Health and safety of portable display screen equipment

Prepared by:
T. Heasman, A. Brooks, T. Stewart

CONTRACT RESEARCH REPORT
304/2000

Health and Safety of Portable Display Screen Equipment

Tanya Heasman
Ann Brooks
Tom Stewart
System Concepts
2 Savoy Court
London WC2R 0EZ

This report describes the findings of research into the use of portable and handheld computers in the UK. The aims of the project were:

- to determine the extent to which portable computers are used within organisations;
- to determine the extent of any health problems associated with portable computer use, and the risk factors involved, in comparison with full-sized display screen equipment (DSE);
- to identify the features of portables that were desirable and undesirable from the point of view of users' health and safety; and
- to identify the key features of good working practice with such equipment, including task design and user training requirements.

We conducted a market review and telephone survey to determine the extent to which portable computers are used within organisations. Approximately one in every five computers purchased was a portable computer, and they were more widely purchased in the business market than the small office/home computer market.

We conducted a questionnaire survey of portable and desktop computer use, and carried out extensive statistical analysis on the returned questionnaires. In general use, we found that portable computer users and desktop computer users reported very similar levels of health problems. We found a strong correlation between reported discomfort and hours per week spent using *any* computer, and hours per week spent using a desktop, but no significant correlation between discomfort and hours/week using a portable. The *proportion* of working time spent using a computer showed a strong correlation with reported discomfort and appeared to be a predictor of discomfort for all types of computer use (desktop, portable and mixed use). Frequent breaks (or changes in task activity) and undergoing training relevant to working with computers appeared to provide benefits for portable, docking station, and desktop users.

The nature of the portable computer users' jobs appeared to have the effect that they operated their machines "alone" (i.e. without attaching it to an external keyboard, screen or "docking station") for considerably fewer hours per week than desktop users used their desktop computers. The mobility in a (currently) "typical" portable computer users' job may mitigate against discomfort by limiting the proportion of their working time they spend using (any) computers.

However, some specific aspects of portable computer use (which are *not* undertaken by desktop users) *did* appear to be associated with a risk of musculoskeletal discomfort. The two main aspects consisted of manual handling issues, such as carrying large amounts of paperwork or carrying several additional items with the portable; and use in non-ideal locations (which encourage poor posture) such as motor vehicles and hotels. Both of these aspects were associated with various types of discomfort.

We also conducted *qualitative* research using the questionnaires, and made ergonomics observations on-site to identify the features of portable computers that were undesirable or desirable from the users' point of view, and to examine the key features of good working practice with such equipment. Users perceived there to be several risks associated with portable computer use, particularly postural and musculoskeletal risks, visual risks, theft and mugging. They disliked the weight of their portable computers, and many suggested improvements that could be made to the overall designs.

The work contained within this report addresses all of the project aims. The report contains recommendations on portable computer design, information and training, working patterns and breaks, manual handling issues, and the working environment.

This report and the work it describes were funded by the Health and Safety Executive. Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

First published 2000

ISBN 0 7176 1890 0

Table of Contents

0. DEFINITIONS AND ABBREVIATIONS 7

1. MANAGEMENT SUMMARY 9

2. INTRODUCTION 13

3. AIMS AND OBJECTIVES 14

3.1 Aims 14

3.2 Objectives 14

4. OUR APPROACH 15

4.1 Determine the extent to which portable computers are used 15
4.1.1 Desk-based research 15
4.1.2 Telephone-based research 15

4.2 Investigate use of portable computers within organisations 16
4.2.1 Develop end-user questionnaire 17
4.2.2 Develop observer and evaluation checklist 18
4.2.3 Pilot user questionnaire and observer checklists 19
4.2.4 Finalise data collection instruments, sample and conduct data collection 20
4.2.5 Statistical approach 20
4.2.6 Description of results 23

5. OUR FINDINGS – LITERATURE REVIEW 24

5.1 Literature review 24

5.2 Overall summary of results from literature review 30

6. OUR FINDINGS – MARKET REVIEW 31

6.1 Sales of desktop and portable computers in the UK 31

6.2 Summary of market review 32

7. OUR FINDINGS - RESULTS FROM TELEPHONE RESEARCH 33

7.1 The questionnaire 33

7.2 The results 33
7.2.1 Organisation information 33
7.2.2 Extent of personal computer use 35
7.2.3 User details 37
7.2.4 Risks associated with the use of portable computers 41

7.2.5 Assessment and policy 41

8. TECHNICAL SPECIFICATIONS 45

9. OUR FINDINGS - BASIC INFORMATION DERIVED FROM QUESTIONNAIRE RESPONSES 46

9.1 Organisations participating, job types and types of computer used 46

9.2 Years spent using computers, years in current job/organisation 48

9.3 Time spent working and using computers 50

9.4 Personal information 56

9.5 Overall symptoms and discomfort reported 58

9.6 Portable computer use in different locations 61

9.7 Overall ratings of the working environment 63

10. OUR FINDINGS – RESULTS OF STATISTICAL ANALYSIS FOR PORTABLES 70

10.1 Type of computer used 70
10.1.1 Possession and use of portable computer 70
10.1.2 Types of computer user 71
10.1.3 Brand of portable computer used 72
10.1.4 Influence of home computer use on discomfort or symptoms 73

10.2 Hours spent using a computer 74
10.2.1 Hours per week spent using a desktop 75
10.2.2 Hours per week spent using a portable (with no docking station) 76
10.2.3 Hours per week spent using a portable with docking station 77
10.2.4 Hours per week spent using any portable (with and without docking station) 78
10.2.5 Hours per week spent using any work computer (all work computer time) 80
10.2.6 Hours per week spent using any computer (including home use) 81
10.2.7 Proportion of working time spent using a computer 82

10.3 Total working hours and time between computer breaks 82
10.3.1 Total working hours 83
10.3.2 Time spent using a computer continuously before taking a break or changing activities 83

10.4 Can we recommend "safe" durations of use? 84
10.4.1 Hours/week on a desktop 84
10.4.2 Other duration of use measures 85
10.4.3 Time before taking a break from computer use 86
10.4.4 Proportion of working time using any computer 88

10.5 Effects of training 89

10.6 Location of portable computer use 91

10.7 Years spent using computers, time in job, time in organisation 94
10.7.1 Years spent using computers 94
10.7.2 Years spent using portable 94
10.7.3 Years spent in current job 95
10.7.5 Differences between computer users in years spent using computers 96

10.8 Ratings of aspects of the working environment 97

10.9 Effects associated with stature 98

10.10 Effects associated with age 99
10.10.1 Differences in age profile across the various computer user groups 99
10.10.2 Analysis of symptoms and discomfort by age group 100
10.10.3 Analysis according to each computer group separately, within age groups 100

11. OUR FINDINGS - MANUAL HANDLING 102

11.1 Correlations with weight carried 102

11.2 Recommended weights 102

11.3 Method of carrying portable 106

11.4 Number of additional items carried 107

11.5 Association of carrying a particular item with discomfort 109

12. OUR FINDINGS - PORTABLE COMPUTER INPUT DEVICES 112

13. OUR FINDINGS - PERCEIVED RISKS OF USING PORTABLE COMPUTERS 113

14. OUR FINDINGS – HANDHELD COMPUTERS 115

14.1 Location of handheld use 116

14.2 Type of handheld computer used 116

14.3 Hours per week using handheld 117

14.4 Manual handling issues related to handheld computer use 117

14.5 Handheld input devices 118

15. OUR FINDINGS – USER-REPORTED QUALITATIVE DATA FOR PORTABLE COMPUTERS 119

15.1 Desirable features 120

15.2 Undesirable features 121

15.3 Main improvement to design 122

16. OUR FINDINGS – USER-REPORTED QUALITATIVE DATA FOR HANDHELD COMPUTERS 123

16.1 Desirable features 123

16.2 Undesirable features 124

16.3 Main improvement to design 125

17. RECOMMENDATIONS 126

17.1 Portable computer design issues 126

17.2 Information and training 128

17.3 Working patterns and breaks 129

17.4 Manual handling issues 130

17.5 The working environment 132

17.6 Handheld computers 133

18. CONCLUSION 134

REFERENCES 135

HSE PUBLICATIONS 136

APPENDIX 1A. TECHNICAL SPECIFICATIONS FOR 159 PORTABLE/LAPTOP/NOTEBOOK COMPUTERS 137

APPENDIX 1B. TECHNICAL SPECIFICATIONS FOR 24 HANDHELD DEVICES 141

0. DEFINITIONS AND ABBREVIATIONS

CD-ROM Compact disk read-only memory.

Desktop computer. This is the arrangement of computer equipment most commonly found used on permanent office workstations. It consists of a display screen, keyboard, mouse and processor unit. The display screen and keyboard are separate from each other and can be positioned independently of each other in location and height.

Discomforts In the questionnaire, respondents were asked how frequently they experienced pain, aches, tingling, pins and needles or general discomfort in their*"feet, legs, back, neck, shoulder, arms, wrists, hands/fingers"*. These are subsequently referred to using the category term "discomforts".

Docking station. A docking station, for the purposes of this research, was defined as an arrangement of external equipment which could be connected up to the portable to achieve a more ergonomic layout. It could consist of an external keyboard (alone), an external display screen (alone) or both; or a 'full' docking station where the user slides their portable into a special housing which connects the portable computer directly to an external screen, keyboard and mouse.

DSE Display screen equipment.

FPD Flat panel display.

Handheld computer. We define this as a device which has a display screen and keyboard not separate from each other, with a screen measuring between 2.5 and 10.9 inches (measured across the diagonal); a keyboard or keypad (which may be Qwerty or non-qwerty in layout); which may or may not have an additional input device. It can be operated with one or two hands, and is likely to be held in one hand while being operated with the other.

HSE Health and Safety Executive.

IT Information technology.

LCD Liquid crystal display.

PC Personal computer.

Popliteal height. The vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps femoris muscle inserts into the lower leg.

Portable computer, (alternative terms "laptop" and "notebook"). We define portable computer to mean a device which has a display screen and Qwerty keyboard not separate from each other, but hinged in a "clamshell" arrangement. A portable computer commonly consists of a display screen with screen size of between 11 and 15 inches (measured across

the diagonal), a keyboard, and typical dimensions (when "closed") of 310mm width, 240mm depth, and 50mm height, and an integral input device (which may be a touchpad, trackpoint, stylus, or rollerball). A portable computer is usually operated with both hands while the computer is resting on a flat surface.

RSI Repetitive strain injury.

SOHO Small office / home office.

Symptoms In the questionnaire, respondents were asked to describe how frequently they experienced symptoms of *"Fatigue, stress, headache, irritated eyes, difficulties reading your work on the screen"* Throughout the report these five health effects are described using the category term "symptoms".

TFT Thin film transistor technology.

Touch pad (glide pad). This is an input device which consists of a touch-sensitive pad, usually provided as an integral part of a portable computer, across which the user moves a finger tip to control the cursor on the screen. It is usually used in conjunction with two or more buttons to activate the selection ("click") on an item.

Tracker ball. This is an input device which consists of a rollerball which the user operates with their finger tip to control the movement of a cursor on the screen. It is usually used in conjunction with two or more buttons to activate the selection ('click') on an item.

Trackpoint (pointing stick, "nipple") This is an input device which consists of a small device (with dimensions less than fingertip-width) which the user moves with their finger tip to control the movement of a cursor on the screen. It is usually used in conjunction with two or more buttons to activate the selection ('click') on an item. It usually has a 'rough' or textured surface to help prevent the user's fingers from slipping off the pointer when using it.

VDT Visual display terminal.

WRULD Work-related upper limb disorder.

1. MANAGEMENT SUMMARY

During the 1990s the Health and Safety Executive (HSE) had become aware that increasing numbers of people were using portable computers to carry out their tasks at work. HSE noted that reports of actual or possible problems associated with the use of portable computers appeared to be increasing. It was thought possible that the risks associated with desktop Display Screen Equipment (DSE) use (i.e. musculoskeletal problems, visual fatigue, etc.) could be exacerbated by the use of portable computer equipment. For example the design of portable computers includes some features (such as the lack of keyboard/screen separation) which may make them more difficult to use in a comfortable posture; and they are likely to be used in a range of different working environments, some of which may be poorly suited to computer use.

HSE commissioned System Concepts to conduct research into the use of portable and handheld computers in UK organisations. The stated aims and objectives of the research project are given below:

- To determine the extent to which portable computers are used, who uses them, what types of machine they use, what kind of tasks they use them for, and under what circumstances they use them.
- To determine the extent of health problems associated with portable DSE, and the risk factors involved. How do these risk factors compare with those in using full-sized DSE?
- To identify the features of portables that are i) desirable and ii) undesirable from the point of view of users' health and safety, and to identify the key features of good working practice with such equipment (including task design and user training requirements).

We carried out the following activities to address these aims. We conducted desk-based literature and market reviews, and telephone-based research with health and safety managers in public and private sector organisations to determine: the extent to which portables are used; to identify who uses portable computers; the tasks they are used for; and the working environment contexts in which they are used.

From the market review and the telephone survey it became clear that handheld computers represented a small proportion of the overall market (less than 2% of the overall PC market, including desktops, portables and handhelds). Therefore the focus of the research was shifted strongly towards the use of portable computers. Two organisations did employ relatively small numbers of people using handhelds, and some investigation was carried out with these users. Most of the observations made appeared to be highly dependent on the unusual tasks carried out, and the environments in which they were used.

For the main part of this research we developed a detailed eight-page questionnaire with which to match and compare desktop DSE users and portable DSE users. Not only did we wish to compare purely desktop DSE users with purely portable DSE users, but also to be able to compare both of these types of user with those portable DSE users who used 'docking stations' i.e. a portable computer with a separate full sized screen and/or keyboard attached.

We were interested in this comparison because, in theory, the use of docking stations is widely regarded as good practice for the safe use of portables when they are in prolonged use at a workstation.

We used the results of a pilot test to refine the data collection materials and the analysis techniques. During our telephone research, we identified five organisations which employed groups of people using different types of computer equipment, i.e. standard desktop DSE and portable or handheld DSE. The questionnaires were administered to a sample of people within these groups. The returned questionnaires provided the basis for statistical comparisons between desktop users, portable users, and docking station users.

Although user questionnaire data provides much valuable information, self-report data can be subject to various sources of bias. We used supplementary interviews and observations conducted by qualified ergonomists as part of the research to identify features of portable equipment and the environments in which they are used which are undesirable or desirable from the point of view of users' health and safety. Key aspects of task design, break patterns, and other working practices were explored, in discussions with users, with health and safety personnel, and through our ergonomists' observations.

In brief, our main findings are as described below. In general use, we found no differences in the reported experience of discomfort between portable users, desktop users and docking station users. We found a strong correlation between discomfort and hours per week spent using *any* computer, and hours per week spent using a desktop, but no significant correlation between discomfort and hours/week using a portable. However, typical portable computer users operated their machines 'alone' (i.e. without attaching it to an external keyboard, screen or 'docking station') for considerably fewer hours per week than desktop users, making direct comparisons difficult.

The proportion of working time spent using a computer showed a strong correlation with discomfort and appeared to be a useful predictor of discomfort for all types of computer use (desktop, portable and mixed use). Frequent breaks (or changes in task activity) and having training relevant to working with computers appeared to provide benefits for both portable and desktop users. Furthermore, the use of docking stations with portable computers appeared to reduce some of the reported discomfort associated with general computer use.

However, certain aspects of portable computer use seemed more likely to be associated with an increased risk of musculoskeletal discomfort than others. For instance, use in non-ideal locations (which encourage poor posture) such as motor vehicles and hotels, and manual handling issues such as carrying large amounts of paperwork, or carrying several additional items with the portable, were associated with discomfort. Users' own comments supported this quantitative data, in particular their wish for lighter weight portables (and accessories) and their concerns about back and shoulder discomfort.

We briefly summarise below recommendations which we believe will help to reduce the risks to portable computer (and other) users. The first set of recommendations outlines points to bear in mind when selecting or designing portable computers, the second group

consists of points to bear in mind when planning tasks and training users of portable computers. These recommendations are drawn from the combined quantitative and qualitative results of the questionnaire survey, our site visits and workstation assessments, other available literature, and our ergonomics expertise. Full explanations of each recommendation are given in Chapter 17.

Points to bear in mind when designing or selecting portable computers

- Design portable computers with screen/keyboard separation and screen height adjustability
- Select new portable computers with ergonomic features in mind, including:
  - As low a weight as possible (e.g. 3kg or less) for portable computer and accessories
  - As large and clear a screen as possible (e.g. 14" diagonal or more)
  - Detachable or height adjustable screen
  - As long a battery life as possible, or extra transformer/cable sets so the user has a set in each main location where the portable is used, and only carries the computer, not the cables etc
  - Touch pad, rollerball or external mouse rather than 'nipple' trackpoint device
  - Wrist pad between keyboard and front edge of portable
  - Lightweight non-manufacturer-branded carrying case with handle and shoulder straps
  - Tilt adjustable keyboard
  - Facility for attaching external mouse and numeric keypad
  - Friction pads underneath to prevent computer sliding across surfaces when in use
  - Sufficient memory and speed (for the applications used)
  - "Add-ons" that improve usability and reduce maintenance time, such as (removable) CD-ROM drives and additional memory.
- Enhance battery life (without increasing battery weight) and improve battery management for portable computers
- Reduce the weight of the portable computer and its accessories
- Minimise the use of trackpoint ("nipples") as input devices.

Points to bear in mind when planning tasks and training users of portable computers

- Ensure that all staff who use computers (portables, desktops, docking stations, handhelds) receive health and safety training relevant to computer use
- Ensure that managers of portable computer users receive health and safety training relevant to portable computer use
- Provide guidance on setting up and using a docking station; and provide advice on using a portable computer when a docking station is not available
- Ensure that staff who use portables are encouraged to report any symptoms of discomfort that may be associated with their use of portable computers as soon as they arise

- Take regular breaks from computer use
- Ensure that organisations, managers and staff are aware of the increasing risk of discomfort associated with increased computer use
- Provide manual handling training for users of portable computers
- Carry out manual handling risk assessments with portable computer users
- Ensure that staff who use portables only use portable computer equipment when out of the office, or when a docking station is unavailable
- Provide good facilities such as external keyboards and monitors, (or ‘full’ docking stations) at workstations where portable computers will be in prolonged use
- Minimise the use of portables in non-ideal locations
- Ensure that handheld computers are carefully selected for ergonomic features which match the requirements of the tasks undertaken.

In the main body of this report we provide full descriptions of our data collection methods, our findings from all of the techniques employed, a statistical analysis of the questionnaire data, and our recommendations and conclusions.

2. INTRODUCTION

The number of employees who use display screen equipment in the UK is increasing every year. Display screen technology evolves rapidly, and over the past ten years the use of portable computers has become widespread. At the time of commissioning this research, although there was plenty of research and guidance on the use of 'standard' desktop display screen equipment (DSE) there was little specific information on which to base guidance on the safe and effective use of portable computers. (The term portable computers, for the purposes of this report, includes laptops and notebooks. Handheld computers are a second category which will be treated separately.)

A considerable body of evidence indicates that using display screen equipment can cause musculoskeletal and visual discomfort and fatigue. A major causal factor appears to be that display screen work encourages fixed and sometimes awkward postures. Using a keyboard tends to fix the position of the hands. Reading the screen determines head position and sitting on a chair locates the rest of the body. There is little scope for movement and with increasing facilities available through computer systems, little opportunity for the incidental breaks which previously accompanied paperwork, for example collecting files, changing paper in typewriters, referring to ledgers and so on.

There are a number of features of portable computers, primarily designed to be carried, which may exacerbate such problems. They usually possess display screens and keyboards that cannot be positioned independently of each other. The screens and keyboards are generally smaller than a 'standard' desktop screen and keyboard. Thus the user of a portable is likely to be more constrained in the range of postures they can adopt for keyboard and screen usage than a desktop computer user. This may lead to a greater incidence of musculoskeletal discomfort and fatigue, which may then give rise to longer-term work-related musculoskeletal disorders. Similarly, the screen quality, certainly in early portables, can be much poorer than standard desktop screen quality, which may cause people visual difficulties.

The Health and Safety Executive (HSE) had become aware that increasing numbers of people use portable computers to carry out their work. HSE noted that reports of actual or possible problems associated with the use of portable computers appeared to be increasing. It was thought possible that the risks associated with desktop DSE use (i.e. musculoskeletal problems, visual fatigue, etc.) could be exacerbated by the use of portable computer equipment. For example the design of portable computers includes some features (such as the lack of keyboard/screen separation) which may make them more difficult to use in a comfortable posture; and they are likely to be used in a range of different working environments, some of which may be poorly suited to computer use.

The Health and Safety (Display Screen Equipment) Regulations 1992 cover the use of display screen equipment in the workplace. Prolonged use of a portable computer brings the user under the requirements of these Regulations, and the potential musculoskeletal and other risks should be assessed and minimised by employers in the same manner as for desktop equipment. However, the potential risks associated with portable computer usage are not

limited to those normally associated with display screen equipment use. There may be other risks associated with portable computer usage due to manual handling, the possibility of theft and mugging, etc.

3. AIMS AND OBJECTIVES

In the following section we describe the stated aims and objectives of the research project, as laid down by HSE in their commissioning documents.

3.1 Aims

This research was intended to:

A. Determine the extent to which portable computers are used, who uses them, what types of machine they use, what kind of tasks they use them for, and under what circumstances they use them.

B. Determine the extent of health problems associated with portable DSE, and the risk factors involved. How do these risk factors compare with those in using full-sized DSE?

C. Identify the features of portables that are i) desirable and ii) undesirable from the point of view of users' health and safety.

D. Identify the key features of good working practice with such equipment (including task design and user training requirements).

3.2 Objectives

The objectives of this research were to:

E. Conduct a literature review.

F. Examine, through survey and fieldwork, current technology, tasks, jobs where it is used, working practices, and to establish problem areas.

G. Distil general principles of good practice, and test these against likely or hypothetical developments of the technology and its applications that may occur in future.

H. Make recommendations for improvements to guidance to employers and users.

4. OUR APPROACH

In this chapter we describe the multiple approaches we used to help meet these aims. The results from these activities are presented later in a series of "findings" chapters.

4.1 Determine the extent to which portable computers are used

We addressed aim A by conducting desk-based and telephone-based research to determine the extent to which portables are used by a sample of public and private sector organisations. This gave us an insight into who uses portable computers, the tasks they are used for, and the contexts within which they are used. It also provided an initial ergonomics-based perspective on those features of portables which may be desirable or undesirable, and the type of use to which portable computers are being put throughout public and private sector industry.

4.1.1 Desk-based research

There was little published information available on specific health effects associated with the use of portable computer equipment. However, we conducted a literature review of UK and international literature sources, to identify any ergonomics, health and safety information relating to the use of portable computer equipment. We also used our contacts within certain organisations to identify advice they provided to their own employees who used portable computers.

We estimated the unit volumes of different types of portable computers shipped in the UK over the past few years, using industry data, computer manufacturers' information, and other published market sources. We contacted the main manufacturers of portable computer equipment, to attempt to obtain technical specifications of their existing product ranges.

4.1.2 Telephone-based research

During the course of several previous assignments for clients, we have found that portable computers are used widely across industry by the following types of staff for a variety of tasks:

- managerial staff in most organisations
- people who regularly work from home
- professional service staff, for example, advisors, accountants, consultants, and lawyers, who may spend much of their time working at client sites
- sales people in the field, for order taking, updating records, etc. at customer sites and on-the-road
- people with jobs based mainly outdoors, for example, traffic wardens, telecommunications infrastructure maintenance engineers
- computer/IT companies' sales, demonstrators, and maintenance personnel
- journalists filing copy from remote locations.

To formalise this knowledge about the extent to which portable computers are used, we contacted a sample of 300 public and private sector organisations by telephone. We used a directory containing contact details of health and safety personnel (Personnel Managers Yearbook 1998-99) to source our contacts. We covered small, medium and large enterprises, from geographically diverse regions of the UK, and across both public and private sectors. We attempted to speak to the person responsible for DSE health and safety within each organisation, explained the purpose of HSE's research, and, if they were willing to help, administered a questionnaire to them.

Before making the calls, we developed a telephone interview brief that addressed the questions in which HSE was interested. The questions we asked covered:

- the organisation's business activity
- the number of people employed (in any capacity) by the organisation
- the approximate number of (any type of) DSE users within the organisation
- the approximate number of people using portables for their work
- whether portable computers were used alone, or in addition to desktop computers
- the types of equipment they use, i.e. manufacturer, keyboard technology, screen technology, type of non-keyboard input devices, type of battery/power supply, etc
- the type of work, i.e. job and task descriptions of the people who use portables
- the tasks for which they would use their portable computers
- the locations in which their staff used portables
- the estimated amount of time these people spend using their portables
- any problems (of any type – musculoskeletal, visual, theft etc) that had been reported by portable users which they believed to be associated with the use of their portable
- any other comments about the use of portable computers within their organisation
- and finally, whether they would be prepared to co-operate in data collection in later stages of the project.

4.2 Investigate use of portable computers within organisations

In section 4.1 we described the methods we used to address HSE aim A. Here we describe the main data collection steps of the project, which addressed HSE aims B, C and D. We used a three-part user-centred method that we had developed and used during many other client assignments. The components of this method are described briefly below.

Staff views. Much of HSE's recent legislation places great importance on the views of staff themselves. We gathered staff views using questionnaires and interviews, which supplemented our own ergonomic observations and direct measurements. In general, the interviews and questionnaires covered various aspects of the working environment, the health symptoms staff may experience, and working practices.

Direct observations. Our researchers, who were all qualified ergonomists, spent time on site directly observing working practices, task design, and taking measurements of equipment, furniture and the working environment.

Analysis of organisational data. We collected information from key personnel about other relevant aspects, including health and safety policies, accident/injury statistics (where available), training policy and practices and so on.

Our method for this assignment consisted of a number of key steps, which we describe in the following sections.

4.2.1 Develop end-user questionnaire

One of our standard practices in ergonomics surveys is to distribute questionnaires to a sample of end-users. We used a variety of scales within these questionnaires, performed statistical analyses on the completed questionnaires, and compared user populations on different variables.

For this research we developed a detailed questionnaire with which to match and compare desktop DSE users and portable DSE users. Not only did we wish to compare purely desktop DSE users with purely portable DSE users, but we also wanted to be able to compare both of these types of user with those portable DSE users who used 'docking stations' i.e. a portable computer with a separate full sized screen and/or keyboard attached. We were interested in this comparison because, in theory, the use of docking stations is widely considered to be good practice for the safe use of portables when they are in prolonged use at a workstation. Many companies amongst our client base provide some form of docking station for their portable computer users to use if they are operating the portable computer for a long period of time in a particular location.

We were also interested in gathering information on how long people carried out particular tasks using their portable computer; and on average, how long people worked in different locations (at home, while travelling, at client sites, etc) in the course of a typical week. We included questions on all of these issues. A single combined questionnaire was developed for desktop and portable users. A separate questionnaire was developed for handheld computers, as these have very different designs and features (for example, they are much smaller than a portable computer, have much smaller screens/keyboards, often have non-standard keyboards) to portable computers, and are used in highly variable contexts.

The user questionnaires covered the following issues:

- job type
- the type(s) of computer equipment used
- the input devices used with the computer equipment
- total weekly hours spent by respondents on their jobs, including computer-based tasks and non-computer-based tasks
- average weekly hours of computer use for work
- formal and informal break patterns
- information and training on health and safety aspects of DSE use
- frequency of musculoskeletal, visual, and other health effects experienced by users
- overall staff satisfaction with a range of aspects such as working environment and features of the equipment
- computer usage at home for non-work activities
- background information such as age, sex, length of time within the job/organisation, etc.
- tasks carried out with portable computers
- the locations where portable computers were used, and the average time spent using them in each location
- manual handling aspects of portable computer use
- aspects of the design of their portable computers that the respondent liked and disliked
- what improvements would they make to the design
- perceived risks associated with their use of portable computers.

4.2.2 Develop observer and evaluation checklist

Although user questionnaire data provides much valuable information, self-report data can be subject to various sources of bias. We conducted independent observations of equipment, environments and tasks, and interviewed users to explore certain issues in more depth. Using supplementary interviews and observations as part of the research, we helped to meet aims C and D: to identify features of portable equipment, and the environments in which they are used, which are undesirable or desirable from the point of view of users' health and safety. Key aspects of task design, break patterns, and other working practices were explored, in discussions with users, with health and safety personnel, and through our ergonomists' observations.

In order to gather relevant detailed information about the equipment, key design features, and working practices in a systematic and organised manner, we developed a checklist which was used as the basis of the ergonomists' observations and the structured interviews. This checklist included:

- size and technology of display screen
- size and layout of keyboard and keys
- nature of non-keyboard input devices
- system performance issues
- details of DSE and non-DSE tasks
- working practices and break patterns
- measured weight of computer, accessories, and paperwork
- method of carrying - shoulder strap(s), handle, backpack, etc. and ergonomics aspects of the method of carrying.

Between 15 and 20 respondents per organisation were identified from the questionnaires and interviewed. As far as was practicable, we attempted to meet and interview respondents in the locations where they used their portable computer for the greatest length of time, to observe them carrying out typical tasks under these environmental conditions. Most interviews with portable computer users took place at the user's main office or satellite office. The interviews with handheld users (sales staff and parking attendants) took place in the retail outlets and during the parking attendant's 'beat'.

4.2.3 Pilot user questionnaire and observer checklists

It is essential to carry out pilot testing of research materials before widespread use. After developing our initial questionnaire designs, we piloted them with a small sample of portable and handheld computer users within one organisation, and modified them in the light of their responses. This enabled us to ensure that we were covering the main points in the right level of detail and asking questions that the recipients could understand and answer consistently. It also provided an opportunity for us to:

- check that the questionnaires were free from ambiguity and bias
- plan the data analysis procedures
- check that the statistical techniques used were appropriate
- schedule the data collection.

4.2.4 Finalise data collection instruments, sample and conduct data collection

We used the results of the pilot test to refine the data collection materials and the analysis techniques. During our telephone research, we identified four organisations which employed groups of people doing similar jobs to one another, using different types of computer equipment, i.e. standard desktop DSE and portable DSE, and two organisations whose staff used handheld computers. The questionnaires were administered to a sample of people within both groups. The returned questionnaires provided the basis for the statistical comparisons between desktop users, portable users, and docking station users.

4.2.5 Statistical approach

The data from the self-completed questionnaires were analysed using the commercial statistical analysis package Statistical Package for Social Scientists (SPSS PC Version 10). Data from each site were first analysed separately, to obtain a feel for the likely patterns of results. Following this, the key data from each site were combined and analysed as a group. The majority of the results in this report come from this large combined data file – all the basic descriptive details of the sample are provided in Chapter 9.

To meet the requirements of aim B (determine the extent of health problems associated with portable DSE and the risk factors involved; and compare these with standard full-sized DSE) much of the analysis centred around the results of the "symptoms and discomfort" section of the questionnaire. In this section participants were asked to describe how frequently they experienced symptoms of:

> *"Fatigue, stress, headache, irritated eyes, difficulties reading your work on the screen"*

Throughout the report these five are described as the "symptoms". Respondents were also asked how frequently they experienced pain, aches, tingling, pins and needles or general discomfort in the:

> *"feet, legs, back, neck, shoulder, arms, wrists, hands/fingers"*

These are subsequently referred to as the "discomfort areas". Respondents were given four frequency descriptions from which to choose:

Frequently *– means you experience symptoms several times a week*
Sometimes *– means you experience symptoms more than every few months, but less than several times a week*
Rarely *– means you only experience symptoms every few months*
Never *– means that you never experience these symptoms*

So, for each symptom and discomfort area, respondents gave a rating of frequency of occurrence. These ratings were used in two ways during the analysis, either as a specific measure of a particular symptom or discomfort area, or as an "amalgam". The amalgams were created to give a more general indication of the occurrence of symptoms and discomfort. For each respondent, four new amalgam measures were calculated:

1. the total number of "sometimes" and "frequently" responses given for all of the five symptoms
2. the total number of "frequently" responses given for all of the five symptoms
3. the total number of "sometimes" and "frequently" responses given for all of the eight discomfort areas
4. the total number of "frequently" responses given for all of the eight discomfort areas.

Several main statistical tests and procedures were used to analyse these and the other data. *T tests for independent samples* were used to test for differences between two groups of respondents where the dependent data were at an appropriate level (for instance for the amalgams, or for the number of items carried in addition to the portable computer). We mainly used t-tests for testing differences between groups of respondents on the symptom and discomfort "amalgam" measures. These data are at interval level and, since the range of the amalgams was very limited, the variance was very similar across groups. The amalgams were not, however, likely to have been drawn from a normally distributed population since many more people reported very few, or no, sometimes/frequentlys on the symptom and discomfort ratings than reported several. Although, ideally, the t-test is only used where the data are drawn from a normally distributed population, we believe that the test was, none-the-less appropriate. We were comparing similarly shaped distributions which had a limited range (no outliers). Our data satisfied two of the three main requirements and, since the t-test is well known to be robust even when some of the usual requirements are not met, we are confident that the results obtained are reliable.

There were significant correlations between the individual symptoms, and between the individual discomfort ratings, that were summed to make the amalgams. This is entirely expected, but does not, in our view, compromise the validity of the amalgams or of the t-test procedure. Amalgams were used to give a picture of the overall pattern of symptoms or discomfort. Given that all respondents were presented with identical symptoms and discomfort areas to rate for frequency (so they could not "add" their own options), it is reasonable to assume that summing the answers does give an overall total which reflects the relative amount of discomfort felt. We did not believe that this intercorrelation between symptoms and discomfort would adversely affect the outcome from the t-test.

Mann Whitney U tests were used for similar comparisons between two groups where the dependent data were not ideally suitable for a t-test (for instance, the individual symptom and discomfort frequencies). We used the Mann Whitney test to compare

the “raw” data from respondents about the frequency of individual symptoms and discomfort areas. This test seemed most appropriate since the data were not at interval level (they were ordinal). We believed that without interval data, a non-parametric test would be more reliable that a parametric test (such as the t-test).

Both parametric (Pearson) and non-parametric (Spearman) correlation co-efficients were used, again depending on the level of data. Pearson was used for measures such as respondent height, years using a portable, hours worked per week, and the four amalgams. Spearman was used primarily where the frequencies of individual symptoms and discomfort areas were investigated in a correlation.

In most cases, independent variables were tested in pairs, one *versus* another, so that the results could be clearly understood. For instance, in comparing the discomfort ratings of users of three different brands of portable computer, brand A was compared to brand B and brand C in two separate tests rather than using one test for a three-way comparison. Tests comparing more than two variables at one time (such as Analysis of Variance, ANOVA) can give ambiguous results which require further interpretation, since they do not specify exactly which variables differ significantly from one another. For instance, using the previous example, if a significant ANOVA result was obtained, it would not be clear whether the significant difference was between brand A *vs* B, B *vs* C or A *vs* C.

Although this pair-wise comparison method has the advantage of avoiding ambiguity, the risk of giving “false positive” results is increased – i.e. results which are shown to be significant, but which are in fact due to chance. This effect is due to the larger number of tests required, which increases the likelihood of random effects. This risk has been considered in the interpretation of the results.

Finally, there are two points to note regarding the inclusion of the various companies’ data. One company provided many more respondents than all the others counted together (1680 people vs 512). Early analysis of the separate companies’ data showed that the results from this company did not appear to be unusual compared to the other sites, and so it was included in the full analysis without weighting.

Secondly, the activities of participants in one of the companies differed very considerably from those in the rest of the sample, involving large amounts of standing and walking throughout the whole of the working day. The questionnaire responses from this group showed a disproportionate amount of foot and leg discomfort. When the analysis of all questionnaires was carried out this gave skewed results by introducing more frequent than normal amounts of feet and leg discomfort, which were related to the nature of the job rather than the use of the computers. For this reason, responses from this company were excluded from much of the data analysis, although they were included where the skewing effect was not a problem.

4.2.6 Description of results

In the following Chapters 5 to 16 we provide our results. There are 12 Chapters providing the results from each of the activities we have undertaken in the course of this research. Within these chapters we describe our findings, and also analyse and discuss the implications of these results in each section. We believe that this approach will make the interpretation of the results clearer to the reader than placing all of the discussion of the results in a separate chapter. In the final Chapter 17 we bring together our recommendations. These are based on a synthesis of all the varied sources of information collected during this research.

5. OUR FINDINGS – LITERATURE REVIEW

In this chapter we review the literature that we have found to date relating specifically to the use of portable computers. The literature review was carried out using a keyword search of Ergonomics Abstracts (which contains approximately 50,000 abstracts from journal articles, conference papers, books and reports pertinent to ergonomics/human factors) using the Ergonomics Information Analysis Centre. The relatively small number of papers found is likely to be associated with the fact that portable computer use has only become widespread in the last five to ten years. Eight of the papers were published in peer-reviewed research journals, books and conference proceedings. The remainder were summarised from information identified from other sources, such as regulatory guidance leaflets, in-house company policies and trade magazines.

5.1 Literature review

Our literature review took place in the early stages of the project, between January and April 1999. Each paper is summarised briefly below.

Peer reviewed journals, books and conference papers:

Bringelson, L.S. et al. *An empirical investigation of pointing devices for notebook computers.* Advances in Occupational Ergonomics and Safety. IOS Press. 1998

This study examined the effect of a conventional mouse and an integrated push-button device on a notebook computer (IBM ThinkPad 700C PS/2) with ten subjects. The results indicated that response time was significantly faster with a conventional mouse, and there was no difference in errors between the two input devices. The post experimental questionnaire indicated that users were willing to buy a conventional mouse if they had a notebook with the integrated push-button, to make the entire system quicker and easier to use.

Harbison and Forrester. *The ergonomics of notebook computers: problems or just progress? Journal of Occupational Health and Safety* – Aust NZ, 11 (5):481-487. 1995.

This was a research study using five subjects taken from the accounting staff of a major company. The staff used their portables in the office and "in the field" and their postures, joint angles and subjective ratings of discomfort were taken while using the portable computers.

The basic result was that the participants in the study showed considerable forward head inclination when using their portables, and that there was increased discomfort in the neck and upper back region. The average forward head inclination was 45°, trunk posture was nearly vertical and the average elbow angle was over 100°. The highest discomfort ratings

were for the neck and upper thoracic regions. The average time using the portables was measured at 22 hours per week (less than the subjects' estimate of 29 hours).

The authors concluded that the forward neck angle was considerably more inclined than the recommended viewing angle for screens and this was likely to cause significant loading on the neck muscles. They suggested that detachable screens could alleviate this problem, by allowing the user to place the screen much higher than currently. However, they noted that this would only work if there were a suitable higher surface on which to place the screen. They also noted that portable document holders might help, since their subjects tended to place reference documents on the desk to the side of the keyboards, which increased the tendency to bend the neck down (to see the documents).

Horie, Yoshinorie. *A Comparison of psycho-physiological responses from users of desktop PCs versus notebook PCs.* Proceedings of the 5th Pan-Pacific Conference on Occupational Ergonomics. 1998.

Ten male university students, aged 22-23 carried out two experimental word processing tasks on a desktop PC and a notebook PC. The English translation in this paper was poor and difficult to understand, but from what we could determine, it appeared to say that the notebook PC had a better display luminance and sight angle than the desktop. This surprises us, and may be due to the poor translation.

Rejmaniak et al. Compaq and University of Houston. *An evaluation of trackball device placements during elemental pointing and dragging tasks.* Proceedings of the 4th Pan-Pacific Conference on Occupational Ergonomics 1996.

Nineteen participants performed pointing and dragging tasks on four notebook computers: Contura, Contura Aero, Contura 400 and Elite. Each had the trackball located in a different place:

Table 1. Speed and accuracy effects associated with trackball location on portable computer (ranked within columns)

Notebook type	Position of trackball	Speed of dragging (1 is quickest)	Speed of pointing (1 is quickest)	Mean positioning error – dragging (1 is lowest error)	Mean positioning error – pointing (1 is lowest error)
Contura	Attached to right hand side of notebook at 45 degree angle	2=	3	2	2
Contura Aero	Built into lower right hand corner of keyboard	1	2	3	3
Contura 400	Just below keyboard in middle of notebook	2=	4	4	4
Elite	Lower right hand corner of display panel	3	1	1	1

Straker et al. *A comparison of the postures assumed when using laptop computers and desktop computers.* Applied Ergonomics. 1997.

This research compared postures and discomfort in 16 people using laptop and desktop computers for tasks taking approximately 20 minutes. Statistical analysis showed significantly greater neck flexion and head tilt with laptop use. Other body angles showed no statistical differences. 75% reported visual tiredness after using the laptop display for just 20 minutes. Prolonged laptop use was considered likely to lead to musculoskeletal and visual disorders. Although laptop use resulted in poorer postures, it also resulted in a trend for improved performances.

Saito et al. *Ergonomics evaluation of working posture of VDT operation using personal computer with flat panel display.* Industrial Health 1997, 35, 264-270.

Ten people carried out word processing tasks using both notebook and desktop computers. Significant differences were recorded for viewing distance, viewing angle and head angle. Work posture using the notebook was characterised by a very short viewing distance and forward head inclination. The EMG of the neck muscle was higher using the notebook compared to the desktop.

Villanueva, M.B. et al. *The human factors of notebook PCs. Evaluation of posture and muscle activities.* Proceedings of the 5th Pan-Pacific Conference on Occupational Ergonomics. 1998

Ten subjects performed a text entry task using five different types of computer – one desktop, four notebooks (PC-Flat Panel Display (FPD)). The results showed lower viewing and neck angles, forward trunk inclination and shorter viewing distances for the PC-FPDs. Increasing discomfort and difficulty of keying for smaller FPDs was observed. Greater inward rotation of the shoulders was observed using FPDs, but the desk was used more effectively as a forearm rest. The two smallest FPDs attracted the highest proportion of complaints of eye and musculoskeletal discomfort, and neck muscle EMG activity. Elbow and wrist discomfort was recorded on two of the FPDs.

Yoshitake, R. *Relationship between key space and user performance on reduced keyboards.* Applied Human Science, Journal of Physiological Anthropology. 1995

Eighteen touch-typists completed a word typing task on five different keyboards, with key spaces of 19.05mm (IBM ThinkPad 700C), 16.7mm, 16.0mm, 15.6mm and 15mm (IBM ThinkPad 220). Keyboard spacing of 19.05mm is typical of 'standard' desktop PC keyboards. The typists were divided into two groups on the basis of finger-tip width. For people with both large and small fingers, there was no difference in performance on the keyboards with 19.05 and 16.7mm key spacing. For people with large fingers, their performance ratings decreased for a key space of 16.0 and 15.0mm. There was no

performance decrement for people with small fingers at any key spacing. No significant effect in error rate for either group was found.

Other publications:

Health and Safety Executive *"Working With VDU's", number INDG36(rev1) dated 2/98*

The HSE has issued general guidance on the issues surrounding the use of DSE, which is almost completely related to desktop machines. However, there is a short section on advice for portable computer users. We understand that HSE included the advice on portables in this publication as an interim measure until research results were available on which more detailed recommendations could be based.

Key recommendations from this document:

- It is best to avoid using portables for long periods when full sized equipment is available
- People who use portables (like other DSE users) should be trained in how to minimise the risks
- This training should include sitting comfortably, angling the screen to avoid reflections and taking frequent breaks
- Where possible keyboards should be placed at the right height for keying.

It is interesting to note that the guidance seems to be suggesting placing the keyboard at the right height for keying. Whilst helpful for the hand/arm posture, this would certainly increase the head/neck angle when looking at the screen.

Major insurance company *Portable computer policy*

This insurance company issues guidance to its staff on the safe use of laptop computers.

Key recommendations from this guidance:

- Laptops should only be used for work outside the office
- Maximum use should not exceed 3 hours/day (and no more than 20 minutes at a time)
- Laptops should be connected to docking stations when they are likely to be in prolonged use
- Manual handling guidance applies to the carrying of laptops and appropriate cases for carrying should be used
- The screen should be adjusted so that the head is slightly downwards to view it
- The laptop should be placed to avoid glare problems.

PC Laptop computers magazine *"How to keep a keyboard from claiming your arms"* September 1996, volume 8 No 9

This is a more general article commenting on the risks from Repetitive Strain Injury "RSI", but with respect to laptop use in particular. It notes that users should watch out for early symptoms to avoid permanent injury (aching, numbness, pain, crackling joints, muscle spasms, limb weakness). The article recommends the use of wrist rests (or simply some rolled up fabric in front of the keyboard) and outlines a suggested best posture for computer use (which is exactly that recommended for normal desktop use). It noted that the impromptu use of laptops means that users are less likely to spend time making sure their posture is good. The negative effect of keying in cold environments is noted, and users are warned to avoid typing when their hands are cold, or in the draught from air conditioning. It suggests trying to keep the neck, shoulders and arms relaxed when using a portable computer and recommends taking frequent breaks. Finally, the article warns against "working through pain", since pain is a signal to stop a harmful activity.

Unison *report on survey of the health and safety problems of careers service advisors using laptop computers. 1998*

The union organisation Unison conducted a survey of careers service advisors who had increased their use of laptop computers in order to meet action plan targets. 500 careers advisors responded to the survey and 62% of these used their laptops for over 5 hours per day (25 hours per week). There were many interesting results from this survey, although several were specific to the environments in which careers advisors work. We summarise the main points here:

- careers advisors had received little (if any) training about the health and safety aspects of portable computer use
- 55% thought their laptops were heavy – carrying them for considerable distances had led to back, neck, and shoulder strains and injuries
- respondents commented that they usually had to carry documents and paperwork as well as their portable computer. These extra items could be very heavy
- 61% suffered back pain (47% "occasional to frequent")
- 60% suffered neck pain (47% "occasional to frequent")
- several respondents reported serious injury which they associated with portable computer use, and had had time off and required physiotherapy
- 55% suffered pain in their arms and hands "as a result of using their laptop" and some respondents' ability to carry out household tasks was affected
- 68% suffered eyestrain (19% "frequently")
- 63% reported headaches (12% "frequently")
- respondents noted that the pressure of work made it difficult to take breaks
- they stated that stress levels were increased by regular "crashing" of the computers
- 49% were concerned about the risks of assault from carrying around their laptops – they felt "vulnerable".

The Unison report commented that:

> "Lap-top computers cannot conform to all the health and safety requirements of the DSE regulations due to their design, therefore extra care is needed in identifying risk factors. They cannot be used for such long periods as conventional VDUs/desktop computers. This means that extra attention needs to be paid to the work environment, workstation layout, pace of work and rest breaks."

The report made several recommendations, both in general terms, and related to specific aspects of laptop use. We include the relevant ones below.

The specific advice for the use of laptop computers was to:

- Replace laptops with PC's
- Carry out a risk assessment on the use of laptops
- Provide training in the importance of adopting a suitable posture
- Provide training in touch typing and ensure careful selection of laptops for best ergonomic features
- Alert staff to the potential dangers and to the importance of reporting any symptoms of aches or pains early
- Provide suitable chairs and workstations
- Monitor staff regularly to find out if they are having any problems
- Reduce length of time used and ensure rest breaks are built-in and taken
- Provide manual handling training
- Assess manual handling risk from carrying the portable computers
- Make staff aware of the risk of eyestrain and provide them with free eyesight tests and special glasses if necessary
- Check the lighting conditions where the user is working to ensure that they are adequate
- Comply with HSE guidelines on stress
- Carry out stress monitoring (anonymously)
- Reduce pace of work, provide rest breaks and ensure variety exists in the job
- Provide training on the risks of violence
- Provide mobile phones or make arrangements to know location of staff.

Wright, J. *Some risk factors for computer use.* Workplace Health and Safety, Department of training and industrial relations. Australia. 1996

Forty-four participants were given a questionnaire based on the Nordic Questionnaire. The measure of risk chosen was the perceived level of pain in the neck, shoulder, or upper extremities. The findings indicated that pain was significantly related to number of hours per week working on laptop computers (more than 2.5 hours/week), and may also be related to total hours per week. If participants performed more than 20% of their computing on a laptop, there was an increased risk of musculoskeletal injury. Lack of adjustable furniture,

level of computer literacy, using a modem, graphical vs text-based interfaces, and Internet usage were not identified as risk factors.

5.2 Overall summary of results from literature review

We summarise the results from the literature review in the bullet points below.

- Work posture with laptop/portable computer use was associated with shorter viewing distances, greater forward head inclination and greater neck flexion than work posture with desktop computer use
- People reported increased neck and upper back discomfort while using portables
- Neck discomfort and shoulder discomfort were associated with the number of hours worked on the portable
- Differences in trackball positioning on portable computers affected the speed of dragging and pointing, and error rates
- Small key spacings were associated with lower performance levels when used by people with large finger-tips
- The weight of the portable computer (and associated equipment and paperwork) and the risk of theft/assault caused considerable concern amongst a group of public sector employees. Musculoskeletal and visual symptoms occurred to a considerable extent amongst this group.

We used some of these findings from the literature review to help develop the approach used in the main part of the research.

6. OUR FINDINGS – MARKET REVIEW

To help meet the requirement stated in aim A, we examined the overall market for portable computers over the 1990's. The market review was conducted in early 1999. Below we illustrate the growth of the market for desktop and portable computers over the years 1993 to 1998.

6.1 Sales of desktop and portable computers in the UK

Over the 1990's, the computer market shifted away from multi-user systems (i.e. terminals linked to mini- or main-frames) towards the desktop market, consisting of personal computers, desktop computers and portable computers based on a single microprocessor. In 1998, sales of personal computers accounted for 57.9% of the total UK market.

The table below shows the growth in the number of units of portable and desktop personal computers between 1993 and 1998. The overall computer market over the six year period grew by 60%, and portable computers were an increasingly large proportion of the overall total. Just under one in five computers sold in 1998 was a portable computer.

Table 2. Keynote Report for 1998 on the UK Personal Computer Market

		1993	**1994**	**1995**	**1996**	**1997**	**1998 (est)**
Value (£m at manufacturer sale price)	Portable	667	816	935	1,188	1,290	1,449
	Desktop	2228	2511	2933	3,308	3,564	3,966
	Total	2905	3327	3868	4,496	4,854	5,415
Average prices (£)	Portable	1794	1895	1978	2057	1938	2102
	Desktop	1204	1241	1240	1283	1297	1364
Units '000	Portable	337.44	430.85	472.64	557.56	665.35	689.44
	Desktop	1850.66	2023.36	2365.30	2,577.89	2,747.04	2,906.76
	Total	2228.1	2454.2	2837.94	3,155.45	3,412.39	3,596.20
Portable computers as proportion of total PC computer market							
	Total	15.1%	17.6%	16.7%	17.7%	19.5%	19.2%

Source: The British Library - Business Information Library. Published October 1998

Other published data confirms these figures. The table below indicates that there was a percentage growth of 62% in the number of portable computers sold between 1993 and 1996.

Table 3. Segmentation of the PC Market: £m at manufacturer sale price (msp), unit volumes ('000) and average price (£),1993 – 1996

	1993	**1994**	**1995**	**1996**	**% change 1993-1996**
£m (at msp)					
Portable PC	548	659	831	967	76.8
Desktop PC	1893	2135	2422	2639	39.3
Total	2441	2794	3253	3606	47.7
'000 units					
Portable PC	392	448	538	636	62.2
Desktop PC	1923	2102	2350	2587	34.5
Total	2315	2550	2888	3223	39.2
Average price (£)					
Portable PC	1395	1471	1544	1520	9.0
Desktop PC	985	1016	1031	1020	3.6

Source: Keynote Report, 1998

Finally, we identified some data concerning the use of portable computers in the 'Small Office Home Office' sector. It appears from this data that portable computers had a lower market penetration than desktop computers in the SOHO market, which is likely to be associated with the difference in price – approximately £800 at 1998 prices.

Table 4. Segmentation of the SOHO (i.e. consumer) computer market, desktops versus portables, in 1998

	'000 units	**%**	**£m**	**%**
Desktop	1,645	94	1,835	90
Portable	105	6	200	10
Total	1,750	100	2,035	100

Source: Mintel 1998

6.2 Summary of market review

The results of the market review show that the overall computer market over the six year period has grown by approximately 60% since 1993, and portable computers occupied an increasingly large proportion of the overall total. Just under one in five computers sold in 1998 was a portable computer. There was a lower proportion of portable computers used in the SOHO sector which may be attributable to price differentials between portable and desktop computers, or the nature of the usage required.

7. OUR FINDINGS - RESULTS FROM TELEPHONE RESEARCH

We conducted a telephone survey of approximately 300 UK companies, contacting those listed as being responsible for health and safety matters, using the Personnel Managers' Yearbook 1998-99 as the main source of contacts.

We were able to speak to 108 health and safety managers in total. Of these 108 people, we received a positive response (i.e. defined as a full telephone interview with 95% of the questions answered) from 70 health and safety personnel (response rate 65%). Of the contacts who did not respond to the full questionnaire, 28 did not believe that anyone in their organisation used portable computers, and ten could not respond as they reported that it was company policy not to provide information for such research surveys. The results in this section provide information most relevant to the first of HSE's aims (aim A) and also provide some information pertinent to aims C and D.

7.1 The questionnaire

Each interview session was guided by an eleven-part questionnaire. The items contained within this questionnaire were open-ended to allow for a variety of answers. Information volunteered by the respondent which did not fit these questions was recorded in a final "Other comments regarding the use of portable computers" section. Each interview session lasted approximately ten minutes on average, and the confidentiality of the responses was assured to each respondent.

7.2 The results

The results of the survey appear in the order we used in the questionnaire to elicit information from the 70 respondents.

7.2.1 Organisation information

The following sections describe the aggregated data for the overall number of people employed in the respondents' organisations, the industry sector, the numbers of computers used, and the number of portable computers used.

(a) Overall number of employees

Table 5. Employee data

Total no. of employees		300,850
Average no. of employees per company	Mean	4298
	Mode	1000
	Median	1600
Minimum no. of employees per company		150
Maximum no. of employees per company		60,000

The table above shows the combined data for the 70 respondents in terms of number of employees. In total, they spoke for organisations employing just over 300,000 people. The largest company employed 60,000 people, and the smallest, 150 people. The average number of employees per company was approximately 4,300.

b) Number of companies and computers per industry sector

The following table describes the industry sectors and numbers of desktop and portable computers per company interviewed.

Table 6. Industry sectors using desktop and portable computers

Industry Sector	Total no. of companies	Total no. of employees	Avg. no. of employees	Total no. of computers (desktops and portables)	Avg. no. of computers (desktops and portables)	Total no. of portable computers	Average no. of portable computers	Proportion of portable computers (%)
Aeronautics & Ships	1	550	550	150	150	35	35	23
Banking, Finance & Insurance	6	121000	20167	97000	16167	9250	1542	10
Building / Construction	4	10100	2525	3535	884	705	176	20
Central Government	1	1000	1000	900	900	100	100	11
Chemicals & Allied Products	1	1550	1550	850	850	700	700	82
Commerce/Retail /Trading	3	36450	12150	10800	3600	1206	402	11
Communications	4	5400	1350	2990	748	304	76	10
Computer Manufacturing & Services	3	9355	3118	9300	3100	4530	1510	49
Consulting / Professional	3	12000	4000	9650	3217	4105	1368	43
Education	2	1200	600	300	150	42	21	14
Electrical Engineering	4	7160	1790	5000	1250	1135	284	23
Energy	2	7000	3500	1900	950	800	400	42
Food, Drink & Tobacco	8	34720	4340	13740	1718	2950	369	21
Health Authorities, Trusts, Hospitals	4	13650	3413	7250	2417	610	153	8
Household Products & Appliances	2	4500	2250	1000	500	100	50	10
Industrial Services	1	1200	1200	250	250	20	20	8
Local Government	2	14070	7035	12250	6125	604	302	5
Mechanical Engineering	3	1950	650	550	183	47	16	8
Metals	1	1600	1600	1000	1000	200	200	20
Motor Vehicles	2	1450	725	400	200	6	3	2
Petroleum	1	2000	2000	1600	1600	800	800	50

Industry Sector	Total no. of companies	Total no. of employees	Avg. no. of employees	Total no. of computers (desktops and portables)	Avg. no. of computers (desktops and portables)	Total no. of portable computers	Average no. of portable computers	Proportion of portable computers (%)
Pharmaceuticals	2	1500	750	950	475	325	163	34
Textiles/Clothing /Footwear	2	2145	1073	180	90	6	3	3
Timber/Paper/ Packaging	2	550	275	65	33	17	9	26
Travel/Transport	4	7000	1750	4000	1000	339	85	8
Other Services/ Products	2	1750	875	750	375	320	160	43

The table shows that the respondents were drawn from a wide organisational base, including both public and private sector organisations from a range of industry sectors.

The five industry sectors which appeared to make the widest use of portable computers were:

- Chemicals, petroleum and allied products
- Computer manufacturing and services
- Consulting/professional
- Other services/products
- Energy.

7.2.2 Extent of personal computer use

We asked respondents approximately how many employees used computers for work purposes, and of these employees, how many used portable computers.

The table indicates that the number of computer users in the sample was approximately two-thirds of the total number of people employed by the organisations. Of these computer users, approximately 15% were portable computer users. This compares well with the information gained in Chapter 6 on the proportion of portable computers sold as a proportion of total computer units sold.

Table 7. Number of computer users and number of portable users

		No. of computer users	No. of portable computer users
Total no. of users		186,210	28,726
Average no. of users per company	Mean	2699	410
	Median	700	90
	Mode	150	10
Minimum no. of users per company		15	2
Maximum no. of users per company		50,000	5000

(a) Were portable computers used in addition to, or instead of, desktop computers?

When asked if their users operated portable computers as well as desktop computers, or whether they only used portable computers, approximately half the respondents reported that their staff used portables in addition to desktops. A quarter reported that their portable computer users used a portable instead of desktop equipment, i.e. it was their only machine. Some respondents thought that people used them both instead of, and in addition to desktops. Twenty-two organisations provided portable users with docking stations or a separate plug-in display screen and/or keyboard.

Table 8. Usage of portable computers in addition to or instead of desktop computers

Category	Number of organisations
Portables used in addition to desktops	32
Portables used instead of desktops	16
Both (instead of & in addition to)	19
Docking stations/extra display screen/keyboard made available for use by portable users in certain office locations	22

(b) Type(s) of portable computer used

The table shows that the majority of portable computer users used laptop/notebook computers (respondents did not distinguish between the terms ‘notebook’ and ‘laptop’ computer, but did see differences between these and ‘handheld’ and ‘palmtop’ computers). Less than ten percent of the sample used handheld computers, and less than five percent used palmtops.

Table 9. Percentage of organisations using portable computers

Type of portable computer	Percentage of organisations
Laptop/notebook	87.5
Handheld	9
Palmtop	3

(c) Manufacturer and model(s) of portable computer used

The table shows that the business portable computer market amongst the respondent sample was dominated by four main manufacturers.

Table 10. Portable computer manufacturer market penetration

Manufacturer	Number of organisations reporting particular manufacturer and model type
Brand A	11
Brand B	10
Brand C	11
Brand D	8
Brand F	2
One mention each of nine branded or badged machines	9
Not sure of exact manufacturer/model	11

For the main part of the research we attempted to identify organisations willing to participate which used the four main types of computer equipment identified here.

7.2.3 User details

This part of the telephone interview asked for information on the occupational status and type of tasks carried out by those people who used portable computers.

a) Job titles/occupations of portable computer users

The respondents were asked to provide job titles for the portable computer users within their organisation. They could give more than one answer if portable computers were used by different groups within their organisations. The table shows that the three main groups of people who used portable computers in this respondent sample were those carrying out managerial jobs; sales staff; and engineering/technical staff. Although this information is based on the respondents' awareness of job titles, we believe that the table below provides a representative picture of portable computer use across the UK manufacturing and services sectors. It also matches our own experience of working closely with a wide range of public and private sector organisations over the past ten years in which portable computers have become more widely used.

Table 11. Occupations of portable computer users

Job Type	No. of times reported
Director/manager	44
Sales staff	22
Engineering/technical	19
Information technology staff	9
Financial staff	9
Supervisors	9
Consultants (e.g. business/tax/information technology//audit)	8
Field staff	5
Human resources	4
Clerical/secretarial staff	3
Marketing staff	2
Health and safety staff	2
Medical staff	2
Security staff	2
Others (one mention each)	Trainers Customer complaints Service requirement staff Central status officers Journalists Lawyers Architects Risk surveyors Advisory contractors Teachers Archaeologists Relationship managers M.I.S. (management information services) Parking management

(b) Tasks undertaken by portable computer users

Respondents were asked what types of tasks their portable computer users carried out. Table 12 shows the results. The overall variety of tasks was considerable, but the major categories consisted of what can be described as typical office tasks, such as word processing, email, creating presentations, and database/spreadsheet manipulation. These tasks reflect the main activities of the people described in the job categories provided in Table 11 on the previous page.

Table 12. Tasks carried out by portable computer users

Task	**No. of times reported**
Word processing/report writing/letter writing	56
E-mail	40
Spreadsheets	35
Database	33
Using software to create and give presentations	18
Sales information/sales tools (including on-screen demonstration)	5
Making temporary notes/records	4
Accounts	4
Technical design	4
Statistics	2
Administration	2
Others (one mention each)	Auditing/checklists Intranet use Programming Using mainframe territorial applications Invoicing & purchase ordering Using main business systems network "Alerting" (linked to burglar alarms) Building management services Law Programming machinery Fault-finding On-site client work Corporate strategy work Access to network Logistics Issuing/printing parking tickets Customer service Using Special software

c) Locations where portable computers are used

The range of locations in which portables were used was also varied. The four most common locations in which portables were used were at home, in (own) company locations, at client/customer locations, and while travelling on various forms of transport. Again, we believe this information to be representative of the locations of portable computer use within UK industry as a whole.

Table 13. Locations where portable computers were used

Location		**No. of times reported**
Home		58
Office	Own	27
	Regional branches	8
	Client/other	11
On-site	Own	24
	Client	18
Travel	General	35
	Car	6
	Train	3
	Plane	2
Customer premises (general)		4
Hotel		9
Abroad		1
Airport lounge		1
Home visits (customer house)		1
Meetings (general)		1
Streets/car park		1

d) Estimate of the amount of time that an employee will typically spend using their portable computer

Respondents found this question difficult to answer. Eighteen of the respondents mentioned that the hours varied “a lot”, and 20 respondents could not give an answer (“don’t know”). Of those that could give an answer, some chose to answer it in terms of the total average number of hours per day or as a percentage of working time. These responses produced a total average of 2 hours per day.

Other respondents found it easier to report the typical number of hours that their employees spent using a portable computer in terms of a minimum and maximum number of hours per day or per week (or in terms of minimum and maximum % of working time). The average minimum time given was three hours per day, the average maximum time, six hours per day.

7.2.4 Risks associated with the use of portable computers

Respondents were asked if any portable computer users had reported any problems associated with the use of their portable computers. They were not 'prompted' in any way by the interviewer in their responses.

Musculoskeletal issues such as shoulder and back pain, upper limb problems, and issues associated with carrying the portable computers and associated equipment had been reported to the health and safety managers on fifteen occasions. Eight had received reports of theft and/or mugging. The problems in the table below were reported by a total of 13 health and safety managers. The remaining 57 stated that they had not had any problems reported to them by portable users (although some volunteered the information that *desktop* users had reported problems to them). Musculoskeletal issues were reported on 15 (out of 28, 53%) occasions, theft/mugging on eight occasions (29%).

Table 14. Number of times different risks were reported

Problem	**No. of instances reported to health and safety managers**
Upper limb discomfort	4
Manual handling	4
Shoulder discomfort	3
Back discomfort	2
Posture problems	1
RSI	1
Visual discomfort	3
Theft (non-violent)	6
Mugging	2
Stress	2

7.2.5 Assessment and policy

(a) Were portables included in any DSE assessment?

The health and safety managers were asked if the portable computer users had received display screen equipment assessments of any description. Two-thirds of the sample covered portable computer users as part of the general DSE assessments that they undertook for all

their computer users. Only four organisations treated portable computers as an issue to be assessed separately.

Table 15. Nature of DSE assessments for portable users

Are portable users assessed?		**Number reporting and percentage (%)**
Yes	Under a general DSE assessment	43 (61)
	Specific portable DSE assessment	4 (6)
No		13 (19)
Not at the moment, but will be		3 (4)
Yes, but only those in the office		2 (3)
Don't know/unknown		5 (7)

(b) Was there any policy or guidance on the use of portable computers?

Approximately one-third of the respondents had a specific policy or guidance aimed at the use of portable computers within their organisations. Approximately half did not have any guidance specifically on portables.

Table 16. Number of formal policies and guidance on use of portable computers

Policy/guidance on use of portables		**Number reporting and percentage (%)**
Yes	Specifically targeting use of portables	23 (33)
	Covered by general DSE policy	9 (13)
No		24 (34)
Not at the moment, but there will be		3 (4)
Don't know/unknown		11 (15)

(c) Type of policy/guidance

Organisations made portable computer related advice available in a number of forms. The most common form of formal advice was a written company policy or a leaflet/booklet.

Table 17. Type of policy or guidance issued by organisations

Type of guidance		**Number**
Formal	Company policy	12
	Booklet/leaflet	7
	Advice	3
	Video	1
	Lifting training	1
Informal advice		8
Didn't specify		1

(d) Detailed descriptions of policy/guidance

The table below outlines the type of advice given by health and safety managers to their portable computer users.

Table 18. Description of various policies or guidance

Category of guidance	**Specific examples within category**
Commercially published guidance	- laptop user handbook
Guidelines for flexible/home working:	- guidelines for flexible working - best practice on flexible working includes a section on portables
General DSE:	- DSE training for all - advise home users & provide general DSE training - covered by general DSE policy - guidelines - give general DSE advice in company handbook
Specific examples (direct quotes from respondents):	*- don't allow portables to be carried by anyone except for IT staff* *- health and safety officer enforces the use of an additional monitor where possible* *- shouldn't use a portable while one's vehicle is in motion* *- limit use (*in order to eliminate problems of being classified as a user!*), encourage use of desktops where possible, try to use docking stations, & if used at bedside try to limit use* *- take breaks* *- don't use portable if desktop is available* *- use 30 minutes at a time* *- users must plug into a "comfort station" for prolonged use at the office or home (provided they have been issued with one at home)* *- advised to use desktops or docking stations where possible* *- encourage people not to use portables* *- advice re: "optimum posture" – e.g. posture & using high instead of low tables at home*
Others	- on-site H&S manager is constantly patrolling - individual self-assessment - if there are problems then employees are encouraged to go back and see their managers

(e) Was special equipment provided?

Some of the respondents were aware of several instances of additional equipment which had been provided at the request of portable computer users. Improved means of carrying the portable computers, such as rucksacks and trolleys, had been provided in six instances. Additional equipment to enable an equipment configuration more similar to a desktop machine (such as docking stations, external monitors, external keyboards), had been provided in six instances.

Table 19. Instances of additional measures provided for users with portables

Special equipment provided to portable computer users	No. of times reported
Rucksacks/backpacks	4
Docking station	3
Trolleys	2
Gel rest	2
Wrist support	1
Eyesight testing	1
Correctional lenses	1
Visual screening	1
Variety of different keyboards	1
New chairs	1
Changed office lighting	1
Good screens	1
External monitor	1
Install desktop at home	1

8. TECHNICAL SPECIFICATIONS

We contacted (by telephone, letter or email) all the major manufacturers of portable and handheld computer equipment and attempted to obtain technical specifications from them. The tables in Appendix 1 provide an overview of the data extracted from the technical specifications. The list is not comprehensive and was dependent on the responses received from manufacturers.

Appendix 1A lists the data for 159 portable/laptop computer devices, with weight, dimensions, screen size and technology, keyboard, pointing device, and any other 'ergonomic' features. Table 20 summarises the main aspects of the technical specifications extracted from Appendix 1A for portable computers.

Table 20. Main characteristics of portable computer technical specifications

	Average weight	Average screen size	Range of keyboard sizes	Most common screen technology	Most common pointing device
Portable computer	3kg	12.7 (inches)	82-101 keys. average 88 keys	Thin film transistor (TFT)	Touchpad

Appendix 1B lists the data for 24 handheld devices, in terms of weight, overall dimensions, screen size and type, keyboard, any pointing device, and any other 'ergonomic' features. Table 21 summarises the main aspects of the technical specifications extracted from Appendix 1B for handheld computers.

Table 21. Main characteristics of handheld computer technical specifications

	Average weight	Range of screen sizes	Range of keyboard sizes	Most common screen technology
Handheld computer	0.64kg	4 lines x 20 characters to 9.4 inches	27 keys to 80 keys	Liquid crystal display (LCD)

9. OUR FINDINGS - BASIC INFORMATION DERIVED FROM QUESTIONNAIRE RESPONSES

In this chapter we provide an overview of the basic information provided by respondents in their questionnaires.

9.1 Organisations participating, job types and types of computer used

Five organisations participated in the data collection and 2,192 people responded to the questionnaire. The numbers of questionnaires returned from each company were as follows:

Table 22. Numbers of respondents, business activity of organisation, and response rates

Organisation	Business activity	Number of respondents	% response rate
A	Financial services	177	59
B	Oil, gas and chemicals	1680	39
C	Sales, distribution and manufacture of beverages	107	54
D	Multi-utility company (electricity, gas, water and telecommunications)	93	47
E	Parking services and facilities management consultancy	135	45
Total		**2192**	41

The total number of desktop users was 1114 and the total number of portable users was 1197, of whom 917 used some form of docking station with their portable computer, for part of their working time. Docking station was defined in the questionnaire as connecting the portable computer to a separate screen or keyboard. 109 people used their portable computers “alone”, i.e. without connecting it to a separate screen or keyboard. There were 107 people who used handheld computers “alone”.

Table 23 indicates the breakdown of computer usage by 'type of computer equipment', and 'company'. The table shows that respondents across all companies used a number of different variations of computer equipment to carry out their tasks.

Table 23. Type of computer equipment used across companies A-E

Company	A	B	C	D	E	Total
Type of computer equipment						
Just portable (no docking station)	28	41	39	1		109
Just desktop	71	673	3	43	76	866
More than one type (portable with docking station, portable alone, desktop alone in varying combinations)	34	451	7	34	7	576
Just portable with docking station	15	511		15		526
Just handheld			55		52	107

The difference in the total numbers here is attributable to the fact that some portable/handheld users also used desktop computers for at least part of their working time. From the site visits we observed that docking stations exist in a variety of forms:

- an external keyboard and/or mouse to attach to the portable
- an external display screen to attach to the portable
- or a unit consisting of an external display screen, keyboard and mouse into which the portable is slotted.

Our ergonomists observed that there was relatively little standardisation at the sites visited in what companies supplied as a docking station – they supplied some combination of external display screen, external mouse and external keyboard.

The main job types of these users and the computers they used are shown below:

Table 24. Job types of different types of computer users

	Just portable (no docking station)	Just desktop	Just portable with docking station	Just handheld	More than one type
Administrative & clerical	2	384	45		41
Managerial & professional	50	216	374		374
Operational	2	34	11		15
Technical	4	131	72		100
Parking attendant	-	-	-	50	-
Sales	39	3	-	55	7
Other	4	47	6		24
No job type given	8	51	18	2	15
TOTAL	109	866	526	107	576

9.2 Years spent using computers, years in current job/organisation

For the total sample, Table 25 below shows the mean number of years people had spent using (any) computers, the mean number of years using portable computers for their work, the mean number of years in their current job and organisation. Tables 26 to 29 show the same information broken down by "category" of computer user.

Table 25. Descriptive statistics indicating time in job; organisation; using any computers; using portable computers

	Mean (years)	Standard deviation (years)	N
Length of time working with computers	12.3	6.3	2159
Length of time using portable computer for work	3.7	2.3	1123
Length of time using a handheld computer for work	1.7	1.9	140
Length of time in current job	3.1	3.8	2161
Length of time in current organisation	10.9	9.0	2161

The table indicates that many users had worked with (any) computers for more than a decade, but that their use of specifically *portable* computers was much shorter. On average, people had spent approximately ten years in their current organisation, and the past three years in their current job. Handheld computers had been used for the shortest average length of time which reflects the fact that they have not been available on the market for as long as portable computers.

Table 26. Years spent working with computers for each group of computer users

	Mean (years)	Standard deviation (years)	N
Just portable (no docking station)	11.0	6.8	108
Just desktop	10.9	5.8	855
More than one type	14.4	6.2	570
Just portable with docking station	13.9	6.0	519
Just handheld	5.5	4.0	100

Table 26 indicates that of the five groups, the handheld users had spent the smallest amount of time working with computers. The 'more than one type' and docking station users had spent the greatest length of time, and the 'just portables' and 'just desktop' users very similar lengths of time.

Table 27. Years spent in current job for each group of computer users

	Mean (years)	Standard deviation (years)	N
Just portable (no docking station)	1.9	2.2	108
Just desktop	3.5	4.4	853
More than one type	2.9	3.4	568
Just portable with docking station	3.0	3.6	520
Just handheld	1.7	1.7	104

Here, the 'more than one type' users and docking station users had been in their current jobs for similar amounts of time. The handheld users the least, and the desktop users the most. People who only used portable computers had been in their current job for approximately two years.

Table 28. Years spent in current organisation for each group of computer users

	Mean (years)	Standard deviation (years)	N
Just portable (no docking station)	9.0	8.3	106
Just desktop	8.6	8.3	848
More than one type	13.5	8.7	574
Just portable with docking station	14	8.8	523
Just handheld	1.7	1.7	102

The 'more than one type' and docking station users had spent the greatest number of years in their current organisation, and the handheld users the least.

Table 29. Years spent using a portable for work

	Mean (years)	Standard deviation (years)	N
Just portable (no docking station)	3.3	2.4	67
Just desktop	3.8	2.4	21
More than one type	3.6	2.2	536
Just portable with docking station	3.7	2.4	497
Just handheld	0.0	0.0	0

The number of years that people had spent using a portable for work was similar across the four non-handheld-user groups.

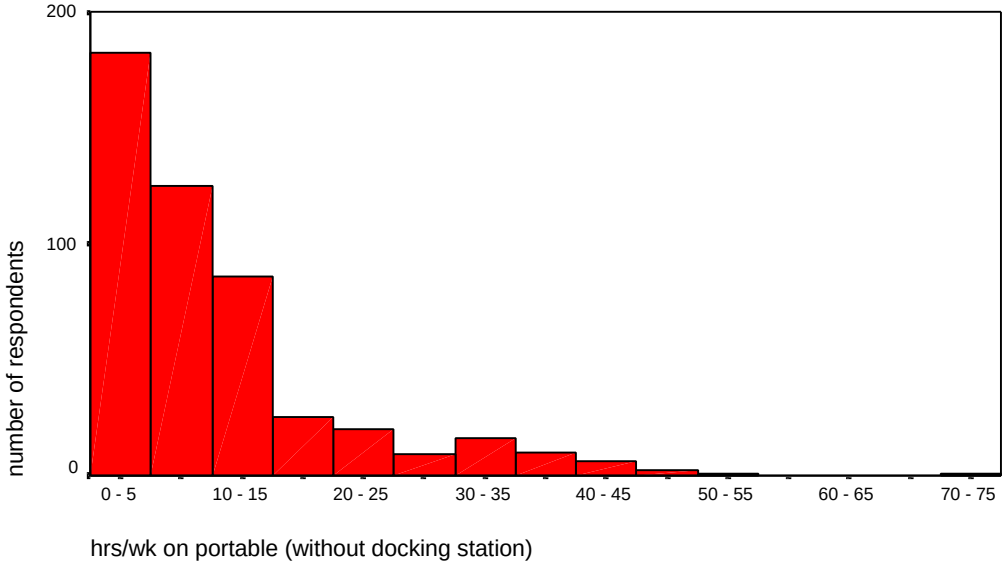
N.B. Desktop users appear in this table presumably because at some point during their working career they had previously used portable computers for work.

9.3 Time spent working and using computers

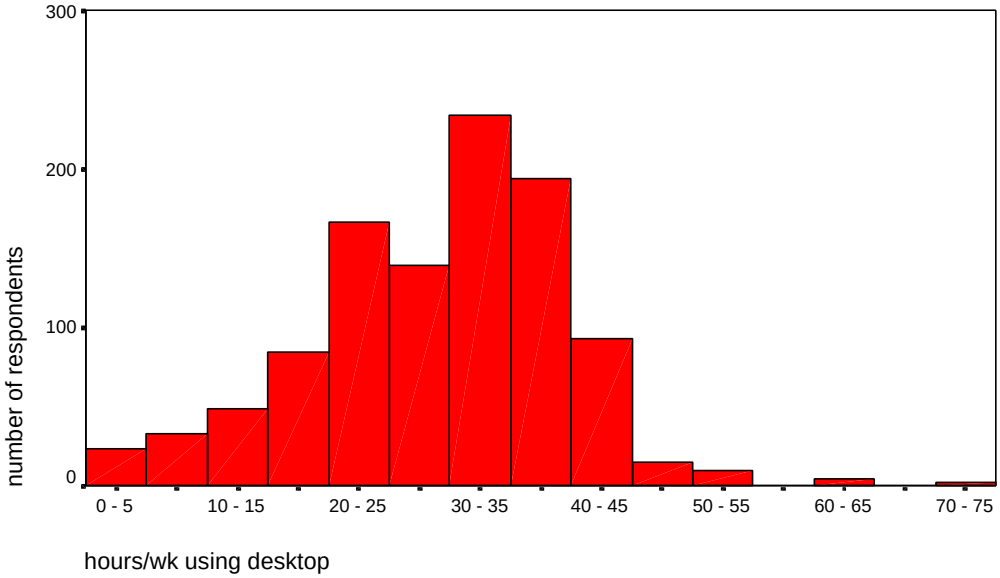
The hours/week which respondents typically reported using their portable computers 'alone', without the use of an external keyboard and/or screen (i.e. docking station) are shown below. The graph captures all the people in the following categories: those who just used portable computers "alone"; those who used portable computers both "alone" and with docking stations, but only the part of their time that they used their portable computers "alone"; and those people who reported using more than one type of computer for work, but only the part of their time that they used the portable computers "alone". It can be seen from the graph that the majority of people reported using *portable* computers without a docking station for less than fifteen hours per week.

Graph 1. Hours per week spent using portable computer alone (without docking station)

(Mean=9.0 hours/week, standard deviation=9.61 hours/week, N=483)

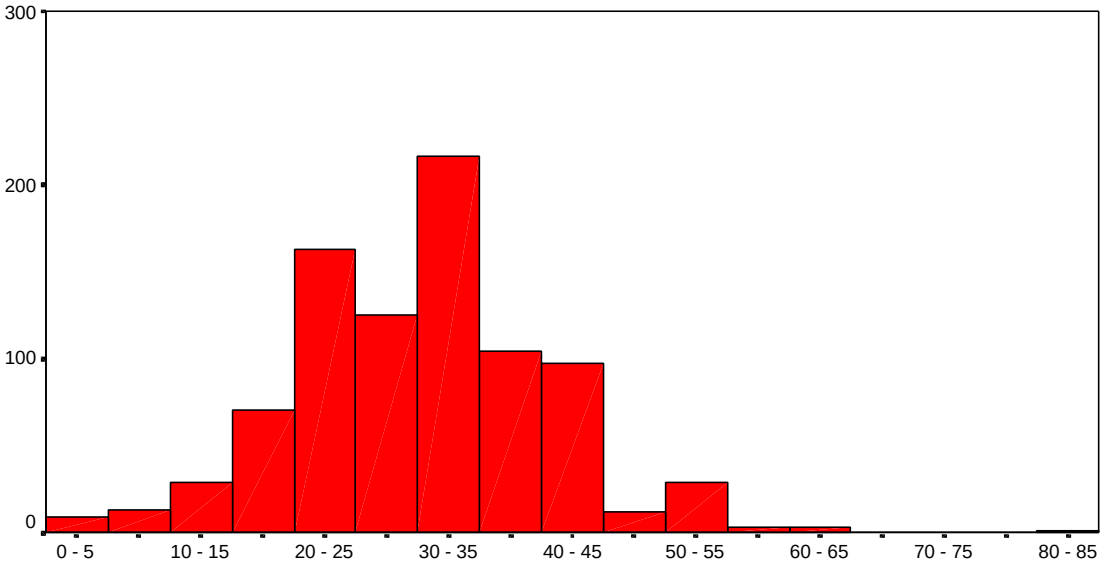


Graph 2. Hours per week spent using desktop computer
(Mean=27.2 hours/week, standard deviation=10.3 hours/week, N=1044)



By comparison, Graph 2 shows that the majority of desktop users reported that they worked at their *desktop* computers for between 20 and 40 hours per week. This is considerably different from the portable users, and made direct comparisons on the 'hours per week' variable difficult to achieve.

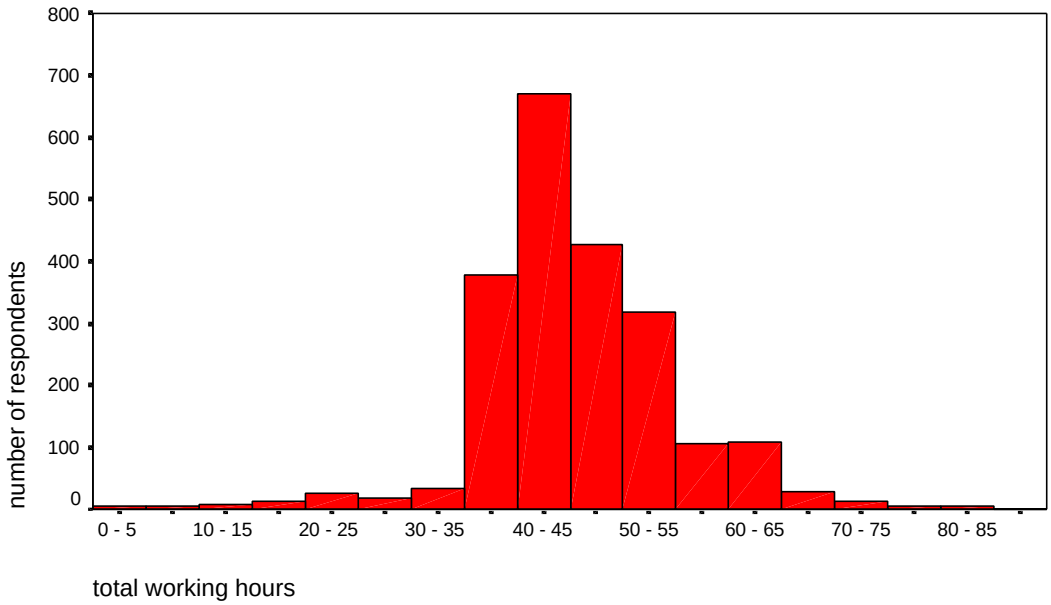
Graph 3. Hours per week spent using portable computer with docking station
(Mean=28.1 hours/week, standard deviation=10.0 hours/week, N=876)



Graph 3 shows that people who used their portable computer with some form of docking station used it for a similar amount of time as the desktop computer users.

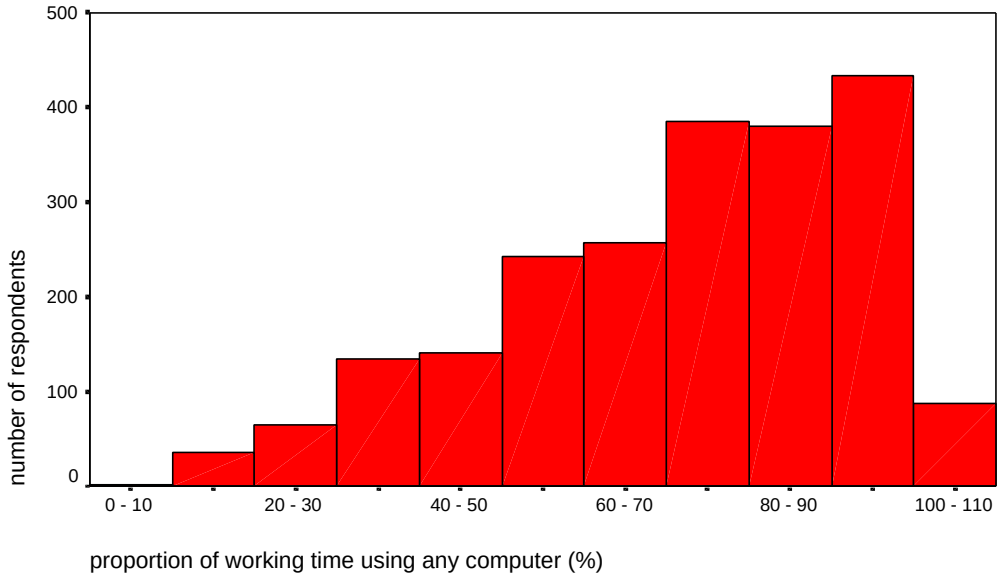
The total working hours which respondents (all users) reported showed a typical spread, with the majority of respondents working between 35 and 55 hours per week, as shown in Graph 4.

Graph 4. Total working hours for all respondents
(Mean=44 hours/week, standard deviation=8.81 hours/week, N=2168)



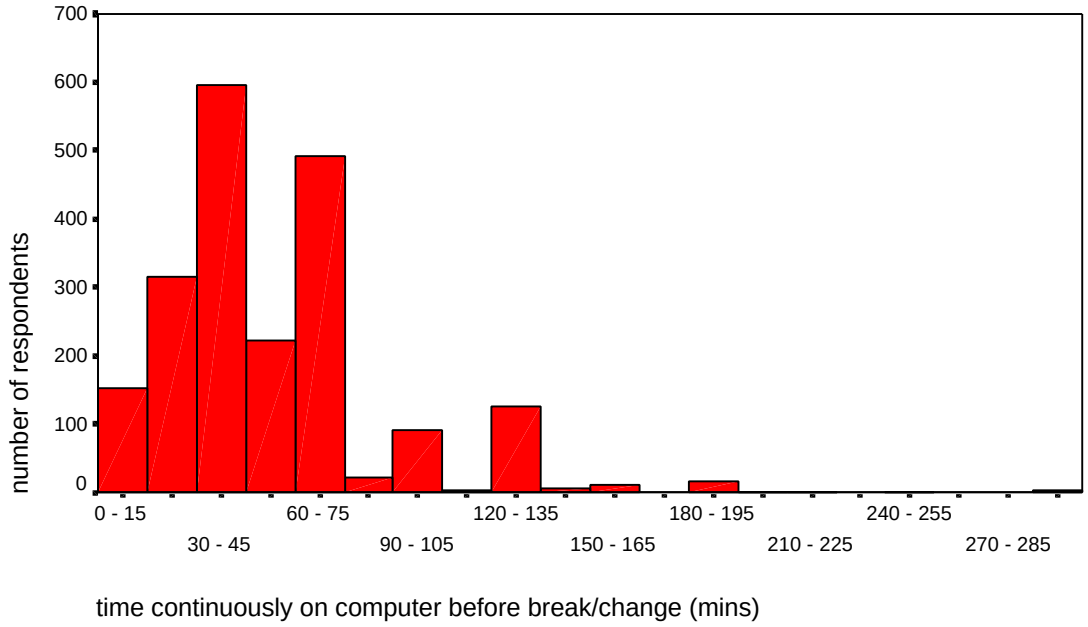
The proportion of working time which respondents (desktop, portable, handheld users) reported spending on *any* computer was generally high with most users reporting that they spent between 60 and 100% of their time using a computer, as shown in Graph 5.

Graph 5. Proportion of time spent using any computer
(Mean=67%, standard deviation=21.76%, N=2163)



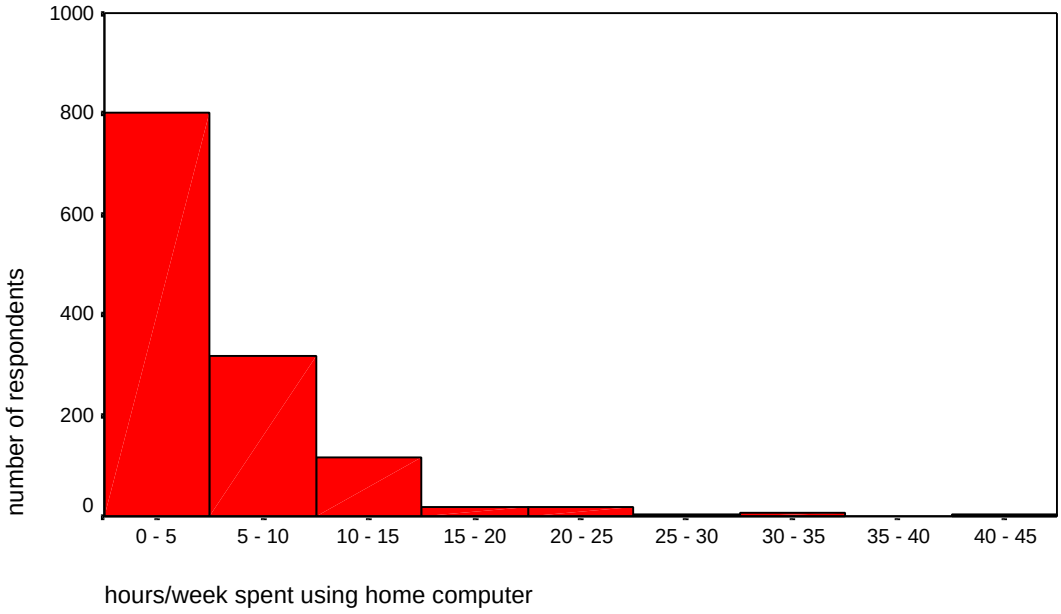
Graph 6 shows that most people thought that they took breaks from computer tasks at least once an hour. This included changes in task activity as well as extended breaks such as lunch.

Graph 6. Estimated time spent using computer before taking a break
(Mean=48 minutes, standard deviation=36.48 minutes, N=2062)



84% of the sample reported having a computer at home, of which 86% were desktops. Graph 7 shows the hours per week that people spent using a home computer. They used these computers at home for an average of five hours per week. The activities included playing games, using the Internet for various tasks, personal administration/finance, and undertaking further education course work.

Graph 7. Hours per week spent using home computer
(Mean=5 hours/week, standard deviation=4.8 hours/week, N=1286)



9.4 Personal information

63% of the sample were male, and the age profile of the whole sample was as follows:

Table 30. Age profile of sample

Age	Male (%)	Female (%)	Whole sample (%)
<21	1	3	2
21-30	15	35	23
31-40	34	37	35
41-50	37	19	30
51-60	12	6	10
>60	1		0

The age profile of people using different types of computer equipment is provided in Table 31 below.

Table 31. Age profile according to computer usage

Age	Just portable (%)	Just desktop (%)	Just portable with docking station (%)	Just handheld (%)	More than one type (%)
<21	0	3	0	9	0
21-30	36	29	10	61	16
31-40	32	34	36	22	39
41-50	23	22	42	6	36
51-60	8	10	11	2	9
>60	0	1	0	1	0

The gender profile within each computer group is shown in Table 32 below. A slightly higher proportion of the females occur in the just desktop group, whereas male users predominate in the other four groups.

Table 32. Gender profile according to computer usage

	Just portable (%)	Just desktop (%)	Just portable with docking station (%)	Just handheld (%)	More than one type (%)
Male	64	45	76	62	77
Female	36	55	24	38	23

The job types reported by respondents using different types of computer equipment are provided in Table 33 below.

Table 33. Job types according to computer usage

	Just portable (%)	Just desktop (%)	Just portable with docking station (%)	Just handheld (%)	More than one type (%)
Administration /clerical	2	47.1	8.9		7.3
Managerial/ Professional	49.5	26.5	73.6		66.7
Operational	2	4.2	2.2		2.7
Technical	4	16.1	14.2		17.8
Information technology		.4	.4		1.1
Engineering		1.1	.6		1.1
Parking attendant				47.6	
Supervisory		1.1			
Consultant	1	.9			.5
Human Resources	1	.5			.5
Sales	38.6	.4		52.4	1.2
Other	2	1.8	.2		1.1

9.5 Overall symptoms and discomfort reported

We asked respondents to tell us how frequently they experienced symptoms and discomfort. Respondents were given four descriptions from which to choose:

Frequently – *means you experience symptoms several times a week*
Sometimes – *means you experience symptoms more than every few months, but less than several times a week*
Rarely – *means you only experience symptoms every few months*
Never – *means that you never experience these symptoms.*

The basic results for all users (portable, desktop, handheld) are shown in the following two tables.

Table 34. Frequency of non-musculoskeletal "symptoms"

	Never	Rarely	Sometimes	Frequently	Total
Fatigue (%)	10	23	46	21	100
Stress (%)	15	31	41	12	100
Headaches (%)	21	37	33	9	100
Irritated eyes (%)	20	31	35	14	100
Difficulties reading your work on the screen (%)	40	33	19	7	100

Table 35. Frequency of musculoskeletal "discomforts"

	Never	Rarely	Sometimes	Frequently	Total
Feet (%)	79	12	6	3	100
Legs (%)	70	17	9	4	100
Back (%)	33	25	29	13	100
Neck (%)	31	23	31	15	100
Shoulder (%)	39	22	25	13	100
Arms (%)	64	20	12	4	100
Wrists (%)	55	21	19	5	100
Hands/fingers (%)	54	20	19	7	100

Some of these results are less surprising than others – we might expect relatively frequent fatigue at work, and with current trends at work, the high incidence of stress is also to be expected. It is interesting to see that the three most frequent "discomfort areas" were back, neck and shoulder – these areas are known to be affected by sedentary work, particularly involving computers.

Table 36 shows the mean frequency of symptoms and discomfort reported by each group of computer users. The mean score is derived from giving a "frequently" response a score of 3, a "sometimes" response a score of 2, a "rarely" response a score of 1 and a "never" response a score of 0. The pattern of mean responses appears similar between portable computer and other users – these were statistically tested for differences between the groups and our findings are presented in Chapter 10.

Table 36. Mean frequency of "symptoms" for each computer group

	Just portable (mean)	Just desktop (mean)	Just portable with docking station (mean)	Just handheld (mean)	More than one type (mean)
Fatigue	1.9	1.7	1.8	1.6	1.8
Stress	1.6	1.5	1.5	1.6	1.5
Headache	1.5	1.9	1.8	1.8	1.7
Irritated eyes	1.5	1.6	1.5	1.5	1.5
Difficulties reading work on screen	0.9	1.5	1.2	1.2	1.4

Table 37. Mean frequency of "discomforts" for each computer group

	Just portable (mean)	Just desktop (mean)	Just portable with docking station (mean)	Just handheld (mean)	More than one type (mean)
Feet	0.3	0.3	0.3	1.1	0.3
Legs	0.4	0.4	0.4	1.1	0.4
Back	1.2	1.3	1.2	1.3	1.2
Neck	1.3	1.3	1.2	1.2	1.3
Shoulder	1.2	1.2	1.1	1.3	1.1
Arms	0.7	0.6	0.5	0.7	0.5
Wrists	0.7	0.8	0.7	0.7	0.8
Hands/fingers	0.7	0.8	0.7	0.7	0.8

The pattern of responses for "discomforts" indicates that the "just handheld" group was experiencing more feet and leg discomfort than the other groups. This can be explained by the nature of the job – many of the handheld users were parking attendants, who spend the whole of their "beat" on foot. For this reason they were excluded from the main statistical analysis presented in Chapter 10. The table also indicates that back, neck and shoulder discomfort appeared to be reported relatively frequently across all the computer groups.

Tables 38 and 39 show the mean frequencies of the "amalgam" ratings for symptoms and discomfort. Again, the pattern appears similar between the "just portable" computer users and the other groups.

Table 38. Mean frequency of "symptom" amalgamated ratings for each computer group

	Just portable (mean)	Just desktop (mean)	Just portable with docking station (mean)	Just handheld (mean)	More than one type (mean)
No. of sometimes or frequentlys on 5 symptom ratings	2.3	2.3	2.2	1.8	2.1
No. of frequentlys on symptom ratings	.6	.6	.5	.6	.6

Table 39. Mean frequency of "discomfort" amalgamated ratings for each computer group

	Just portable (mean)	Just desktop (mean)	Just portable with docking station (mean)	Just handheld (mean)	More than one type (mean)
No. of sometimes or frequentlys on 8 discomfort ratings	1.8	2.0	1.8	2.1	1.8
No. of frequentlys on discomfort ratings	.5	.6	.5	.8	.5

9.6 Portable computer use in different locations

People used their portable computers in a wide range of locations, with the five most commonly cited being at home (without docking station), in the office with a docking station, in hotels, in other offices, and on trains/aeroplanes, as shown in Graph 8.

Graph 8. Locations of portable computer use

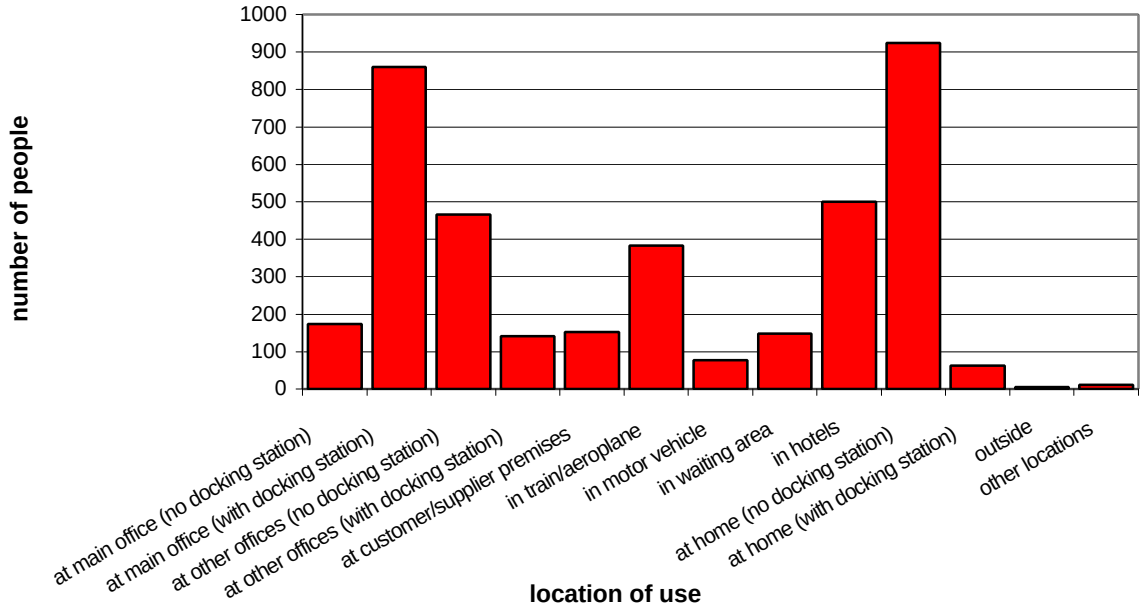


Table 40 shows the mean number of different locations reported for people who used portable computers "alone"; people who used "more than one type" of computer, and those who used their portables with a docking station.

Table 40. Percentage of respondents reporting different number of locations where portable computers were used

No. locations reported	1	2	3	4	5	6	7	8
Type of computer equipment								
Just portable computer (no docking station) (%)	8	30	27	18	13	4	0	0
More than one type of computer (%)	16	20	17	18	14	10	3	1
Just portable with docking station (%)	17	26	21	14	12	8	1	0

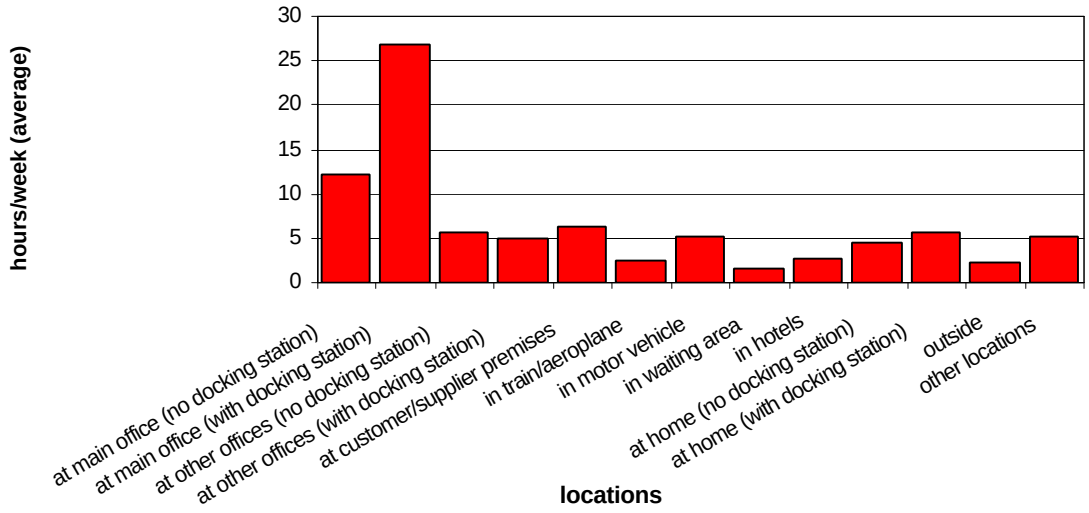
Table 41. Mean number of locations where portable computers used

Type of computer equipment	Mean no. of locations reported
Just portable computer (no docking station)	3.09
More than one type of computer	3.40
Portable with docking station	3.11

There was a significant difference between "more than one type of computer" and "just portable" users (t=-2.08, p=0.039) and between "more than one type" and "portable with docking station" users (t=2.76, p=0.006), but not between the portable groups, which is to be expected.

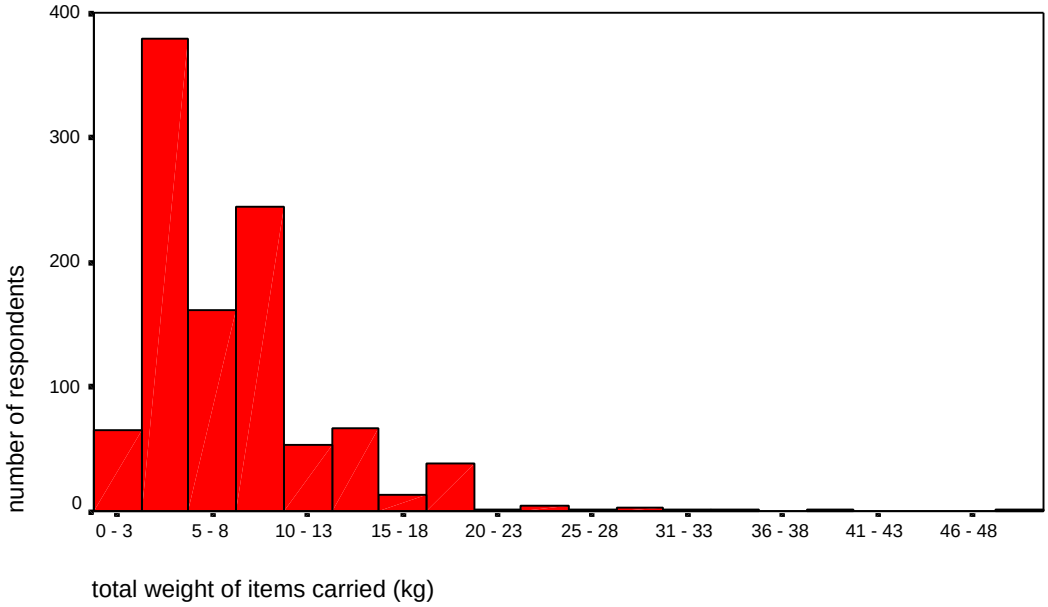
Although there was a large range of locations where portables were used, the majority of hours/week using the portable were spent at the main office. At the main office, most people used their portable connected to some form of docking station.

Graph 9. Hours per week spent using portable computer in each location



We asked respondents to give an estimate of the total weight they typically carried when transporting their portables. Quite a range of weights were given:

Graph 10. Estimate of total weight carried by portable computer users (Mean=8, standard deviation=5.19, N=1037)



Most people estimated that they carried between 3 and 10 kg in total weight when carrying their portables. This estimate includes the weight of other material, such as paperwork, and accessories such as spare batteries, carrying cases etc.

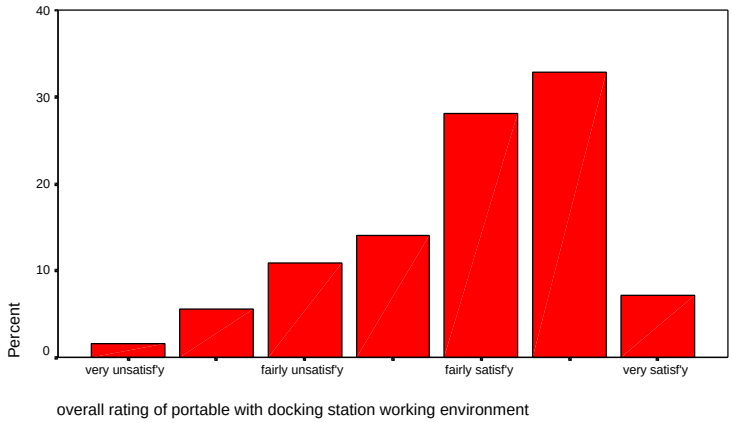
9.7 Overall ratings of the working environment

In this section we report the overall levels of satisfaction with their working environment (where 1 was very unsatisfactory, 4 was neutral, and 7 was very satisfactory) for:

- Portable computers with docking station working environment (N=923, mean =4.9)
- Desktop working environment (N=1239, mean=4.9)
- Portable computer working environment (i.e. the environment experienced when the portable computer was used "alone") (N=714, mean=4.4)
- Handheld computer working environment (N=45, mean=4.7).

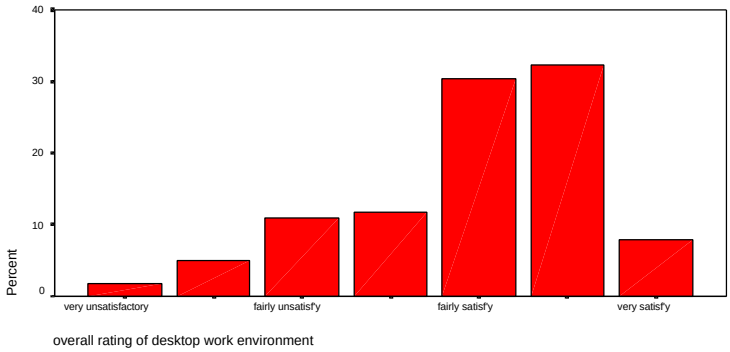
Graphs 11 to 14 below show the overall satisfaction ratings for each type of working environment.

Graph 11. Overall rating of satisfaction for docking station working environment



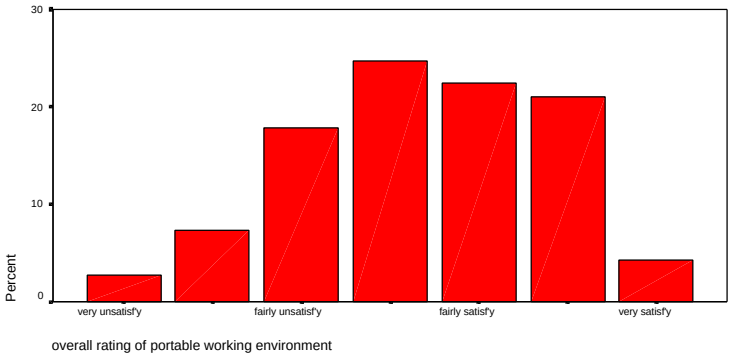
Graph 11 indicates that most docking station users found their docking station working environment reasonably satisfactory.

Graph 12. Overall rating of satisfaction for desktop computer working environment



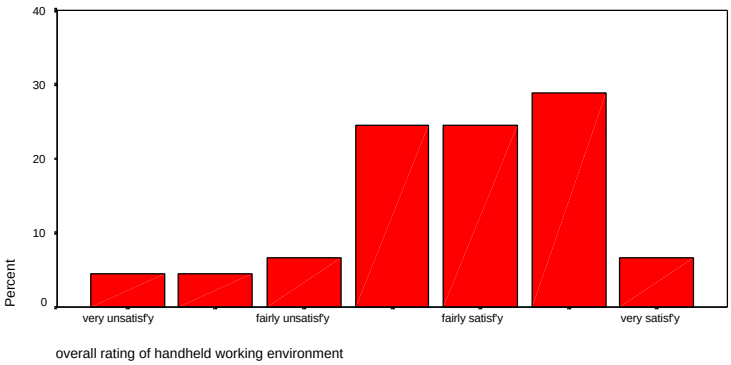
Graph 12 indicates that most desktop users found their desktop working environment reasonably satisfactory.

Graph 13. Overall rating of satisfaction for portable computer working environment



Graph 13 indicates that approximately one-third of portable computer users found their portable computer working environment (when using it "alone") very or fairly *unsatisfactory*.

Graph 14. Overall rating of satisfaction for handheld computer working environment

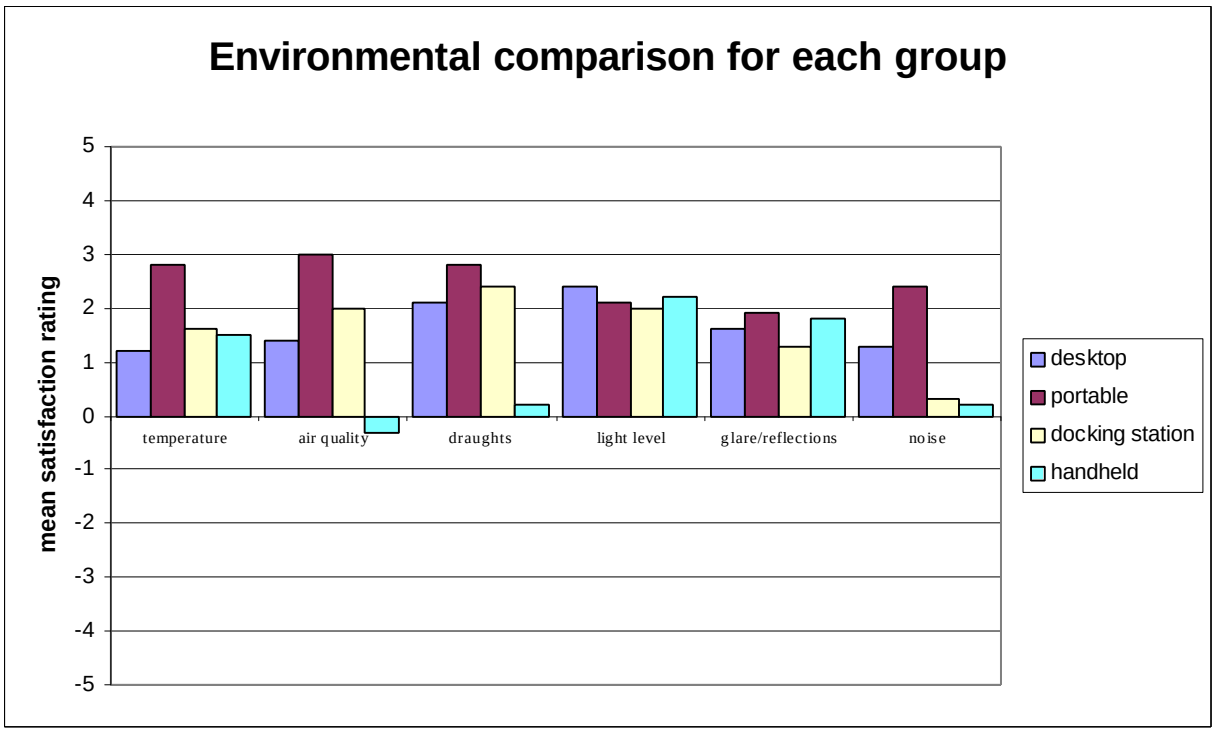


Graph 14 indicates that most handheld users found their handheld computer working environment reasonably satisfactory.

Overall, this family of graphs indicate that respondents were most satisfied with the desktop and docking station environments, and least satisfied with the portable computer working environment.

These overall satisfaction ratings were split down into individual aspects of the working environment that can affect peoples' use of computers. The following graphs 15 to 18 show comparisons between each of these for groups, for each of the individual aspects.

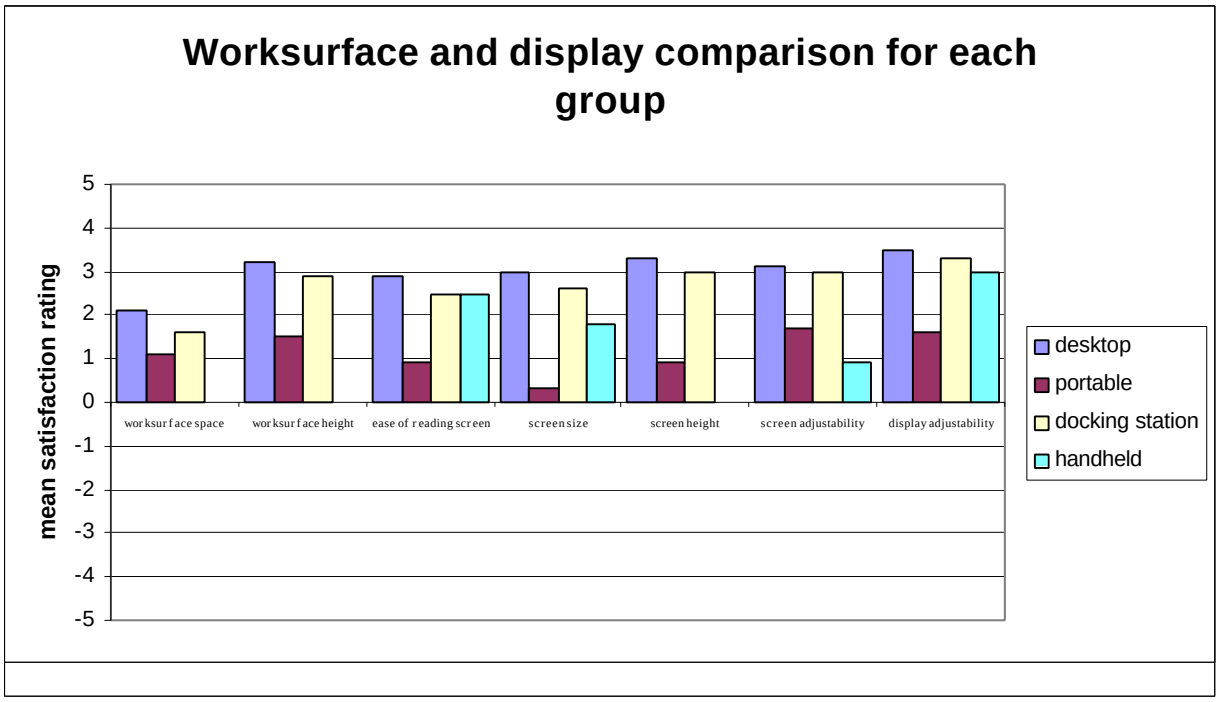
Graph 15. Comparison between 'environmental' aspects for each group



The pattern of responses indicates that portable computer users are the most satisfied with this group of working environment features. The handheld users were least satisfied, particularly with air quality and draughts, which is to be expected given the nature of their jobs as parking attendants, at the mercy of the elements and exhaust fumes.

Docking station users reported low levels of satisfaction with noise, which may be due to the shared nature of their working environment and the tendency of people with mobile jobs to hold informal meetings in their immediate work area to 'catch up' on company/project/personal information.

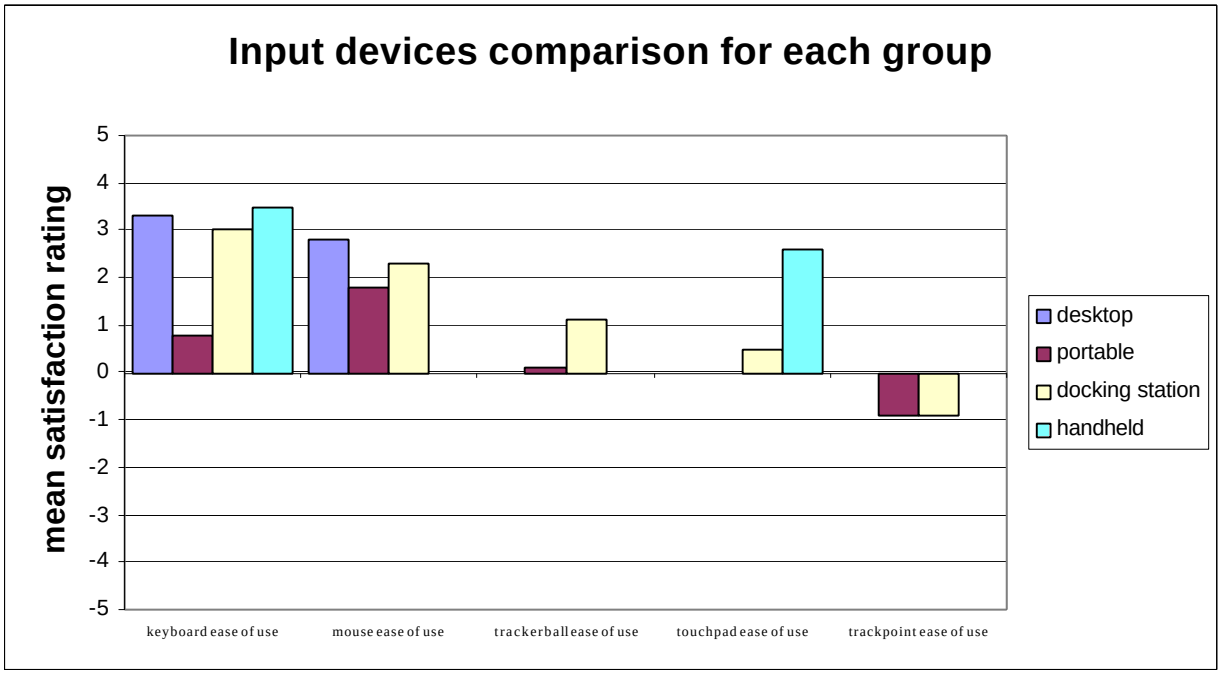
Graph 16. Comparison between aspects of the worksurface and display characteristics for each group



In this graph, screen adjustability was defined by tilt, angle, etc, and display adjustability by brightness and contrast. There are no responses for handheld users for worksurface space and height, and screen height.

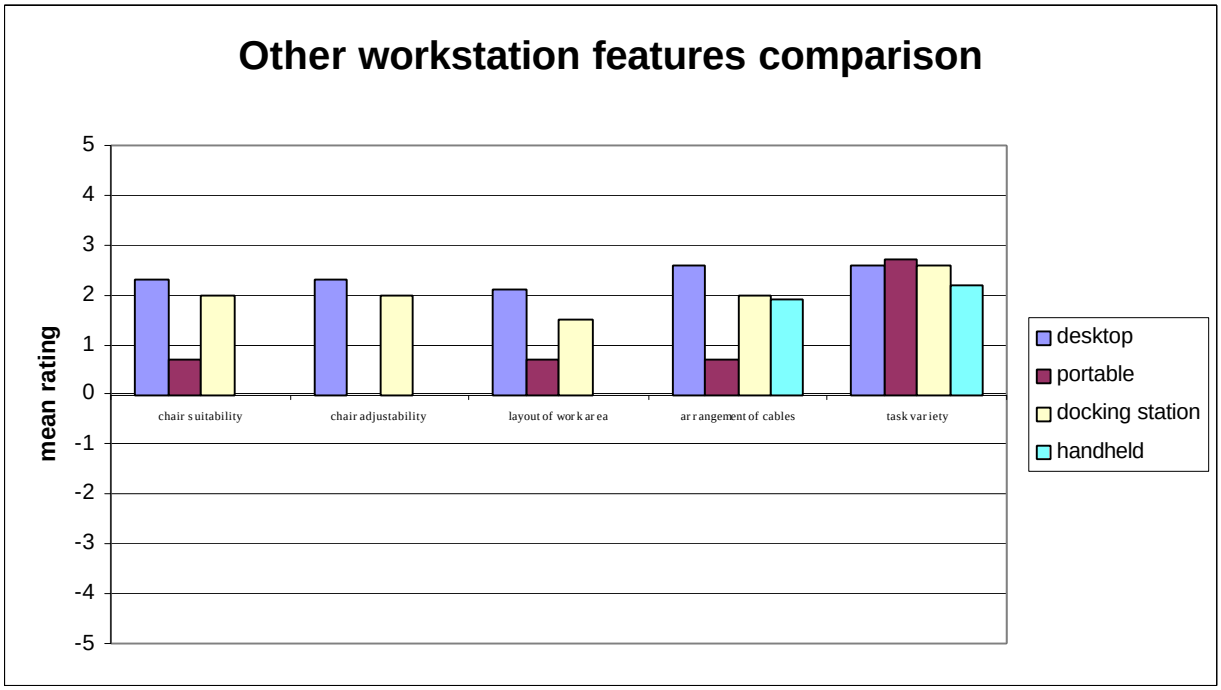
The graph indicates that desktop users were most satisfied with these particular aspects of their working environment. Clearly, the portable users were the least satisfied with each one of these aspects, which is to be expected given the lack of adjustability of portable computer worksurfaces and screens.

Graph 17. Comparison between input device characteristics for each group



All groups of users operated some form of keyboard as an input device. For the other input devices used for cursor control, some docking station users used external mice, some used the portable computer touch pad, trackerball or trackpoint ('nipple') when they used the docking station. The graph shows that users found the trackpoints least easy to use. Portable computer users also showed low levels of satisfaction with the ease of use of their trackerballs and keyboards.

Graph 18. Comparison between other aspects of the workstation for each group



The handheld users were not asked the chair and layout of work area questions displayed in this graph, as they spend their working day on foot. For the other features of a typical workstation, portable computer users were least satisfied with chair suitability and adjustability, the layout of their work area, and the cable arrangement. Portable computer users, as will be seen later, spend part of their time working in non-ideal locations, such as on public transport and in hotels, where they have little adjustability in their chairs and work areas, so this result is not unexpected.

10. OUR FINDINGS – RESULTS OF STATISTICAL ANALYSIS FOR PORTABLES

In the following sections we provide the findings from our statistical analysis of the questionnaire data from portable users (all staff from company E – mainly parking attendants using handhelds have been excluded from this analysis, due to the high level of reported feet/leg symptoms which skewed the results). Handheld usage is dealt with separately in a later chapter. This chapter addresses research Aim B: to determine the extent of health problems associated with portable DSE and the risk factors involved, and how these risk factors compare with those associated with full-sized desktop DSE.

10.1 Type of computer used

One of the main areas of interest was whether the type of computer used by respondents was related to their experience of discomfort or other symptoms. There were several ways of looking at this, which are discussed below.

10.1.1 Possession and use of portable computer

This is a relatively simple question – regardless of other computers also used, and of the availability of a docking station (or not) – did simply *using a portable computer* make any difference to the users' experience of discomfort or symptoms?

T-tests and Mann Whitney tests did reveal some apparent differences in symptoms and discomfort between users of portables and non portable users. There was also a difference in one of the amalgam ratings. However, there was a possibility that the differences between these two groups was not really their use of a portable, but due to some other factor, e.g. sex, job type, age or hours used. For this reason, the portable *vs* no portable tests were repeated for all of the following groups separately:

Table 42. Group sample sizes for categories of questionnaire respondent

Group	Total	Uses portable	Does not use portable
Males	1278	897	381
Females	757	285	472
Administrative/clerical staff	441	85	356
Managerial/professional staff	987	786	201
Operational staff	63	28	35
Technical staff	305	175	130
Sales staff	107	44	63
Age group (21-30)	453	175	287
Age group (31-40)	716	439	277
Age group (41-50)	633	447	186
Age group (51-60)	206	121	85

Generally, within these groups, the differences at first observed (for the whole sample) between portable users and non portable users disappeared. This suggests that these differences were indeed due to the other factors of sex, age or job type, rather than computer type as such. None of the differences observed in the whole sample were repeated across all the groups - in fact only one result remained in more than one subgroup of respondents. This result was hand/finger discomfort, which was significantly better for the total sample portable users than non portable users (total sample, U=374753, p=0.025) and significantly better for female portable users versus female non portable users (U=42945, p=0.038).

There were also some differences between portable users and non portable users within the subgroups which had not been observed in the total sample, but none of these was repeated sufficiently frequently in other groups to suggest a genuine difference caused by portable use.

Overall, this result suggests that, in our sample, any differences in the frequency of discomfort or symptoms experienced by users of portables versus non-users were most likely to be explained by factors other than computer type.

10.1.2 Types of computer user

Excluding handhelds (which are dealt with separately in Chapter 14), there were four main types of computer users in the sample:

1. people who only used a portable (without a docking station) – 109 users
2. people who only used a desktop – 790 users
3. people who only used a portable with a docking station – 526 users
4. people who used more than one of these computer types or configurations – 569 users.

These groups were compared to each other in terms of symptoms, discomfort areas and the four amalgam ratings. Once again, there were a few differences between groups (in particular between the "just desktop" group and other groups) but none of these were "supported" within the subgroups of sex, age or job type.

The main conclusion must therefore be:

When individual factors were accounted for, there were no significant differences between users of the various configurations of computer equipment in terms of symptoms and discomfort.

10.1.3 Brand of portable computer used

Respondents were asked to name the brand of portable computer which they habitually used. There were 4 main brands used, which are referred to here as A, B, C, D. 169 people used brand A, 145 brand B, 20 brand C and 302 used brand D. Table 29 shows the typical features of each brand.

Table 43. Description of main features of portable computer brands

Brand #	Screen	Keyboard	Input device	Weight	Carry case
Brand A	14", tilt adjustment, no independent height or swivel adjustment, TFT/LCD. Colour.	Qwerty, 83 keys, no tilt adjustment. Wrist pad approx 320x70mm Strike surface 13x15mm	Trackpoint "nipple" inset into Qwerty part of keyboard, two cursor activation keys in wristpad area in front of qwerty area	Computer 3kg. Batteries and cables 0.75kg	Black cloth, handle and shoulder strap. Case weight 2kg
Brand B	13", tilt adjustment, no independent height or swivel adjustment, TFT/LCD. Colour	Qwerty, 88 keys, no tilt adjustment. Wrist pad 310x105mm. Strike surface 13x13mm	Touchpad 60x50mm in centre of wrist pad area. Two cursor activation keys in front of touchpad	Computer 3kg, cables 0.25kg	Black leather, handle and shoulder strap. Case weight 3kg
Brand C	14", tilt adjustment, no independent height or swivel adjustment, TFT/LCD. Colour	Qwerty, 86 keys, no tilt adjustment. Wrist pad 310x90mm. Strike surface 13x14mm	Various input devices, trackerballs, trackpoints, touchpads, and external mice.	Computer 3kg. Battery and cables 0.5kg	Black cloth, handle and shoulder strap. Case weight 2kg
Brand D	13.5", tilt adjustability, no independent height or swivel adjustment, TFT/LCD. Colour	Qwerty, 86 keys, tilt adjustability. Strike surface 14x14mm. Wrist pad 290x98mm.	Trackpoint "nipple" inset into qwerty part of keyboard. Three cursor activation keys in front of keyboard	Computer 3kg, battery and cables 0.75kg	Black leather, handle and shoulder strap. Case weight 3kg

These four groups of portable users were compared to see if they reported different frequencies of symptoms or discomfort which might be associated with the design of the equipment.

There were a few differences between the brand groups when the whole sample of portable users was included in the analysis. Once again, care was needed to ensure that there was not some underlying cause for these, such as a difference in frequency of discomfort between the sexes. It was possible to repeat the analysis taking males and females separately for groups A, B and D, but with only 20 users of type C, this group could not be divided further. Since

most of the users of portables fell into the management/professional category of job type, it was only possible to look at this job group individually (the sample size in the other job types were too small). The spread of brand across age groups did not differ greatly, and so these groups were not tested separately. There was only one significant result of interest: Brand C users reported significantly fewer "frequently" ratings on the symptom ratings than all of the other brands. ($t = -2.6$, $p = 0.014$ for Brand C vs Brand A; $t = -2.43$, $p = 0.021$ Brand C vs Brand B; $t = -2.017$, $p = 0.055$ Brand C vs Brand D).

Unfortunately, it was not possible to test this within the main subgroups as the numbers were so small (20 users). None-the-less, although caution is required, the consistency of this result across all the brands does suggest that the features (or perception of the features) of brand C may be "better" than the other brands in some way which keeps the incidence of "symptoms" low. In particular, users of brand C reported significantly less frequent irritated eyes than users of brand A and brand B. During the on-site visits we examined the display quality of Brand C portables, and there did not appear to be any obvious differences which could account for this difference – they were the same thin film transistor technology, similar sizes, similar range of tilt adjustability. The only other difference was a slight colour rendering difference – Brand C portables had a "pinkish" tinge to the colour display while the others had a "bluish" or "greyish" tinge to their displays.

10.1.4 Influence of home computer use on discomfort or symptoms

There was the possibility that home computer use might aggravate any effects of computer use at work. For this reason we checked for any apparent effects of home computer use.

84% (n=1312) of the people who answered this question (n=1484) reported having a computer at home, of which 86% were desktop computers. Testing the whole sample it was seen that:

There were no significant differences in terms of symptoms and discomfort between people who did and did not have a computer at home.

Although there were some differences in the whole sample, these were not present in the subgroups of sex and job type.

Spearman correlation coefficients were also calculated between the number of hours/week respondents reported spending on their home computer, and all the individual symptoms and discomfort ratings. There were only two significant correlations, in a *negative* direction, which indicated that people spending *more* hours per week on their home computers reported *less* frequent stress ($r_s = -0.064$, $p = 0.022$) and headaches ($r_s = -0.053$, $p = 0.022$) than those spending fewer.

Taken together, these results suggest that home computer use did not exacerbate any effects of computer use at work, although it could be the case that people experiencing symptoms of discomfort chose not to use a computer at home, or to minimise its use.

10.2 Hours spent using a computer

If computer use had an effect on the frequency of discomfort or symptoms experienced by users then we would expect to see significant correlations between duration of computer use and discomfort/symptoms. In this section, a number of factors related to duration of computer use were investigated, these included:

- Hours per week spent using a desktop
- Hours per week spent using a portable (with no docking station)
- Hours per week spent using a portable with docking station
- Hours per week spent using any portable (with and without docking station)
- Hours per week spent using any work computer (all work computer time)
- Hours per week spent using any computer (including home use)
- Proportion of working time spent using a computer.

Again, with most of these investigations, the approach was to test the whole sample first, followed by subsets, such as male/female and job groups, to check whether any observed effects remained. Where effects were observed across several subgroups the conclusion was that an effect was genuine. The main statistical tests used were Pearson (r) and Spearman (r_s) correlation coefficients and associated tests for the significance of the correlation. Where a correlation is referred to as "significant" it fell between 0.05 and 0.01, where we describe it as "very significant" it was significant at 0.009 or better. Although this is an arbitrary distinction, it gives some idea of the likely robustness of a result.

The table below provides descriptive statistics indicating the mean hours per week on any computer, the total working hours, and the time continuously on a computer before a break or change in task activity.

Table 44. Hours per week on computers, total working hours, time before a break

	Just portable (no docking station)	**Just desktop**	**Just portable with docking station**	**More than one type**
Mean hours per week on any computer	28.8	28.6	30.1	32.8
Mean total working hours	48.6	40.2	46.1	46.4
Mean time continuously on computer before a break/change in task activity (minutes)	55.8	48.5	47.4	47.4

There were no significant differences between people in each computer category for hours per week spent working on any computer, and for length of time before taking a break. However, the "just portable" users reported that they worked significantly longer hours than

the "just desktop" group (t=7.65, p=0.000). Some of the means calculated in this table differ from those in Graphs 1-3

10.2.1 Hours per week spent using a desktop

Several very significant correlations were found between hours/week using a desktop and various amalgams, symptoms and discomfort areas. Sufficient of these were also repeated within sex and job type subgroups to allow the conclusion that:

There was a very significant correlation between hours/week using a desktop and:

- The number of "sometimes" and "frequently" ratings on the symptoms (r=0.207, p=0.000)
- The number of "frequently" ratings on the symptoms (r=0.193, p=0.000)
- The number of "sometimes" and "frequently" ratings on the discomfort areas (r=0.133, p=0.000)
- Back discomfort (r_s=0.18, p=0.000)
- Neck discomfort (r_s=0.204, p=0.000)
- Shoulder discomfort (r_s=0.173, p=0.000)
- Fatigue (r_s=0.167, p=0.000)
- Stress (r_s=0.159, p=0.000)
- Headaches (r_s=0.171, p=0.000)
- Irritated eyes (r_s=0.239, p=0.000)
- Difficulties reading the work on screen (r_s=0.148, p=0.000)

There was some evidence for females (r_s=0.116, p=0.018) and administrative/clerical staff (r_s=0.136, p=0.016) who were 80% female, that hand/finger discomfort was also correlated with hours/week using a desktop. This result was not found for males or other occupational groups.

So, there is clear evidence that time spent using a desktop was related to all the symptoms that respondents were asked about (fatigue, stress, headaches, irritated eyes, difficulties reading the work on screen) and also with three key discomfort areas – back, neck and shoulder.

The relationship with fatigue and stress is, to a certain extent, to be expected – we would expect a longer duration of any sort of work to be correlated with these. There is also a well recognised relationship with duration of computer use and visual symptoms such as irritated eyes and difficulties reading the work on the screen. It is reassuring to find this result repeated in our questionnaire data.

The very significant correlations with the three discomfort areas back, neck and shoulder not only replicate previously observed relationships, but are to be expected from longer durations of a stationary, seated work task involving relatively "fixed" postures. The appearance of this result in our data is not unexpected, and suggests that our sample was representative of typical computer users.

The correlation with hand/finger discomfort was only observed for the female and administrative/clerical subgroups. These two groups may, in fact, be viewed as similar in composition – the administrative/clerical group was 80% female and 49% of the females in our sample worked in administrative/clerical jobs. It was therefore unclear whether the hand/finger result was genuinely related to computer use, or whether it was an effect of sex/job type. It is worth noting this result however, as similar effects for hand/finger discomfort are seen in later sections.

10.2.2 Hours per week spent using a portable (with no docking station)

None of the individual symptoms or discomfort areas correlated significantly with hours/week using a portable "alone" (i.e. with no docking station). Only the two discomfort area amalgams showed a significant correlation, and this was repeated in the male and technical subgroups but no others.

Hours/week spent using a portable on its own is not significantly correlated with any symptom or discomfort area.

However, it should be borne in mind that the overall average number of hours reported using a portable computer without a docking station (as shown in Graph 1 in Section 9.2) was low (mean=9 hours per week, standard deviation=9.61) compared to the number of hours using a desktop (as shown in Graph 2 in Section 9.2) where the mean usage was 27.2 hours per week, standard deviation 10.3. This indicates a considerable difference between the hours/week typically spent using a desktop computer, and the hours/week typically spent using a portable (without a docking station). The fact that most of the people in our sample who used a portable spent less than 20 hours per week using it might have led to an "artificially" low incidence of discomfort for these users (compared to the desktop users).

In order to match the desktop and portable users for duration of computer use, we attempted to compare the frequency of discomfort and symptoms reported by those desktop and portable users who used their computers for less than 20 hours per week. Unfortunately there were insufficient numbers of desktop users in this category to perform the necessary tests and thus we cannot determine from a matched sample what the effect on symptoms and discomfort would be of using a desktop computer on its own for a similar amount of time as the portable users claim to use their portable computers.

It is interesting, none-the-less, that in such a large sample there is a distinct difference between the time portable computer users spent using a portable "alone" and the time desktop computer users spent using a desktop computer. The very "mobility" of the portable computer users' jobs appeared to have the effect that they operated their machines 'alone' (i.e. without attaching it to an external keyboard, screen or 'docking station') for considerably fewer hours per week than desktop users used their desktop computers, making direct comparisons difficult. In sections 10.1.2 we observed that there were no significant differences between the users of various configurations of computer equipment in terms of

symptoms and discomfort. It is possible that the mobility in a (currently) "typical" portable computer users' job may mitigate against discomfort by limiting the proportion of their working time they spend using (any) computers.

10.2.3 Hours per week spent using a portable with docking station

For the total sample, the following were very significantly correlated with the hours/week spent using a portable computer with a docking station: fatigue, stress, irritated eyes, both symptom amalgam ratings.

However, the correlations with fatigue and stress were only "supported" by two subgroups (males and one job type each). In general then, we can say:

The hours/week spent using a portable with a docking station correlated significantly with:

- the number of "sometimes" and "frequently" ratings for symptoms (r=0.104, p=0.002)
- the number of "frequently" ratings for symptoms (r=0.138, p=0.000)
- irritated eyes (r_s=0.130, p=0.000)

There was a possible relationship with fatigue (r_s=0.1, p=0.004) and stress (r_s=0.105, p=0.003).

Since, functionally, a portable with a full docking station is very similar to a desktop computer, we would expect to see a similar set of correlations as were observed with "hours/week on a desktop". Surprisingly, there were considerably fewer correlations with hours/week on a docking station. In particular, the relationships with body discomfort (back, neck and shoulder) were not observed at all. This suggests either that the docking station arrangement is in some way superior to the desktop configuration, or that there is some other feature of docking station use which is having an effect. This could be, for instance, the time docking station users spent on other computers, the total hours worked per week, the task variety, the proportion of total working time spent using computers or the time worked continuously on a computer before a break.

It was possible to test for these differences between people who use just a desktop and those who use just a docking station. We observed that people who only used a docking station:

- Worked significantly *longer* hours than just desktop users (t=-14.08, p=0.000)
- Spent significantly *more* hours/week using any computers than just desktop users (t=-2.67, p=0.008)
- Spent a significantly *smaller* proportion of their total working time using computers (t=5.65, p=0.000)
- Did not differ from desktop users in terms of the time spent working on a computer before taking a break.

Of these factors, only the smaller proportion of working time spent using computers might lead to less musculoskeletal discomfort for docking station users than desktop users. The

longer working hours and hours spent on a computer would be expected to have the opposite effect (i.e. to increase musculoskeletal discomfort relative to desktop users) unless the computer activity is more interspersed with breaks and/or changes in task activities. In fact, we see later that "proportion of working time spent using computers" shows almost exactly the same correlation relationships as "hours/week using a desktop" – which means that it is a strong predictor of discomfort and symptoms. So, the smaller proportion which docking station users reported is likely to account for the results here.

Two other reasons for the apparent "superiority" of docking station use over desktop use might be either the pattern of work of docking station users or the focus of docking station users on workspace arrangement. The "proportion of working time" result indicates that docking station users have a less desk-bound job than desktop users, a job which includes more non-computer activities. In addition, the use of a docking station and the (presumably) frequent need to connect the computer and arrange the workstation, may lead to a greater focus on health and safety and on comfort for a docking station user compared to a desktop user whose workstation is always "pre-arranged".

10.2.4 Hours per week spent using any portable (with and without docking station)

"Hours/week spent using any portable" captures all the time that respondents spent using a portable computer, whether connected to a docking station or not. If portable use in itself had an effect on discomfort and symptoms, not already revealed by the two previous "portable" categories, then this might manifest itself here in correlations with symptom and discomfort ratings.

Once again, although there were some significant correlations here, the results were not completely clear (certainly not as clear as for hours using a desktop). Most of the correlations for the whole sample were repeated within the male sample and within the management/professional group (which was predominantly male), but not within the female or administrative/clerical group.

The only discomfort area to correlate significantly with hours/week on any portable was hand/finger discomfort – this was repeated within males, and within the management/professional group (80% male). This result is interesting when compared to "hours/week on a *desktop*" which correlated significantly with hand/finger discomfort for females and administrative/clerical staff (i.e. for the "opposite" subgroups). This suggests that there is, here at least, some relationship between duration of computer use and hand/finger discomfort.

We can say, then, that:

There were no significant correlations between hours/week using any portable and any symptom or discomfort area which could be generalised across *all users*. However:

for *males (Ar)* and *management/professional* staff *(Br)*, hours/week using any portable computer configuration correlated significantly with:

- The number of "sometimes" and "frequently" ratings on the symptoms (Ar=0.096, p=0.007; Br=0.084, p=0.027)
- The number of "frequently" ratings on the symptoms (Ar=0.119, p=0.001; Br=0.128, p=0.001)
- The number of "sometimes" and "frequently" ratings on the discomfort areas (Ar=0.110, p=0.002; Br=0.08, p=0.034)
- Hand/finger discomfort (Ar_s=0.142, p=0.000; Br_s=0.138, p=0.001)
- Fatigue (Ar_s=0.109, p=0.003; Br_s=0.106, p=0.006)
- Stress (Ar_s=0.093, p=0.012; Br_s=0.113, p=0.004).

One of the main ergonomics problems with portable computer use is the lack of physical separation between the screen and keyboard. This either prevents the screen from being positioned at a comfortable height, because the user keeps the keyboard at a comfortable height; or prevents the keyboard from being positioned at a comfortable height, because the user keeps the screen at a more comfortable height. It may be the case that men (being generally taller than women) compromise on the 'screen at correct height' and therefore use the keyboard in a poor position, which may lead to the hand/finger discomfort observed here, or perhaps it could be that males have less manual dexterity and so end up more tense in hands/fingers when keying and using the mouse. It may also be associated with the manual handling aspects of portable computer use, which are examined in Chapter 11, where we will see increased wrist, hand and finger discomfort associated with increases in the amount of weight carried in conjunction with the portable computer.

10.2.5 Hours per week spent using any work computer (all work computer time)

"Hours per week using any work computer" is the sum of *all* the hours that respondents reported spending using a computer at work – whatever the computer type, portable, desktop, or docking station.

Several very significant correlations were found between hours/week using any work computer and various amalgams, symptoms and discomfort areas. Sufficient of these were also repeated within sex and job type subgroups to allow the conclusion that:

Hours/week using any work computer was significantly correlated with:

- The number of "sometimes" and "frequently" ratings on the symptoms (r=0.157, p=0.000)
- The number of "frequently" ratings on the symptoms (r=0.158, p=0.000)
- The number of "sometimes" and "frequently" ratings on the discomfort areas (r=0.111, p=0.000)
- The number of "frequently" ratings on the discomfort areas (r=0.082, p=0.000)
- Back discomfort (r_s=0.110, p=0.000)
- Neck discomfort (r_s=0.134, p=0.000)
- Shoulder discomfort (r_s=0.105, p=0.000)
- Hand/finger discomfort (r_s=0.094, p=0.000)
- Fatigue (r_s=0.132, p=0.000)
- Stress (r_s=0.148, p=0.000)
- Headaches (r_s=0.113, p=0.000)
- Irritated eyes (r_s=0.165, p=0.000)
- Difficulties reading the work on screen (r_s=0.105, p=0.000).

There was also a significant correlation with wrist (r_s=0.071, p=0.004) and leg discomfort (r_s=0.065, p=0.009) which applied to the whole sample and within the male subgroup, but was not repeated within any other group.

This set of correlations is very similar to the results for "hours using a desktop" with the addition of correlations with hand/finger discomfort and the number of "frequentlys" on discomfort areas. The emergence of the hand/finger result is no surprise given its appearance for males in the sections relating to hours of portable use and for females in the desktop section. We can probably conclude therefore, that many of the correlations with "hours/week using a work computer" are due to desktop computer use. The duration of portable computer use may exacerbate hand/finger discomfort for some users.

10.2.6 Hours per week spent using any computer (including home use)

Hours per week spent using any computer includes all work computer use, plus the hours respondents told us that they spent using their computer at home. Generally, it correlated with the same symptoms and discomfort areas as "hours/week on any work computer":

Hours per week spent using any computer (including home) correlated significantly with:

- The number of "sometimes" and "frequently" ratings on the symptoms (r=0.101, p=0.000)
- The number of "frequently" ratings on the symptoms (r=0.104, p=0.000)
- The number of "sometimes" and "frequently" ratings on the discomfort areas (r=0.091, p=0.000)
- The number of "frequently" ratings on the discomfort areas (r=0.059, p=0.01)
- Back discomfort (r_s=0.075, p=0.002)
- Neck discomfort (r_s=0.110, p=0.000)
- Shoulder discomfort (r_s=0.08, p=0.001)
- Hand/finger discomfort (r_s=0.09, p=0.000)
- Fatigue (r_s=0.088, p=0.000)
- Stress (r_s=0.102, p=0.000)
- Headaches (r_s=0.06, p=0.010)
- Irritated eyes (r_s=0.118, p=0.000)
- Difficulties reading the work on screen (r_s=0.082, p=0.001).

The only new result was that wrist discomfort correlated with this measure for the whole sample (r_s=0.062, p=0.011), males and management/professional staff (not females or administrative/clerical staff). This is not enough to state with confidence that home computer "hours" caused wrist discomfort, since not all groups were affected, but it is an indication that home computer use may be "additive" to work use, in terms of musculoskeletal discomfort.

10.2.7 Proportion of working time spent using a computer

We asked respondents to tell us about the proportion of their working time which was spent using computers (as a percentage). Results from the analysis of individual company data had already suggested that this proportion was a key measure relating to discomfort, and this was borne out in the total sample:

The proportion of working time spent using a computer was significantly correlated with:

- The number of "sometimes" and "frequently" ratings on the symptoms (r=0.153, p=0.000)
- The number of "frequently" ratings on the symptoms (r=0.116, p=0.000)
- The number of "sometimes" and "frequently" ratings on the discomfort areas (r=0.145, p=0.000)
- The number of "frequently" ratings on the discomfort areas (r=0.097, p=0.000)
- Back discomfort (r_s=0.119, p=0.000)
- Neck discomfort (r_s=0.132, p=0.000)
- Shoulder discomfort (r_s=0.122, p=0.000)
- Wrist discomfort (r_s=0.136, p=0.000)
- Fatigue (r_s=0.104, p=0.000)
- Stress (r_s=0.095, p=0.000)
- Headaches (r_s=0.158, p=0.000)
- Irritated eyes (r_s=0.151, p=0.000)
- Difficulties reading the work on screen (r_s=0.07, p=0.002).

Leg (whole sample r_s=0.07, p=0.000), arm (whole sample r_s=0.089, p=0.000), and hand/finger (r_s=0.122, p=0.000) discomfort were also very significantly correlated with this measure for the total sample, the male subgroup and the management/professional staff (but not for females or admin/clerical workers). This suggests that there may also be a relationship between proportion of working time using a computer and these three discomfort areas for some people.

Therefore, the proportion of working time spent using computers appears to be a key predictive measure for discomfort and symptoms in computer users.

10.3 Total working hours and time between computer breaks

Two additional measures which might be related to the experience of symptoms or discomfort were the total number of hours worked (regardless of computer use) and the length of time people spent using a computer continuously before taking a break or changing activities.

10.3.1 Total working hours

Respondents were asked to estimate their typical working hours per week. Taking into account factors such as sex and job type, we found that:

Total working hours was significantly correlated with:

- The number of "sometimes" and "frequently" ratings on symptoms (male r=0.097, p=0.001), (female r=0.072, p=0.048)
- Back discomfort (r_s=0.067, p=0.004)
- Fatigue (r_s=0.066, p=0.004)
- Stress (r_s=0.114, p=0.000).

This is an interesting result. The fact that total working hours does *not* correlate with as many symptoms or discomfort areas as, say, hours using a desktop or hours using any computer, suggests that the effects we observed in the previous section were genuinely to do with *computer use*. The previously observed correlations between discomfort and duration of computer use could have occurred because the hours/week spent on computers were linked to the overall working hours of the respondents (which might have been the "real" causal factor for discomfort). In fact, total working hours were not as closely related to all the discomfort areas and symptoms as was the duration of computer use, which suggests that the element of *computer use* was more important than the overall time at work.

10.3.2 Time spent using a computer continuously before taking a break or changing activities

It is widely recommended that people take regular breaks, or regularly change activities, when using computers. If this advice is appropriate, we would expect people taking regular breaks to be "better off" in terms of their experience of discomfort and symptoms than colleagues who take less frequent breaks.

The picture in terms of correlations between "time before a break" and discomfort and symptoms was in fact, far from clear, although a few results can be stated with some confidence. Again, this analysis includes portable, desktop, and docking station users.

There was a significant correlation between "time before a break" (in minutes) and:

- Back discomfort (r_s=0.072, p=0.003)
- Neck discomfort (r_s=0.081, p=0.001)
- Irritated eyes (r_s=0.163, p=0.000)
- Headaches (r_s=0.077, p=0.001)
- Difficulties reading the work on the screen (r_s=0.103, p=0.000).

Several other discomfort areas and symptoms were very significantly correlated with "time before a break" for the total sample, but the results were not totally supported by all the other subgroups. We cannot be totally confident that these are "real" results as the sexes and job

types were interrelated (for instance, the management/professional group was 80% male). This leaves the results open to the risk that an underlying sex or job related factor was in fact the cause of the correlation, rather than some effect of the time before taking a break. However, those which were also significantly correlated with at least one sex and one job type subgroup were:

- Leg discomfort
- Shoulder discomfort
- Wrist discomfort
- Hand/finger discomfort
- Fatigue.

There does seem to be sufficient evidence to suggest that taking breaks early is worthwhile. We explore the details of exactly when to take a break in Section 10.4.3.

10.4 Can we recommend "safe" durations of use?

Understanding that correlations exist between various measures of duration of computer use and symptoms/discomfort suggests that there might be time "limits" which could be recommended to reduce the chance of symptoms or discomfort occurring. This was explored by testing for a significant difference in symptoms/discomfort between those using a computer for less than a certain duration *vs* more than a certain duration. The analysis was also repeated for "proportion of working time spent using a computer" and "time before taking a break", as well as several of the more interesting duration of computer use measures.

10.4.1 Hours/week on a desktop

The number of "frequentlys" on *symptom* ratings was significantly higher for people using their desktop for longer than 20 hours/week than for people using it for less than this. This was also the case at 25, 30, 35, 40 and 45 hours a week (i.e. people using desktops for longer than these durations reported more "frequently"s than those using a desktop for a shorter period). This is consistent with the correlations reported earlier, and demonstrates that, generally, using a desktop for a shorter duration is always better than using it for longer. What the results do not tell us is what the ideal "safe" duration is.

A similar result was seen for the number of "frequentlys" reported on *discomfort* ratings in a particular body area for people using a desktop – there were significant differences at more/less than 25, 30, and 35 hours (no difference at 20, 40, or 45 hours). Here, the change between 20 and 25 hours suggests that discomfort does significantly increase at durations longer than 25 hours, which might suggest than 25 hours could be an appropriate maximum (although this would be quite low for many jobs).

10.4.2 Other duration of use measures

For clarity, the results for "hours/week on a desktop" (explained above) and other duration measures are shown in the following table. A tick (✓) indicates a significant result, a dash (-) that there was no difference.

Table 45. Incidence of symptoms reported after different durations of computer use

	Significantly more "frequentlys" after … hours											
	symptom ratings						**discomfort area ratings**					
Hours/week:	**20**	**25**	**30**	**35**	**40**	**45**	**20**	**25**	**30**	**35**	**40**	**45**
Using desktop	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	-	-
Using any portable	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-
Using any work computer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
Using portable with docking station	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
Total working time	-	-	-	-	-	-	-	-	-	-	-	-
Hours/week:	**5**	**10**	**15**	**20**			**5**	**10**	**15**	**20**		
Using portable alone	-	-	-	-			✓	✓	-	-		

What the table mainly shows is that it is in fact quite difficult to recommend a particular duration of use as "safer" than any other – generally, the longer computers are used for, the more frequent symptoms and discomfort become.

It is, however, interesting to note that there does not seem to be any general increase in symptoms or discomfort as overall working hours (i.e. non-computer work hours plus computer work hours) increase. This is true even up to 65 working hours/week (the small numbers of people working longer than this make further comparisons pointless). This reinforces the earlier finding that *computer use* is a more important predictor of discomfort and symptoms than working hours alone.

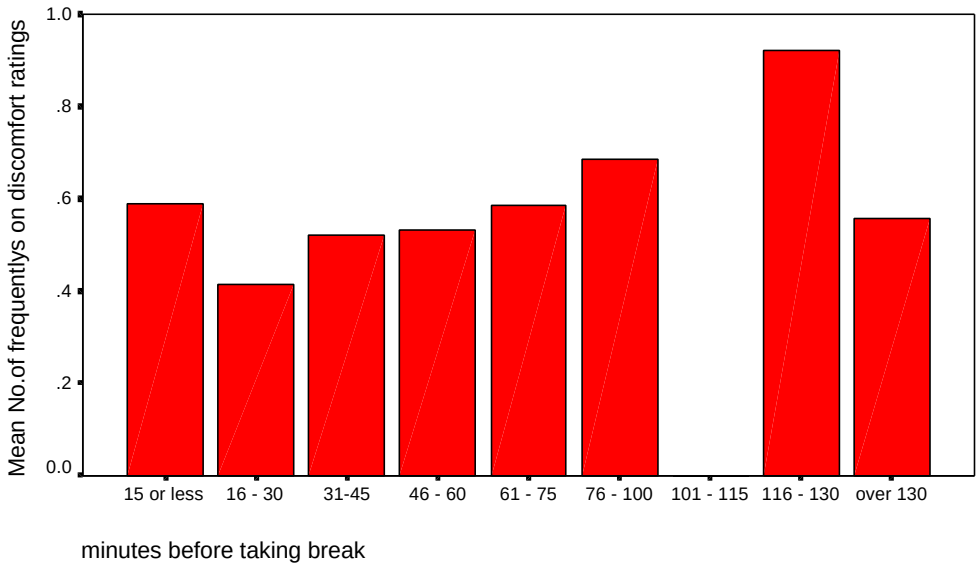
Also, the pattern for "portable alone" (no docking station) is interesting – people used their portables on their own for considerably shorter periods than they used other computer configurations. Within this pattern, there are no differences at more/less than 5, 10, 15, 20 hours for symptoms and only at more/less than 5 and 10 hours for discomfort areas. Once the portable is used for longer than 15 hours, the frequency of discomfort does not seem to increase significantly. This is in contrast to the results for "any portable" use (which includes docking station use) – here the frequency of symptoms and discomfort clearly increases with increased duration of use. However, given that we have previously observed that the overall hours of use per week of portable computers 'alone' were relatively low compared to desktop use, we cannot predict what effect on discomfort would be observed if the overall hours of portable computer use 'alone' were more similar to those reported by desktop users.

10.4.3 Time before taking a break from computer use

We have seen that a few symptoms and discomfort ratings increased in frequency as the time before people took a break from computing activity increased. Is there a recommended "break time" which might help to avoid the occurrence of symptoms or discomfort?

Commonly 30-60 minutes is recommended as the ideal time after which to take a break from computing, or to change task activities. The number of "frequentlys" on symptoms and discomfort ratings was, indeed, significantly lower for people taking a break at 30 minutes or before (compared to those leaving it longer than 30 minutes). Unfortunately this result was also true at 45 and 60 minutes – so that it is difficult to give a recommended time limit. In fact, graphs showing the frequency of symptoms and discomfort (see example below) do show a general increase with reduced frequency of breaks, but there are no obvious points where the situation becomes distinctly worse.

Graph 19. Incidence of discomfort associated with different times before taking break



To pursue this further we investigated portable, desktop and docking station users separately:

Table 46. Discomfort after time before taking a break by type of computer user

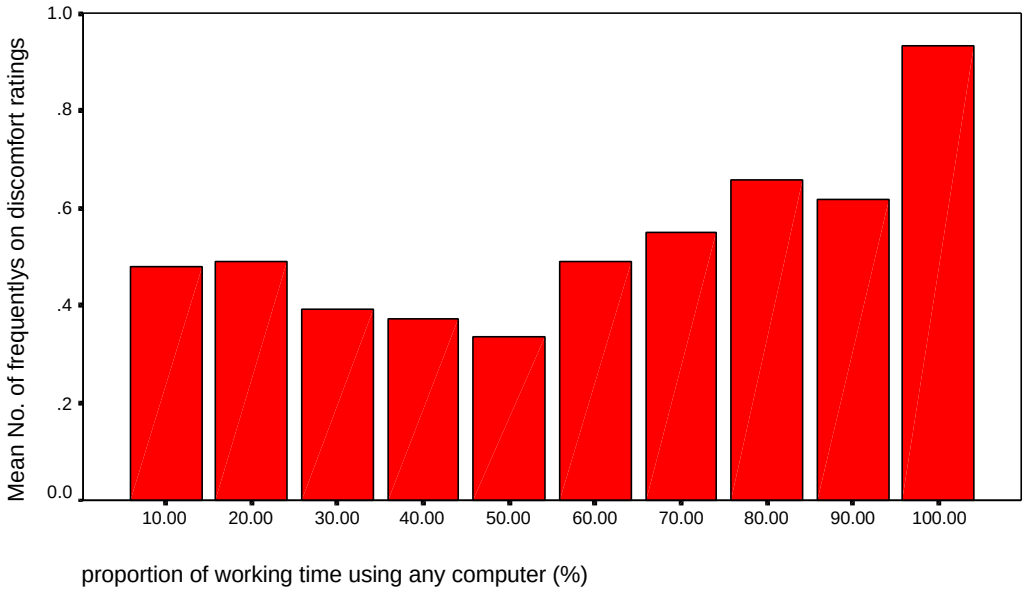
Category and % of people in group	No. of ratings significantly worse after…	These were:
Just portable users (n=106)		
More than 30 minutes (63%)	**2**	Hand/finger discomfort (t=2.31, p=0.024), Fatigue (t=2.09, p=0.04)
More than 45 minutes (47%)	**2**	Hand/finger discomfort (t=2.93, p=0.005), Fatigue (t=2.11, p=0.038)
More than 60 minutes (18%)	**0**	---
Just desktop users (n=731)		
More than 30 minutes (55%)	**5**	Back (t=2.54, p=0.011), Shoulder (t=2.16, p=0.031), Hand/finger discomfort (t=2.05, p=0.041), Irritated eyes (t=5.41, p=0.000), Difficulties reading work on screen (t=4.01, p=0.000)
More than 45 minutes (41.5%)	**9**	Back (t=2.29, p=0.023), Shoulder (t=2.04, p=0.042), Wrist (t=2.05, p=0.041), Hand/finger discomfort (t=3.08, p=0.002), Fatigue (t=2.39, p=0.017), Stress (t=2.15, p=0.032), Headaches (t=2.24, p=0.025) Irritated eyes (t=5.86, p=0.000), Difficulties reading screen or documents (t=4.47, p=0.000)
More than 60 minutes (16%)	**6**	Feet (t=2.61, p=0.01), Leg (t=2.95, p=0.004), Back discomfort (t=2.04, p=0.043), Fatigue (t=2.83, p=0.005), Irritated eyes (t=4.4, p=0.000), Difficulties reading work on screen (t=2.98, p=0.003)
Just portable with docking station users (n=502)		
More than 30 minutes (57%)	**4**	Leg (t=2.24, p=0.026), Shoulder discomfort (t=2.58, p=0.01 Irritated eyes (t=2.57, p=0.01), Difficulties reading work on screen (t=1.93, p=0.05
More than 45 minutes (41%)	**2**	Irritated eyes (t=2.6, p=0.01), Difficulties reading work on screen (t=2.79, p=0.006)
More than 60 minutes (10%)	**1**	Difficulties reading work on screen (t=2.1, p=0.041)

Although there was no completely clear "limit" for a recommended break in these results, we can see from the table above that just portable, just desktop and just docking station users may need to take breaks at different frequencies. For just desktop users, taking a break at 45 minutes or before may provide the most benefit. For docking station users, 30 minutes may be most suitable. For portable users without docking stations, there seems little difference between 30 and 45 minutes.

10.4.4 Proportion of working time using any computer

The graph below suggests that once the proportion of working time spent using any computer exceeds 50% there is a steady increase in the frequency of discomfort. This is borne out in the statistics – there is no significant difference between people using a computer for more/less than 40% of their time in terms of "frequentlys" on either symptoms or discomfort. People using their computer for 50% or more, however, report significantly more "frequentlys" on symptoms (t=2.16, p=0.031) and discomfort (t=2.92, p=0.004) ratings than those using a computer for less than 50% of their working time. This is repeated at every 10% interval right up to 90%.

Graph 20. Incidence of discomfort associated with computer use as an increasing proportion of working time for whole sample of respondents



We can conclude then, that the proportion of working time to spend using a computer which appears to *minimise* any risks is 50% or less.

10.5 Effects of training

A previous study suggested that there may be significant benefits from training computer users about how to avoid the health and safety risks from Display Screen Equipment work (*Display screen equipment health problems.* HSE Contract Research Report. Travis, D.S and Heasman, T.A. 1998). So we asked all our respondents (desktop, portables, docking station, handheld users) whether they had received any training or information from their current employer on the health and safety issues which are relevant to working with computers. We also asked whether they had used this information and training to set up and operate their computers or workstations.

We were interested in three main questions:

1. Did receiving the training make any difference to the experience of symptoms and discomfort reported?
2. Did using the information gained in the training make any difference to the experience of symptoms or discomfort?
3. Did receiving or using training make any difference to the people's satisfaction with their overall working environment?

Table 47. Number and percentage of people who had received training and used it

Company #	Issue	Yes (n)	%
Company A	Training received on H&S issues relevant to working with computers	122	69
	Used knowledge gained from training	111	89
Company B	Training received on H&S issues relevant to working with computers	1229	98
	Used knowledge gained from training	1056	99
Company C	Training received on H&S issues relevant to working with computers	84	82
	Used knowledge gained from training	74	85
Company D	Training received on H&S issues relevant to working with computers	76	87
	Used knowledge gained from training	70	91
Company E	Training received on H&S issues relevant to working with computers	34	26
	Used knowledge gained from training	27	71
All users	Training received on H&S issues relevant to working with computers	1545	70
	Used knowledge gained from training	1338	87

Overall, 70% of the sample reported that they had received health and safety training regarding computer use. Of these, 87% claimed that they had used the knowledge gained from this training to set up and operate their workstations.

To answer the first question we compared people who had received training with those who had not:

People who had received training reported significantly less frequent back discomfort (U=51595, p=0.039) and irritated eyes (U=55699, p=0.013) than people who had not received the training.

So, the training may have had a positive effect on users. Back discomfort is certainly an issue that can be affected by correct adjustment of the chair, good seated posture and taking frequent breaks – all of which would be encouraged in appropriate training. The less frequent back discomfort in trained individuals is therefore consistent with having received training. Similarly, irritated eyes can be exacerbated by sitting at an inappropriate distance from the screen, poor positioning of the screen, by lighting and glare, and by taking insufficient breaks. Training would be expected to advise on these issues and so might well reduce the occurrence of visual difficulties.

To answer the second question we compared the group who had used their training with those who had not received any training:

People who had used the training they received reported significantly less frequent back discomfort (U=51607, p=0.038) and irritated eyes (U=55753, p=0.013) than people who had not received any training.

As an additional check we looked at the people who had received training to see whether there were any differences within this group between those who had chosen to use the training and those who had not:

There were no significant differences in terms of individual symptoms or discomfort areas between those who had and had not used the training they received.

This suggests that the act of training staff had a positive effect – whether or not staff feel that they have actually put the training to use.

The third effect of training might be a change in satisfaction with the working environment. We had asked respondents to rate their overall satisfaction with their typical desktop and portable working environment and so could test for a training effect:

There was no significant difference in the overall satisfaction reported with the desktop working environment between people who had and had not received training. There was also no difference in satisfaction between those who had used this training and those who had not.

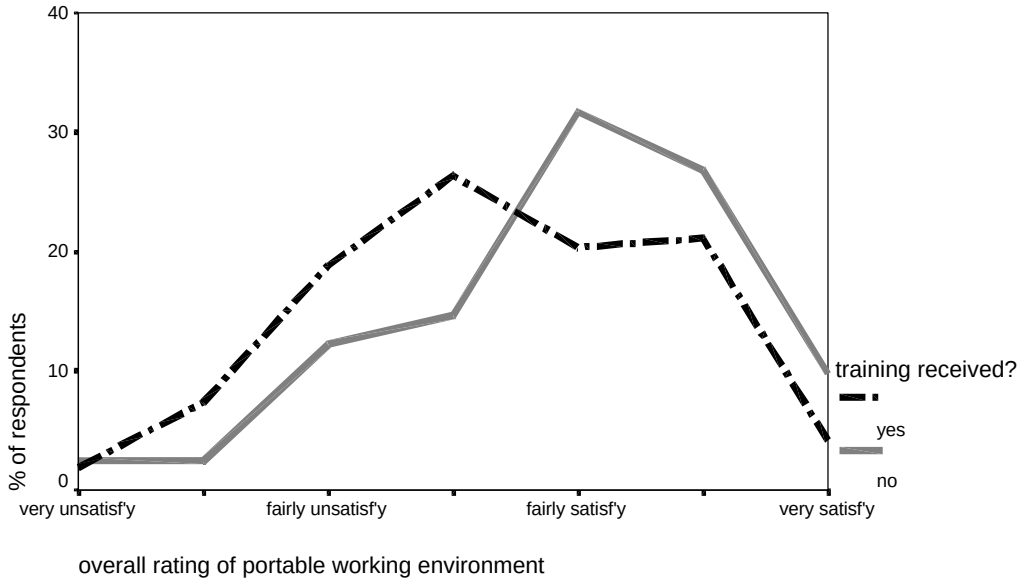
Portable computer users who had received training were significantly less satisfied with their working environment than those portable computer users who had received no training (U=9376, p=0.012). There was no difference between people who had used, or not used, this training.

This interesting result suggests that training can breed dissatisfaction in some groups (despite its apparent positive results for others). One explanation of this result, which would also explain the apparent difference between desktop and portable computer users is that the training could make portable users more aware of the failings in their “portable” working

environment. Unfortunately, they are perhaps less able to make changes to their "mobile" working environment than desktop users who have the ability to improve their permanent workstations and environment. This would result in increased dissatisfaction with the working environment in portable compared to desktop users. This does not imply that portable computer users should not be trained, but that providing training to them, although it allows them to recognise "bad" environments, also provides them with the knowledge to minimise the risks associated with those environments.

The result is illustrated in the line graph below – the broken line, representing people who had received training clearly lies to the left (more dissatisfied) side of the graph.

Graph 21. Rating of portable computer working environment by trained and untrained users



10.6 Location of portable computer use

One of the principal benefits of a portable computer is that it can be used in a wide variety of locations. This, of course, may also be one of the main disadvantages in that portable users may be encouraged to use their portables in locations and environments which are unsuitable for computer use.

We asked respondents to list the locations at which they used portable computers, and to tell us how many hours/week they typically spent using their portables at these locations. In this section we investigate the relationship between these locations and durations of use, and the frequency of discomfort.

First we looked for correlations between the hours spent using a portable at each location and frequency of discomfort.

The results were as follows:

Table 48. Correlation between hours spent using the computer at different locations with musculoskeletal discomfort

Hours/week…	**Significant correlation with discomfort in…**
At home (without docking station)	Neck (r_s=0.106, p=0.002, Arm (r_s=0.076, p=0.036)
At home (with docking station)	Back (r_s=0.417, p=0.002)
On trains/aeroplanes	Neck (r_s=0.208, p=0.000), Shoulder (r_s=0.170, p=0.001), Hand/finger (r_s=0.109, p=0.043)
In waiting areas	Arm (r_s=0.171, p=0.052)
At main office (with docking station)	Neck (r_s=0.070, p=0.047
Hotels	Shoulder (r_s=0.099, p=0.034)

This suggests that there is a relationship between portable use in "non standard" locations and discomfort – in particular on public transport and at home. It is also interesting to note that use with a docking station did seem partly to mitigate against the negative effects of portable use. This is demonstrated, for instance, by the comparison in the table above, between use with and without a docking station at home. The discomfort associated with working from home may be related to issues such as a lack of an adjustable 'office' style chair, although as we did not visit anyone in their home location, this remains in the realm of speculation.

Another way to look at the location of use was to compare people who used a portable at a particular location with those who did not – to see whether using the portable at this location had any effect on discomfort. (This differs from the approach above which looked at correlations with "hours/week" at locations). We found that:

People who used their portable in a motor vehicle reported significantly more frequent back (t=2.05, p=0.049) and neck (t=3.04, p=0.005) discomfort than those portable users who did not use their portable in a vehicle.

People who used their portable in their main office (with a docking station) reported significantly more frequent hand/finger discomfort (t=2.89, p=0.004) than those who did not use their portable in this location.

The motor vehicle result is not unexpected in that such locations are likely to be cramped and offer no work surface on which to place the portable. This would lead to poor postures, with back and neck discomfort a predictable result.

The apparent difference in hand/finger discomfort between people using their portable in the office with a docking station and other portable users is less easy to explain. We would expect that the use of a docking station in a relatively controlled office environment would be better for the user than use in other locations. The table below probably provides the answer

– it shows the average number of hours for which portable users reported using their computers at the various locations. Clearly, the people using portables in their main office spent much longer on their portable there than at other locations (on average). This considerable difference in duration of use is most likely to be the explanation for the difference in hand/finger discomfort, rather than the location itself. We saw earlier that duration of computer use is often related to increased discomfort.

Table 49. Hours per week spent using portable computer at different locations

Hours per week at location	Mean
Main office (with docking station)	27
Main office	12
At other offices	6
At customer or supplier premises	6
At home (with docking station)	6
At other offices (with docking station)	5
In motor vehicle	5
At other locations	5
At home (without docking station)	4
In hotels	3
Outside	2
In train or aeroplane	2
In waiting area	2

Finally, the data was checked to see whether the number of different locations which each respondent mentioned was related to discomfort. The only result of significance was for hand/finger discomfort:

There was a significant correlation between the number of different locations mentioned for portable use and the frequency of hand/finger discomfort (r_s=0.068, p=0.026).

In summary then, location of use did seem to make a difference to the experience of discomfort for portable computer users. Cramped areas with no suitable worksurface or chair, such as aeroplanes, trains and cars were particularly unfavourable but the use of a docking station arrangement did appear to make a positive difference in other locations (such as at home). However, other factors, such as duration of use, may be more important than location for predicting discomfort.

10.7 Years spent using computers, time in job, time in organisation

We also asked respondents how many years they had spent using computers, and how long they had been in their current job and organisation. We report our findings in the following sections.

10.7.1 Years spent using computers

We explored the data for correlations between the four amalgams, eight discomforts and five symptoms and "years spent using a computer for work" for the whole sample (i.e. all computer users).

We identified significant *negative* correlations between the number of years spent using computers and:

Both symptom amalgams (sometimes/frequently amalgam r=-0.072, p=0.001; frequently amalgam r=-0.088, p=0.000)
Headache (r_s=-0.116, p=0.000)
Irritated eyes (r_s=-0.136, p=0.000)
Back (r_s=-0.097, p=0.000)
Neck (r_s=-0.066, p=0.005)
Shoulder (r_s=-0.043, p=0.048)

This suggests that 'years using a computer' is not a harmful factor – people who started using a computer more recently reported more symptoms than those who had used computers for longer. This could be explained by self selection of course – those who have difficulties leave the job or the organisation.

10.7.2 Years spent using portable

We looked for relationships between the reported health symptoms and "years spent using a portable computer" for the whole portable-using sample, and similarly for the smaller group of users who used only portables.

We observed significant *negative* correlations for the whole portable-using sample between years spent using a portable and:

Headache (r_s=-0.067, p=0.030)
Irritated eyes (r_s=-0.066, p=0.032)
Shoulder (r_s=-0.07, p=0.026)

There were no correlations observed in the 'only uses a portable' group.

This too indicates that 'years using a portable' does not seem to be a harmful factor for health and comfort. However, there could be a "yet to emerge" factor – portable use has not been widespread until relatively recently, and early portable users may perhaps have been senior

managers etc, whose actual use of the portable, other than as a status symbol, may have been infrequent.

10.7.3 Years spent in current job

We looked for significant correlations between the number of years all respondents had spent in their current job and the health effects.

We observed two *negative* correlations:

Irritated eyes (r_s=-0.069, p=0.003)
Back discomfort (r_s=-0.067, p=0.004)

So "time in job" does not appear to be associated with an increase in adverse health effects.

We also looked at portable users (all of them, regardless of other computer use)

There was only one significant correlation, in the positive direction:

Years in current job correlated significantly (r_s=0.071, p=0.023) with wrist discomfort for portable users.

10.7.4 Years spent in current organisation

We explored the data for correlations between 'years in current organisation' and the amalgams, symptoms and discomfort.

There were significant *negative* correlations with:

Both symptom amalgams (sometimes/frequently amalgam r=-0.049, p=0.026; frequently amalgam r=-0.088, p=0.000)
Number of sometimes and frequentlys on discomfort ratings (r=-0.045, p=0.044)
Headache (r_s=-0.114, p=0.000)
Irritated eyes (r_s=-0.131, p=0.000)
Back (r_s=-0.078, p=0.001)
Neck (r_s=-0.051, p=0.029)
Shoulder (r_s=-0.051, p=0.029)

This data indicates that we cannot implicate increased length of time in an organisation as a factor in health/comfort, but again, there may be a self-selection effect operating here, with people who have problems in the organisation opting to leave.

10.7.5 Differences between computer users in years spent using computers

We explored the data to see if there were any significant differences between computer user groups in terms of the years they had spent using computers. The table below shows the mean length of time working with computers for each computer user group.

Table 50. Mean length of time working with computers for each user group

	Length of time working with computers (years)	**N**
Just portable	10.96	108
Just desktop	11.31	781
More than one type	14.42	781
Just portable with docking station	13.91	564

The just portable and just desktop groups were not significantly different from one another. The "more than one" group and just docking station groups did not differ from one another. However the following *were* significantly different:

Just portable *vs* more than one type, (t=-4.896, p=0.000)
Just portable *vs* just docking station, (t= -4.181, p=0.000)
Just desktop *vs* more than one type, (t= -9.351, p=0.000)
Just desktop *vs* just docking station, (t= -7.830, p=0.000)

This data indicates that the length of time using computers does not appear to have an influence on the just desktop/just portable symptoms and discomfort comparison, as the two groups do not differ on this variable.

We also checked for any differences between user groups in terms of "years using a portable" – there were none.

10.8 Ratings of aspects of the working environment

We compared the satisfaction ratings reported by the desktop users and portable users for each aspect of the working environment using a Wilcoxon signed ranks test.

The following aspects of the working environment were rated significantly more satisfactory by desktop users when compared to portable users:

Worksurface height (Z=-4.029, p=0.000)
Ease of reading information on screen (Z=-6.761, p=0.000)
Size of screen (Z=-7.458, p=0.000)
Height of screen (Z=-6.717, p=0.000)
Adjustability of screen (Z=-3.364, p=0.001)
Adjustability of display (Z=-6.39, p=0.000)
Ease of use of keyboard (Z=-8.338, p=0.000)
Ease of use of mouse (Z=-4.312, p=0.000)
Chair suitability (Z=-3.625, p=0.000)
Chair adjustability (Z=-5.118, p=0.000)
Overall layout of work area (Z=-2.794, p=0.005)
Arrangement of cables (Z=-5.051, p=0.000)

The following were rated significantly more satisfactory by portable users when compared to desktop users:

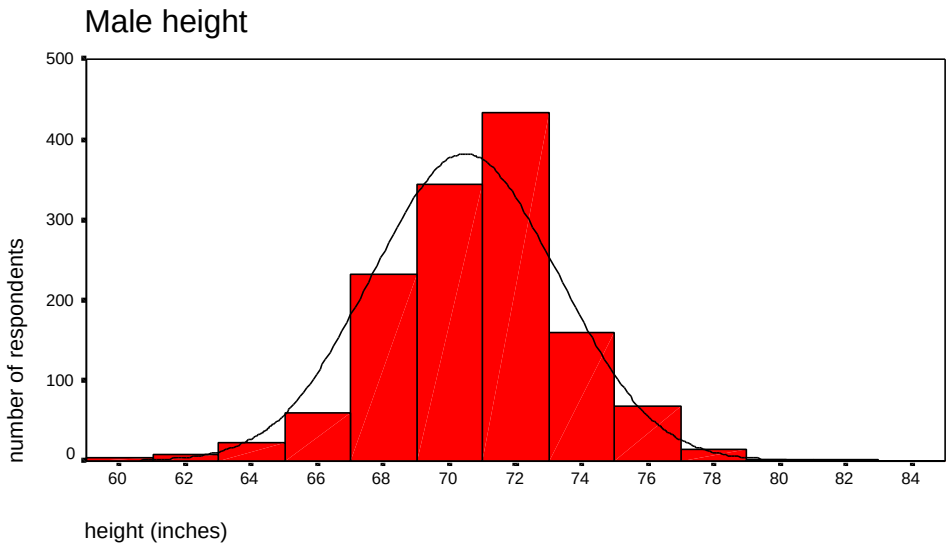
Temperature (Z=-5.429, p=0.000)
Air quality (Z=-5.420, p=0.000)
Draughts (Z=-2.635, p=0.008)
Noise (Z=-6.220, p=0.000).

These results are mostly to be expected due to the greater amount of control that desktop users have over their immediate working environment, and the greater adjustability in their workstations and equipment. This clearly reinforces the necessity to provide appropriate equipment and working environments (such as docking stations) for portable computer users wherever possible.

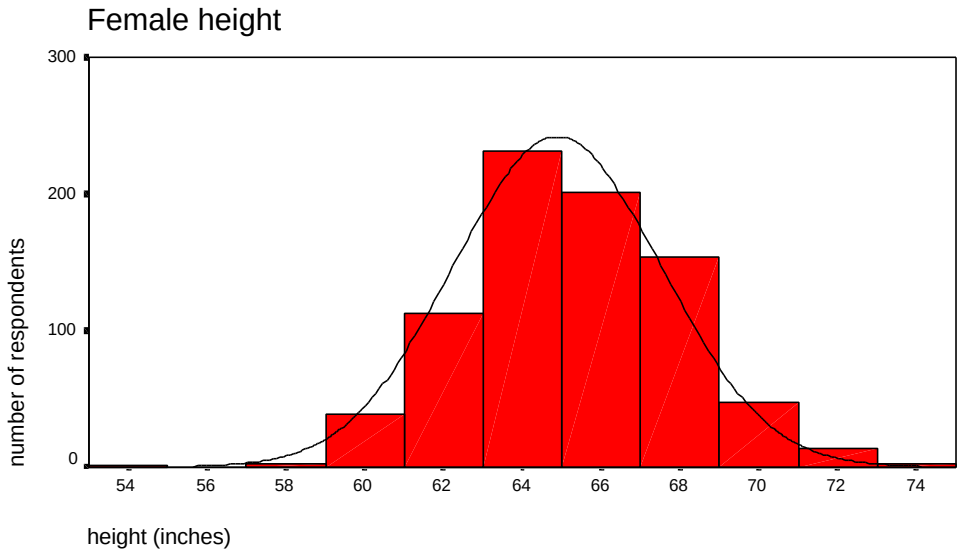
10.9 Effects associated with stature

We asked respondents to tell us about their height, in order to see whether this "personal factor" had any influence on discomfort. Since males and females generally differ in height we considered them separately. The height profile of the sample is shown in the following graphs:

Graph 22. Distribution of male respondent height



Graph 23. Distribution of female respondent height



We looked for correlations between height and discomfort rating. For both males and females there was a significant, negative correlation between height and arm discomfort (male r_s=-0.067, p=0.025; female r_s=-0.079, p=0.050). This means, roughly speaking, that taller people reported significantly less arm discomfort than shorter people. There were no other significant correlations.

The most likely explanation of this apparently odd result, is that taller people probably also have longer arms than shorter people. Having longer arms may mean that reaches to the mouse and keyboard result in less extreme postures than for shorter-armed individuals. Furthermore, in a typical workplace, desks are designed for 95% popliteal height (popliteal height is defined as the vertical distance from the floor to the angle at the underside of the knee). This means that taller people are more likely to be sitting at the correct keying height, because the desk is at the right height for them anyway. A shorter person has to adjust themselves upwards and use a footrest - which for portable computer users, is unlikely to be provided in all the workplaces they occupy, so they may key at the wrong height, resulting in higher levels of arm discomfort.

10.10 Effects associated with age

In this section we examine the health effects associated with different age groups, and with each computer type grouping within each age group.

10.10.1 Differences in age profile across the various computer user groups

The table below shows that the age profile for different types of users does not differ significantly across the age groups, with the exception of handheld users, who were younger than the other groups.

Table 51. Percentage of each age group by computer usage group

	<21	21-30	31-40	41-50	51-60	>60
Just portable (no docking station) %	0	36	32	23	8	0
Just desktop %	3	29	34	22	10	1
More than one type %	0	16	39	36	9	0
Just portable with docking station %	0	10	36	42	11	0
Just handheld %	9	61	22	6	2	1

10.10.2 Analysis of symptoms and discomfort by age group

In this analysis we examined whether there was any relationship with age in terms of their experience of the symptoms and discomforts.

We observed the following *negative* correlations between symptoms and age:

Fatigue (r_s = -0.53, p=0.021)
Headaches (r_s = -0.139, p=0.000)
Irritated eyes (r_s = -0.124, p=0.000)

And the following *negative* correlations between discomforts and age

Back (r_s = -0.081, p=0.001)
Neck (r_s = -0.046, p=0.045)
Arms (r_s = -0.075, p=0.002)

Fatigue, headaches, irritated eyes, back discomfort and neck discomfort all correlated significantly with age, but negatively – in other words, older people were experiencing these health effects less frequently than younger people. Again, this may be due to a self-selection effect.

10.10.3 Analysis according to each computer group separately, within age groups

To see whether age affected any of the main discomfort results we explored the data for correlations between age and discomfort *within* each computer user group separately. We provide the results below, and summarise all these in a table at the end:

a) Just portables
In this group, age correlated negatively (but significantly) with fatigue, headaches, irritated eyes, i.e. the same result as for the whole sample.
Fatigue (r_s = -0.197, p=0.049)
Headaches (r_s = -0.285, p=0.004)
Irritated eyes (r_s = -0.351, p=0.000)

In terms of discomfort, the only significant correlation was with back discomfort, which was negative again (r_s = -0.248, p=0.022)

b) Just desktops
For people who only use a desktop, headaches and irritated eyes correlated negatively with age:
Headaches (r_s = -0.090, p=0.014)
Irritated eyes (r_s = -0.103, p=0.005)
Arm discomfort correlated significantly and positively with age (r_s = 0.122, p=0.002). So, desktop users get more frequent arm discomfort the older they are.

c) More than one type
For this group, headaches correlated negatively with age ((r_s = -0.116, p=0.008) but no discomfort areas correlated with age.

d) Just docking station
Here we observed the same result as for the total sample – fatigue, headaches and irritated eyes all correlated with age, but negatively:
Fatigue (r_s = -0.092, p=0.040
Headaches (r_s = -0.110, p=0.015)
Irritated eyes (r_s = -0.112, p=0.013)

For discomfort, feet and back discomfort correlated with age, feet positively and back negatively:
Feet (r_s = 0.102, p=0.032)
Back (r_s = -0.120, p=0.008)

Table 52 provides a summary of the above results. The negative correlations indicate that the incidence of reported symptoms and discomfort decreases with age, positive correlations indicate that it increases with age.

Table 52. Summary of health correlations of age and computer group

	Age correlated significantly with…						
	Fatigue	**Head-aches**	**Irritated eyes**	**Back**	**Neck**	**Arms**	**Feet**
Just portable	negative	negative	negative	negative			
Just desktop		negative	negative			positive	
Just portable with docking station	negative	negative	negative	negative			positive
More than one type		negative					
Whole sample	negative	negative	negative	negative	negative	positive	

11. OUR FINDINGS - MANUAL HANDLING

One of the features of portable computers which may cause additional physical discomfort is the need for manual handling – portable computers must be carried around by the user. We asked respondents to tell us about several of the manual handling aspects of portable computer use:

- How they carried their portable (using the handle/shoulder strap, in a briefcase etc)
- What other items they typically carried with their portable
- An estimate of the total weight they typically carried with them.

11.1 Correlations with weight carried

We tested whether the estimated weight carried correlated with any discomfort areas. The results are shown below.

Weight carried correlated significantly with:

- Leg discomfort (r_s=0.073, p=0.036)
- Neck discomfort (r_s=0.066, p=0.048)
- Arm discomfort (r_s=0.068, p=0.050)
- Hand/finger discomfort (r_s=0.092, p=0.007)

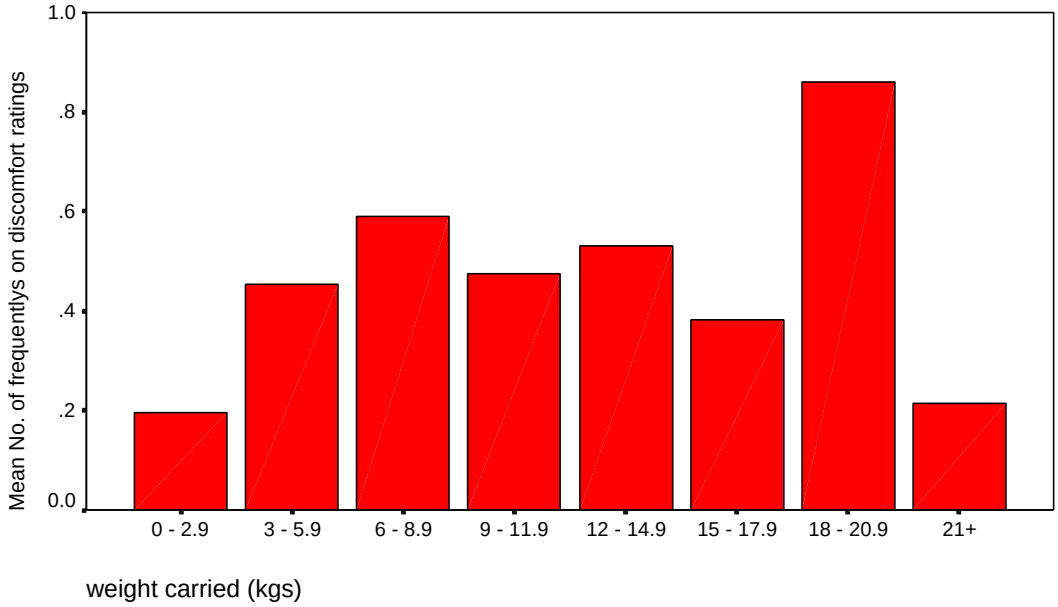
This strongly suggests that the weight carried by our respondents (including their portable computer) affected their physical discomfort. The relationship with leg discomfort is particularly interesting since this is most likely to be related to aspects of having a 'mobile' job, for example, walking/standing activities such as carrying, driving, sitting on non-adjustable chairs, and is less likely to be affected by other computer related activities.

11.2 Recommended weights

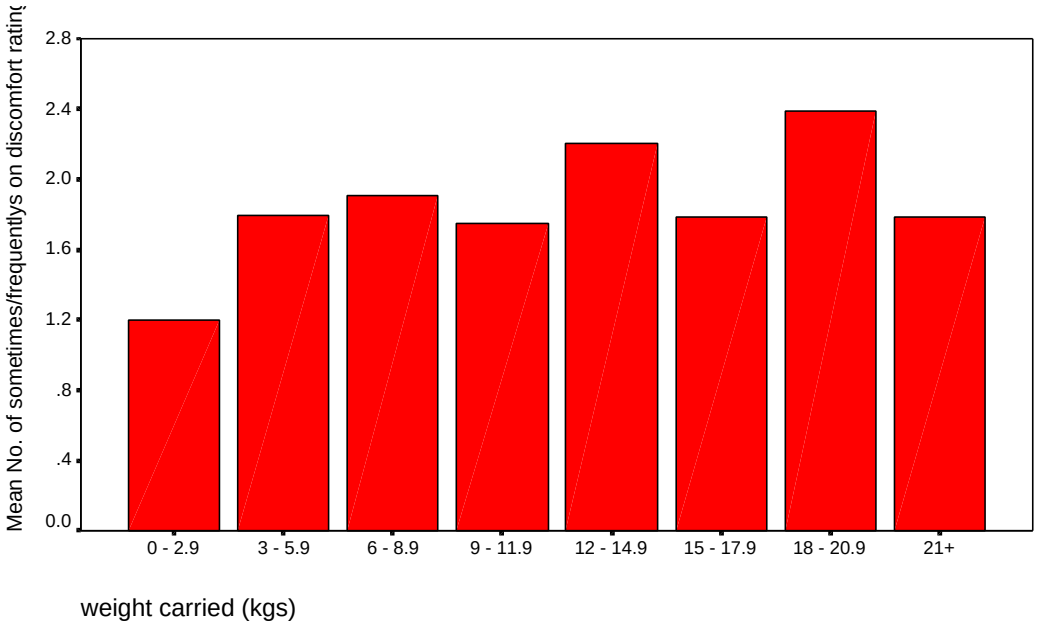
The Manual Handling Operations Regulations (1992) require employers to assess manual handling risks, and to reduce the risk by eliminating or minimising manual handling where possible. In this section we attempt to identify the incidence of musculoskeletal discomfort associated with increasing weight carried by portable computer users.

Graphs of the average number of “frequentlys” on the discomfort ratings, and the average number of “sometimes” and “frequentlys” might give some clue as to the relationship between the weights carried by portable computer users, and the incidence of discomfort.

Graph 24. Incidence of “frequent” musculoskeletal discomfort associated with weight carried



Graph 25. Incidence of "sometimes" or "frequent" musculoskeletal discomfort associated with weight carried



The weight that minimises the risk appears to be more/less than 3kg. However, a portable computer alone (i.e. not including power cables, transformers, carry case etc) weighs at least 3kg. This effect then may be due to people who did not find carrying their portable a problem and so their estimates of weight were artificially low. During the site visits, all portable users interviewed were carrying typical weights (measured by our ergonomist) in excess of 6kg.

Testing to see whether discomfort was more frequent for people carrying more than 3kg, we found that:

Leg, neck, arms, wrist and hand/finger discomfort are all reported as more frequent by portable users who estimate that they carry 3kg or more, compared to those who carry less.

However, testing for other relationships, we also found the following:

Table 53. Significant differences in musculoskeletal discomfort at different weight thresholds

More frequent discomfort above…	…in these body areas	Number of areas affected
3 kgs	Leg (t=3.9, p=0.000), Neck (t=3.6, p=0.001), Arms (t=7.03, p=0.000), Wrists (t=2.94, p=0.005), Hand/fingers (t=3.6, p=0.001)	5
6 kgs	Shoulder (t=2.25, p=0.025), Arms (t=3.6, p=0.001), Hand/fingers (t=2.15, p=0.032)	3
9 kgs	No differences	0
12 kgs	Feet (t=1.9, p=0.049), Arms (t=1.96, p=0.05), Hand/fingers (t=2.52, p=0.013)	3
15 kgs	Feet (t=1.98, p=0.05), Hand/fingers (t=1.97, p=0.051)	2

We would expect to see these sorts of results given the correlation already observed between weight carried and leg, neck, arm and hand/finger discomfort. This correlation simply suggests that the more weight that is carried, the more frequent will be the discomfort, especially in the feet, hands, and fingers. Although there is no clear answer, minimising the weight carried appears to have the greatest effect on minimising discomfort.

We also checked to see whether there were any differences in discomfort experienced between those people who estimated a weight (N=1037, 47.3%), and those who left that section of the questionnaire blank (N=1155, 52.7%):

There were no differences in frequency of discomfort experienced (on any body area) between people who did, and did not, choose to estimate a weight.

This offers the reassurance that the group who chose to give a weight was not atypical in their reporting of frequency of discomfort.

We also examined the data for correlations between weight carried and discomfort within each age group. We observed correlations in only the 31-40 age group, for hand/finger discomfort ($r_s = 0.140$, p=0.012), and leg discomfort ($r_s = 0.114$, p=0.045). This lack of correlations contrasts with the results for the total sample where leg, neck, arm and hand/finger all correlated with weight carried.

11.3 Method of carrying portable

People carried their portables in a variety of ways:

Table 54. Number of portable users adopting different transportation methods

Method of transportation	N
By shoulder strap	511
By its handle	346
In my briefcase	153
In a backpack	140
More than one way	48
Trolley	8
Bicycle rack	6

Clearly, most people used the handle or shoulder strap provided on the carry case but a significant minority used a backpack or carried the portable in their briefcase. A Kruskal-Wallis test was used to see whether any of these methods seemed "superior" in terms of discomfort experienced:

There were no significant differences in any discomfort area between the people choosing the various methods to carry their portable

This result is quite surprising – we would expect to see those using a backpack experiencing less frequent discomfort as backpacks load the body more evenly, if worn using both straps. Perhaps, as the user has both hands free, the temptation may be to carry another bag, which is likely to cause asymmetric loading and lead to discomfort. Alternatively, they may wear it over one shoulder, not using both straps, which loads the body asymmetrically which is more likely to lead to discomfort.

We looked for any significant differences in terms of discomfort within age groups between the methods of carrying portables. For the age 31-40 group there was a difference for arm discomfort ($?^2$=16.3, p=0.012). The table below indicates that people (in the 31-40 age group) who carry their portable on trolleys and bicycle racks may be worse off than others.

For the 31-40 age group the table below indicates the mean arm discomfort experienced by respondents in this group.

Table 55. Mean arm discomfort associated with each method of carrying, for 31-40 age group

Method of carrying	Mean arm discomfort
By its handle	0.49
By shoulder strap	0.33
In a backpack	0.48
In my briefcase	0.59
Trolley	3.00
Bicycle rack	1.00
More than one way	0.85

11.4 Number of additional items carried

A variety of additional items were carried with portable computers as shown in the table below. A "small amount of paperwork" was defined as "less than 2-3cm (1 inch) thickness of paper", and a "considerable amount of paperwork" was defined as more than 2-3cm (1 inch) thickness of paper".

Table 56. Number of additional items carried by portable computer users

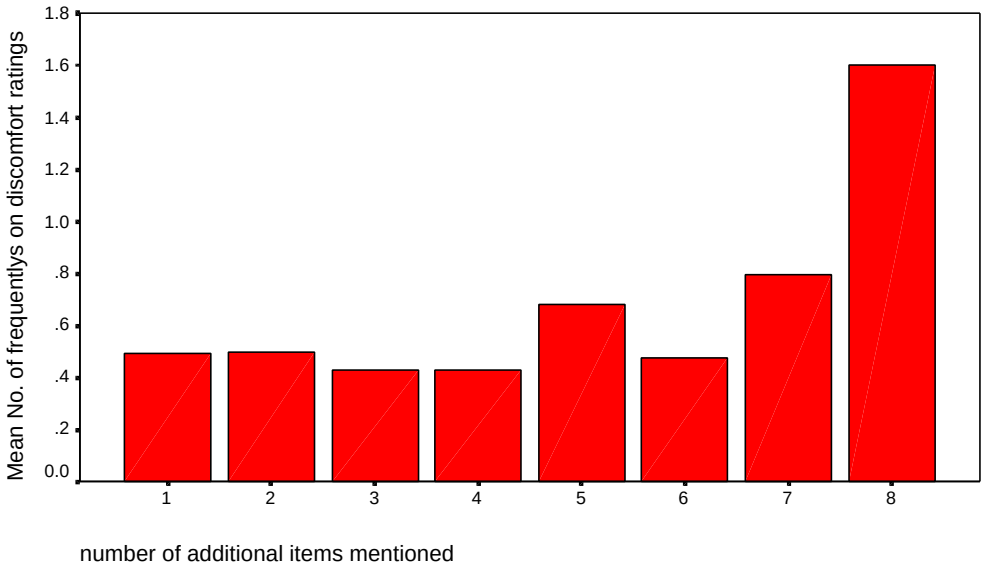
Additional item carried	N	%
Carried power supply and cables	957	80
Carried mobile phone	671	56
Carried considerable amount of paperwork	563	47
Carried small amount of paperwork	484	41
Carried additional bag for work	375	32
Carried additional luggage	350	29
Carried a spare battery	293	25
Carried handbag/small bag	258	22
Carried CD ROM drive	225	19
Carried external disk or ZIP drive	151	13
Carried projector	8	1

NB These are percentages of ***portable users*** – not percentages of whole sample

The analysis of the individual company data had suggested that one cause of discomfort might be the number of additional items carried along with the portable. Intuitively this makes sense, since carrying lots of extra items places an additional burden on the body, not just in terms of weight, but in terms of control – possibly leading to uncomfortable or fixed postures when carrying, and difficulties in gripping which may also lead to discomfort.

The graph below shows how the number of “frequently” ratings on the discomfort areas increased with the number of additional items. (Note that although the graph changes dramatically at 8 items, only 5 people carried as many extra items as this).

Graph 26. Correlation between discomfort and number of items carried



Testing to see whether there might be a useful maximum number of additional items which might be used as a recommendation, we found that there was no difference on any discomfort area between people carrying:

- Less than 4 additional items versus 4 or more items
- Less than 6 additional items versus 6 or more items
- Less than 7 additional items versus 7 or more items.

However,

People carrying 5 or more items reported significantly more frequent back (t=3.17, p=0.002), neck (t=2.87, p=0.004) and shoulder (t=2.75, p=0.006) discomfort than those carrying less than this.

It would seem, therefore sensible to minimise the number of items carried with the portable computer.

11.5 Association of carrying a particular item with discomfort

We tested to see whether people who reported that they carried any of the following items experienced more frequent discomfort than those not carrying them. We added one category "any bags/luggage (all bag carriers together)"

> *Power supply cables, spare battery, small amount of paperwork, considerable amount of paperwork, CD Rom drive, external/ZIP drive, projector, mobile phone, handbag/small bag, other bag, additional luggage, any bags/luggage (all bag carriers together).*

As in previous sections the analysis was conducted for the whole sample, plus male, female and job subgroups. The rationale for this was to try to eliminate any factors which might be related to sex or job type rather than to the items carried.

Only two results were repeated across sufficient subgroups to be considered reliable:

People who carried a considerable amount of paperwork reported significantly *more* frequent back (U=129681, p=0.001) and neck (U=130668, p=0.000) discomfort than those who did not carry this amount of paperwork.

People who carried a small amount of paperwork reported significantly *less* frequent back (U=132300, p=0.045), neck (U=128839, p=0.004) and wrist (U=119914, p=0.039) discomfort than those not carrying this amount of paperwork.

These two results are very interesting, particularly when considered together. First, the people carrying considerable amounts of paperwork were probably carrying quite a heavy amount of paper which could certainly contribute to neck and back discomfort. Also, the fact that they carried this large amount of paperwork might suggest that their job involved more movement between locations – as they needed to carry more of their work with them.

People who chose to describe the paperwork they carried as "a small amount" reported less discomfort than others. The key to understanding this seems to be that the important comparison group for these people is not the people who carried no paperwork at all, but the people who carried considerable amounts, who we know reported more discomfort. Indeed, of the nearly 1,200 portable users, only 143 claimed not to carry any paperwork at all (i.e. they did not choose either of the paperwork categories). The majority of respondents, who regularly carry paperwork, had to choose between describing it as a "considerable" or a "small" amount – if they chose "small" then it is reasonable to assume that they typically carried less weight than the "considerable paperwork" group which should lead to less discomfort. They may also have felt that carrying their paperwork was relatively insignificant to them (perhaps if they were not aware of any discomfort) and so "small" was a more appropriate choice.

We looked at all the age groups individually to see if carrying specific items made any difference to discomfort. The table below summarises our findings.

In the table "worse" indicates respondents in this group reported significantly more frequent discomfort if the specific item was carried, "better" indicates significantly less frequent discomfort if the item was carried.

Table 57. Significant correlations with body areas according to age group and additional item carried

Body area: **Item/age group:**	**Leg**	**Wrist**	**Hands/ fingers**	**Back**	**Feet**	**Neck**	**Shoulder**
Mobile phone							
31-40	Worse U=15204 p=0.011						
41-50		Worse U=15891 p=0.030					
CD Rom							
21-30		Worse U=1279 p=0.051	Worse U=1218 p=0.014				
External/Zip drive							
21-30				Worse U=844 p=0.004			
41-50					Worse U=6242 p=0.051		
51-60			Worse U=635 p=0.031				
Spare battery							
21-30					Worse U=1276 p=0.032		
51-60	Better U=544 p=0.014						
Small amount of paperwork							
31-40				Better U=17676 p=0.032			
41-50			Better U=16529 p=0.043			Better U=16161 p=0.035	

Body area: Item/age group:	Leg	Wrist	Hands/ fingers	Back	Feet	Neck	Shoulder
Considerable amount of paperwork							
21-30						Worse U=2163 p=0.030	Worse U=2083 p=0.013
31-40	Worse U=16468 p=0.049			Worse U=17238 p=0.005	Worse U=16467 p=0.026	Worse U=18708 p=0.043	
41-50				Worse U=17390 p=0.010		Worse U=17547 p=0.046	
Handbag/small bag							
21-30						Worse U=2082 p=0.012	Worse U=1935 p=0.020
31-40						Worse U=14220 p=0.090	Worse U=13433p =0.011
41-50				Worse U=8773 p=0.026		Worse U=8634 p=0.011	Worse U=7929 p=0.009
Additional bag							
41-50						Worse U=14891 p=0.029	Worse U=14133p =0.031
Additional luggage							
31-40		Worse U=13215 p=0.039					
Any form of bag/luggage							
21-30						Worse U=2233 p=0.054	Worse U=1991 p=0.022
41-50						Worse U=15086 p=0.005	Worse U=14980 p=0.008

From the data there does not appear to be a pattern in terms of symptoms worsening with age. The older group (51-60) appear to be reporting lower levels of discomfort than the younger groups. The table also supports the finding that carrying a considerable amount of paperwork is associated with discomfort, and that carrying any type of bag appears to increase neck/shoulder discomfort.

12. OUR FINDINGS - PORTABLE COMPUTER INPUT DEVICES

A variety of input devices were used with both portable and desktop computers, as illustrated in the table below. Users may appear in more than one column.

Table 58. Number of computer users reporting use of different input devices

	Desktop input device	**Portable with docking station input device**	**Portable input device**
Touchpad	3	1	14
Tracker ball	3	14	15
Standard mouse	1039	701	85
Ergonomic mouse	54	34	14
Trackpoint	6	13	275
Stylus/pen			1
Speech recognition		1	
More than one type	60	96	82

Clearly the majority of desktop users used mice when using a desktop, and the picture was very similar for the docking station users. Most of our sample who used a portable alone had a trackpoint device although about 20% used some form of mouse.

For all three computer configurations above, where numbers allowed, we compared each input device against each other device, to see whether users of either device reported more frequent symptoms or discomfort than the other.

Although there were a few significant differences these did not persist across the relevant subgroups of respondents, which suggested that they were not “true” differences due to the input device. In addition, most of these differences were on symptoms such as irritated eyes and headaches, which were less likely to vary with input device, and were more likely to be affected by other factors such as duration of computer use or working hours.

We can conclude, for our sample, that there were no significant differences between types of input device in terms of frequency of either discomfort or symptoms.

13. OUR FINDINGS - PERCEIVED RISKS OF USING PORTABLE COMPUTERS

We asked respondents to describe any risks to which they felt exposed from using a portable computer, and to rate the severity of these risks. They were able to list any risks which concerned them – there were no predetermined categories. The table below shows the number of respondents who spontaneously mentioned each type of risk (with no indication of the severity rating):

Table 59. Number of portable users reporting perceived risks associated with portable computer use

Perceived risk	N
Perceived risk to back	425
Perceived risk to shoulder	307
Perceived risk of arm ache	193
Perceived risk to eyesight/of eyestrain	175
Perceived risk to neck	150
Perceived risk of theft	115
Perceived personal risk of mugging	70
Perceived risk to wrist	56
Perceived risk of finger fatigue	49
Perceived risk from headaches	34
Perceived risk of RSI	23
Perceived risk due to weight carried	16
Perceived risk of general muscle strain	12
Perceived risk to posture	11
Perceived risk of stress	9
Perceived risk of losing it	8
Perceived risk of radiation	7
Falling over	6
Unbalanced load	4
Perceived risk of damage to computer	4
Perceived risk to hand	2
Car damage during theft	1

Many people (about 35% of portable users) were concerned about back discomfort, with about 25% concerned about their shoulder, followed by concerns about arm ache, eyesight/eyestrain, neck, theft and mugging. If we combine the numbers for theft and mugging (arguably both crime-related), this concern would jump up the "ratings" to fourth place. It should be noted that "arm ache" was given as the example in the questionnaire – this may partly explain its high rating here.

People were asked to rate the severity of each risk they reported from 1 ("mildly severe risk") to 5 ("extremely severe risk") – the average ratings for each risk are shown in the table below:

Table 60. Reported severity of perceived risks

Perceived risk	Severity 1:mildly severe 5:extremely severe
Perceived risk of repetitive strain injury (RSI)	3.7
Perceived risk to neck	3.6
Perceived risk to eyesight/of eyestrain	3.6
Perceived risk from headaches	3.5
Unbalanced load	3.5
Perceived risk of losing it	3.5
Perceived risk to back	3.5
Perceived risk to shoulder	3.4
Perceived risk of general muscle strain	3.4
Perceived risk to wrist	3.3
Perceived risk of damage to computer	3.3
Perceived risk of finger fatigue	3.2
Perceived risk of arm ache	3.2
Perceived risk to posture	3.2
Falling over	3.2
Perceived risk of theft	3.1
Car damage during theft	3.0
Perceived risk to hand	3.0
Perceived risk due to weight carried	2.9
Perceived risk of radiation	2.9
Perceived personal risk of mugging	2.8
Perceived risk of stress	1.0

Although the same sort of risks still appeared in the top few, the interesting appearance at the "number one" spot was "risk of RSI". This came 11th in the first list and was only mentioned by a few people (23), but in terms of severity it seems to be quite an important concern.

Perceived risk is clearly not always the same as the actual risk to which portable users may be exposed. However, understanding users' concerns provides employers, and other agencies offering advice, the opportunity to address specifically these very real concerns. In many cases it may be possible to demonstrate that the risks are actually less severe than users believe, or to show that simple tactics (such as taking regular breaks, avoiding use in certain environments) can reduce the risks. Genuine reassurance and targeted training will not just make portable users "feel better", but may actively reduce the potential negative effects of portable use by minimising stress and highlighting areas where users can themselves participate in reducing the risks.

14. OUR FINDINGS – HANDHELD COMPUTERS

The market review (Chapter 6) and telephone survey (Chapter 7) indicated that the market size and current use of handheld computers was low. However, two of the companies included in the study issued handheld computers to some of their staff. Hand held computers are generally smaller (although not necessarily lighter) than portables, typically do not have full size keyboards, and may have limited or job-specific functionality.

Although numbers were relatively small, we were able to examine some aspects of handheld use, for two types of handheld, which are described in the sections below.

Table 61. Type of handheld computer used

Type of handheld	Characteristics of handheld	N
E	Device consisted of computer+ detachable printer; 3.5" LCD backlit display, black characters on green background; Non-qwerty keyboard layout; 53 keys six keys across by nine down; arranged alphabetically with numeric keypad below alpha keypad; key strike surface 7.5x7.5mm. No screen or keyboard adjustability. Weight computer + printer 1kg; black plastic carry case weight <0.25kg.	40
F	7" LCD colour display screen; screen tilt adjustability (no independent height or swivel adjustability); qwerty keyboard, 82 keys, key strike surface 9.5x9mm; 10mm diameter mouse on right-hand-side of screen; weight 1kg; small cloth case, weight <0.25kg.	57

Handheld computers E and F were used in different companies, had different capabilities and were used for quite different purposes. This means that comparisons between them were risky, and grouping them together as "handhelds", as if they were the same type of machine, was equally tenuous an approach – both were treated with caution.

Table 62. Descriptive statistics indicating time in job, organisation, using computers, using handheld computers, for handheld users

	Mean	Standard deviation
Years using a handheld for work	1.7	1.9
Years in current job	1.7	1.7
Length of time working with computers (years)	5.5	4.0
Years in current organisation	1.7	1.7
Years using a handheld at work	1.4	1.8

14.1 Location of handheld use

For company E users, the locations of handheld use were:

Table 63. Location of handheld use, company E users

Location	N
Outside (on the street)	48
At company office	20
At indoor car park	16
In motor vehicle	10
At local authority site	5

For company F users, the location of handheld use were:

Table 64. Location of handheld use, company F users

Location	N
In field (i.e. at retail outlet)	52
At home	45
At company office	39
In motor vehicle	22
In hotels	3

14.2 Type of handheld computer used

As with the other types of computer, we compared the two main types of handheld computer with each other, to see if users of one type experienced different frequencies of symptoms or discomfort from the other. We observed the following differences.

Users of handheld type E reported significantly more frequent feet (U=283, p=0.000), leg (U=281, p=0.000), shoulder (U=403, p=0.008) and arm (U=327, p=0.001) discomfort than users of type F.

Users of F reported significantly more frequent headaches (U=448, p=0.021), irritated eyes (U=320, p=0.001) and difficulties reading the work on the screen (U=347, p=0.047) than users of type E.

In fact, these differences are much more likely to be due to job factors than any differences in the handhelds themselves. Users of handheld E mainly had jobs consisting of large amounts of walking and standing, which involved carrying approximately 3 kg of equipment with them for most of the day, but only small amounts of screen work. This could certainly result in more feet, leg, shoulder and arm discomfort (and less visual discomfort) than type F users.

Users of type F were in sales-related jobs and used their handhelds as “mini portables”, their comments about their handhelds revealed that the small screen size was a source of considerable irritation to them – this may well be the source of the increased visual difficulties they appeared to experience.

14.3 Hours per week using handheld

We asked respondents how long, typically, they spent using their handhelds in a week. The mean hours per week was 34.7, standard deviation=6.2 hours per week for these users. Correlation coefficients were calculated between this and the frequency of symptoms and discomfort reported by handheld users.

There were no significant correlations between hours/week using a handheld and any individual symptom or discomfort area, or any amalgam rating.

We also looked for correlations between the number of years for which respondents had used a handheld (mean=1.7 years, standard deviation= 1.8 years), and frequency of symptoms and discomfort:

There were no significant correlations between number of years using a handheld and any amalgam, individual symptom or discomfort area.

14.4 Manual handling issues related to handheld computer use

As with portable computer users, we asked respondents to estimate the weight which they typically carried along with their handheld computer. This allowed us to look for correlations between weight carried and frequency of discomfort:

There was a significant correlation between the weight carried with the handheld computers and foot discomfort (r_s=0.4, p=0.017) but no other discomfort area.

14.5 Handheld input devices

A range of input devices were used with the handheld computers:

Table 65. Type of input device used with handheld computer

Handheld input device	N
Standard mouse	39
More than one type	31
Keypad	26
Trackpoint	8
Stylus pen	8
Bar code reader	6
Touchpad	5
Tracker ball	3
Scanner	1

We compared the frequency of discomfort and symptoms experienced by the users of standard mice, keypads and "more than one type" of input device. Unfortunately, as previously seen, the type of activities of the two main job types amongst handheld users appeared to have a considerable effect on the results. Although several significant differences were observed, it would be risky to assume that these were truly related to the input device. The observed differences were:

1. Users of more than one type of input device reported significantly more fatigue, headaches and leg discomfort than mouse users and more frequent irritated eyes and headaches than keypad users
2. Mouse users reported significantly more frequent irritated eyes than keypad users and users of more than one type of input device
3. Keypad users reported significantly more frequent feet, leg, shoulder and arm discomfort than mouse users and more frequent feet and leg discomfort than users of more than one type of input device.

Generally, handheld computers are much less prevalent at work than portable computers, and tend to be used for specific applications, rather than more general computer tasks. This makes investigating the effects of their use difficult, because the job-specific factors tend to be very strong and confound the results. Future investigations would need to match samples and job types very carefully to enable the accurate comparison of brands of handheld, or of handheld tasks.

15. OUR FINDINGS – USER-REPORTED QUALITATIVE DATA FOR PORTABLE COMPUTERS

Three qualitative questions in the portable user questionnaires asked respondents to state which feature(s) of their portable computers they liked least and liked most, and what they would most like to change. These were 'free' responses where users were given space to write down what they felt, rather than selecting from a list. The tables in this chapter provide aggregated summaries of their responses.

Some caution should be borne in mind when examining these results. The fact that a user likes a particular feature may be: because it was genuinely good, e.g. as good or better than the standard achieved on desktop PCs; or because it was better than the user's previous model. However, it may also be worse than the desktop equivalent, but better than the user was expecting given what they had heard about portable computers. They may also discount the faults because, taken as a whole, they like having the portable because it makes their job easier.

15.1 Desirable features

Table 66 below shows that the feature of their portable that a considerable number of users of each type of computer liked most was the convenience, portability, and flexibility it gave them to work where they liked, when they liked. The second most popular aspect was communications, such as access to company mainframes and email. This is likely to be linked to the convenience aspects. The quality of the portable computer display screens was reported to be the third most liked feature, indicating perhaps the considerable advances in portable display screen technology that have taken place over the last few years.

Table 66. Feature of portable computer which users liked most

Brand A users (n=169)	**Brand B users (n=64)**	**Brand C users (n=14)**	**Brand D users (n=228)**
Convenience/portability/flexibility (109)	Convenience/portability/flexibility (41)	Convenience/portability/flexibility (11)	Convenience/portability/flexibility (151)
Good screen (14)	E-mail & communication(4)		Screen quality/Large screen(25)
Access to company main frame/e-mail (6)	Screen clear(2)		Email and communication (22)
Easy to use (5)	Battery life (1)		Light (22)
Can be used for presentations (5)	Trackball precise(1)		Small size(15)
Compact (5)	Touchpad(1)		Slim design(13)
Speed of use (4)	Keyboard(1)		Fast performance(12)
Docking station facility/Ease of docking and undocking from workstation (2)	Weight(1)		Reliable(7)
Familiarity with equipment (2)	Performance(1)		Allows use of ‘specialist’ software(3)
Robust (1)	Colour screen(1)		Durability(3)
Lightweight (1)			Touchpad/mouse(2)
Up to date and functional (1)			Long battery life(2)
Can do most things can do at office (1)			Large memory capacity(2)
It works (1)			Easy electronic presentations(2)
CD Rom (1)			Good memory management(1)
Fast (1)			Keyboard(1)
Touch pad better than rollerball (1)			
Sloping front doesn’t dig into my wrists (1)			
Good keyboard (1)			

15.2 Undesirable features

Table 67 below shows that the feature of their portable that a considerable number of users of each type of computer liked least was the weight. The second least liked aspect was the type of input device for controlling the cursor, especially on those portables that had a trackpoint ('nipple') for cursor control. Battery life, screen size, and aspects of the keyboard (small size, position) were also rated poorly.

Table 67. Feature of portable computer which users liked least

Brand A users (n=169)	**Brand B users (n=64)**	**Brand C users (n=14)**	**Brand D users (n=228)**
Weight (64)	Weight(36)	Small screen/hard to read (3)	Weight(149)
Trackpoint/nipple/internal mouse(38)	Trackpoint/nipple/mouse(9)	Slow (3)	Battery life(29)
Neck and shoulder discomfort when used (10)	Size (7)	Keys too small (2)	Performance(26)
Close keys/small keyboard (8) Keyboard position/angle (2) Keyboard layout differs from standard keyboard(3) Keys too soft (1) Grey keys with black surround (1) Keyboard positioning is poor – no room between it and edge of laptop to rest wrists (1)	Slow(5)	Carrying it about/weight (2)	Screen size(25)
Battery life (10)	Battery life(4)	Battery life (1)	Computer size(23)
Screen too small (9)	Screen size(4)	Processing speed (1)	Weight & no. of peripherals(13)
Slow (8)	Keyboard layout(3)	Insufficient memory (1)	Reliability(12)
Work more hours because have it/can take work home (5)	Weight and no of peripherals (3)	Mouse (1)	Trackpoint/nipple/mouse(10)
Lack of docking station/screen attached to keyboard (4)	Dated(2)		Keyboard layout(8) No numerical keypad(5) Bulky keyboard(5) Keyboard too small(6) Keyboard hard to use in low, non-office lighting(1)
Reliability (3)	Screen flickers(2)		Connection problems(11)
Carrying case (2)	Depth of keyboard(2)		Screen quality(7)
Security threat (2)	Transporting it(2)		Bulky bag/case(7)
Can be sore on wrists (1)	No CD-rom(2)		Fragile(6)
Monochrome screen (1)	No anti-glare(1)		Speed of access to network(6)
Cannot access e-mails (1)	Time taken to synchronise e-mail(1)		No internal floppy(5)
Printer access (1)	Unreliable(1)		Heat generation(4)
Not as easy to use as a desktop (1)	Internal drives(1)		RAS is hit & miss(4)
	Bad typing position(1)		Screen flicker(2)
			Transporting it(2)
			Incompatibility of peripherals throughout range(2)
			Security risk(2)
			Not network capable (1)

15.3 Main improvement to design

When asked which feature of their portable they would most like to change, the answers reflected the features that users liked least. Table 68 below shows that the majority of users wanted their portable computers to be lighter. Improving the input device (or providing an external input device such as an external mouse), increasing the battery life (without increasing the weight), and improving the keyboard were also rated desirable.

Table 68. Feature of portable computer which users would most like to see changed

Brand A users (n=169)	**Brand B users (n=64)**	**Brand C users (n=14)**	**Brand D users (n=228)**
Make it lighter (48)	Make it lighter(27)	Make it lighter (3)	Make it lighter(149)
Easier to use integral mouse/pointing device/cursor controller (17)	Make it smaller(9)	Larger screen (2)	Make it smaller/thinner(44)
Provide external mouse/roller ball (11)	Improve touchpad/trackball(7)	Bigger keyboard (2)	Improve mouse/trackpoint(31)
Increase battery life (10)	Make it faster(5)	Make it faster (1)	Longer battery life(18)
Larger screen/better angle and height (9)	Make screen size larger(3)	Easy method of connecting PC to network (1)	Make it faster(14)
Enable remote access via mobile phone/ISDN modem-line for remote connectivity/email (9)	Battery life(3)	Increase hard drive size (1)	Bigger screen(9)
Make it faster (5)	Improved connections to network(3)		Make it easier to connect to network/e-mail(7)
Smaller (5)	Voice recognition(2)		Internalise all peripherals(7)
More positive response from keyboard (1)	Upgrade(2)		Bigger keyboard/pad/buttons(6)
Keyboard lowered (2)	Better carry case(2)		Make it more reliable(5)
Improve keyboard (3)	Docking station at home(2)		More sturdy(3)
Detachable keyboard (1)	Increase size of keyboard/keys(2)		More sensitive keyboard(2)
Ability to angle keyboard relative to desk (1)	Including CD-rom(1)		Have a numerical keypad(2)
Pop-up keyboard (1)	Improve typing position(1)		Include docking system at home(2)
Provide docking station (3)	More sturdy(1)		Improve height flexibility of screen(1)
Integral hydraulic legs (1)	Internalise all peripherals(1)		Voice recognition software(1)
Provide wrist pad (1)	Upgrade(1)		Larger memory(1)
Clearer screen (1)	More reliable(1)		Have a separate keyboard(1)
Built in printing (1)			Automatic backup reminders(1)
Proper backpack for carrying it around (1)			Better screen clarity(1)
Easier to access company on line system (1)			Combined charger for phone & computer(1)
Be able to access e-mails (1)			Improve bag(1)
Screen in colour (1)			Brighter screen(1)
Voice/speech system (1)			Improve com port management(1)
Reduce weight of battery (1)			Detachable sub-unit for e-mail(1)
Improve reliability (1)			Spare battery(1)
CD-rom installed			
Solve more problems (1)			
Screen higher (1)			
New PC (1)			
Easier to use off-line (1)			
Storage capacity for on-line manuals (1)			
Leave it permanently at home (1)			

16. OUR FINDINGS – USER-REPORTED QUALITATIVE DATA FOR HANDHELD COMPUTERS

Three qualitative questions in the handheld user questionnaires asked respondents to state which feature(s) of their handheld computers they liked least and liked most, and what they would most like to change. The tables in this chapter provide aggregated summaries of their responses.

16.1 Desirable features

Table 69 below shows that the features of their handheld computer that users of each type of computer liked most, were the small size, light weight, and ease of carrying.

Table 69. Feature of handheld computer which users liked most

Brand F users (n=60)	**Brand E users (n=43)**
Small (23)	Light(5)
Portability/easy to carry (18)	Easy to carry(5)
Light (17)	Small(5)
Access to applications (Word, Excel, Powerpoint) (4)	Prints ticket well(4)
Easy to use (5)	Ease of use(4)
Compact (4)	Fast(4)
Easy to access (2)	Built in printer(3)
Easy to hold (2)	Backlit screen(2)
Having less paperwork (2)	Keypad(2)
My work looks more professional (2)	Immediately move on to next car when ticket printed(1)
Can move the screen (2)	Colourful buttons(1)
Good case facility(1)	Everything in one(1)
Fast(1)	
Instruction key uses underneath(1)	
Programs that enable us to be totally accountable(1)	
Organisation(1)	

16.2 Undesirable features

Table 70 below shows that the features of their handheld computer that users liked least were the small screens in the case of Brand F, and the reliability (especially in poor weather) and slow speed of input and operation for the Brand E users.

Table 70. Feature of handheld computer which users liked least

Brand F users (n=60)	**Brand E users (n=43)**
Small screen (23)	Slow(18)
Keys too small when working or typing (data input) (15)	Jams easily in rain(7)
Mouse/trackpoint (11)	Takes too long to input information(5)
Crashes a lot (10)	Not accepting 2000 tax codes(3)
Screen hard to read/cannot see work on screen in bright light/daylight (5)	Uncomfortable(3)
Slow (5)	Battery life(3)
Weight (4)	Weight(2)
Lack of functions – i.e. works programmes now removed (3)	Have to input time(2)
Cannot be used for personal use (3)	Screen clarity(1)
Battery life (3)	Too large(1)
Worrying about loss, theft, etc, (3)	Keypad(1)
Takes ages to dial in/download information (3)	Not enough makes of vehicle(1)
Holding it on my hand and using it/hurts my wrist by end of the day (2)	
Quite heavy/awkward when balancing in-call (2)	
Does not create any less paperwork (1)	
It would be good to print off software directly (1)	

16.3 Main improvement to design

When asked which feature of their handheld they would most like to change, the answers unsurprisingly reflected the features that users liked least. Table 71 below shows that the majority of Brand F users wanted their portable computers to have a larger screen. The Brand E users wanted the speed and reliability of operation to be faster and more reliable, especially in wet weather.

Table 71. Feature of handheld computer which users would most like to see changed

Brand F users (n=60)	**Brand E users (n=43)**
Larger screen (11)	Make it faster(19)
Better design for mouse/touchpad (9)	Make it smaller(9)
To be given a full sized monitor at home (8)	Make it lighter(7)
Larger keys (4)	Quicker input of information(4)
Touch screen (4)	Work in all weather(2)
No technical problems/crashing, better dialling in, etc. (3)	Update programme(1)
Being able to see screen in sunlight (2)	Faster registering of change in location(1)
Longer battery life (2)	Put a wiper on it(1)
Better software (2)	Show time and date(1)
Being able to access and print from software system directly (1)	Easier to read screen(1)
Better screen (1)	Be able to void penalty charge notices(1)
Faster processor (1)	
Available to access more information (1)	
Print my calls before I visit them (1)	
Touch-tone screen (1)	
Non-slip pads on base (1)	
Internet access (1)	
Programmes to make better use of screen size (1)	
All packages necessary to organise successfully (1)	
Carry handle on computer itself so you can actually use it in your hand (1)	

17. RECOMMENDATIONS

From this research it appears that some aspects of portable computer usage are no worse than using a desktop computer, but others, such as manual handling, pose additional risks to portable computer users. The research has identified that there are risks, symptoms and discomfort associated with the use of *both* portables and desktop computers that employers need to address in order to help minimise the risks to all computer users and to help maximise staff comfort, safety and productivity.

In this section we make a number of recommendations which we believe will help to reduce the risks to portable computer users. These recommendations are based on the combined results of the questionnaire survey, our site visits and workstation assessments, other available literature, and our ergonomics expertise.

17.1 Portable computer design issues

The results of this research indicate that there are features of the design of portable computers which appeared to cause difficulties for users and could be improved. In the following paragraphs we outline our main recommendations.

a) Design portable computers with screen/keyboard separation and screen height adjustability

One of the main ergonomics problems with portable computer use is the lack of physical separation between the screen and keyboard. This either prevents the screen from being positioned at a comfortable height, because the user keeps the keyboard at a comfortable height; or prevents the keyboard from being positioned at a comfortable height, because the user keeps the screen at a more comfortable height.

The literature review papers indicated that head tilt and neck flexion were pronounced with portable computer use. The statistical analysis in Section 10.4.2 indicated that people reported significantly more (amalgamated rating) discomfort when using their portable computer alone for more than five hours, and again more than ten hours per week. The qualitative data reported in chapter 13 showed that the main user-perceived risks were to their back/neck/shoulder/arms and eyesight.

For this combination of reasons we believe that manufacturers of portable computers should be encouraged to provide a means of separating the portable computer screen from the keyboard, and providing height adjustability, so that portable computer users can set both screen and keyboard at a comfortable height for their computer use.

b) Select new portable computers with ergonomic features in mind

Taking all the sources of information examined here, we believe that new portables purchased should be chosen primarily on the basis of user requirements, not simply cost, or prestige. An injured employee is more expensive to the company than a good specification

portable machine. Purchasers should conduct a task analysis of the activities that the portable computer users are most likely to undertake, and match the purchase to those features which will be most useful for those tasks.

The generally important features to look for are:

- As low a weight as possible (e.g. 3kg or less) for portable computer and accessories
- As large and clear a screen as possible (e.g. 14" diagonal or more)
- Detachable or height adjustable screen
- As long a battery life as possible, or extra transformer/cable sets so the user has a set in each main location where the portable is used, and only carries the computer, not the cables, etc.
- Touch pad, rollerball or external mouse rather than 'nipple' trackpoint device
- Wrist pad between keyboard and front edge of portable which people appeared to like and also fulfils the requirement in the Schedule to the Health and Safety (Display Screen Equipment) Regulations 1992 for space in front of the keyboard to rest the user's hands and arms when not keying.
- Lightweight non-manufacturer branded carrying case with handle and shoulder straps
- Tilt adjustable keyboard
- Facility for attaching external mouse and numeric keypad
- Friction pads underneath to prevent computer sliding across surfaces when in use
- Sufficient memory and speed (for the applications used)
- "Add-ons" that improve usability and reduce maintenance time, such as (removable) CD-ROM drives and additional memory.

c) Minimise the use of trackpoint ("nipples") as input devices

Although there did not appear to be any statistical differences in the symptoms of discomfort associated with input devices, trackpoints featured highly on users' selection of 'least liked' features, for three out of the four brands. It may be the case that these trackpoint input devices were so disliked that users attached an external mouse to the computer, which may have confounded the statistical results by minimising the reported discomfort effects. We believe that the qualitative data collected from the users is powerful enough to recommend that trackpoints are no longer used as an input device for portable computers, and for employers, the ease of use of such input devices may represent more of a productivity/ performance problem, than a health risk.

17.2 Information and training

Training users in health and safety associated with computer use appeared to have a positive effect for both portable and desktop users. It may also account for the fact that the use of docking stations appeared to limit symptoms of discomfort in the back, neck and shoulders (compared to desktops). We provide our information and training recommendations in the paragraphs below.

d) Ensure that all staff who use computers (portables, desktops, docking stations, handhelds) receive health and safety training relevant to their computer use

The statistical results show that those people who had received such training, and those who had used the training, reported significantly less frequent back discomfort and irritated eyes than those who had not received any training regardless of the type of computer used. Portable computer users who had received training were significantly less satisfied with their overall working environment than those who had not, perhaps reflecting an awareness that the portable mobile environment is less than ideal for comfortable computer usage.

Providing information and training for users is a requirement of the Health and Safety (Display Screen Equipment) Regulations 1992. The results of this research support other evidence which indicates that training computer users in the safe and comfortable use of their display screen equipment has a beneficial effect, decreasing the reported levels of musculoskeletal and other symptoms of discomfort. It underlines the value to employers of ensuring that all types of computer users receive such training.

e) Ensure that managers of portable computer users receive health and safety training relevant to portable computer use

It is important that managers of staff using portables are also aware of the risks associated with computer use of any type, so that they can work with their staff to reduce risks. The key issues indicated by this research of which managers should be aware are:

- understanding the need to take regular breaks from portable, desktop and other computer usage
- ensuring that there is adequate variety in users' tasks which can be used to break up long periods of computer activity
- limiting the proportion of overall working time spent using any computers
- providing docking station equipment and ensuring that portable computer users can use it wherever they are likely to spend long periods of time working with their portables
- raising awareness of the benefits of training.

f) Provide guidance on setting up and using a docking station; and provide advice on using a portable computer when a docking station is not available

It is not necessarily immediately obvious to most people how to set up a docking station correctly. Given the apparent benefits to be gained from using a docking station arrangement

we believe that it is important for employers to provide guidance on the most effective way to set up and use a docking station. Users should also be strongly encouraged to use docking stations wherever available. Simple instruction on the main elements of an ideal working posture, and on the arrangements of workstation elements can overcome most problems in this area. In addition, it is important that staff understand the benefits of using a docking station, which will help to motivate them to use one, even for short periods of time when they are using the portable and a docking station is available.

g) Ensure that staff who use portables are encouraged to report any symptoms of discomfort that may be associated with their use of portable computers as soon as they arise

We believe that organisations would benefit from the implementation of a continuous programme to monitor the long term symptoms of discomfort in portable and desktop users. We suggest the use of a small self-report discomfort questionnaire at regular intervals to keep a close watch on any patterns of discomfort experienced. We believe that this would represent a relatively small investment of time and effort for the considerable benefit of remaining (demonstrably) diligent in this area.

Any adverse symptoms should be investigated so that the organisation can take action to help their staff to reduce risks, for example by encouraging regular breaks from portable computer use; providing docking station equipment; improving task variety, etc.

h) Provide staff with information to help minimise the perceived risk of theft and mugging

The question on perceived risks indicated that many users were concerned about the risk of theft and mugging associated with carrying a piece of expensive computer equipment. We recommend that information and training in steps to take to reduce the risk of theft or mugging should be provided by employers. Provision of non-branded carrying cases may also help to make the computer equipment less obvious.

17.3 Working patterns and breaks

It is widely recommended that users take regular breaks from continuous computer operation, either through changes in task activity (to a non computer-based task) or through more formal breaks. The statistical analysis indicated that this appears to be appropriate advice, for all types of computer user – those who use portables, docking stations, and desktop machines. The overall proportion of working time spent using any computer was also a key predictor of discomfort.

i) Take regular breaks from computer use

The statistical analysis showed that the length of time before a break was correlated with back and neck discomfort, irritated eyes, headaches and difficulties reading the screen, for

both portable and desktop users. This effect held for people taking breaks after 30, 45 and 60 minutes, so it is difficult to give a recommended time limit, and there were some apparent variations between desktop users, portable users, and docking station users in the length of time before taking a break.

It does, however, imply that regular breaks (or changes in task activity) should always be taken from computer use (and this supports the recommendations in the current HSE guidance), but these are likely to be particularly important in portable use. While apparently a minor measure, we cannot overemphasise the benefits of these micro-breaks, and they should be encouraged by all levels of management. It is at times of stress, when the pressure to continue working is considerable, that people do not take their breaks, and it is also at these times that the risk factors for developing Work Related Upper Limb Disorders (WRULDs) are greatest. The importance of breaks must be taken seriously enough that people feel able to stop for a few minutes even when working under these conditions.

j) Ensure that organisations, managers and staff are aware of the increasing risk of discomfort associated with increasing proportion of working time spent using computers

One of the most important findings from the survey data was that, although there was no difference in the frequency of discomfort or symptoms experienced by users of different configurations of computer equipment (i.e. portables, desktops, docking stations), discomfort related to all three types of computer usage increased with an increasing proportion of their work time carrying out computer-based tasks.

The implication from this finding, given that most people reported that they spent between 60 and 100% of their work time using computers, is that most people should be encouraged to spend a lower proportion of their working time using the computer, and should take more frequent breaks from computer-based activities.

17.4 Manual handling issues

The results show a correlation between symptoms of musculoskeletal discomfort in the legs/neck/arm/hands/fingers and:

- the estimated weight carried.

There was also a relationship between back, neck and shoulder discomfort and:

- the number of extra items carried
- the amount of paperwork carried.

The top user-reported undesirable feature of portable computers, for all four brands, was the weight, and this was also reflected as the first feature that people would like to change, by making the computer and its accessories lighter.

We provide below our recommendations for minimising any risks associated with manual handling issues which users undertake while working with portable computers.

k) Enhance battery life (without increasing battery weight) and improve battery management for portable computers

Users reported that the poor battery life of their portables was an undesirable feature, and which caused approximately one third of portable users to carry an extra battery around with them. Nearly all portable users carried the transformer/power supply and associated cables around with them. The two most frequent locations for portable computer use were at home, and in the main company office with a docking station. Manufacturers should continue to improve battery life and battery management, and perhaps offer extra sets of transformer/power cables as standard with the purchase of a portable computer, so that, when travelling between home and office, the user only has to carry the portable itself, not the cables. Companies who supply docking stations at the main office could also supply cables/transformers as part of the docking stations.

l) Reduce the weight of the portable computer and its accessories

The feature of their computers that portable computer users disliked most was the weight, and increasing weight was correlated with increased levels of musculoskeletal discomfort. The weight of portable computers and their accessories should continue to be reduced, wherever possible.

m) Provide manual handling training for users of portable computers

The results of this research indicate that portable computer users would benefit from manual handling training. This will help to make them aware of the potential risks of transporting their portable computers, and would help to encourage them to minimise the amount of extra weight in paperwork and other items that they carry in conjunction with their portable computers.

n) Carry out manual handling risk assessments with portable computer users

Carrying portable computers is a manual handling activity (as defined in the Manual Handling Operations Regulations, 1992) and we recommend that organisations take measures to assess the level of risk from this activity in their own typical working contexts.

In addition, carrying portables in the normal carrying case may introduce two more risks for users:

1. it makes them feel vulnerable to attack from people who can easily see that they are likely to be carrying an expensive piece of computer equipment
2. it places a load asymmetrically on one side of the body.

From an ergonomics perspective we would recommend rucksack-type bags as the best way of carrying portable computer and associated equipment, as these load the back and shoulders more evenly. However, we did not observe a reduction in symptoms of discomfort amongst those who used backpacks, perhaps because people were not using both straps. Staff should be advised to minimise the amount of extra items, luggage, paperwork that they carry with them as part of the assessment.

Clearly, users should have a choice of bag. Pressure could also be brought to bear on employers of portable computer users to provide appropriate, lightweight, luggage which cannot be easily identified as containing a portable computer.

17.5 The working environment

o) Ensure that staff who use portables only use portable computer equipment when out of the office, or when a docking station is unavailable

The statistical analysis showed that docking station arrangements (external keyboard, and/or external display screen or "full" docking station) compared well on the incidence of musculoskeletal symptoms (particularly for back, neck and shoulder discomfort) with desktop arrangements (although this may be related to proportion of working time using a computer, or increased variety in the job rather than the docking station *per se)*. We recommend that portable users be encouraged to use their portables 'alone' only when they are out of the office and need to use a computer. In the office, or at home, we recommend that they use a desktop machine, or connect to a docking station. Clearly, docking station equipment must therefore be made available to all of those portable users who work for long periods in a particular location (or locations).

Docking station arrangements should be available for use by anyone who will need to use their portable in the office for any significant length of time. In particular docking station equipment should be available at "hot-desks" so that the people who use these areas can use their portable more comfortably when in the office.

p) Provide good facilities such as external keyboards and monitors, (or 'full' docking stations) at workstations where portable computers will be in prolonged use

In addition to docking stations, hot desks should be provided with document holders (preferably ones that can support books/files), footrests and good adjustable chairs. This will ensure that users are able to adjust their workstation appropriately and adopt a good posture. It is also important that cabling on electrical equipment and telephones be long enough for people to move them around the desks to suit themselves, and that power supplies can be connected up at desktop level, rather than floor level.

q) Minimise the use of portables in non-ideal locations
We saw in the survey that portable use in some locations (for instance in hotels, public transport, motor vehicles) appeared to be worse for users than other locations (although again, this may also be associated with duration of use). For preference, users should find the best "office-type" environment available for working on their portables, and try to avoid locations which make it difficult to adopt a good posture, such as on public transport, in motor vehicles, and in hotels. Often, people can adjust their working patterns so that they can do this. For instance, a portable computer user might opt to read some papers when on the train, and then use the portable when she (or he) arrives at the client office, rather than the other way around.

17.6 Handheld computers

From the market review and the telephone survey it was clear that handheld computers represented an extremely small part of the PC market – less than 2%, compared to portable computers at 20% of the PC market. Hence our focus for this research shifted more strongly towards the effects associated with portable computer usage. Two organisations did employ relatively small numbers of people using handhelds (57 sales people, and 49 parking attendants). Users of one type of handheld (the parking attendants) reported significantly more frequent shoulder, arm, feet and leg discomfort than the other. The sales representatives, by comparison, reported significantly more frequent headaches, irritated eyes, and difficulties reading the small screen than the parking attendants.

Most of the recommendations that could be drawn from our on-site observations were extremely specific to the design of that particular handheld. Our main general recommendation, therefore, is given below.

r) Ensure that handheld computers are carefully selected for ergonomics features which match the requirements of the tasks undertaken
The parking attendant users spent nearly all their working time outside, on foot, at the mercy of the elements. They also carried a considerable amount of items, and had to use the handheld computer while standing up. The sales people used their handhelds in their motor vehicles, and while inside retail (customer) outlets. Both groups had a considerable number of complaints about the design of the handhelds for the tasks that they were carrying out. For example, the handheld used by the parking attendants was prone to jamming when exposed to the rain, the keyboard of the sales people's handhelds was too small to use comfortably when entering data, and the screen was too small (7" diagonal) to view comfortably.

When selecting handheld computers for purchase, task analysis, ergonomics evaluations and user trials should be carried out before the purchase, to guide the final selection and to help maximise staff productivity and minimise musculoskeletal and other forms of discomfort.

18. CONCLUSION

In general use, we found that the levels of reported discomfort experienced by portable users, desktop users and docking station users were very similar. There did not appear to be any major differences between the three groups of computer users when comparisons were made on similar variables. However, certain aspects of portable computer use (not undertaken by desktop computer users) seemed more likely to be associated with the risk of musculoskeletal discomfort than others. For instance, use in non-ideal locations (which encourage poor posture) such as motor vehicles and hotels, and associated manual handling issues such as carrying large amounts of paperwork, or carrying several additional items with the portable.

Users' own comments supported the quantitative data, in particular their wish for lighter weight portables (and accessories) and their concerns about back and shoulder discomfort. We found a strong correlation between discomfort and hours per week spent using any computer, and hours per week spent using a desktop, but no significant correlation between discomfort and hours/week using a portable. Proportion of working time spent using a computer showed a strong correlation with discomfort and appeared to be a useful predictor of discomfort for all types of computer use (desktop, portable and mixed use). Frequent breaks (or changes in task activity) and having training relevant to working with computers appeared to provide benefits for both portable and desktop users. The use of docking stations appeared to reduce some of the potentially negative effects of general computer use.

We have outlined some recommendations for improving the use of portable computers that we believe could have a substantial positive effect. We also anticipate that portable computer manufacturers will be encouraged by this research to listen to customer requirements for their machines, which may increasingly be based as much on ergonomics requirements as they are currently on technological advances and functionality. We would encourage large purchasers of such equipment to make their requirements known as soon as possible.

We would like to thank the Health and Safety Executive for the opportunity to carry out such an interesting piece of work. In addition, we are grateful to all the organisations, and desktop and portable/handheld computer users who assisted us in the study, particularly those who took the time to complete the questionnaire, and those who discussed their workstations and working practices with us.

REFERENCES

Bringelson, L.S. et al. *An empirical investigation of pointing devices for notebook computers.* Advances in Occupational Ergonomics and Safety. IOS Press. 1998

Harbison and Forrester. *The ergonomics of notebook computers: problems or just progress? Journal of Occupational Health and Safety* – Aust NZ, 11 (5):481-487. 1995.

Horie, Yoshinorie. *A Comparison of psycho-physiological responses from users of desktop PCs versus notebook PCs.* Proceedings of the 5th Pan-Pacific Conference on Occupational Ergonomics. 1998.

Keynote Report for 1998 on the UK Personal Computer Market. The British Library - Business Information Library. October 1998.

PC Laptop computers magazine *"How to keep a keyboard from claiming your arms"* September 1996, volume 8 No 9.

Personnel Managers Yearbook 1998-99. AP Information Services.

Rejmaniak et al. Compaq and University of Houston. *An evaluation of trackball device placements during elemental pointing and dragging tasks.* Proceedings of the 4th Pan-Pacific Conference on Occupational Ergonomics 1996.

Saito et al. *Ergonomics evaluation of working posture of VDT operation using personal computer with flat panel display.* Industrial Health 1997, 35, 264-270.

Straker et al. *A comparison of the postures assumed when using laptop computers and desktop computers.* Applied Ergonomics. 1997.

Unison *report on survey of the health and safety problems of careers service advisors using laptop computers. 1998.*

Villanueva, M.B. et al. *The human factors of notebook PCs. Evaluation of posture and muscle activities.* Proceedings of the 5th Pan-Pacific Conference on Occupational Ergonomics. 1998.

Wright, J. *Some risk factors for computer use.* Workplace Health and Safety, Department of training and industrial relations. Australia. 1996.

Yoshitake, R. *Relationship between key space and user performance on reduced keyboards.* Applied Human Science, Journal of Physiological Anthropology. 1995.

HSE PUBLICATIONS

Health and Safety (Display Screen Equipment) Regulations 1992.

Manual Handling Operations Regulations 1992.

Travis, D.S and Heasman, T.A. 1998. *Display screen equipment health problems.* HSE Books. CRR:198/1998

Working With VDUs number INDG36 (rev1) dated 2/98.

APPENDIX 1A. TECHNICAL SPECIFICATIONS FOR 159 PORTABLE/LAPTOP/NOTEBOOK COMPUTERS

MODEL	TOTAL WEIGHT (kg)	BATTERY WEIGHT	AC ADAPTER WEIGHT	DIMENSIONS (cm)	SCREEN SIZE (in)	SCREEN TECHNOLOGY	KEYBOARD	POINTING DEVICE	OTHER (ERGONOMIC) FEATURES
ACER EXTENSA 500	3.3			30.8 x 4.5 x 25.7	12.1	SVGA TFT		Touchpad	
ACER EXTENSA 710	3.15			30.8 x 4.5 x 25.1	13.3	XGA TFT		Touchpad	
ACER TRAVELMATE 310	1.2			23.6 x 3.5 x 17.4	8	DSTN VGA		Touchpad	Palm-rest
AMS ROADSTER	3.2			29.7 x 4.6 x 23.9	12.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 1000	2.95			29.7 x 3.8 x 24.4	12.1	SVGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 1000	2.95			29.7 x 3.8 x 24.4	13.3	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 1010	2.95			29.7 x 3.8 x 24.4	12.1	SVGA	88 Keys (101 compatible)	Trackpad	
AMS RODEO 1010	2.95			29.7 x 3.8 x 24.4	13.3	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3015	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3020	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3030	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3037	3.4			32.0 x 5.6 x 26.2	13.3	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3038	3.4			32.0 x 5.6 x 26.2	13.3	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3040	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3042	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3052	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3062	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3072	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3500	3.9			31.8 x 5.6 x 25.9	13.3	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3500	3.9			31.8 x 5.6 x 25.9	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3500	3.9			31.8 x 5.6 x 25.9	15.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3520	3.9			31.8 x 5.6 x 25.9	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 3520	3.9			31.8 x 5.6 x 25.9	15.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS RODEO 5000 SERIES	3.4			32.0 x 5.6 x 26.2	14.1	XGA TFT	88 Keys (101 compatible)	Trackpad	
AMS TRAVELEX	1.4			26.9 x 2.5 x 22.1	12.1	SVGA TFT	88 keys (101 compatible)	Trackpad	
AMS TRAVELPRO 2500 SERIES	3.3			30.5 x 4.8 x 24.4	12.1		88 keys (101 compatible)	Touchpad	
AMS TRAVELPRO 2500 SERIES	3.3			30.5 X 4.8 X 24.4	13.3	XGA TFT	88 keys (101 compatible)	Trackpad	
APPLE POWERBOOK	3.3			32.3 x 5.1 x 26.4	12.1	SVGA TFT	Full-size keyboard, 77 (ISO) keys	Trackpad	
APPLE POWERBOOK	3.5			32.3 x 5.3 x 26.4	14.1	SVGA TFT		Trackpad	
AST ASCENTIA M	3.3	0.42		30.4 x 4.3 x 24.6	12.1	SVGA TFT	87/88 full size keys (101/102 compatible), 19mm key spacing, 3mm travel	Touchpad	Palm-rest
AST ASCENTIA M	3.4	0.42		30.9 x 4.7 x 24.1	13.3	XGA TFT	87/88 full size keys (101/102 compatible), 19mm key spacing, 3mm travel	Touchpad	Palm-rest
AST ASCENTIA M6000	2.9			31.0 x 4.3 x 24.1	12.1	SVGA TFT	87/88 keys (101/102 compatible), 19mm key, 3mm travel	Touchpad	
AST ASCENTIA M6000	3.1			31.0 X 4.8 X 24.1	13.3	XGA TFT	87/88 keys (101/102 compatible), 19mm key, 3mm travel	Touchpad	
BRICK BIGSCREEN	3.6			31.0 x 5.6 x 25.9	14.1	XGA TFT	86 full size keys, 3mm travel	Touchpad	
BRICK ELITE	3.1			29.7 x 4.1 x 25.4	13.3	XGA TFT	88 full size keys, 3mm travel	Touchpad	
BRICK ELITE	3.1			29.7 x 4.1 x 25.4	14.1	XGA TFT	88 full size keys, 3mm travel	Touchpad	
BRICK MOBYBRICK	4.6			28.2 x 5.3 x 35.6	15.1	TFT	101 full size keys, 3mm travel	Touchpad	
BRICK NOTEBRICK	3.1			24.4 x 4.6 x 30.1	12.1	SVGA TFT	86 full size keys, 3mm travel	Touchpad	
BRICK NOTEBRICK	3.1			24.4 x 4.6 x 30.1	14.1	AC TFT	86 full size keys, 3mm travel	Touchpad	
BROTHER PN-8500MDS	1.9			28.4 x 4.8 x 24.6					
COMPAQ C-SERIES 2015C	18ounces	2.8ounces		18.6 x 4.1 x 10.1	6.5	VGA	QWERTY keyboard	Stylus	
COMPAQ PRESARIO 1200 SERIES	3.4			31.1 x 4.9 x 25.4	12.1	HPA	88 full size keys (101 compatible)	Touchpad	Palm-rest
COMPAQ PRESARIO 1655	3.4			31.1 x 4.9 x 25.4	13.3	XGA TFT	88 full size keys (101 compatible)	Touchpad	Palm-rest
COMPAQ PRESARIO 1810	3.6			31.1 x 4.9 x 25.4	13.3	XGA TFT	88 full size keys (101 compatible)	Touchpad	Palm-rest
COMPAQ PRESARIO 1920	3.1			29.5 x 4.7 x 23.5	13.3	XGA TFT	88 full size keys (101 compatible)	Touchpad	Palm-rest
CTX EZBOOK 7 SERIES	3.1			29.7 x 4.8 x 22.8	12.1	TFT	87 keys	Touchpad	
CTX EZBOOK 893T-FK	3.5			31.5 x 4.8 x 24.5	13.3	XGA TFT	87 full size keys	Touchpad	
CTX EZNOTE M SERIES	1.6			26.9 x 2.5 x 22.1	12.1	SVGA TFT	85 keys	Touchpad	
CTX V92 SERIES	3.1			29.7 x 4.8 x 22.8	12.1	TFT		Touchpad	
CYBERCHRON SCOUT	2.6			23.4 x 7.1 x 16.5		VGA			
DELL INSPIRON 3500	3.1		0.3	31.6 x 3.5 x 25.0	13.3	XGA TFT	88 keys	Touchpad	
DELL INSPIRON 3500	3.0			31.6 x 3.9 x 25.0	14.1	XGA TFT	88 keys	Touchpad	
DELL INSPIRON 7000	3.8			31.8 x 5.4 x 25.4	14.1		88 keys	Touchpad	
DELL INSPIRON 7000	4.0			32.8 x 6.4 x 26.7	15.0		88 keys	Touchpad	
DIGITAL HINOTE ULTRA 2000	3.0			30.5 x 3.6 x 24.6	14.1	XGA TFT	85 keys, full size ergonomic keyboard	Touchpad	

MODEL	TOTAL WEIGHT (kg)	BATTERY WEIGHT	AC ADAPTER WEIGHT	DIMENSIONS (cm)	SCREEN SIZE (in)	SCREEN TECHNOLOGY	KEYBOARD	POINTING DEVICE	OTHER (ERGONOMIC) FEATURES
DIGITAL HINOTE VP 500	3.3			30.0 x 4.8 x 26.6	12.1	SVGA TFT	85 keys	Touchpad	Palm-rest
DIGITAL HINOTE VP 700	3.4			30.2 x 5.3 x 23.6	12.1	SVGA TFT	86 keys	Touchpad	
DIGITAL HINOTE VP 700	3.4			30.2 x 5.3 x 23.6	13.0	XGA DSTN	86 keys	Touchpad	
DIGITAL HINOTE VP 700	3.4			30.2 x 5.3 x 23.6	13.3	XGA TFT	86 keys	Touchpad	
FUJITSU LIFEBOOK B112	1.2			22.9 x 3.0 x 17.0	8.4	SVGA TFT	15mm spacing, 2mm stroke	Quick Point / Touch Screen & Stylus	
FUJITSU LIFEBOOK C	3.7			31.2 x 5.0 x 25.9	12.1	SVGA TFT	87 full size keys, 19mm spacing, 3mm stroke	ErgoTrac	Palm-rest
FUJITSU LIFEBOOK L	2.0			30.2 x 2.8 x 23.9	13.3	XGA TFT	86 full size keys, 19mm spacing, 3mm stroke	TouchPoint	Palm-rest
FUTURETECH FM OHP	3.6			29.7 x 6.2 x 23.0	10.4	SVGA	86 full size keys	Trackpoint / Touch Pad	
FUTURETECH FM OHP	3.6			29.7 x 6.2 x 23.0	12.1	SVGA	86 full size keys	Trackpoint / Touch Pad	
FUTURETECH FM OHP2				30.5 x 5.8 x 23.5	12.1	SVGA TFT	87 keys	Touchpad	Palm-rest
FUTURETECH FM11XP2/11XLP2	3.0			30.1 x 4.6 x 24.9	13.3	XGA TFT	Detachable, full size keyboard	Track Pad	
FUTURETECH FM11XP2/11XLP2	3.0			30.1 x 4.6 x 24.9	14.1	XGA TFT	Detachable, full size keyboard	Track Pad	
FUTURETECH FM4000	3.1			29.7 x 4.9 x 22.6	10.4	SVGA TFT	87/88 keys (101/102 compatible)	Touch Pad	
FUTURETECH FM4000	3.1			29.7 x 4.9 x 22.6	11.3	DUAL SCAN	87/88 keys (101/102 compatible)	Touch Pad	
FUTURETECH FM4000	3.1			29.7 x 4.9 x 22.6	12.1	SVGA TFT	87/88 keys (101/102 compatible)	Touch Pad	
FUTURETECH FM4600	3.4			29.7 x 4.9 x 22.6	12.1	TFT	87/88 keys (101/102 compatible)	Touch Pad	Palm-rest
FUTURETECH FM5400	3.5 w/o bat			30.1 x 5.3 x 22.6	10.4	TFT	Detachable, A4 size keyboard	Glide Pad	
FUTURETECH FM5400	3.5 w/o bat			30.1 x 5.3 x 22.6	11.3	DUAL SCAN	Detachable, A4 size keyboard	Glide Pad	
FUTURETECH FM5400	3.5 w/o bat			30.1 x 5.3 x 22.6	12.1	TFT	Detachable, A4 size keyboard	Glide Pad	
FUTURETECH FM5580	3.0 w/o bat			29.7 x 5.6 x 25.1	10.4	TFT	87 keys	Touch Pad	
FUTURETECH FM5580	3.0 w/o bat			29.7 x 5.6 x 25.1	11.3	DUAL SCAN	87 keys	Touch Pad	
FUTURETECH FM5580	3.0 w/o bat			29.7 x 5.6 x 25.1	12.1	TFT	87 keys	Touch Pad	
FUTURETECH FM6300XL/FM6300XLP2	3.4			32.0 x 5.1 x 24.4	13.3	XGA TFT	86 keys, 3mm travel	Track Point	
FUTURETECH FM6800	3.4 w/o bat			30.1 x 5.1 x 22.6	12.1	SVGA DSTN TFT	Detachable, A4 size keyboard	Glide Pad	
FUTURETECH FM7300XL	4.1 w/o bat			32.3 x 5.8 x 26.4	13.3	TFT	Detachable, A4 size keyboard	Track Pad	
FUTURETECH FM7300XL	4.1 w/o bat			32.3 x 5.8 x 26.4	14.1	TFT	Detachable, A4 size keyboard	Track Pad	
FUTURETECH FM8700XL/FM87XLP2/FM88XLP2	4.3			35.6 x 4.8 x 27.4	15.1	XGA TFT	102 full size keys	Track Pad	
FUTURETECH FM9700XL/FM97XLP2	3.4			31.5 x 5.6 x 25.9	12.1	SVGA TFT	88/89/90 keys, 19mm pitch	Track Pad	
FUTURETECH FM9700XL/FM97XLP2	3.4			31.5 x 5.6 x 25.9	14.1	XGA TFT	88/89/90 keys, 19mm pitch	Track Pad	
FUTURETECH FM9750	2.9			30.2 x 4.6 x 24.4	12.1	SVGA TFT	Detachable, A4 size keyboard	Glide Pad	
FUTURETECH FM9750	2.9			30.2 x 4.6 x 24.4	12.1	SVGA DSTN	Detachable, A4 size keyboard	Glide Pad	
FUTURETECH FM9750	2.9			30.2 x 4.6 x 24.4	13.3	XGA TFT	Detachable, A4 size keyboard	Glide Pad	
GATEWAY SOLO 2500SE					12.1		85 keys	EZ Pad	
GATEWAY SOLO 2500 XL / LS					13.3	VGA	85 keys	EZ Pad	
GATEWAY SOLO 3100 SERIES				28.4 x 3.0 x 21.3	12.1	SVGA	Full size keyboard	EZ Point	
GATEWAY SOLO 5150 SERIES					14.1	XGA	88 full size keys	EZ Pad	
GATEWAY SOLO 9100 SERIES					14.1	XGA TFT	88 keys	EZ Pad	
HITACHI PRO 7000	3.85			31.2 x 4.57 x 26.2	12.1	SVGA TFT	Full-size	Touch Pad	Palm-rest
HITACHI PRO 7000	3.85			31.2 x 4.57 x 26.2	13.3	XGA TFT	Full-size	Touch Pad	Palm-rest
HITACHI TRAVELER 600	1.32			25.7 x 3.05 x 21.3	10.4	SVGA TFT	90% size keyboard	Alps Glidepoint Touch Pad	PalmSoft Palm-rest
HP OMNIBOOK 2000 SERIES	3.58			29.5 x 4.9 x 22.6	12.1	SVGA TFT	85/86 keys, full-size key spacing	TrackPoint	
HP OMNIBOOK 2100 SERIES	2.9			29.9 x 4.6 x 23.7	12.1	SVGA TFT	87/88 keys, full-size key spacing	Touch Pad	Palm-rest
HP OMNIBOOK 3000 SERIES	3.35			30.3 x 5.24 x 23.73	13.3	XGA TFT	87/88 keys, full-size key spacing	Touch Pad	
HP OMNIBOOK 3100 SERIES	3.0			29.9 x 4.9 x 23.7	13.3	XGA TFT	87/88 keys, full-size key spacing	Touch Pad	Palm-rest
HP OMNIBOOK 3100 SERIES	2.9			29.9 x 4.6 x 23.7	12.1	SVGA TFT	87/88 keys, full-size key spacing	Touch Pad	Palm-rest
HP OMNIBOOK 4100 SERIES	2.99			32.8 x 3.56 x 25.4	14.1	XGA TFT	87/88 keys, full-size key spacing	Touch Pad / Pointing Stick	

MODEL	TOTAL WEIGHT (kg)	BATTERY WEIGHT	AC ADAPTER WEIGHT	DIMENSIONS (cm)	SCREEN SIZE (in)	SCREEN TECHNOLOGY	KEYBOARD	POINTING DEVICE	OTHER (ERGONOMIC) FEATURES
HP OMNIBOOK 4150 SERIES	2.99			32.8 x 3.56 x 25.4	14.1	XGA TFT	87/88 keys, full-size key spacing	Touch Pad / Pointing Stick	
HP OMNIBOOK 5500 SERIES	3.58			29.5 x 4.9 x 22.6	10.4	SVGA TFT	85/86 keys, full-size key spacing	TrackPoint III	
HP OMNIBOOK 5700 SERIES	3.58			29.5 x 4.9 x 22.6	12.1	XGA TFT	85/86 keys, full-size key spacing	TrackPoint III	
HP OMNIBOOK 5700 SERIES	3.58			29.5 x 4.9 x 22.6	12.1	SVGA TFT	85/86 keys, full-size key spacing	TrackPoint III	
HP OMNIBOOK 600 SERIES	1.7			18.5 x 4.1 x 28.2	8.5	VGA DSTN		Pop-up Mouse	
HP OMNIBOOK 7100 SERIES	3.95			32.4 x 5.64 x 25.2	14.1	XGA TFT	87/88 keys, full-size key spacing	Touch Pad / Pointing Stick	
HP OMNIBOOK 800 SERIES	2.5			28.2 x 4.0 x 18.5	10.4	SVGA TFT	85 keys, touch-type keyboard, industry standard, full size key spacing	Pop-up Mouse	Hand grips / Mouse - two position height
HP OMNIBOOK 900 SERIES	2.2		0.41	30.0 x 3.2 x 22.5	12.1	SVGA TFT	87/88 full size keys	Touch Pad / Pointing Stick	
HP OMNIBOOK SOJOURN	2.7			29.7 x 4.0 x 21.8	12.1	SVGA TFT	82 keys	Touch Pad	
HP OMNIBOOK XE NOTEBOOK SERIES	3.0			31.1 x 4.0 x 24.9	13.3	XGA TFT	87/88 keys	Touch Pad	Palm-rest
IBM THINKPAD 600 NOTEBOOK	2.2			30 x 3.6 x 24	13.3	TFT			
MITSUBISHI PEDION	1.5			29.7 x 1.8 x 21.8	12.1	XGA TFT	82 keys	Point Pad	
NEC VERSA LX	3.36			30.7 x 4.6 x 25.4	14.1	XGA	83 key, low profile keyboard	VersaGlide Touch Pad	Palm-rest
NEC VERSA LX	3.36			30.7 x 4.6 x 25.4	13.3	XGA	83 key, low profile keyboard	VersaGlide Touch Pad	Palm-rest
NEC VERSA LX	3.27			30.7 x 4.6 x 25.4	12.1	SVGA	83 key, low profile keyboard	VersaGlide Touch Pad	Palm-rest
NEC VERSA NOTE	3.08			30.2 x 3.8 x 24.6	13.3	XGA	87 key, low profile keyboard	VersaGlide Touch Pad	Palm-rest
NEC VERSA NOTE	3.13			30.2 x 3.8 x 24.6	12.1	SVGA	87 key, low profile keyboard	VersaGlide Touch Pad	Palm-rest
NEC VERSA SX	2.4			30.5 x 3.3 x 25.1	14.1	XGA	83 key, low profile keyboard	VersaGlide Touch Pad	Palm-rest
NEC VERSA SX	2.4			30.5 x 3.3 x 25.1	13.3	XGA	83 key, low profile keyboard	VersaGlide Touch Pad	Palm-rest
OLIVETTI XTREMA 223S	3.3			32.5 x 4.7 x 25.0	12.1	SVGA TFT	88/89 keys	Touch Pad	
OLIVETTI XTREMA 226S	3.3			32.5 x 4.7 x 25.0	12.1	SVGA TFT	88/89 keys	Touch Pad	
OLIVETTI XTREMA 423S	3.3			32.5 x 4.7 x 25.0	12.1	SVGA TFT	88/89 keys	Touch Pad	
OLIVETTI XTREMA 423X	3.4			32.5 x 4.7 x 25.0	13.3	XGA TFT	88/89 keys	Touch Pad	
OLIVETTI XTREMA 426S	3.3			32.5 x 4.7 x 25.0	12.1	SVGA TFT	88/89 keys	Touch Pad	
OLIVETTI XTREMA 426X	3.4			32.5 x 4.7 x 25.0	13.3	XGA TFT	88/89 keys	Touch Pad	
OLIVETTI XTREMA 430X	3.4			32.5 x 4.7 x 25.0	13.3	XGA TFT	88/89 keys	Touch Pad	
QUANTEX T SERIES NOTEBOOK	2.9			31.6 x 3.7 x 25.0	13.3	XGA TFT	87 keys (101/102 compatible), standard pitch, 3.0mm travel	Touch Pad	Palm-rest
SAMSUNG M6000 SERIES	2.81	0.21		30.9 x 4.2 x 24.1	12.1	SVGA TFT	87/88 full-size keys (101/102 compatible), 19mm key spacing, 3mm travel	Touch Pad	Palm-rest
SAMSUNG M6000 SERIES	2.97	0.21		30.9 x 4.2 x 24.5	13.3	XGA TFT	87/88 full-size keys (101/102 compatible), 19mm key spacing, 3mm travel	Touch Pad	Palm-rest
SAMSUNG M6000 SERIES	2.93	0.21		30.9 x 4.2 x 24.5	14.1	XGA TFT	87/88 full-size keys (101/102 compatible), 19mm key spacing, 3mm travel	Touch Pad	Palm-rest
SONY VAIO NOTEBOOK	2.5			29.7 x 3.8 x 21.4	12.1	XGA TFT	86 keys	Touch Pad	
SONY VAIO NOTEBOOK	2.5			29.7 x 3.8 x 21.4	12.1	SVGA HPA	86 keys	Touch Pad	
TOSHIBA PORTEGE 3000 SERIES	1.32			25.7 x 1.9 x 21.6	10.4	TFT	86 keys	MousePoint	
TOSHIBA PORTEGE 7000 SERIES	1.9	2.2	1.2	29.7 x 2.5 x 23.6	12.1	SVGA TFT	86 keys	MousePoint	
TOSHIBA PORTEGE 7000 SERIES	1.9	2.2	1.2	29.7 x 2.5 x 23.6	13.3	SVGA TFT	86 keys	MousePoint	
TOSHIBA SATELLITE 2515	1.9	2.2	1.2	30.9 x 4.3 x 25.9	12.1		84/86 keys, 3mm travel	AccuPoint	
TOSHIBA SATELLITE 2535	1.9	2.2	1.2	30.9 x 4.3 x 25.9	13.0		84/86 keys, 3mm travel, key pitch 19.05 mm	AccuPoint	
TOSHIBA SATELLITE 300 SERIES	3.6	0.4	0.2	30.4 x 5.3 x 23.9	12.1	TFT	84/86 keys, 3mm travel	AccuPoint	
TOSHIBA SATELLITE 4000/4010	3.18			30.3 x 5.5 x 23.9	12.1	STN	86 keys	MousePoint	
TOSHIBA SATELLITE 4030	3.18			30.9 x 4.2 x 25.9	13	STN	86 keys	MousePoint	
TOSHIBA SATELLITE 4030	3.18			30.9 x 4.2 x 25.9	13.3	STN	86 keys	MousePoint	
TOSHIBA SATELLITE 4080	3.18			30.9 x 4.1 x 25.9	14.1	TFT	86 keys	MousePoint	
TOSHIBA TECRA 8000	2.85			31.1 x 4.2 x 25.4	12.1	STN TFT	86 keys	MousePoint	
TOSHIBA TECRA 8000	2.85			31.1 x 4.2 x 25.4	13.3	TFT	86 keys	MousePoint	

MODEL	TOTAL WEIGHT (kg)	BATTERY WEIGHT	AC ADAPTER WEIGHT	DIMENSIONS (cm)	SCREEN SIZE (in)	SCREEN TECHNOLOGY	KEYBOARD	POINTING DEVICE	OTHER (ERGONOMIC) FEATURES
TOSHIBA TECRA 8000	2.85			31.1 x 4.2 x 25.4	14.1	TFT	86 keys	MousePoint	
TRANSMONDE VIVANTE SE 12.1	3.1			31.4 x 4.6 x 24.2	12.1	SVGA			
TRANSMONDE VIVANTE SE 13.3	3.1			31.4 x 4.6 x 24.2	13.3	XGA			
TRANSMONDE VIVANTE XL 13.3	3.6			32.0 x 4.8 x 25.0	13.3	XGA			
TRANSMONDE VIVANTE XL 14.1	3.6			32.0 x 4.8 x 25.0	14.1	XGA			
WINBOOK LM	3.05			29.9 x 4.9 x 22.9	12.1		87 keys		
WINBOOK XL	3.5			30.9 x 5.0 x 24.0	12.1	TFT	84 keys, 17.0mm key size, 2.7mm key travel		
WINBOOK XL2	3.17			30.9 x 3.8 x 24.4	14.1	TFT	87 keys, 17.0mm key size, 3.0mm key travel		
WINBOOK Xli	3.5			30.9 x 5.0 x 24.0	13.3	TFT	84 keys, 17.0mm key size, 2.7mm key travel		
WINBOOK XP	2.82			29.2 x 4.8 x 22.0	9.4		82 keys, 3mm travel		
WINBOOK XP	2.82			29.2 x 4.8 x 22.0	10.3		82 keys, 3mm travel		
WINBOOK XP5	2.7			29.2 x 5.1 x 22.0	10.3	SVGA	82 keys, 3mm travel		
WINBOOK XP5	2.7			29.2 x 5.1 x 22.0	11.3	SVGA	82 keys, 3mm travel		
WINBOOK XP5 PRO	2.93			28.5 x 5.7 x 22.8	12.1		85 keys		

AC = ACTIVE COLOUR
HPA = HIGH PERFORMANCE ADDRESSING

APPENDIX 1B. TECHNICAL SPECIFICATIONS FOR 24 HANDHELD DEVICES

MODEL	TOTAL WEIGHT (kg)	BATTERY WEIGHT	AC ADAPTER WEIGHT	DIMENSIONS (cm)	SCREEN SIZE	SCREEN TECHNOLOGY	KEYBOARD	POINTING DEVICE	OTHER (ERGONOMIC) FEATURES
HAND HELD PRODUCTS BEAMER	0.31			21.3 x 3.2 x 4.4	4 lines x 20 character (6 x 8 pixel matrix)	LCD	36 keys		
HAND HELD PRODUCTS DOLPHIN	0.84			14.2 x 12.5 x 14.0	8 lines x 20 character (119 x 73 graphics pixels)	LCD			
HAND HELD PRODUCTS DOLPHIN IBUTTON	0.39			17.9 x 5.0 x 7.0	8 lines x 20 characters (119 x 73 graphics pixels)				
HAND HELD PRODUCTS DOLPHIN WITH IMAGE-CAPTURE	0.41			14.2 x 12.5 x 14.0	8 lines x 20 characters				
HAND HELD PRODUCTS DOPHIN RF	0.41			17.0 x 5.0 x 7.0	8 lines x 20 character (119 x 73 graphics pixels)	LCD			
HAND HELD PRODUCTS MICRO-WAND IIIE									
INTERMEC 2010 JANUS	0.51			20.3 x 4.6 x 8.4	16 lines, 20 columns, 25 x 80	CGA	Emulates PC-AT 102 keyboard		
INTERMEC 2010RF JANUS									
INTERMEC 2020 JANUS	0.6			8.0 x 2.25 x 3.3	16 lines, 20 columns, 25 x 80	CGA LCD	Emulates PC-AT 101 keyboard		
INTERMEC 2020RF JANUS									
INTERMEC 4400/4410	0.68			22.23 x 4.83 x 8.41	4 line	LCD	23 key (numeric), 40 key (alphanumeric		
INTERMEC 4500	0.68			22.23 x 4.83 x 8.41	16 line	LCD	23 key (numeric), 40 key (alphanumeric		
INTERMEC 9440 TRAKKER	0.5			19.3 x 4.1 x 8.3	4 lines x 20 character	LCD	48 keys		
INTERMEC PEN*KEY 6210	0.85			24.13 x 7.11 x 8.38	160 (width) x 200 (length) pixels	VGA			
INTERMEC PEN*KEY 6400	0.49			21.72 x 4.06 x 2.6	2.4", 16 lines x 32 character	CGA LCD	41/51 key		
INTERMEC T2420 TRAKKER ANTARES	0.62			26.9 x 7.1 x 8.2	25 x 80 virtual screen	CGA LCD	56 key		
INTERMEC T2425 TRAKKER ANTARES RF	0.77			26.9 x 7.1 x 8.2	25 x 80 virtual screen	LCD	56 key		
INTERMEC TRAKKER T2090	0.29			18.7 x 4.2 x 8.0	8 line x 20 character	LCD	13 key		
TELXON PTC-710	0.54			17.8 x 3.8 x 8.1	4 line x 16 character	LCD	45 key		
MOBILON HC-4100	0.41			18.6 x 26.4 x 93.6	6.5"	LCD Touch Screen	64 keys		
MOBILON HC-4500	0.49			18.6 x 9.5 x 29.6	6.5"	LCD Touch Screen	64 keys		
MOBILON HC-4600	0.49			18.6 x 9.5 x 29.6	6.5"	LCD Touch Screen	64 keys		
MOBILON PRO PV-5000	1.22			23.6 x 2.79 x 19.6	8.2"	LCD Touch Screen	69 keys		
MOBILON PV-6000	1.45			28.9 x 2.44 x 22.6	9.4"	LCD Touch Screen	63 keys		
TELXON PTC-860	0.92			22 x 4.3 x 8.4	16 line x 21 character	LCD	50 key		
TELXON PTC-910	0.51			23.6 x 6.0 x 8.3	4 line x 16 character	LCD	27 key		
TOSHIBA LIBRETTO	1.09			21.0 x 3.5 x 13.2	7.1"	TFT	80 keys, 15mm key pitch, 1.5mm travel	AccuPoint	

MAIL ORDER
HSE priced and free
publications are
available from:
HSE Books
PO Box 1999
Sudbury
Suffolk CO10 2WA
Tel: 01787 881165
Fax: 01787 313995
Website: www.hsebooks.co.uk

RETAIL
HSE priced publications
are available from
good booksellers

HEALTH AND SAFETY ENQUIRIES
HSE Infoline
Tel: 08701 545500
or write to:
HSE Information Centre
Broad Lane
Sheffield S3 7HQ
Website: www.hse.gov.uk

CRR 304/2000