UNIVERSITI PUTRA MALAYSIA

THE PREVALENCE OF WORK-RELATED MUSCULOSKELETAL PROBLEMS AND ERGONOMIC RISK FACTORS AMONG WOMEN PRODUCTION LINE EMPLOYEES IN THE SEMICONDUCTOR INDUSTRY

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FPSK (M) 2001 2

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By

C. ABHERHAME A/P S. CHANDRASAKARAN

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Science in the Faculty of Medicine and Health Sciences
Universiti Putra Malaysia

October 2001

To God, Naina, Amma, my husband, Jasmin, Annais, Annees, my nephews and to the development of policies on women's health in the semiconductor industry.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Associate Professor Chee Heng Leng, Ph.D.

Faculty: Medicine and Health Sciences

This cross-sectional study aimed to determine the work-related musculoskeletal problems of women production line employees in relation to their work postures and movements. At the beginning of the study in each of the eight factories, a walk-through survey was carried out to enable the researcher to understand the processes and tasks as well as to briefly observe the ergonomic risk factors (work postures and movements).

Women who were Malaysians, production line employees (up to the level of line leader) who were directly involved in production, and had worked for at least one year in the current factory were selected by the management of each factory for a questionnaire survey. A total of 529 respondents participated in the survey. The data was collected using a guided self-administered questionnaire. Further information was collected from a sub-sample of 330 women workers to obtain in-depth information about the description, severity and treatment of the most frequent body pain site. In

addition, an observational study was carried out on five employees who were running the automated machines in the chip testing department in one factory. The objective of the observations was to identify the most common work postures for the back, arms, legs and neck and to estimate the workload.

It was found that the prevalence of pain was high, as more than two-thirds of the 529 respondents had some symptoms relating to the musculoskeletal system. The one-year prevalence of having any musculoskeletal ache or pain ranged from 7% to 48% for different body sites, with the highest prevalence reported was for the lower leg. In terms of ergonomic risk factors, the highest exposures were repetitive hand and wrist movement (77.9%), standing (61.2%) and lifting manually (55.6%) for four or more hours in a work day.

This study was able to show a clear relationship between work-related musculoskeletal pain and ergonomic exposures based on prolonged hours spent in particular work postures and movements. The overall severity of the problems among the sub-sample of 330 respondents gave an indication that most of the problems were at an early stage where the pain or discomfort occurs during work and begins to slowly show over weeks or months but usually disappears with rest.

The observational study found that about one-third of the time the workers in the automated chip testing department were sitting and another one-third

of the time standing with both their legs straight, in relation to leg postures. With reference to their back postures, 50% of the time their backs were in a bent position. Also, for more than 50% of the observed time, their necks were in a bent forward position.

In conclusion, the hypothesis which stated that there was no significant relationship between musculoskeletal problems and work postures and movements could be rejected except for upper back pain. The study recommended the use of an observational method for assessing work postures and movements in future studies.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PREVALENS MASALAH MUSKULOSKELETAL YANG BERKAITAN DENGAN KERJA DAN FAKTOR-FAKTOR RISIKO ERGONOMIK DI KALANGAN OPERATOR PENGELUARAN WANITA DI INDUSTRI SEMIKONDUKTOR

Oleh

C. ABHERHAME A/P S. CHANDRASAKARAN

Oktober 2001

Pengerusi: Profesor Madya Chee Heng Leng, Ph.D.

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Kajian yang bercorak irisan lintang ini bertujuan mengenalpasti masalah muskuloskeletal berkaitan dengan kedudukan dan pergerakan anggota badan di kalangan operator pengeluaran wanita. Pada peringkat awal kajian ini, pemerhatian di tempat kerja dijalankan di lapan buah kilang agar penyelidik dapat memahami dan mengetahui proses dan tugas operator-operator di samping meninjau faktor-faktor risiko ergonomik (kedudukan dan pergerakan anggota badan) secara ringkas.

Pemilihan dilakukan oleh staf pengurusan setiap kilang di kalangan wanita yang berwarganegara Malaysia, berstatus operator pengeluaran yang terlibat secara langsung dengan aktiviti pengeluaran (sehingga tahap ketua operator) dan telah bekerja sekurang-kurangnya satu tahun di kilang tersebut. Sejumlah 529 responden telah terlibat dalam kajian ini. Data dikutip menggunakan borang soal selidik yang diisi sendiri oleh operator dengan panduan penyelidik. Sehubungan dengan itu, satu sub-sampel

yang melibatkan seramai 330 responden turut diberi soal selidik bagi mendapatkan maklumat yang terperinci mengenai deskripsi, gejala dan rawatan untuk anggota badan yang mereka kerap sekali merasa sakit. Selain daripada itu, satu kajian pemerhatian dilakukan ke atas lima operator yang menjalankan mesin 'testing' automatik di salah sebuah kilang yang mengambil bahagian dalam kajian ini. Objektif pemerhatian tersebut adalah bagi menentukan kedudukan dan pergerakan anggota badan di bahagian belakang, tangan, kaki dan leher dan untuk menjangka beban kerja.

Keputusan menunjukkan bahawa lebih dua-pertiga daripada 529 responden telah mengalami sekurang-kurangnya satu gejala yang berkaitan dengan masalah muskuloskeletal. Prevalens masalah muskuloskeletal bagi satu tahun kebelakangan pada anggota-anggota badan adalah antara 7% dan 48% dengan prevalens tertinggi untuk kaki bawah. Kedudukan dan pergerakan anggota badan yang dialami untuk jangkamasa empat jam atau lebih sehari adalah pergerakan tangan dan pergelangan tangan (77.9% responden), berdiri (61.2%) dan mengangkat menggunakan tangan (55.6%).

Masalah muskuloskeletal yang dilaporkan oleh 330 responden dalam sub-sampel adalah pada peringkat awal (kesakitan dialami semasa waktu kerja dan bertambah selepas berminggu atau berbulan, tetapi kesakitannya berkurangan selepas berehat).

Kajian pemerhatian di kalangan pekerja yang menjalankan mesin 'testing' automatik mendapati bahawa satu per tiga daripada masa pekerja adalah dalam kedudukan duduk dan satu per tiga lagi pekerja berdiri dengan kedua-dua kaki lurus. Merujuk kepada posisi belakang, 50% daripada masa pemerhatian, pekerja membongkok. Tengkok mereka pula berada dalam keadaan menunduk lebih 50% daripada masa ditinjau.

Kesimpulannya, hipotesis yang menyatakan bahawa tiada kaitan signifikan antara masalah muskuloskeletal dan pergerakan dan kedudukan anggota badan semasa kerja boleh ditolak kecuali kesakitan pada bahagian belakang atas. Kajian ini mensyorkan penggunaan cara pemerhatian untuk menentukan pergerakan dan kedudukan anggota badan untuk kajian-kajian yang akan datang.

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Associate Professor Dr. Chee Heng Leng for constantly guiding me throughout the course of the study. Her guidance and rationalization during the whole research was essential in the completion of this thesis. I am also grateful for the level of tolerance, understanding and support she had during the process of this write-up. I would also like to thank Professor Dr. Krishna Gopal Rampal and Associate Professor Dr. Evelyn Tan Guat Lin for their advice, motivation and support to complete my studies. Finally, my appreciation is also extended to Professor Dr. Khor Geok Lin, Rani Sarmugam, Ng Wei Khiang, Lim Hwei Mian, Yim Hip Seng, Foo Leng Huat, Phan Yng Yih, Ruhaya Salleh, Cheong Mee Leng and factories that participated in the studies, for their assistance, support and encouragement throughout this study.

I would like to acknowledge funding under the study entitled 'Reproductive Health Hazards and Its Management in the Manufacturing Sector' by the Ministry of Science, Technology and Environment's Intensification Research in Priority Areas (IRPA 06-02-05-7011) for the success of this study.

I certify that an Examination Committee met on the 16th October 2001 to conduct the final examination of C. Abherhame a/p S.Chandrasakaran on her Master of Science thesis entitled "The Prevalence of Work-related Musculoskeletal Problems and Ergonomic Risk Factors Among Women Production Line Employees in the Semiconductor Industry" in accordance with Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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Date: 14 MAR 2002

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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Date: 16 . 10 . 2001

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CI	Confidence Interval
OR	Odds Ratio
OWAS	Ovako Working-posture Analysis System

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

A diverse range of electronic products are produced in Malaysia. The products manufactured are semiconductor devices (integrated circuits, microprocessors and other products), consumer and industrial electronic equipment (television, video players, telephones, computers, satellite receivers and others) and electronic components such as capacitors, leadframes, resistors, printed circuit boards and many others. Among these products, semiconductor products make up the largest share in the electronics industry. In 1997, it constituted 38% of total electronics exports (MIDA, 1998:10).

The production of semiconductor products largely involves women workers. As early as the 1970's, there has been a steady increase of women entering the labour force in the electronics industries (Jamilah Arrifin, 1984: 59). Table 1 shows that the total workforce in the electronics industry has grown from 57,000 employees in 1986 to 343,300 employees in 1997. Majority of these women work in the production line of one of many processes in the semiconductor industry.

The electronics industry can be divided into five major processes. They are wafer fabrication, semiconductor assembly, printed circuit board

fabrication, printed circuit board assembly and final product assembly. This study concentrates on the semiconductor industry, which consists of the two major processes, wafer fabrication and semiconductor assembly.

Table 1: Growth of the workforce in the electronics industry in Malaysia (1986 to 1997)

Year	No. of employees	Growth (%)
1986	57,000	-
1987	89,000	56.7
1988	106,000	19.1
1989	123,000	16.0
1990	144,000	17.1
1991	171,000	18.8
1992	204,000	19.3
1993	231,000	13.2
1994	278,000	20.3
1995	313,000	12.6
1996	329,000	5.1
1997	343,300	4.3

Source: MIDA, 1998:116.

The wafer fabrication process starts with the forming of semiconductor crystals. These crystals are grown into ingots (big cylinder rods) by a chemical process. However, these initial processes are not carried out in the factories in Malaysia. The wafer fabrication process in Malaysia only involves a number of processes, especially those prior to and after the wafer polishing process. They start with mounting the ingots onto rods. The mounted ingots are sliced into thin wafers by laser cutters or diamond saws. After slicing, the thin wafers are put through several chemical (etching, lapping and annealing) and mechanical (grinding and sand blasting) treatment processes to obtain a very clean and smooth

surface for each wafer. The lapping process also evens out the thickness of the wafer and etching strengthens the wafer. In the chemical treatment processes, many types of acids and solvents are used. After these treatment processes, the wafers are taken into the polishing process to obtain a wafer with a mirror finish. Later, the wafers are packed and transported out of the country for photomasking (a process to transfer the electrical circuit design onto the wafers) and the subsequent cleaning and treatment processes which are not available in Malaysia. At various steps and before packing the wafers, visual inspection is carried out. (Gassert, 1985; Cheong, 1994).

In the semiconductor factories, wafers are imported into Malaysia for the subsequent assembly steps. Each wafer may contain several thousands of dies and every die is tested by machines. Good dies are distinctly identified (by marking) for further processes. Each wafer is mounted onto a plastic film clamped on metal frames. Then the dies are physically singulated by diamond saws. Testing, marking, mounting and separating the dies are the die preparation steps.

During the die attach process, the die is attached onto a leadframe using a form of attachment injected by a syringe type nozzle. The defective units (that were marked earlier) are not picked up by the machines. Some die need oven treatment to obtain good adhesion for the attachment. After that, the die will be connected with gold wires in the wire bonding process which is done by programmed machines that are accurate and extremely

fast. The dies are now electrically useful as electricity can flow in and out of the semiconductor through the gold wires. From die preparation until die attach, the process is known as front of line process.

The next step is to mold or encapsulate the exposed die with epoxy resin to prevent contamination. For this process, many factories have installed automated molding machines but there are still some semi-automated machines in use. Then the die goes through automated processes of forming and trimming and soldering. From the molding process until soldering, the process is known as middle of line process.

Next, end of line starts with marking and ends with packing. Marking is done either by using ink or laser machines. Testing checks on the electrical circuits of each die are carried out. To further test the reliability under severe operating conditions or critical devices, the die is subjected to extreme temperatures in the burn-in process. In between the processes of forming and trimming, soldering, marking and testing the tedious task of inspection is carried out with the aid of microscopes or magnifying lens and sometimes with the naked eye of the production line employees. Some of the semiconductor assembly factories also produce diodes and other electronic parts, and these basically consist of manual tasks.

Integrated circuits, microprocessors, transistors and diodes are small in size. Moreover they are being designed smaller by the day. Therefore, production of these products not only involves automation but also

precision and tedious work. Workers also need to be tolerant of the monotonous and routine jobs.

The exposure to chemicals, physical hazards, psychological and ergonomic hazards and problems are present in any of the work processes, whether involving automated, semi-automated or manual tasks. These hazards and problems may cause dizziness, nausea, headaches, dermatitis, musculoskeletal problems and other symptoms in workers (Hunt, 1979: 134).

Musculoskeletal problems are caused by ergonomic risk factors that may result in fatigue and pain of the muscles as well as tingling and numbness. The risk increases as the women production line employees work at workstations that are rigid in design, causing them to use awkward postures and movements, repetitively at a fast pace. This sometimes causes strain to their muscles during material handling and other tasks that has to be carried out to achieve a high production output. Sometimes their tasks require them to remain seated or standing for long periods at a time, and this prolonged work posture can lead to musculoskeletal problems. Standing still or sitting still is disadvantageous, and it is better if the posture can be changed often during the workday. This includes interludes of walking if the worker is in a standing operation, and the seated person should also walk occasionally. Motions of head, trunk, arms and legs should also change as they should not strain any muscle group with extensive use.