Kappa statistics for the primary items of the observational checklist. This was done to evaluate the level of agreement between the two observers when performing observations on the same subjects at the same time. For the neck flexion variable, observations were rated as less than 20 degrees and equal to or greater than 20 degrees. The Kappa was 0.41 indicating the level of agreement between the observers (Table 4.1). Observations for the forward arm reach variable were assessed as less than 10 or equal to or greater than 10 times per minute. The Kappa for the forward arm reach variable was 0.63 between the observers. (Table 4.2) The potential for social interaction, rated as present or absent, revealed an agreement level by a Kappa of 0.68 (Table 4.3). However, for the adequacy of work surface height variable, the Kappa was 0.28 for the agreement between the observers (Table 4.4). Table 4.5 shows the percent agreements for some other selected items of the observational checklist consisting of forward lean (<20 versus ≧ 20 degrees), seated versus standing working position, and lifting (≦ 5 versus > 5 kilograms per task) with values of 83.7, 93.4, and 98.8 percent, respectively. No items were dropped due to poor inter-rater agreement in the observational checklist.

Although the Kappa coefficient was found to be only 0.28 in the inter-rater agreement for work surface height, which may be due to the use of only very few observers, the agreement percentage reached 76.5%. Among previous literatures on ergonomics of work stations, work surface height seems to be an important variable in measuring physical work load and was kept in the model for further comparison with previous literatures.

Table 4.1 Inter-rater agreement for neck flexion

	Neck Flexion (degrees)		
	Observer 1		
Observer 2	< 20’	≧20’	Total
<20’	1	1	2
>=20’	1	13	14
Total	2	14	16
Agreement= 14/16=87.5%			
Kappa Coefficient= 0.429			

Table 4.2 Inter-rater agreement for forward arm reach

	Forward Arm Reach (times/minute)		
	Observer 1		
Observer 2	<10	≧10	Total
<10	3	0	3
>=10	3	10	13
Total	6	10	16
Agreement=13/16= 81.3%			
Kappa Coefficient= 0.556			

Table 4.3 Inter-rater agreement for potential for social interaction

	Potential for Social Interaction		
	Observer 1		
Observer 2	No	Yes	Total
No	7	1	8
Yes	2	7	9
Total	9	8	17
Agreement=14/17= 81.8%			
Kappa Coefficient= 0.648			

Table 4.4 Inter-rater agreement for work surface height

	Work Surface Height		
	Observer 1		
Observer 2	Not Adequate	Adequate	Total
Not Adequate	2	4	6
Adequate	0	11	11
Total	2	15	17
Agreement= 13/17= 76.5%			
Kappa Coefficient= 0.393			

Table 4.5 Inter-rater agreement for other selected variables

Item	% Agreement
Position (Sitting vs Standing)	93.4
Lean Forward (<20 vs ≧20 degrees)	83.7
Lifting (≦5 vs >5 kilograms per task)	98.8

4.1a2 Intra-rater Agreement

The intra-rater agreement assesses the agreement of the same observer when performing observations on the same subject at different times. Comparisons of these observations carried out in the morning and in the afternoon by the observer on the same worker are shown in Table 4.6. The intra-rater agreement was lowest for the forward arm reach. The percent agreement for the neck flexion variable was 75% for both observers.

Table 4.6 Intra-rater agreement for morning versus afternoon observations

	Neck Flexion (≧20’ vs <20’)	Forward Arm Reach (≧10 vs <10 times per minute)	Lifting (>5 vs ≦5 kilograms per task)	Lean Forward (≧20’ vs <20’)	Adequate Height of Work surface (yes vs no)	Potential for Interaction (yes vs no)
Observer 1 (out of 4)	3 (75%)	2 (50%)	4 (100%)	3 (75%)	3 (75%)	4 (100%)
Observer 2 (out of 4)	3 (75%)	3 (75%)	3 (75%)	3 (75%)	4 (100%)	3 (75%)

4.1b Validity and Reliability of the Job Content Questionnaire Scales

The validity and reliability of the Job Content Questionnaire have previously been assessed (121). In this study, the inter-item reliability was examined using Cronbach’s alpha for every scale as shown by Table 4.7. Validity was assessed by factor analysis. As shown in Table 4.7, all scales showed moderate alpha coefficients, equal to or greater than 0.61 which is similar to those reported by Karasek and colleagues (121).

The factor analyses in the Chinese version of the questionnaire showed four components, psychological demand, decision latitude, supervisor support, and coworker support, were found separately in the sample by principal component analysis with the criterion of Kaiser's eigenvalue >1 (125). Scree plot analysis also revealed a four-component solution. The four factors extracted by the principle axis factoring method in the sample corresponded very closely to the theoretical constructs. After the Varimax rotation, the variance explained for the first three factors was evenly distributed (i.e., 12.7%, 11.6%, and 11.6%).

Table 4.7 Reliability of the scales in the job content questionnaire expressed as Cronbach's alpha

Psychosocial Variable Scale	Items in Scale	Cronbach's Alpha
Decision Latitude	9	0.63
Skill Discretion	6	0.61
Decision Authority	3	0.69
Total Social Support	8	0.84
Coworker Support	4	0.76
Supervisor Support	4	0.89
Total Psychological Job Demands	9	0.65
Total Physical Demands	5	0.80
Physical Exertion	3	0.73
Physical Isometric Loads	2	0.86

4.2 Characteristics of the Final Study Sample

The following results were based on the final sample consisting of a total of 373 female workers. For some continuous variables where the mean is presented, the standard deviation is also reported and referred to as SD.

4.2a Individual Factors

Results are presented in Tables 4.8. The age distribution of the female semiconductor manufacturing workers ranged from 18 to 41 years with a mean of 28.4 (SD=7.6). The mean Body Mass Index (BMI) of the participants was 24.0 kg/m2 (SD=5.2) indicating that the average BMI of the participants lies within normal limits according to the guidelines published by Department of Health, Taiwan, and the range was 15.2 to 42.1 kg/m2 (Table 4.8).

Table 4.8 Mean (SD) and range of selected characteristics of study participants

Characteristic	n	Mean (SD)	Range
Age (years)	358	28.4 (7.6)	18-41
Height (cm)	373	159.8 (10.7)	145-178
Weight (kilograms)	346	48.4 (6.8)	32-76
Body Mass Index (kg/m2)	346	24.0 (5.2)	15.2-42.1

Table 4.9 shows the frequency of the individual characteristics of study participants. The majority (77.6%) were under 35 years old, and no workers were 65 years or older. Only 19.1% of the participants fell in either the overweight group (BMI of 25 to 29.9) or the obese group (BMI ≧30). The majority of the participants (74.6%) had never married and only 18.3% were either married or were living with a partner. The rest of the workers were either widowed, separated or divorced (7.1%). Table 4.9 also presents the level of education of the participants. All of the participants had completed high school education, and more than two-thirds completed

further education such as some college. The majority of the workers (89%) were right-handed. Out of 350 workers who filled out the question on household income, 49 (14.0%) had an income equal to or less than $20,000, while 72.5% had an income exceeding $20,000. Some participants (13.4% of the sample) selected the “don’t know” item choice on his question.

Table 4.9 Frequency distribution of the individual characteristics of the study population of female semiconductor manufacturing workers

Characteristic	n	%
Age (years)		
<25	75	20.9
25-34	203	56.7
35-44	80	22.4
Body Mass Index (kv/m2)		
<25 (slender/medium)	280	80.9
25-29 (over weight)	58	16.8
[illegible]	8	2.3
Marital Status		
Married or Living with a Partner	68	18.3
Widowed, Separated or Divorced	26	7.1
Never married	279	74.6
Education		
High School Completed	116	31.1
College Completed	225	60.3
Graduate School Completed	32	8.6
Handedness		
Right-handed	332	89.1
Left-handed	36	9.7
Able to use both hands equally well	5	1.2
Household Income ($)		
[illegible]	49	14.0
20,001-30,000	189	54.0
>30,000	65	18.6
Don’t know	47	13.4

Body Mass Index (Weight in kg)/(Height in m)^2

4.2b Work-Related Factors

The mean length of employment among participants was 4.3 years (SD=3.5), ranging from 1 month to 10 years (Table 4.10). The mean time spent on the primary job operation was 3.2 years (SD=2.9) with a range of 1 month to 9.1 years. The mean number of hours worked per week was approximately 42 (SD=2.5) (Table 4.12). The majority (78.6%) were full-time workers, and approximately 21.4% of workers worked more than 40 hours per week.

Table 4.10 Mean (SD) and range of selected work-related variables

Characteristic	n	Mean (SD)	Range
Length of Employment (years)	373	4.3 (3.5)	1-10
Time on Primary Job Operation (years)	368	3.2 (2.9)	1-9.1
Time spent working per week (hours)	371	42.5 (2.5)	32-56

Out of 373 workers, 24 (6.5%) reported having a second job. The mean hours worked per week in the second job was 6.2 (SD=1.8), with a range of 2 to 18 hours.

The distribution of the job titles is presented in Table 4.11, which shows that the majority of the semiconductor manufacturing workers were operators (47.6%). Other job titles were engineer (16.4%), supervisor (18.2%), office work (13.7%), and alterations (4.0%).

Table 4.11 Frequency distribution of the job titles

Variable	n	%
Operator	178	47.7
Engineer	61	16.4
Supervisor	68	18.2
Alterations	15	4.0
Office	51	13.7

4.2c Health and Lifestyle Factors

Only 12.1% were current smokers. Out of the 328 currently non-smoking workers, just 21 (5.6%) were ex-smokers. Thus, workers who never smoked constituted most of the workers (Table 4.12). More than one-third of the workers (42.9%) reported that they exercised and raised their heart rate for 20 minutes or more at least 3 times a week (Table 4.12).

Table 4.12 Frequency distribution of selected health related variables in the study population

Variable	n	%
Smoking Status		
Current Smoker	45	12.1
Ex-Smoker	21	5.6
Never Smoker	307	82.3
Exercise		
Yes	106	42.9
No	213	57.1

Among the various activities that the workers were more commonly involved in when they were not at work included sewing (17.2%), cooking (29.0%) and shopping (72.1%) (Table 4.13).

Table 4.13 Frequency distribution of hobbies and activities outside of work

Activities	n	%
Sewing	63	17.2
Shopping	269	72.1
Cooking	108	29.0

Table 4.14 shows the distribution of physician-diagnosed health conditions that were reported by the participants. Some workers reported arthritis (16.1%), which included rheumatoid arthritis, osteoarthritis of an unknown type of arthritis to the worker. Specifically for the neck area, arthritis of the neck was reported by 4.8% of the workers, while 4.3% indicated a ruptured disc or pinched nerve in the neck. Those who had either arthritis of the neck or a ruptured disc/pinched nerve in the neck constituted 9.1% of the workers. Other frequently reported conditions included back disorder (26.4%), anemia (21.5%), and tendonitis (18.5%).

Table 4.14 Distribution of self-reported physician-diagnosed health conditions

Physician-Diagnosed Health Condition	n	%
Anemia	80	21.5
Thyroid Problems	19	5.1
Kidney Disease	9	2.4
Any Arthritis	60	16.1
Gout	2	0.8
Hypertension	8	2.3
Lupus	3	0.8
Back Disorder	99	26.5
Carpal Tunnel Syndrome	33	8.8
Tendinitis	69	18.5
Bursitis	32	8.6
Ruptured Disc or Pinched Nerve in the Neck	16	4.3
Arthritis of Neck	18	4.8

4.2d Physical Exposure Factors

The majority of the workers (63.2%) took a bus to work. The time spent commuting to and from work per day ranged between 10 to 45 minutes with a median of 23.2 minutes.

Results for family, household and lifestyle factors are present in Table 4.15. The percentage of workers having children under 6 years old living at home was 24.7%. Some workers (20.3%) had a disabled relative in their household, while 19.8% provided personal care on help to an aged or disabled relative(s), but not necessarily in their own homes.

Table 4.15 Family, household and lifestyle information

Variable	n	%
Have children living at home < 6 years old		
Yes	91	24.7
No	277	75.3
Have disabled relative(s) at home		
Yes	74	20.3
No	296	79.7
Provide personal care/help to an aged/disabled relative		
Yes	73	19.8
No	295	80.2

The working position of the worker (standing versus seated), posture and body movements, assessed through the observational checklist, are presented in Table 4.16. Two-thirds of the workers were seated while doing their primary job operation (66.8%), while 20.6% were standing and only 12.6% did both. A neck flexion equal to or greater than 20 degrees was observed for the majority of the participants observed (86.4%), and a forward body lean defined in the same manner (≧ 20 degrees) was found for 36.5% of the workers. Lifting more than 5 kilograms per work task was recorded for only 2.6% of the workers. The workstation was assessed for adequacy of the work surface height, and the height judged to be adequate for 74.1% of the workers. One item on the observational checklist also assessed whether there was a potential for social interaction among the workers and results showed that there was an opportunity for interaction while working in the case of 174 out of 326 participants (53.4%).

Table 4.16 Frequency distribution of the workers' working position, posture and movements from observations (n=234)

Variable	n	%
Working position		
Sitting	224	56.8
Standing	69	40.2
Both	42	3.0
Neck flexion		
≧ 20◦	289	88.0
≦ 20◦	46	12.0
Lifting		
> 5 kilograms	8	1.7
< 5 kilograms	326	97.4
Forward arm reach		
≧ 10 times per minute	112	34.0
< 10 times per minute	217	66.0
Lean forward		
≧ 20。	127	38.6
< 20。	202	61.4
Adequate height of work surface		
Yes	248	74.1
No	86	25.9
Potential for social interaction		
Yes	178	53.4
No	155	46.6

4.2e Work-related Psychosocial Factors

Table 4.17 presents the mean, median and range of possible and observed values for the work-related psychosocial variables. From these figures, it is evident that the observed values for all scales covered most of the possible range of the values, indicating a wide distribution of values over all. For the decision latitude and psychological demands variables, workers did not report extremely high values, while total social support among the workers did not reach the lowest levels. For physical demands, reports covered the entire possible range. Table 4.17 also presents the median value for each of these variables, which was later used to split the variable into low and high levels, depending on whether they were at or below the median value or above the median, respectively.

Table 4.17 Distribution of the work-related psychosocial variables

Psychosocial Variable	n	Mean (SD)	Median	Range of Values	
				Possible	Observed
Total Decision Latitude	373	21.6(3.3)	23	9-36	12-34
Skill Discretion	373	14.5(2.1)	15	6-24	6-22
Decision Authority	373	7.3(1.3)	8	3-12	3-12
Total Social Support	368	22.5(4.5)	21	8-32	10-32
Coworker Support	371	10.7(1.9)	10	4-16	4-16
Supervisor Support	370	11.8(2.8)	10	4-16	4-16
Total Psychological Job Demand	373	24.2(2.6)	24	9-36	11-32
Total Physical Demands	373	12.2(3.5)	11	5-20	5-20
Physical Isometric Loads	373	4.8(1.8)	4	2-8	2-8
Physical Exertion	373	7.4(1.7)	7	3-12	3-12

Table 4.18-4.20 present the results based on median-splits of subscale scores measuring the total physical demands, total decision latitude, and total social support, respectively. Table 4.21 shows the distribution of the total work-related psychosocial factors.

Table 4.18 Frequency distribution of the Physical Demands subscales by low and high levels

Total Physical Demands	n	%
Physical Isometric Loads		
Low	237	63.5
High	136	36.5
Physical Exertion		
Low	225	60.3
High	148	39.7

Table 4.19 Frequency distribution of the Decision Latitude subscales by low and high levels

Total Decision Latitude	n	%
Skill Discretion		
Low	194	52.0
High	179	48.0
Decision Authority		
Low	228	61.1
High	145	38.9

Table 4.20 Frequency distribution of the Social Support subscales by low and high levels

Total Social Support	n	%
Coworker Support		
Low	151	40.7
High	220	59.3
Supervisor Support		
Low	194	52.4
High	176	47.6

Table 4.21 Distribution of the final primary work-related psychosocial variable of interest by low and high levels

Psychosocial Variable	n	%
Total Decision Latitude		
Low	191	51.2
High	182	48.8
Total Social Support		
Low	203	55.2
High	165	44.8
Total Psychological Job Demands		
Low	207	55.5
High	166	44.5
Total Physical Demands		
Low	210	56.3
High	163	43.7

In Table 4.22, the different cells were formed by the varying degrees of high and low levels of psychological demands, decision latitude, and social support. The low strain group of low psychological demands, high decision latitude and high social support consisted of 13.3% of the workers. The high strain group consisting of those with high psychological demands, low decision latitude and low social support consisted of 13.0% of the workers.

Table 4.22 Matrix showing the distribution formed by combinations of work-related psychological demands, decision latitude and social support

				Psychological Demands			
				Low		High	
				N	%	N	%
Social Support	Low	Decision Latitude	Low	71	19.3	48	13.0
			High	44	12.0	52	14.1
	High		Low	39	10.6	30	8.2
			High	49	13.3	35	9.5

4.3 Prevalence Rates of Neck Symptoms

Table 4.23 presents the result of prevalence rates according to different definition of neck symptoms. In this study, we define neck symptoms as comprising of (1) any reported pain, aching, or stiffness or limited movement, and (2) absence of injury/accident to neck, and (3) interference with either work at home or work on the job. The prevalence of neck symptoms was 23.9% in the previous 12 months.

Table 4.23 Prevalence rates of neck symptoms according to different definitions

Definition of neck pain N=368	n	Prevalence Rate (PR)
*If reported (a) pain/aching or stiffness or limited movement, and (b) absence of injury/accident to neck and (c) there is interference with either work at home or work on the job	88	23.9
Pain/aching or stiffness and (b)	163	44.3
(a) and (b)	185	50.3
(a) and (b) and interference with work at home	56	15.2
(a) and (b) and interference with work on the job	78	21.2
(a) and (b) and seek medical care	44	12.0
(a) and (b) and interrupt sleep	91	24.7

*Definition selected for this study.

4.3a Characterization of Neck Symptoms

Table 4.24 presents the results of neck symptoms characteristics. Of the 88 workers who reported neck symptoms according to the definition used in this study, 41.4% reported that these symptoms lasted more than 6 months while 37.9% had symptoms that lasted for less than one month. About three fourths (76.6%) of the participants with neck symptoms reported having experienced these symptoms during a certain task or activity at work. A substantial minority (42.7%) reported that they took medicine or pain relievers for this problem, and 42.9% sought medical care for this problem. Interference with work on the job was reported by the majority of participants meeting criteria for neck symptoms (94.3%), while 67.7% reported its interference with work at home. Interruption of sleep due to the neck problem was reported by 62.4% of the workers with neck symptoms.

Table 4.24 Frequency distribution of the symptom characteristics for workers with neck symptoms (n=88)

Neck	n	%
How long did symptoms last (n=88)		
<1 month	33	37.9
1-3 months	12	14.0
4-6 months	3	3.5
>6 months	36	41.4
Experience symptoms during a certain task/activity at work	67	76.6
Experience symptoms during a certain task/activity at home	16	18.6
Take any medicine or pain relievers for this problem	38	42.7
Seek medical care	38	42.9
Interfere with work at home	60	67.7
Interfere with work on the job	83	94.3
Interrupt sleep	55	62.4

Table 4.25 presents the result of items in the disability scale for those with neck symptoms. The disability scale in this study was used to characterize the extent of the neck symptoms reported. Out of those reporting neck symptoms, 55.8% had interference with managing daily activities, and a similar percentage reported interference with ability to concentrate. A substantial number of workers with neck symptoms reported interference with participating in usual leisure time activities (64.6%) and being bothered by headaches during the time they had neck pain (67.5%).

Table 4.25 Neck disability scale items for those with neck symptoms (n=88)

Item	n	%
Managing your daily activities?	49	55.8
Putting on your clothes in the morning?	35	39.8
Brushing your teeth without getting neck pain?	18	20.5
Lifting objects weighting 5-10 kilogram?	31	35.2
Reducing your reading activity?	26	29.5
Reducing your ability to concentrate?	42	47.7
Participating in your usual leisure time activities?	57	64.6
Influencing your emotional relationship with your closest family members?	29	33.0
Staying away from other people during the past 2 weeks?	1	1.1
Have you been bothered by headaches during the time that you have had neck pain?	59	67.5
Do you feel that neck pain will influence your future?	40	45.5

In Table 4.26, The values of all the 11 items of the disability scale were summed and their median (equal to 4) was used to distinguish the less disabled group (disability score ≦ median) from the more disabled group (disability score > median). Table 4.26 showed according to this definition, 55.7% of the workers with neck symptoms had less disabling pain, and 44.3% had a more disabling type of neck symptoms .

Table 4.26 Frequency distribution of those with neck symptoms by degree of disability (n=88)

Disability	n	%
Less Disabled	49	55.7
More Disabled	39	44.3

Table 4.27 presents the result when the less and more disabled groups with neck symptoms were compared by the work-related psychosocial and physical factors, no significant associations were found. The distribution of the less and more disabled groups appeared to be

similar between the low versus the high groups for each of the work-related psychosocial variables of decision latitude, social support, psychological demands, and physical demands.

Table 4.27 Characteristics of less and more disabled groups with neck symptoms by work-related psychosocial and physical variables

Variable	Less Disabled N	Less Disabled %	More Disabled N	More Disabled %	X2 Statistic	p-value
Decision Latitude						
Low	21	53.8	18	46.2	0.096	0.756
High	28	57.1	21	42.9		
Social Support						
Low	20	54.1	17	45.9	0.069	0.793
High	29	56.9	22	43.1		
Psychological Demands						
Low	25	59.5	17	40.5	0.481	0.488
High	24	52.2	22	47.8		
Physical Demands						
Low	21	60.6	13	39.4	0.831	0.362
High	28	51.9	26	48.1		

4.4 Bivariate Analyses

4.4a Associations between Dependent and Independent Variables

Bivariate associations of each possible determinant with presence or absence of neck symptoms were tested using chi-square for categorical independent variables, and Student's t-test for continuous variables. Crude odds ratios (OR) and their 95% confidence interval (CI) were calculated.

Table 4.28 shows that factors that were considered in this study as potential determinants of neck symptoms did not yield any significant differences between those with and without neck symptoms, and these include whether there were children under 6 years of age living at home and whether the worker provided care to an aged or disabled relative. These results were possibly affected by small numbers.

Table 4.28 Characteristics of semiconductor manufacturing workers with and without neck symptoms by physical variables

Variable	With Neck Symptoms N	With Neck Symptoms %	Without Neck Symptoms N	Without Neck Symptoms %	X2 Statistic	p-value
Children < 6 years						
Yes	21	23.1	70	76.9	0.046	0.320
No	67	24.2	210	75.8		
Provide care to aged or disables relative						
Yes	17	23.3	56	76.7	0.02	0.886
No	71	23.9	224	76.1		

Table 4.29 shows cross-tabulations of potential associations between health variables and neck symptoms were performed, and several showed significant results. Current smoking was marginally associated with neck symptoms (p=0.05). A highly statistically significant association was found between neck symptoms and self-reported physician diagnosed back disorder of the muscles, nerves or discs (p<0.001) and with tendonitis (p<0.001). Other self-reported physician diagnosed health variables that were found to be significant were arthritis of an unknown type (p=0.01), arthritis of the neck (p=0.01), ruptured disc or pinched nerve in the neck (p=0.04), bursitis (p=0.02), and tennis elbow (p<0.01). The experience of a major change in social life over the previous 12 months, such as getting married or divorced or having a close family member or

friend become ill or leave home, showed a significant association with neck symptoms (p=0.05).

Table 4.29 Characteristics of semiconductor manufacturing workers with and without neck symptoms by health variables

Variable	% with Neck Symptoms	% without Neck Symptoms	X2 Statistic	p-value
Current smoker Yes	24.4	75.6	0.008	0.929
Arthritis (unknown type) Yes	33.3	66.7	3.496	0.061
Back disorder of the muscles, nerves or discs Yes	44.4	55.6	31.378	<0.001
Tendonitis Yes	40.6	59.4	12.965	<0.001
Bursitis Yes	40.6	59.4	5.380	0.020
Arthritis of neck or Ruptured disc/pinched nerve in the neck Yes	41.2	58.8	6.136	0.013
Stressful life event over the last year Yes	27.7	72.3	0.416	0.519

Possible associations between neck symptoms and other individual and physical factors were examined to see if there were any significant differences between the groups. These are presented in Table 4.30, which shows that the mean age and BMI in the two groups were very similar. On average, workers with neck symptoms had been working at the plant slightly longer than those without symptoms (3.4 versus 2.8 years) but the time spent on the primary job operation was almost equal between the groups. These results were not significant.

Table 4.30 Characteristics of semiconductor manufacturing workers with and without neck symptoms by individual variables

Variable	With Neck Symptoms		Without Neck Symptoms		T Test	p-value
	N	Mean (SD)	N	Mean (SD)	Statistic	
Age	88	30.9 (17.7)	277	28.1 (22.7)	-0.139	0.881
BMI (kg/m2)	88	24.6 (6.6)	279	24.0 (15.4)	0.196	0.843
Length of employment	88	4.5 (3.1)	280	4.2 (3.9)	-0.365	0.669
Time on primary job operation (years)	88	3.4 (2.0)	280	2.8 (2.5)	-0.239	0.767

Income was significantly associated with the occurrence of neck symptoms. Workers with income levels exceeding 20,000 dollars had greater odds of reporting neck symptoms than those with income levels less than or equal to this amount (OR=3.49; CI=1.63-9.58).

The work-related psychosocial factors were first examined as continuous variables and comparisons of their means between the groups were carried out as can be seen in Table 4.31. Neck symptoms were significantly associated with psychological demand. On average, those with neck symptoms perceived slightly higher demands than those without symptoms. Another factor that showed significant differences between the groups was the physical demands variable with its physical isometric loads component showing a highly significant association with neck symptoms. Those with neck symptoms had a higher mean score on physical demands compared to those without. For physical exertion, the difference was less strong(105), but in the expected direction. In the final analyses, the physical isometric loads variable was chosen and was examined separately. There were no significant differences for the decision latitude variable with neck symptoms. Similarly, the mean scores for both coworker and supervisor social support were not significantly different in the two groups.

Table 4.31 Characteristics of the work-related psychosocial variables for workers with neck symptoms and without neck symptoms

Work-related Psychosocial Variable	With Neck Symptoms N	With Neck Symptoms Mean (SD)	Without Neck Symptoms N	Without Neck Symptoms Mean (SD)	T Test Statistic	p-value
Total Decision Latitude	88	23.2 (3.4)	285	22.6 (3.8)	-1.271	0.210
Skill Discretion	88	15.5 (3.0)	285	14.9 (2.5)	-0.893	0.349
Decision Authority	88	7.2 (1.8)	285	6.9 (1.3)	-1.478	0.218
Total Social Support	87	22.0 (4.2)	281	22.5 (3.4)	1.279	0.303
Coworker Support	88	11.3 (2.5)	283	11.6 (2.0)	0.826	0.375
Supervisor Support	87	10.1 (2.8)	283	10.5 (2.4)	1.167	0.294
Total Psychological Job Demands	88	25.3 (2.3)	285	24.4 (2.1)	-2.412	0.020
Total Physical Demands	88	13.5 (2.9)	285	11.9 (2.8)	-3.365	0.002
Physical Isometric Loads	88	5.6 (2.1)	285	4.6 (1.5)	-3.738	0.001
Physical Exertion	88	7.9 (2.0)	285	7.2 (2.8)	-1.802	0.080

The work-related psychosocial variables were then categorized into low and high levels according to whether they were less than or equal to the median or fell above the median (Table 4.32). The odds ratio for each variable with neck symptoms was also calculated along with its 95% confidence limits. According to Table 4.32, psychological and physical demands showed significant associations. The odds of neck symptoms were greater among those with high psychological demands (OR=1.95; CI=1.06-3.44), and the odds were also greater in the high physical demands group (OR=2.06; CI=1.05-3.52). Although no significant differences were found for the other variables, the distribution of WMD symptoms of neck symptoms between low and high levels of these variables did not represent the expected trend in the case of the decision latitude variable. Among workers in the low decision latitude group, 21.7% had neck symptoms compared to 28.6% in the high decision latitude group. We had expected to find a higher reporting of WMD symptoms of neck symptoms among the low decision latitude group.

Table 4.32 Characteristics of semiconductor manufacturing workers with and without neck symptoms by work-related psychosocial variables, including ORs (95%CI)

Variable	With Neck Symptoms		Without Neck Symptoms		OR	95 CI
	N	%	N	%		
Total Decision Latitude						
Low	34	21.7	134	79.3	0.65	0.40-1.02
high	54	28.6	146	71.4	1.00	
Total Social Support						
Low	32	20.0	128	80.0	0.84	0.51-1.48
high	55	26.4	153	73.6	1.00	
Coworker Support						
Low	35	24.5	108	75.5	1.17	0.72-1.97
high	53	23.6	172	76.4	1.00	
Supervisor Support						
Low	32	23.2	106	76.8	1.19	0.67-1.88
high	55	23.7	177	76.3	1.00	
Total Psycho. Demands						
Low	29	16.6	146	83.4	1.00	1.10-3.24
high	59	29.8	139	70.2	2.06	
Total Physical Demands						
Low	28	15.6	151	84.4	1.00	1.05-3.52
high	60	30.9	134	69.1	2.12	
Physical Exertion						
Low	31	18.5	137	81.5	1.00	0.91-2.63
high	57	27.8	148	72.2	1.37	
Physical Isometric Loads						
Low	31	17.6	145	82.4	1.00	1.00-3.08
high	57	28.9	140	71.1	1.77	

The percentage of workers with neck symptoms was then looked at according to the 3 primary work-related psychosocial variables: psychological demands, worker control and social support (Table 4.33). First, this figure shows that the workers were distributed across all 8 groups formed by the combination of the high and low levels of these variables. It was hypothesized that the group with high demands, low control and low social support (high strain group) would have the highest prevalence of symptoms. Similarly, it was expected that the low strain group (low demands, high control and high social support) would have the lowest prevalence. Contrary to this expectation, neck symptoms were experienced by 18.8% of those in the high strain group and by 22.4% of those in the lowest strain group. The highest percentage (44.2%) was found among those with low social support, high decision latitude and high psychological demands. The decision latitude variable in this study did not conform to the expectation.

Table 4.33 Proportion of neck symptoms by psychological demands, decision latitude and social support

				Psychological Demands			
				Low		High	
				x/n	%	x/n	%
Social Support	Low	Decision Latitude	Low	10/71	14.1	9/48	18.8
			High	8/44	18.2	23/52	44.2
	High		Low	9/39	23.1	7/30	23.3
			High	11/49	22.4	11/35	31.4

The percentage of workers with and without neck symptoms was also assessed by working position, posture, body movements and potential for social interaction, all of which were assessed by the observational checklist (Table 4.34). Except for the working position, sitting versus standing, the rest of the variables were not significantly associated with neck symptoms. Those working in a seated position during their primary job operation had more neck symptoms, and the association was significant (p=0.027). Unexpectedly, neck symptom reporting was higher among those with neck flexion less than 20 degrees, and with forward arm reach less than 10 times per minute. However, forward lean by 20 degrees or more had higher neck symptom reporting (32.4% versus 24.7%). Workers whose workstations were judged to be adequate had a higher percentage of neck symptoms, and workers who were found to have the possibility for social interaction while working had a lower reporting of neck symptoms. It is important to keep in mind that these observations were few in number that in the case of lifting, for example, there were no workers with neck symptoms who had lifted more than 5 kilograms.

Table 4.34 Characteristics of semiconductor manufacturing workers with and without neck symptoms by variables from observations

Variable	With Neck Symptoms		Without Neck Symptoms		X2 Statistic	p-value
	N	%	N	%		
Working position						
Sitting	45	26.2	87	73.8	6.882	0.009
Standing	43	21.2	160	78.8		
Neck flexion						
≧20°	58	22.8	196	77.2	6.396	0.011
<20°	30	37.0	51	63.0		
Lifting						
>5 kilograms	12	20.7	46	79.3	1.127	0.288
≦5 kilograms	76	27.4	201	72.6		
Forward arm reach						
≧10 times per minute	11	18.6	48	81.4	2.149	0.143
<10 times per minute	77	27.9	199	72.1		
Lean forward						
≧20°	22	32.4	46	67.6	3.266	0.202
<20°	66	24.7	201	75.3		
Adequate height of work surface						
Yes	44	33.1	89	66.9	9.625	0.021
No	44	21.8	158	78.2		
Potential for social interaction						
Yes	13	21.0	49	79.0	0.355	0.293
No	75	27.5	198	72.5		

4.4b Associations between Independent Variables

Income was associated with the level of decision latitude. Among workers with income above 20,000 dollars, more than half perceived that they had high decision latitude (p=0.05).

Pearson correlation coefficients were also calculated for the work-related psychosocial factors of total decision latitude, total psychological demands, and total social support as shown in Table 4.35. Social support was positively correlated with decision latitude and negatively correlated with psychological demands. In addition, psychological demands were correlated with decision latitude.

Table 4.35 Pearson correlation coefficients for work-related psychosocial variables

Variable	Total Decision Latitude	Total Psychological Demands	Total Social Support
Total Decision Latitude	1.00	0.241 *** (p < 0.001)	0.182 ** (p = 0.003)
Total Psychological Demands		1.00	-0.216 ** (p = 0.001)
Total Social Support			1.00

** p-value < 0.01
*** p-value < 0.001

The Spearman's correlation coefficients for nominal individual and health variables are shown in Table 4.36. Education was negatively correlated with arthritis.

Table 4.36 Spearman's rho correlation coefficients for selected nominal variables

Variable	Income (≦20,000 vs > 20,000 dollars)	Education (< high school vs ≧ high school)	Arthritis of neck (yes vs no)
Income (≦20,000 vs > 20,000 dollars)	1.00	0.065	0.092
Education (< high school vs ≧ high school)		1.00	-0.159 * (p = 0.012)
Arthritis of neck (yes vs no)			1.00

* p-value < 0.05
** p-value < 0.01
*** p-value < 0.001

4.5 Multivariate Analyses

4.5a Selecting the Variables

The variables that were considered for inclusion in the logistic regression analyses were chosen in the following manner. Some were selected a priori due to the hypotheses of the study, and examples of these include the primary work-related psychosocial factors of psychological demands, decision latitude and social support, as well as potential confounders. Another factor for inclusion was related to whether the variables were found to be significant in bivariate analyses. A brief description of these variables follows.

All three work-related psychosocial variables, (psychological demands, decision latitude, and social support) were included since these were the primary independent variables for this study, although only psychological demands showed significance in bivariate analyses (p=0.02). One component of the physical demands variable, the physical isometric loads, was selected for further inclusion in the logistic regression model, since bivariate analyses revealed its significance with neck symptoms (p=0.05).

Income was found to be significant in bivariate analyses (p=0.01). This was assessed as a dichotomous variable in the regression model: those with income less than or equal to 20,000 dollars and those with income greater than 20, 000 dollars.

Smoking was selected based on a priori interest in its association with neck symptoms. Bivariate analyses showed marginal significance with a p-value equal to 0.056. Smoking status was based on current smoking versus non- and ex-smokers.

Two non-work-related variables that were of interest to this study were having children less than 6 years old and providing care for aged or a disabled relative. Although not significant in bivariate analyses, yet due to the physical and psychosocial demands associated with these activities, they were therefore considered potential confounders for multiple logistic regression models.

Other variables, which were significant in bivariate analyses included history of arthritis, and experience of a stressful life event over the last year and were considered as potential confounders.

4.5b Main Effects Model

For the initial analyses, the main effects, which constitute the psychological demands, decision latitude, and social support, were entered into a logistic regression model without including any potential confounders. The outcome variable was presence or absence of neck symptoms. Table 4.37 shows the results of this analysis. Only for the psychological demands variable, the odds ratio was elevated (OR=1.91; CI=1.06-3.53). The decision latitude and social support variables did not show the expected pattern.

Table 4.37 Main effects multiple logistic regression model of neck symptoms

Variable	β	OR	95% CI
Psychological Demands (high demands)	0.64	1.91	1.06-3.53
Decision Latitude (low latitude)	-0.53	0.71	0.37-1.08
Social Support (low support)	-0.21	0.88	0.39-1.62

4.5c Assessing Interaction

Prior to including any potential confounding variables, interaction between the different work-related psychosocial variables was assessed. Two-way and three-way interaction terms were entered, each into a separate basic main effects model. Results of the terms, decision latitude x psychological demands, decision latitude x social support, psychological demands x social support, and decision latitude x psychological demands x social support, are presented in Tables 4.36-4.39. None of the interaction terms showed significance and were not included in further analyses. However, it was interesting to find that unlike the significant associations found for the psychological demands variable in all the models, as can be seen by Table 4.40, psychological demands lost significance when the psychological demands x social support interaction term was introduced into the model. It is worth noting that other than the significance of the main effect, the effects of interaction terms, when introduced into the model, were observed in interpretation. And when all the two-way and three-way interaction terms were introduced into the model, psychological demands remained significant.

Table 4.38 Main effects multiple logistic regression model of neck symptoms and the decision latitude x psychological demands interaction term

Variable	β	OR	95% CI
Psychological Demands (high demands)	0.90	2.38	1.08-5.36
Decision Latitude (low latitude)	-0.19	0.77	0.30-2.03
Social Support (low support)	-0.16	0.80	0.51-1.62
Decision Latitude x Psychological Demands	-0.53	0.70	0.23-1.97

Table 4.39 Main effects multiple logistic regression model of neck symptoms and the decision latitude x social support interaction term

Variable	β	OR	95% CI
Psychological Demands (high demands)	0.71	2.03	1.13-3.62
Decision Latitude (low latitude)	0.06	0.98	0.37-2.58
Social Support (low support)	0.22	1.07	0.48-2.55
Decision Latitude x Social Support	-0.79	0.54	0.16-1.51

Table 4.40 Main effects multiple logistic regression model of neck symptoms and the psychological demands x social support interaction term

Variable	β	OR	95% CI
Psychological Demands (high demands)	0.38	1.52	0.64-3.60
Decision Latitude (low latitude)	-0.47	0.58	0.41-1.23
Social Support (low support)	-0.43	0.65	0.32-1.49
Psychological Demands x Social Support	0.53	1.69	0.55-5.87

Table 4.41 Main effects multiple logistic regression model of neck symptoms and the decision latitude x psychological demands x social support interaction term

Variable	β	OR	95% CI
Psychological Demands (high demands)	0.83	2.25	1.18-4.57
Decision Latitude (low latitude)	-0.24	0.81	0.42-1.52
Social Support (low support)	-0.08	0.89	0.48-1.75
Decision Latitude x Psychological Demands	-0.24	0.73	0.31-1.66
Decision Latitude x Social Support	-0.28	0.62	0.39-1.45
Psychological Demand x Social Support	0.36	2.08	0.61-3.38
Decision Latitude x Psychological Demands x Social Support	-0.59	0.56	0.21-1.84

4.5d Assessing confounders

The next step included looking at potential confounders. When potential confounders were entered into the model, some variables that had been significant in the bivariate analyses lost significance in the presence of the other variables. These included: experiencing a stressful life event over the last year, and having children less than 6 years old, providing care for aged or a disabled relative and having had arthritis. Therefore, these were ultimately removed from the final logistic regression model. Although income can serve as a function of the psychosocial work conditions, the threat of over-controlling may become inevitable and part of the study limitation. However, income was such a common and important variable when discussing health impacts of psychosocial factors, it was kept in the model for further observation and comparison. Table 4.42 presents the model including all potential confounders.

Table 4.42 Multiple logistic regression model of neck symptoms including potential confounders

Variable	β	OR	95% CI
Psychological Demands (high demands)	0.33	1.41	0.31-1.35
Decision Latitude (low latitude)	-0.45	0.61	0.30-1.40
Social Support (low support)	-0.33	0.66	0.28-1.51
Physical Isometric Load (high load)	0.63	1.90	0.86-4.27
Smoking (current smokers)	0.59	1.85	0.81-3.97
Income (>20,000)	1.44	4.36	1.17-9.76
Stressful life event over the last year	0.28	1.33	0.64-2.85
Arthritis	0.48	1.59	0.68-3.69

4.5e Final Multiple Logistic Regression Model

The following variables were included in the model with neck symptoms as the dependent variable. All were categorical variables, and the reference group for each is marked with "*."

- Psychological demands (high versus *low)
- Physical isometric loads (high versus *low)
- Decision latitude (high versus *low)
- Social support (*high versus low)
- Smoking (current smoker versus *non- or ex-smoker)
- Income (*≦20,000 versus > 20,000 dollars)

All the work-related psychosocial factors were kept in the model even though bivariate analysis did not show any significance between social support and decision latitude with neck symptoms. Nonetheless, they remain important variables to include and were chosen a priori. The other variables were considered as potential confounders or modifiers.

Table 4.43 shows that the odds ratio for high versus low psychological demands was elevated (OR=1.52; CI=0.58-3.43) but the confidence interval included unity. For the decision latitude and social support variables, the odds ratios were less than one, an association that is not expected but that was previously seen in the bivariate analyses. The confidence intervals for their odds ratios also included unity. The odds ratio for the high versus low physical isometric load was elevated and statistically significant (OR=2.07; CI=1.03-4.66). Current smoking was only marginally associated with neck symptoms. A household income more than 20,000 dollars was also significantly associated with neck symptoms. The odds of neck symptoms was almost 5 times greater for those with higher income compared to those with income of less than 20,000 dollars.

Table 4.43 Final multiple logistic regression model of neck symptoms

Variable	β	OR	95% CI
Psychological Demands (high demands)	0.37	1.52	0.58-3.43
Decision Latitude (low latitude)	-0.46	0.60	0.31-1.29
Social Support (low support)	-0.43	0.66	0.27-1.39
Physical Isometric Load (high load)	0.84	2.07	1.03-4.66
Smoking (current smokers)	0.64	1.94	0.88-4.21
Income (>20,000)	1.52	4.67	1.27-12.58

The final model shows that there are important factors that need to be controlled for when examining the association between the work-related psychosocial factors and neck symptoms. Throughout the analyses, both of the decision latitude and social support variables did not conform to the expected patterns. On the other hand, psychological demands showed an increased crude odds ratio with neck symptoms as expected; however, the significance disappeared in the final multiple logistic regression model.

CHAPTER 5

DISCUSSION

5.1 OVERVIEW

This study was cross-sectional in design and was performed on a group of female workers in a semiconductor manufacturing plant in the industrial Park, Hsin-Chu, Taiwan. The characteristics of this population were similar to those of population in other studies on female semiconductor manufacturing workers in Taiwan(119). The average age of the workers in this study was 28.4 years and were with a mean BMI of 24.0 kg/㎡. More than three quarters of the workers had an annual household income level above 20,000 US dollars. Their work history revealed that the average length of employment was 4.3 years with about 3.2 years spent doing the primary job operation. The typical working week for the workers was a 40-hour week.

The participation rate of this study reached high (86.5%), which contributes minimizing biases that may be caused by volunteer participation. Although all the workers at the plant were invited to participate, willingness to do so was voluntary and confidential. The original sample of participants included the few men at the plant; however, due to their small numbers (only 18 men were present), they were excluded from the analyses. Therefore, controlling for gender was achieved by restricting the population to women only, which is one of several methods to control for confounding (116). The final sample of the population in this study was 373 female workers.

This study collected data on the workers through a self-administered questionnaire and direct observations on workers while doing their primary job operation. Only those workers who returned a completed questionnaire were invited to participate in the observational phase of the study. The total number of workers who agreed to be observed was 335.

5.2 DISCUSSIONS

5.2a Discussion of the Specific Aims

The first goal of the study was to determine the prevalence of neck symptoms in the semiconductor manufacturing worker population. The definition of neck symptoms in our study was based on the following criteria during the previous year: a. the presence of reported pain, aching, stiffness or limited movement, and b. the absence of injury or accident to neck and c. an interference with either work at home or work on the job. The prevalence rate of neck symptoms in this study was 23.9 per 100 workers. This definition of neck symptoms included a third part of measurement about functional assessment when inquired work interference at home or on the job. If we stick to only the first 2 criteria in the definition, the prevalence rate in this study would have been 50.3 %. However, by incorporating the criteria on interference with work at home or on the job, minor forms of neck symptoms are eliminated.

A study on garment workers by Schill (120) used a different case definition for musculoskeletal symptoms with the following criteria during the previous year: subjective symptoms of pain, aching, numbness, tingling, stiffness, cramping, weakness, or burning; and there was no evidence of an acute traumatic event that was associated with the symptoms; and the symptoms have interfered with activities of daily living or sleep; and there was evidence of work-relatedness for the symptoms. According to that definition, the prevalence rate of neck symptoms was 19.8 per 100 workers. While this rate is very close to what was found in our study, and with its inclusion of a functional status criterion, the measures are somewhat comparable. However, one of the objectives of our study was to improve on the existing definition for the neck symptoms in an attempt to provide a more relevant case definition tailored to the neck in particular. Instead of assessing disorders of different sites by a single measurement, this study asked about the presence of symptoms that mostly pertain to the neck, such as aching, pain, and stiffness versus numbness and tingling for example which are more typical of nerve entrapment disorders.

To further characterize the nature and extent of the neck symptoms reported, the results in the disability scale showed that among the 88 workers with reported neck symptoms, about half said that this problem interfered with their ability to concentrate and with managing their daily activities. More than half reported that their participation in their usual leisure time activities was affected. Over one-third of the workers with neck symptoms reported that these symptoms influenced their emotional relationship with their closest family members.

For the duration of the neck symptoms, most workers reported having these symptoms for less than a month (37.9%) or more than 6 months (41.4%) and only a few reported symptoms that lasted between these periods. It is worthwhile to point out that the reporting of neck symptoms in this study may have been underestimated due to the individual worker's perception of what degree of discomfort defines symptoms. In such a demanding work environment, workers may regard the presence of neck symptoms as part of a normal daily work routine. In addition, the healthy worker effect (HWE) (116) may have played a role in the reported prevalence of neck symptoms in this population. If those workers with more severe neck symptoms have already left their jobs, then this study will miss these cases and underestimate the prevalence.

The second aim of this study was to assess the work-related psychosocial factors. This was carried out by the self-administered questionnaire including a section of Karasek's job content questionnaire (JCQ) (121). Psychological job demands, decision latitude and social support were assessed as the 3 primary work-related psychosocial factors. This study also examined at the interaction of these 3 factors to provide a more comprehensive understanding of their relationship with neck symptoms. The distribution of these factors was wide among the workers, ranging from low levels to high levels of decision latitude, psychological demand and social support as perceived by the workers.

The mean value for each of these work-related psychosocial variables was similar to that reported in the study of garment workers by Schill (120) except that for the decision latitude variable. Our study had a slightly higher mean value (21.6 versus 20.8). The work-related psychosocial variables were then grouped in to low and high categories according to whether they fell below or above the median value of each factor. When each of these variables was looked at according to different characteristics of the workers, including personal, work-related, and non-work-related factors, a few associations were found. Namely, the decision latitude variable was positively associated with higher income. More reflection on this finding is discussed in the hypotheses section.

The third aim of the study was to determine the association between work-related psychosocial factors and the occurrence of neck symptoms. When neck symptoms were examined by the decision latitude variable, the opposite of what was expected was observed. This study showed a higher neck symptom reporting among those who were in the high decision latitude group. The p-value for chi-square approached significance (p=0.09). This unexpected finding will be explored in the section 5.2b in this chapter of discussion and possible reasons will be offered. No significant associations were found for the social support variable. A significant association was found between psychological demands and neck symptoms. Reported neck symptoms were higher in the high demands group compared to that present in the low demands group (29.8% versus 16.6%；p=0.03). Another variable examined in relation to neck symptoms was the physical demands factor of the JCQ. A significant association was found with one of its two components, the physical isometric loads (p=0.04). The physical exertion item under the total physical demands was not related to the occurrence of neck symptoms. This sheds some light on the importance of certain factors in the study of disorders of the neck. For this reason, this study did not use the total physical demands variable, but only included the physical isometric load in the final model as a potential determinant of neck symptoms. Thus, studies that have typically included all the work-related psychosocial factors in studying a combination of disorders of different sites, may only be obtaining a general picture of the situation. Certain components may emerge as important predictors for some disorders while not for others. It is important to distinguish these factors and aim at identifying them.

Testing the demand-control-support model of job strain on the occurrence of neck symptoms was another aim of this study. As mentioned previously, the model is expected to illustrate an increase in symptoms among high strain workers (high psychological demands, low decision latitude, low social support) as compared to low strain workers (low psychological demands, high worker decision latitude, high social support). A matrix formed by the combination of the different levels of these 3 factors was shown in the “Results” section (Table

4.32). The expected finding did not result according to this figure. On the contrary, high strain individuals had a lower reporting of neck symptoms than low strain individuals (18.8% vs. 22.4%, respectively). This may be explained by the role of the decision latitude variable. Unlike the expected effect of the decision latitude variable according to Karasek's model, the relationship found in this study implied that workers with high decision latitude had more neck symptoms. Possible explanations to this lack of expected result are offered in the discussion of hypotheses' section that follows.

The final aim of the study was to perform observational analyses of individual workers' jobs to characterize ergonomic exposures. These observations included looking at those exposures that pertain to the neck region. Supplementing the questionnaire with an observational assessment provides a better assessment of the neck symptoms by adding more information on the posture of the worker that would otherwise missed by using the questionnaire alone. The observations were carried out by 2 observers using a checklist to assess physical exposures that the workers experienced on their primary job operation. Overall, the inter-rater percent agreement was fairly high for the primary physical factors including neck flexion (87.5%) and forward arm reach (81.3%). Respective Kappa values were 0.41 and 0.63.

The observational checklist was also used to assess potential for social interaction among the workers, and this item also had a good inter-rater agreement (81.8%). This item was included in the checklist to allow for comparisons to be made between those who were found to have opportunities for social interaction and those who did not with respect to the occurrence of neck symptoms. It was thought that assessing the potential for social interaction would provide a psychosocial description of the work environment of the worker. No associations, however, were found between social interaction and neck symptoms. This may easily be related to the crudeness of this measure. For example, although a worker may have been found to have the potential for interaction as defined by accessibility or possibility to interact with other workers while on the job, this does not necessarily mean that this interaction will be a positive one. Some workers may need to wait for others while they finish their work load, which in turn may raise frustration and tension between workers. In addition, though some workers may not be working in secluded areas and have potential to interact with fellow workers, no interaction may take place due to the nature of their work which involves prolonged and intense concentration periods. Therefore, this variable was not as useful as originally anticipated.

Overall, the variables measured by the observational checklist did not show any significant associations with the occurrence of neck symptoms with the exception of a seated versus a standing working position. Neck flexion was also assessed by the checklist since it has been listed among the physical factors that are important to consider in measuring posture (114). Forward head tilt is associated with aches in the neck muscles (126). While it was thought that a neck flexion, defined as a forward neck bent equal to or more than 20 degrees, would be associated with neck symptoms, such a finding did not result. One reason for this may be related to the crudeness of the observational methods employed. The observers relied on direct visual assessments, which are subjective and may involve errors in estimation. Also, since relatively small numbers of observations were perform, and these were carried out for only a short period of time, the assessment of the neck flexion of the worker may not be representative of her usual neck flexion during the entire working day. Perhaps workers with neck pain limited their movement on the job. In addition, only the primary job of the worker was assessed, and since many workers had multiple job operations, then the observations did not detect those exposures.

5.2b Discussion of the Hypotheses

The main study hypothesis stated that the occurrence of neck symptoms in WMDs would increase as psychological job demands increase, decision latitude decreases, and social support decreases.

As discussed earlier, this expected association was not found. Though psychological demands were significantly associated with neck symptoms, and results showed that workers with high demands, namely physical isometric loads, reported significantly more symptoms, the other variables did not yield consistent results. The decision latitude variable for example showed an inverse relationship to what was expected. Neck symptom reporting was higher among workers with high decision latitude. It is important to note, however, that decision latitude approached significance (p=0.06) in its association with income. Workers with income exceeding 20,000 dollars reported more decision latitude. This may indicate that income or factors associated with income might be playing a greater role in influencing the workers' perception of decision latitude and workers with more decision latitude get higher income. In addition, income was highly associated with neck symptoms (p=0.01). Workers with higher income levels were about 4 times more likely to report neck symptoms than those with lower income levels (OR=3.49; CI=1.63~9.58). This finding is consistent with what has been reported in the previous literature. An explanation was offered by Brisson and colleagues (127) stating that income or factors associated with income may encourage workers to remain on the job even though they may be experiencing discomfort.

According to Karasek's model, the interaction term between decision latitude and psychological demands should have been more predictive than the additive effects of high psychological demands and low decision latitude with respect to high strain outcomes (128). This was not the case in this study in which the interaction term was found to be non-significant and was eliminated from the final model. This is not entirely unique to this study, however, for other studies have also failed to replicate this interaction model (21). While many studies have replicated the main effects for the decision latitude variable, in this study the decision latitude effect was opposite in direction to what is described in the job strain model. Since the decision latitude variable, as measured by the job content questionnaire, assesses the perception of degree of decision authority and skill discretion, one possible explanation for this is that the measurement of decision latitude, especially in the perception of decision authority, may not show much variance in consideration of standardized manufacture work process among this specific working population.

Social support also was not significantly associated with neck symptoms. Although the observed range of values for the social support variable was diverse, low values were not observed in this population, and implied less variation, which may explain the lack of a finding. Since both the decision latitude and social support were not significantly associated with neck symptoms and only psychological demands were shown to be significantly associated with neck symptoms, there is only limited support for the Karasek model in this setting.

Secondary hypotheses stated that in addition to work-related psychosocial factors, a model including physical exposure variables such as home and family duties, such as caring for children, aged or disabled relatives would better explain the relationship between psychosocial factors and the occurrence of neck symptoms. Other leisure time and lifestyle factors that are believed to be important in the occurrence of neck pain are also considered to be valuable to take into account. For neck pain in particular, physical factors outside the workplace need to be considered. It is important to distinguish between different disorders across various body sites.

Caring for children, or for an aged or disabled relative was believed to be important in the occurrence of neck symptoms, partly because of its potential effect of adding physical burden on the worker, introducing role conflict (51) and partly due to the added stress from this responsibility (129). No significant associations with neck symptom were found, however, in this study. One reason may be that the workers in this study may vary in perceiving the extent of their responsibilities. One other possibility, however, may be due to the quality of measurement and the varied values and definitions for “role” and “responsibility”. The shared responsibility for the children with partners, for example, may play a role, although the reasons for such a lack of relation remain to be explained.

Although the bivariate analyses revealed significant associations between several health and lifestyle factors and neck symptoms, the importance of these variables was diminished in the final logistic regression model while several other job task and demographic variables remained important predictors of these symptoms. Therefore, though there was a significant association between having had a stressful life even over the last year and neck symptoms, this did not remain in the final model. The final model included the following factors in relation to neck symptoms: psychological demands, physical isometric load, decision latitude, social support, current smoking, and income, Including these variables, this model only partly explained the occurrence of neck symptoms. For example, income, a surrogate indicator of socioeconomic status (SES), remained in the model while education which is also a measure of SES was not associated with neck symptoms in this study. Among the interesting findings of this study were that those workers with higher income levels (exceeding 20,000 dollars) reported more neck symptoms.

5.3 Limitations of the Demand-Control-Support Model

The job strain model provides an integrative conceptual framework that has been widely used across studies to assess job strain in different groups (52). However, there are inherent problems which may be present in Karasek's model particularly in considering decision latitude. Using the decision authority and the skill discretion components to assess decision latitude may not be measuring the workers' perception of their own sense of control. There are other factors that affect decision latitude beyond the involvement in these two components of work. For example, sense of security may influence how workers perceive their decision latitude. Those who feel secure, for example, may perceive a higher degree of decision latitude. This point also reveals that individual differences exist and the workers' perceptions of work-related psychosocial factors differ as shown by this study. Also, the incentives for working may vary with time as well.

In addition, this model has been used most extensively to assess strain among men. In our study restricted solely to female workers, the use of Karasek's model to measure their level of strain may be less relevant. Working women have typically had the added responsibility for children, aging and disabled relatives which may involve more stress and require more interruptions of employment. Therefore, these factors may need to be considered because of the poor measurement with low variation and not knowing the extent of responsibilities. Relying on the model by itself would not provide a good identification of the extent of the stress problem. Furthermore, the model may not have a similar predictive ability on this study population as when tested on men.

Another limitation in Karasek's model is that even if associations were found between the work-related psychosocial factors and neck symptoms, one cannot pinpoint which specific workplace stressors are involved (63). Another weakness of the Karasek model relates to its subjectivity in assessing strain levels. The statements used to assess the work-related psychosocial variables are subjective and may easily be interpreted differently by workers. The debate between subjective versus objective measurements has been discussed by Karasek, presenting arguments for both sides, although the need for objective measurements for exposure is more thoroughly discussed (130). Objective measures have the advantage of providing a clearer link to the "actual" environmental conditions, a clearer conceptualization of the etiological process, and a clearer separation of independent and dependent variables. Those in favor of subjective measures argue that there is substantial variation across individuals on the "meaning" of exposure, inability to manipulate the environment, and the subjective exposure makes clearer the etiological mechanism.

5.4 Uniqueness of the Study

This study provided additional information on the work-related physical and psychosocial factors with respect to neck disorders. More specifically, this study attempted to provide a more precise and comprehensive definition in assessing the outcome variable. Whereas previous studies have combined neck problems with that of the shoulder and/or back problems, this study looked separately at neck symptoms, including questions on intensity and severity. This allowed for a better understanding of the risk factors for the neck area.

Many studies on the work-related psychosocial factors and WMDs have failed to adequately control for physical exposures. This study, however, considered such factors as sitting/standing, and sedentary work. This is one of the first studies on neck symptoms in semiconductor manufacturing workers exploring variables related to home and family duties and other leisure time and lifestyle factors that are believed to be important in the occurrence of neck symptoms, such as caring for children, aged or disabled relatives.

Finally, this study included all three psychosocial factors of the Job Strain Model simultaneously, thus adding a more comprehensive analysis of these factors, while most research has considered only one or a few psychosocial factors in a single study. Thus, this research will help fill the gap surrounding the full understanding of these determinants in the work environment on the occurrence of neck symptoms in WMDs.

5.5 Limitations and Methodological Issues

Several limitations arise and are mainly the consequence of the nature of the study design. The cross-sectional design of the study does not allow causal inferences to be reached since no temporal sequence can be established between the exposure variables and the occurrence of neck symptoms. For example, the higher percentage of neck symptoms found among workers whose workstations were adjusted does not necessarily mean that this adjustment led to these symptoms. On the contrary, the presence of neck symptoms may have led to the workstation adjustment.

This study measured prevalence rates, which in turn may introduce a bias referred to as "prevalence bias." Since prevalence rates depend on incidence and duration of the disease, one cannot know whether the observed rates are due to factors related to incidence, duration, or both. Prevalence bias is maximized when the disease outcome used is an acute episode of epidemics with short duration of disease course since target cases may be cured and lost in the data collection time period. However, since the outcome in this study is neck symptoms in WMDs which is a persistent and nonfatal condition with no clear point of onset, prevalence rate can be used as an indicator to the extent of the illness among populations; while the prevalence bias are minimized.

Additionally, since only workers who are present at the time of the data collection were included in this study, the healthy worker effect (HWE) can play a role in the findings. The HWE may result if relatively healthy people are entering and remaining in the workplace. This may lead to a selection bias, particularly if the reasons for those workers leaving work are related to the exposure variable of interest (131). This will lead to underestimation of the risk of the outcome variable. This possible effect of selection bias could not be assessed in this study since no information was obtained on those workers who had left employment.

Another type of selection bias may exist. This is related to the participation of the subjects and may be present if the participants differed from non-participants on the exposure factor or outcome. Given the high participation rate of this study, it is unlikely that this type of bias exists.

Recall bias, a type of information bias, may exist whereby differential recall of past experience among participants may lead to misclassification (129). Since this study relied on the participants' self-reporting of different exposure and outcome variables, recall bias may exist.

Despite these limitations, a cross-sectional study is appropriate to the study of this kind of an outcome since WMDs are persistent, nonfatal conditions with no clear point of onset. The prevalence bias in particular will be minimized in such a case (116).

It is important to mention the use of the observational checklist to assess the posture of the neck. Neck posture is noted to be difficult to accurately assess (114). And since the direct visual observations performed in this study were not objective measures, the lack of finding of an association may be due to the crudeness and subjectivity of the measure. The assessment and training on the observers or coders are needed.

Another issue worth noting is the unique characteristics and homogeneity of this study population when evaluating the findings of this study. The study results thus may not be generalized to other semiconductor manufacturing workers under different working environments and possessing different characteristic. The perceived job strain and its health effects especially in WMDs may be different line workers, administrators and engineers. Still, the study finding offers valuable information on certain exposure factors that pertain to all workers, and the implications of the study provide additional views and approaches to the existing body of knowledge in this field.

5.6 Study Implications and Future Directions

The key implication in implementation of this doctoral research in the discipline of sociomedical sciences is the focused understanding and practice of the social determinants of disease and health and the social causes of public health events through correlation of the epidemiological trends (WMDs) and structural inequities (job strain).

One persistent limitation of a cross-sectional study is the inability to answer the following question: “Are the psychosocial problems perceived by some workers contributing to the symptoms, or are the symptoms experienced by some workers causing them to report these psychosocial problems? “ An alternative study design that will overcome this bias is a longitudinal study, which can better establish a temporal sequence between exposure and outcome. This study would provide an ideal cohort that could be used for a future follow-up longitudinal study, since this population of semiconductor manufacturing workers is a stable group who would be relatively easy to follow. From the perspective of social determinants among WMDs, the population would provide a chance to look at the trend of aging and inequities among gender roles in the Eastern Asian culture. Further investigations using prospective approaches are warranted.

One of the implications in this study is that for future studies on neck symptoms, factors outside the workplace need to be considered. To restrict the study to work-related factors only may preclude a full understanding of the problem since other factors may contribute to health effects as well (132).

Another factor pertains to the use of observational methods to assess physical exposures. More exact definitions of these factors and more emphasis on training of observers would help in improving the reliability and validity of the observations. Hence, more studies with quantitative measurements of physical exposures are needed. Despite difficulties related to conducting observations, these methods have an important place in studies of WMDs, especially when supplemented by other methods such as questionnaires as used in this study. Important information would be collected by this method, which would otherwise go undetected. For example, the layout of the workstation differed across the plant and the observations allowed for these variations to be noted. Even though the neck posture assessed in this study did not yield significant results with neck symptom reporting possibly for the reasons discussed earlier, the prolonged static neck posture commonly held by the workers indicates a need for minor modifications, which could be achieved through effective training of the workers, and/or slight adjustments to the workstation. Since poor posture has been reported to be associated with disability in older workers (133), simple ergonomic and administrative measures may make remarkable differences in the prevention of these symptoms.

Specifically for workplaces that involve multiple working positions such as existing at this plant whereby workers may be sitting, standing, or both, workstation adjustment or ergonomic redesign of the workplace may need to be considered. In addition to training and instruction of new workers, continuous follow-up is advisable. Also, educational sessions for prevention of musculoskeletal symptoms are supported and would be critical in spreading awareness and understanding among workers. Considering work organization, frequent rest pauses are advisable, and making use of the scheduled rest breaks is recommended. Future studies are needed to explore and evaluate the effectiveness of these recommendations. Workers' perception of their psychological demands, decision latitude and social support also has impact on the workers' well-being. While psychological demands are complex and often dictated by the economic factors in the market, decision latitude and social support may be the two variables that can be manipulated more. For example, involving workers in decisions related to the work process and matters related to the work environment would bring about a more positive atmosphere. To improve support both among the workers themselves, or between workers and supervisors can be achieved through sessions that address issues related to tension and stress at work and possible ways to address them and enhance tolerance.

This study provided only partial support to Karasek's model of job strain with psychological demands only showing an association with increased occurrence of neck symptoms. There seems to be the need to reevaluate the decision latitude variable as measured by the job content questionnaire. There may be a conceptual flaw inherent in the definition for decision latitude. According to Karasek's definition, decision latitude assesses the degree of agreement or disagreement with several statements on decision authority and skill discretion. The answers to these statements are often difficult to choose since they do not include measurements to allow for differences in the work process. For example, in certain periods during work workers may perceive to be in high decision latitude while at other times a feeling of low decision latitude may dominate the usual work process. Therefore, the inverse relationship between decision latitude and neck symptoms found in this study, i.e., workers who perceived their decision latitude to be high reported more neck symptoms, needs to be explored further by looking at different methods to assess decision latitude other than using Karasek's term. This measure of decision latitude may not be appropriate for all worker populations. While it may be useful on large national scale, it seems to be somewhat of limited use in smaller, homogeneous, worker populations. This relationship requires more study.

Despite the increased interest in the role of psychosocial factors with the occurrence of WMDs reflected in the escalating number of studies in recent years, there remains no consensus on the definitions of the exposure and outcome variables employed across these studies. Further studies should, nonetheless, investigate these factors and examine their interactions between work and non-work-related factors. More focus on devising objective measures to assess psychosocial factors is needed that would identify specific stressors. These will help better elucidate the extent of the problem in more concrete terms involving effective prevention and intervention mechanisms. Another recommendation for future research in this area is to attempt to be consistent with previous work in terms of the definitions used. There have already been numerous and varied definitions across studies that have precluded understanding and comparisons of the results to obtain a thorough knowledge in this area. Studies on the general population need to be carried out for comparisons.

Psychosocial factors need to be included in future studies, and assessed by both objective as well as subjective measures for the social contribution of WMDs. This will help in obtaining a better understanding of the psychosocial factors, which is needed to produce effective prevention strategies in practice. Knowledge of these factors should be used to develop guidelines for prevention of WMDs that are both feasible and acceptable.

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APPENDICES

Translated Questionnaire

SPARE TIME ACTIVITIES

These questions are about your hobbies and activities you do when you are not at work.

1. Which of the activities on this list do you do at least once a week in your spare time? (Circle all that apply.)

a. Sew
b. Knit/Crochet
c. Needlepoint
d. Play a sport with a racket. Which sports?____________________________
e. Play golf
f. Go bowling
g. Play a musical instrument. What instrument?________________________
h. Garden/Farming
i. Cooking
j. None of these

2. Please note other favorite activities you do at least every week___________

WORK HISTORY

This group of questions is about the work you do.

1. In which section of the plant are you working now? _____________
2. What is the exact name of your primary job operation? _____________
3. How long have you been doing this primary job operation? _____________
4. On average, how many hours do you work each week? _____________
5. How long have you worked for English American? _____________
6. What was your previous primary job operation? _____________
7. For how long did you work on this job operation? _____________

JOB TASKS

These statements are about your primary job operation. Your answers should be based on what you think about your job. Circle the answer that best matches your opinion.

1. I am often required to move or lift very heavy loads on my job	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
2. My work requires rapid and continuous physical activity.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
3. My job requires long periods of intense concentration on the task.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
4. I am often required to work for long periods with my body in physically awkward positions.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
5. I am required to work for long periods with my head or arms in physically awkward positions.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
6. Waiting on work from other people or sections often slows me down on my job.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
7. My tasks are often interrupted before they can be completed, requiring attention at a later time.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know

8. Has your workstation been adjusted?	Yes	No
If yes,	If no, go to question 9	
a. When was it adjusted?	How many years ago?	
b. What was adjusted?	______________________________	
c. Has this adjustment made your workstation more comfortable?	Yes	No
d. Has this adjustment made it easier to do your job more quickly?	Yes	No
e. Did this adjustment change your posture?	Yes	No

If yes, how? ______________________________

These questions are about the job operation you are doing now.

9. Do you take your morning break?	Yes	No
10. Do you take your launch break?	Yes	No
11. Do you take your afternoon break?	Yes	No

DESCRIPTION OF YOUR WORK

These questions relate to your work. These are no right or wrong answers.

1. The following statements are about your job. For each statement, circle the answer that most closely matches your feelings.

a. My job requires that I learn new things.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
b. My job involves a lot of repetitive work.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
c. My job requires me to be creative.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
d. My job allows me to make a lot decisions on my own.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
e. My job requires a high level of skill.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
f. On my job, I have very little freedom to decide how I do my work.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
g. I get to do a variety of different things on my job.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
h. I have a lot to say about what happens on my job.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
i. On my job, I have an opportunity to develop my own special abilities.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
j. My job requires working very fast.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
k. My job requires working very hard.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
l. My job requires lots of physical effort.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
m. I am not asked to do an excessive amount of work.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
n. I have enough time to get the job done.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
o. I am free from conflicting demands hat others make.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
p. My job is very hectic.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know

2. How many people do you work with closely?

1. I work alone	2. 2-5 people
3. 6-10 people	4. -11-20people
5. 21 or more people	

3. The next statements are about your supervisor. For each statement, circle the answer that most closely matches your feelings.

a. My supervisor is concerned about the welfare of those under her/him.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
b. My supervisor pays attention to what I am saying.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
c. My supervisor is helpful in getting the job done.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
d. My supervisor is successful in getting people to work together.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know

4. These statements are about the people you work with. Circle the answer that most closely matches your feelings.
5.

a. People I work with are competent in doing their jobs.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
b. People I work with take a personal interest in me.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
c. People I work with are friendly.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know
d. People I work with are helpful in getting the job done.	Strongly disagree	Disagree	Agree	Strongly agree	Don't know

BASIC HEALTH HISTORY

This section asks questions about your overall health.

1.Has a doctor ever told you that you have/had any of the following conditions?

a. Diabetes mellitus (sugar)	Yes	No
b. Thyroid problems	Yes	No
c. Kidney disease	Yes	No
d. Tuberculosis (TB)	Yes	No

e. Sarcoidosis	Yes	No	
f. Cancer	Yes	No	If yes, the___________
g. Arthritis – don't know type	Yes	No	
h. Rheumatoid arthritis	Yes	No	
i. Osteoarthritis	Yes	No	
j. Gout	Yes	No	
k. Hypertension (high blood pressure)	Yes	No	
l. Lupus	Yes	No	
m. Back disorder of the muscles, nerves of discs	Yes	No	
n. Carpal tunnel syndrome	Yes	No	If yes, the___________
o. Tendonitis	Yes	No	If yes, the___________
p. Trigger finger	Yes	No	If yes, the___________
q. Tennis elbow	Yes	No	If yes, the___________
r. Golfer's elbow	Yes	No	If yes, the___________
s. Bursitis	Yes	No	If yes, the___________
t. Rotator cuff tear of shoulder	Yes	No	If yes, the___________
u. Thoracic outlet syndrome	Yes	No	If yes, the___________
v. Ganglionic cyst (ganglion)	Yes	No	If yes, the___________
w. Ruptured disc or pinched nerve in the neck	Yes	No	
x. Raynaud's disease (white finger)	Yes	No	If yes, the___________
y. Arthritis of neck	Yes	No	

2. have you ever had surgery for any of these conditions? Yes No

If yes, for which problems?	Year of surgery

3. Did you ever break any of the bones in your:

Arms, hands, or wrists?	Yes	No	If yes, what did you break?_______Year______
Shoulder, neck, or back?	Yes	No	If yes, what did you break________Year______
Hips, legs ,or ankles?	Yes	No	If yes, what did you break?_______Year______

4. What medicine/pills do you take regularly?

5. Do you currently smoke cigarettes?	Yes No
If yes, how many cigarettes a day do you smoke? (1 pack = 20 cigarettes)	# cigarettes____
6. Are you a former smoker?	Yes No
7. Do you exercise and raise your heart rate for 20 minutes or more at least 3 times a week?	Yes No

8. I f you have arthritis, please check the joint that are affected:

a. Neck	□			
b. Lower back	□			
c. Upper back	□			
d. Wrists	Left	□	Right	□
e. Elbows	Left	□	Right	□
f. Shoulders	Left	□	Right	□
g. Hips	Left	□	Right	□
h. Knees	Left	□	Right	□
i. Ankles	Left	□	Right	□
j. Feet	Left	□	Right	□

9. Have you ever had low back pain?	Yes	□	No	□
If yes, did you have low back pain:				
a. More than one year ago	Yes	□	No	□
b. Within the last year	Yes	□	No	□

c. More than once in the last year	Yes □	No □
10. Have you ever had neck pain?	Yes □	No □
If yes, did you have neck pain:		
a. More than one year ago	Yes □	No □
b. Within the last year	Yes □	No □
c. More than once in the last year	Yes □	No □

11. The next few questions are for WOMEN only. Men should skip to next section, "Your Health".

a. Are you pregnant now?	Yes	No	
b. Are you going through menopause ("change of life") now?	Yes	No	
c. Have you passed menopause	Yes	No	
d. Have you had surgery to remove ovary?	Yes	No	If yes, year________
e. Are you taking birth control pills now?	Yes	No	
f. Are you taking hormone replacement pills now?	Yes	No	

YOUR HEALTH

In this part of the survey we are interested in learning about different aspects of your physical health. Please check your answers.

PART 1.

In this section, we are interested in learning if you have experienced any problems with your hands, wrists, fingers, or forearms during the last year.

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your hands, wrists, fingers, or forearms?	Yes □	No □
(2) Have you experienced any stiffness in your hands, wrists, fingers, or forearms?	Yes □	No □
(3) Have you experienced any weakness in your hands, wrists, fingers, or forearms?	Yes □	No □
(4) Have you experienced any numbness, tingling, or burning in your hands, wrists, fingers, or forearms?	Yes □	No □
(5) Have you experienced any limited movement in your hands,	Yes □	No □

wrists, fingers, or forearms?(Difficulty moving your hands, wrists, fingers, or forearms in all directions and to the extent that you think you should be able to)

If you answered NO to all of the previous questions about your *hands, wrists, fingers, or forearms*, please go to PART 2 below.If YES to any, continue here.

(6) Did you seek medical care for the problem with your hands, wrists, fingers, or forearms?	Yes □	No □
(7) Have you ever had an accident or sudden injury to your hands, wrists, fingers, or forearms, such as sports injury or fracture, that was not related to your work?	Yes □	No □
(8) Did this problem with your hands, wrists, fingers, or forearms interfere with your work at home?	Yes □	No □
(9) Did this problem with your hands, wrists, fingers, or forearms interfere with your work on the job?	Yes □	No □
(10) Did this problem with your hands, wrists, fingers, or forearms interrupt your sleep?	Yes □	No □

(11)On a scale from 1 to 5, how bothersome was the problem with your hands, wrists, fingers, or forearms?
(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

PART 2

In this section, we are interested in learning if you have experienced any problems with your elbows during the last year.

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your elbows?	Yes □	No □
(2) Have you experienced any stiffness in your elbows?	Yes □	No □
(3) Have you experienced any limited movement in your elbows? (Difficulty moving your elbows in all directions and to the extent that you think you should be able to)	Yes □	No □

If you answered NO to all of the previous questions about your *elbows*, please go to PART 3. If YES to any, continue here.

(4) Did you seek medical care for the problem you're your elbows?	Yes □	No □
(5) Have you ever had an accident or sudden injury to your elbows such as sports injury or fracture that was not related to your work?	Yes □	No □
(6) Did this problem with your elbows interfere with your work at home?	Yes □	No □
(7) Did this problem with your elbows interfere with your work on the	Yes □	No □

job?

(8) Did this problem with your elbows interrupt your sleep? Yes □ No □

(9)On a scale from 1 to 5, how bothersome was the problem with your elbows?

(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

PART 3

In this section, we are interested in learning if you have experienced any problems with your shoulder or upper arms during the last year.

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your shoulder or upper arms?	Yes □	No □
(2) Have you experienced any stiffness in your shoulder or upper arms?	Yes □	No □
(3) Have you experienced any weakness in your shoulder or upper arms?	Yes □	No □
(4) Have you experienced any limited movement in your shoulder or upper arms? (Difficulty moving your shoulder or upper arms in all directions and to the extent that you think you should be able to)	Yes □	No □

If you answered NO to all of the previous questions about your *elbows*, please go to PART 4.

If YES to any, continue here.

(5) Did you seek medical care for the problem with your shoulder or upper arms?	Yes □	No □
(6) Have you ever had an accident or sudden injury to your shoulder or upper arms, such as sports injury or fracture that was not related to your work?	Yes □	No □
(7) Did this problem with your shoulder or upper arms interfere with your work at home?	Yes □	No □
(8) Did this problem with your shoulder or upper arms interfere with your work on the job?	Yes □	No □
(9) Did this problem with your shoulder or upper arms interrupt	Yes □	No □

your sleep?

(10)On a scale from 1 to 5, how bothersome was the problem with your shoulder or upper arms?
(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

PART 4

In this section, we are interested in learning if you have experienced any problems with your neck during the last year.

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your neck? Yes □ No □

(2) Have you experienced any stiffness in your neck? Yes □ No □

(3) Have you experienced any limited movement in your neck?
(Difficulty moving your neck in all directions and to the extent that you think you should be able to) Yes □ No □

(4)If yes to any of above questions, for how long did you have these symptoms?
<1 month □ 1-3 months □ 4-6 months □ >6 months □

If you answered NO to all of the previous questions about your *neck*, please go to PART 5. If YES to any, continue here.

(5) Do you usually get these symptoms during a certain task/activity at work? Yes □ No □
If yes, describe this activity____

(6) Do you usually get these symptoms during a certain task/activity at home? Yes □ No □
If yes, describe this activity____

(7) Do you take any medicine or pain relievers for this problem? Yes □ No □
If yes, what did you take?____

(8) Did you seek medical care for the problem you're your neck? Yes □ No □

(9) Have you ever had an accident or sudden injury to your neck, such as sports injury or fracture that was not related to your work? Yes □ No □

(10) Did this problem with your neck interfere with your work at home? Yes □ No □

(11) Did this problem with your neck interfere with your work at home? Yes □ No □

(12) Did this problem with your neck interrupt your sleep? Yes □ No □

(13) On a scale from 1 to 5, how bothersome was the problem Yes □ No □

with your neck?

(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

(14) Did this problem with your neck interfere with:

a. Managing your daily activities?	Yes □	No □
b. Putting on your clothes in the morning?	Yes □	No □
c. Brushing your teeth without getting neck pain?	Yes □	No □
d. Lifting objects weighing 5-10 pounds?	Yes □	No □
e. Reducing your reading activity?	Yes □	No □
f. Reducing your ability to concentrate?	Yes □	No □
g. Participating in your usual leisure time activities?	Yes □	No □
h. Influencing your emotional relationship with your closest family members?	Yes □	No □
i. Staying away from other people during the past 2 weeks?	Yes □	No □
(15) Have you been bothered by headaches during the time that you have had neck pain?	Yes □	No □
(16) Do you feel that neck pain will influence your future?	Yes □	No □

PART 5

In this section, we are interested in learning if you have experienced any problems with <u>*your upper back*</u> *during the last year.*

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your upper back?	Yes □	No □
(2) Have you experienced any stiffness in your upper back?	Yes □	No □
(3) Have you experienced any cramping in your upper back?	Yes □	No □
(4) Have you experienced any limited movement in your upper back? (Difficulty moving your upper back in all directions and to the extent that you think you should be able to)	Yes □	No □

If you answered NO to all of the previous questions about your *upper back*, please go to

PART 6. If YES to any, continue here.

(5) Did you seek medical care for the problem with your upper back?	Yes □	No □
(6) Have you ever had an accident or sudden injury to your	Yes □	No □

upper back, such as sports injury or fracture that was not related to your work?

(7) Did this problem with your upper back interfere with your work at home? Yes □ No □

(8) Did this problem with your upper back interfere with your work on the job? Yes □ No □

(9) Did this problem with your upper back interrupt your sleep? Yes □ No □

(10)On a scale from 1 to 5, how bothersome was the problem with your upper back?
(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

PART 6

In this section, we are interested in learning if you have experienced any problems with *<u>your lower back</u>* *during the last year.*

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your lower back? Yes □ No □

(2) Have you experienced any stiffness in your lower back? Yes □ No □

(3) Have you experienced any cramping in your lower back? Yes □ No □

(4) Have you experienced any limited movement in your lower back? (Difficulty moving your lower back in all directions and to the extent that you think you should be able to) Yes □ No □

If you answered NO to all of the previous questions about your *lower back*, please go to

PART 7. If YES to any, continue here.

(5) Did you seek medical care for the problem with your lower back? Yes □ No □

(6) Have you ever had an accident or sudden injury to your lower back, such as sports injury or fracture that was not related to your work? Yes □ No □

(7) Did this problem with your lower back interfere with your work at home? Yes □ No □

(8) Did this problem with your lower back interfere with your work on the job? Yes □ No □

If yes, did you miss one day or more of work? Yes □ No □ Total days missed________

(9) Did this problem with your lower back interrupt your sleep? Yes □ No □

(10)On a scale from 1 to 5, how bothersome was the problem

with your lower back?
(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

PART 7

In this section, we are interested in learning if you have experienced any problems with *your hips or thighs* *during the last year.*

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your hips or thighs?	Yes □	No □
(2) Have you experienced any stiffness in your hips or thighs?	Yes □	No □
(3) Have you experienced any weakness in your hips or thighs?	Yes □	No □
(4) Have you experienced any limited movement in your hips or thighs? (Difficulty moving your hips or thighs in all directions and to the extent that you think you should be able to)	Yes □	No □

If you answered NO to all of the previous questions about your *hips or thighs*, please go to

PART 8. If YES to any, continue here.

(5) Did you seek medical care for the problem with your hips or thighs?	Yes □	No □
(6) Have you ever had an accident or sudden injury to your hips or thighs, such as sports injury or fracture that was not related to your work?	Yes □	No □
(7) Did this problem with your hips or thighs interfere with your work at home?	Yes □	No □
(8) Did this problem with your hips or thighs interfere with your work on the job?	Yes □	No □
(9) Did this problem with your hips or thighs interrupt your sleep?	Yes □	No □

(10)On a scale from 1 to 5, how bothersome was the problem with your hips or thighs?
(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

PART 8

In this section, we are interested in learning if you have experienced any problems with *your feet or ankles* *during the last year.*

DURING THE LAST 12 MONTHS…

(1) Have you experienced any pain or aching in your feet or ankles?	Yes □	No □
(2) Have you experienced any stiffness in your feet or ankles?	Yes □	No □
(3) Have you experienced any numbness, tingling, or burning in your feet or ankles?	Yes □	No □
(4) Have you experienced any limited movement in your feet or ankles? (Difficulty moving your feet or ankles in all directions and to the extent that you think you should be able to)	Yes □	No □

If you answered NO to all of the previous questions about your *feet or ankles*, please go to next section, "Driving".
If YES to any, continue here.

(5) Did you seek medical care for the problem with your feet or ankles?	Yes □	No □
(6) Have you ever had an accident or sudden injury to your feet or ankles, such as sports injury or fracture that was not related to your work?	Yes □	No □
(7) Did this problem with your feet or ankles interfere with your work at home?	Yes □	No □
(8) Did this problem with your feet or ankles interfere with your work on the job?	Yes □	No □
(9) Did this problem with your feet or ankles interrupt your sleep?	Yes □	No □

(10)On a scale from 1 to 5, how bothersome was the problem with your feet or ankles?
(Circle one. 1 = not bothersome, 5 = very bothersome) 1 2 3 4 5

DRIVING

These questions are about your driving experience.

1. Do you drive a car? ....Yes □ No □

If yes,

a) On average, how much time do you spend driving per week? ______hours
b) On average, how many miles do you drive per week? ______ miles

2. Do you drive a car to work? ....Yes ☐ No ☐

If yes,

a) How long does take you to get to work? ______hours ______minutes

b) How many miles does it take you to get to work? ______ miles

3. On average, how much time do you spend in the car per week? _____hours

4. Have you held any previous jobs in the transport industry?
(driving trains, trucks, taxi cabs, delivery vans or other motor vehicles) ………………..Yes ☐ No ☐

a) How long did you work at the job? ______years ______months

b) How long ago was that? ______years

5. About how many total miles do you think you drive per year? ______ miles

YOUR IDEAS ABOUT INJURUES

1. Please indicate whether you agree or disagree with the following(Circle one answer):

a) Workers' actions cause back injuries to U.S. workers.

1-strongly disagree 2-disagree 3-agree 4- strongly agree

b) Work conditions cause back injuries to U.S. workers.

1-strongly disagree 2-disagree 3-agree 4- strongly agree

2. What do you think is the most important cause of back injuries to workers in the U.S.? (Pick just one.)

a) Workers' actions

b) Work conditions

c) Some other cause (what is it?) ____________________________________

3. Please rate each of the following causes of back injury on the job as either:

	Not important	Somewhat important	Important	Very important
a) Lifting something too heavy	☐	☐	☐	☐
b) Fate	☐	☐	☐	☐
c) Being physically out of shape	☐	☐	☐	☐
d) Not following proper procedures	☐	☐	☐	☐
e)Lack of training	☐	☐	☐	☐
f) Being careless	☐	☐	☐	☐
g) Smoking cigarettes	☐	☐	☐	☐

h) Jobs that require sitting too long in one place	☐	☐	☐	☐
i) Chance	☐	☐	☐	☐
j) Jobs that require standing too long in one place	☐	☐	☐	☐
k) Bad luck	☐	☐	☐	☐
l) Jobs that require twisting the back	☐	☐	☐	☐
m) Jobs that require doing too many tasks at once	☐	☐	☐	☐
n) Act of God	☐	☐	☐	☐
o) Jobs that require working in an awkward position	☐	☐	☐	☐
p) Using the wrong body motions doing a job	☐	☐	☐	☐
q) Jobs that require working too quickly	☐	☐	☐	☐
r) Tripping on an object	☐	☐	☐	☐

	Not important	Somewhat important	Important	Very important
s) Coming to work tired	☐	☐	☐	☐
t) Jobs that are tiring	☐	☐	☐	☐
u) Unsafe equipment	☐	☐	☐	☐
v) Getting older	☐	☐	☐	☐
w) Having an old back injury	☐	☐	☐	☐
x) Jobs that require holding the same position too long	☐	☐	☐	☐

y) Other (what is it?) ______________________________

4. Please rate each of the following on how likely they are to prevent back injury as:

	Not likely	Somewhat likely	Likely	Very likely
a) Changing the workplace to reduce the need to move materials	☐	☐	☐	☐
b) Reducing the weight of materials	☐	☐	☐	☐
c) Adjusting the humidity of air	☐	☐	☐	☐
d) Staying in shape by exercising	☐	☐	☐	☐
e) Reducing the size of materials	☐	☐	☐	☐

f) Keeping the back straight while lifting	☐	☐	☐	☐
g) Eating a proper diet	☐	☐	☐	☐
h) Using handles on containers	☐	☐	☐	☐
i) Keeping the back bent (or rounded) while lifting	☐	☐	☐	☐
j) Reducing the distance to carry materials	☐	☐	☐	☐
k) Lifting with the legs bent	☐	☐	☐	☐
l) Holding materials away from the body while carrying	☐	☐	☐	☐
m) Using pushcarts instead of carrying materials	☐	☐	☐	☐
n) Using back supports (belts) while lifting	☐	☐	☐	☐
o) Using adjustable work tables	☐	☐	☐	☐
p) Using adjustable chairs	☐	☐	☐	☐
q) Lifting with the legs straight	☐	☐	☐	☐
r) Following the supervisor's directions in doing a job	☐	☐	☐	☐
s) Holding materials close to the body while carrying	☐	☐	☐	☐
t) Not smoking	☐	☐	☐	☐

5. Please rank the importance of each person in safety (put # 1 after the most important, # 2 after the next, etc.):

	Rank
a) the worker	_______
b) The supervisor	_______
c) Health and safety person	_______
d) Management	_______
e) Other (who) ________________________	_______

6. Think of a person you know who had a back injury at work (not necessarily at your company). Circle the likely cause(s) of the injury. More than one answer is possible.

a) Worker's actions

b) Work conditions

c) Flare-up of an old injury
d) Other (What?) ______________________________________

BASIC INFORMATION

This group of questions provides general information about you and your family.

1. What is your sex?..............................	1 Male 2 Female
2. What is your date of birth?.................	___Month______Day______Year
3. About how tall are you without shoes?...	______feet______inches
4. About how much do you weigh without shoes?................................	________pounds
5. Are you left-handed, right-handed, or able to use both hands equally well?.....	1 left-handed 2 right-handed 3 able to use both hands equally well
6. Do you consider yourself to be………	1 White 2 African American 3 Hispanic 4 Native American 5 Asian 6 Other 7 Don’t know
7. What is your first language?...............	1 English 2 Other
8. Are you now…………………………...	1 Married 2 Not married but living with a partner 3 Widowed 4 Separated 5 Divorced 6 Never married

9. Of your, how many are…………………

1 Under 2 years old ______	
2 3 to 5 years old ______	
3 6 to 12 years old ______	
4 13 to 18 years old ______	
5 19 and over ______	
6 No children living at home	

10. How many persons (Total) are in your household? ______

11. Do you have a disabled relative(s) in your household?..........Yes □ No □

12. Do you provide personal care or help to an aged or disabled relative(s)?
……………………………………………………………………Yes □ No □

If yes,

a) How many hours per week do you spend providing care? ______hours
b) Describe the main care activity you do at least every week _________

13. Over the last 12 months have there been any major changes in your family life, such as getting married or divorced or having a close family member or friend become ill or leave home? …………………………………..Yes □ No □

If yes, did you find this event or these events to be very, somewhat, not too, or not at all stressful?	Very stressful	Somewhat stressful	Not too stressful	Not at all stressful

14. Do you have a second job outside of English American? ......Yes □ No □

1. What is your job title in this second job? ....

2. What kind of business do you work for at this second job? …………………….

3. How many hours per week do you work in this second job? ……………... ____________hours per week

4. What are your most important duties in this second job? ……………………….

15. Do you have a third job outside of English American? …......Yes □ No □

16. What is the highest grade of school that you have finished? ……………..

1 Grades 1-4
2 Grades 5-6
3 Grades 7-8
4 Grades 9-11
5 Grades 12 or GED
6 Grades 12 + Trade School
7 Some College
8 Bachelor's Degree
9 Advanced Degree

17. What was your total household income for 1997? ....

1 Below $7,000
2 $7,000-$15,000
3 $15,001-$25,000
4 $25,001-$35,000
5 $35,001-$45,000
6 $45,001-$55,000
7 Above $55,000
8 Don't know

You may add any comments you want in this space.

THANK YOU FOR ANSWERING ALL OF THESE QUESTIONS!!!

Observational Checklist

ID#:____

Observer: _____

Date: ________

Time: ________

Section: Sewing□ Pressing□Cutting□ Tracing□ Hand sewing□ QC□

Participant: Female□ Male□

Number of tasks involved in each work cycle_________

Time of complete work cycle ________min ________sec

Multiple work stations Yes□ No□ Describe_________________________________

Lean forward	Yes□No□	degrees________	
Neck-Flexed	Yes□No□	degrees________	Fixed Yes□ No□
Neck-Rotation	Yes□No□	#_____________	Direction R□ L□
Arm-Forward	Yes□No□	R #____ L #____	Level□ Above□
Arm-Lateral	Yes□No□	R #____ L #____	Level□ Above□
Lifting	Yes□No□	Same level□ Floor to waist□ Waist to high□	Material________ Weight_____ Bundle________ Weight_____
Finger grip	Yes□No□	R #____ L #____	Static□ Rep□
Pressing lever	Yes□No□	R #____ L #____	
Foot-Pedals	Yes□No□	R #_______ L #_______	High□ Low□ High□ Low□
Knee-Pedals	Yes□No□	#_____________	R□ L□
Twist at waist	Yes□No□	#_____________	
Rocking	Yes□No□		
Lean against surface	Yes□No□	Arm R□ L□Trunk□	Sharp edge Yes□ No□

Position of work- Adequate height□ High□ Low□

Chair- N/A□ Yes□ No□ Use back support Y□ N□ Type: adjustable□ swivel□

Floor Mat- N/A□ Yes□ No□ Type: rubber□ carpet□

other_____________________

Social environment- Potential for interaction Yes□ No□

____

Other observations- Arm Pulling/Pushing,

Jerkiness__________________________________