

Observing Mothers Lifting Their Children in Their Own Home to Identify Factors Which Might Give Rise to Musculoskeletal Disorders

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Attestation of Authorship

“I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.”

Signed:

Renée Denise McKay

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Abstract

The lifting associated with childcare has been linked to musculoskeletal disorders (MSDs) in mothers (Griffin & Price, 2000; Sanders & Morse, 2005). The purpose of the current study was to investigate, for the first time through observation, the lifting of young children by mothers in the home environment to identify risk factors which might give rise to MSDs.

Twenty five mothers with one or two children weighing between 9 and 15kg (n = 30) completed a self-report survey modified for the New Zealand context (The Ergonomics of Caring for Children (Sanders & Morse, 2005)). They also took part in a structured observation of lifting in the home using a checklist based on the New Zealand Manual Handling Hazard Control Record NZMHCR (OSH & ACC, 2001). Modifications were derived from careful consultation of current literature to enable contributory factors related to the load, the mother, the environment and the task to be assessed and a rating of low, medium, or high risk to be assigned to each factor. A protocol to guide risk assessment was developed to accompany the tool. The modified observational checklist was named the OMLITH (Observing Mothers Lifting In The Home).

Survey data identified the mothers as aged between 28 and 40 years, predominantly NZ European, and of average height ($\chi = 1.69\text{cm}$) and weight (Body Mass Index = 24). The children in the sample weighed between 9 and 14.5kg and had an average age of 17months. All the mothers were either married (n=20) or living with a significant other (n=5) and their partners frequently (n=13) or always (n=12) helped with childcare. The mean time mothers spent per week on the following activities were: sleep, 6.8hrs (n=25), housework, 14.9hrs (n=25), exercise, 2.9hrs (n=22), watching television or using the home computer, 4.3hrs (n=22), hobbies, 2.2hrs (n=19), gardening or home maintenance, 2.9hrs (n=18). Thirteen of the mothers worked (3 full-time, 10 part-time) and 20 mothers used childcare services.

Ratings of the physical stress associated with 50 childcare tasks showed that mothers differentiated between tasks in terms of physical stress to a significant degree (p.000), typically rating 'Bending while carrying a child' as almost twice as stressful as the average rating. Other categories rated significantly above the average stress rating were: 'Use of a

backpack to carry infant/child', 'Use of baby jogger', 'Carrying child on your shoulders', 'Standing bent over to wash child in bath or sink', 'Lifting child into or out of cot', 'Prolonged squatting or stooping while playing with child', and 'Placing child in car seat or removing child from car seat'. Mothers reported experiencing MSDs most commonly in the low back (n=16), and the neck, shoulder and upper back (n=8 each).

Data from the 87 observations using the OMLITH showed that children were a challenging load due to their moving centre of gravity, and were often unpredictable or awkward to handle. The grip required to lift a child more often than not fell outside the National Institute for Occupational Safety and Health (NIOSH) recommendation. In 72.9% of tasks the child's weight created a high risk level. The lifting tasks involved horizontal and vertical lift distances that presented a moderate to high risk level in 82.8% of situations. Lifting while twisting and side-bending was assigned a moderate to high risk level in 72.4% of tasks. Risk associated with working at an externally controlled pace; and handling children while seated or kneeling/crouching was also observed. The home environment presented risk associated with obstacles, a variety of floor surfaces and stairs or slopes. Mothers were also observed lifting in confined spaces. Individual factors identified as important considerations were: a mismatch between mothers' strength and fitness and the lifting requirements, pain or injury, pregnancy, and fatigue.

The structured checklist proved to be an appropriate tool to identify the contributory risk factors present when mothers lift in the home and to make an assessment of the level of risk. Results suggest a notable number of risk factors which might give rise to MSDs are present when mothers lift their children at home. The author concludes that further research is warranted to quantify risks, to identify prevention strategies for MSDs in this population, and to guide health providers with regard to treatment and rehabilitation of mothers with MSDs.

Key words: Lifting, Mothers, MSDs, Ergonomics, Risk factors, Structured observation

1. INTRODUCTION

1.1 Introduction

1.1.1 Aim of the study

This small-scale descriptive study investigates the physical demands of performing childcare occupations in a sample of healthy mothers between and 28 and 40 years of age, with normally developing children and who reside in Auckland. The intent of the study is to confirm whether risk factors which might give rise to musculoskeletal disorders (MSDs) are present when mothers lift their children in the home environment and in particular when they lift children weighing between 9 and 14 kilograms (kg).

1.1.2 Overview of the thesis content

The introductory chapter will provide a background to the study and introduce key concepts that lay the foundation for the chapters that follow. Chapter 2 will review the contemporary literature pertinent to identifying risk factors that might give rise to MSDs when mothers lift children in the home. The methodology chapter (Chapter 3) will give a detailed outline of the study design, data collection and data analysis processes, and of the development of the data collection tools used in the study. Chapter 4 will present the results. Finally, in Chapter 5, the results of the study and performance of the tools used to collect data will be discussed, along with the limitations of the study. Implications for future research and for clinical practice will be presented.

1.1.3 Overview of the introductory chapter

The introductory chapter will firstly provide the rationale for choosing the research topic and will define the occupation of mothering which is central in the research. This will be followed by a brief description of current knowledge of how MSDs might affect mothers. The choice of research topic will then be supported by a discussion of the significance of the current study. This will include a discussion of the significance of studying MSDs experienced by mothers, and also the significance of the problem of work-related MSDs

world-wide. Finally, the use of risk factors to assess and to design interventions for the problem of MSDs will be introduced and discussed.

1.2 Background to the study

This study grew out of the author's clinical experience of providing physiotherapy treatment to mothers with acquired MSDs. The World Health Organization (WHO, 2003a) defined MSDs as "health problems of the loco motor apparatus, i.e. of muscles, tendons, the skeleton, cartilage, ligaments and nerves" (p. 1) and stated that MSDs include "all forms of ill-health ranging from light, transitory disorders to irreversible, disabling injuries" (p. 1). In more than 10 years of practice it has been the author's observation that mothers are presenting for physiotherapy treatment for MSDs such as lower back pain, neck or shoulder pain, wrist or thumb pain or knee pain which they frequently attribute to the performance of what they felt to be physically-demanding childcare occupations. The author therefore decided to investigate what risk factors for MSDs related to performing childcare occupations might be present when mothers lift their children in the home. The weight range of the children included in the study (9-14kg) was chosen to focus the study on a weight of load which is significant in terms of biomechanical stresses to the mothers as they perform childcare occupations. Within this weight range the children are at a developmental age where they are still dependent enough to require frequent lifting. The chosen weight range also removes the emphasis from the physiological changes to mothers associated with pregnancy and childbirth, which might be used to explain susceptibility to MSDs and places it on the physical load experienced when lifting children. The intention behind recruiting mothers aged between 20 and 40 years was to limit the group of mothers to an age where they have attained adult development but, at 40 years of age and under, are less likely to be affected by biological changes related to age which might affect their physical capacity (e.g. age-related loss of muscle or bone mass) (Mital, Nicholson, & Ayoub, 1997; Rutherford & Jones, 1992). The women were screened and reported themselves as not being affected by any 'serious or mental health condition', defined as an injury, illness or impairment or mental or physical condition for which they were currently receiving treatment from a health provider or which affected their ability to perform normal daily tasks on 1 or more days a week.

The study therefore set out to investigate the link between certain elements of healthy mothers' occupations as caregivers of their children and the occurrence of MSDs. Physiotherapists treating clients with MSDs are professionally drawn toward understanding the link between their clients' musculoskeletal symptoms and the occupations that the clients perform. By definition, the profession of physiotherapy is concerned with "providing services to people and populations to develop, maintain and restore maximum movement and functional ability throughout the lifespan" and with "identifying and maximising movement potential, within the sphere of promotion, prevention, treatment and rehabilitation" (World Confederation for Physical Therapy (WCPT), cited in Higgs, Refshauge & Ellis, 2001, p. 80). In order for physiotherapists to be effective in meeting the aims of the profession with regard to helping their clients recover from MSDs, it is important to understand how the demands of their clients' daily activities may have contributed to the occurrence of the MSDs, or how they may interfere with rehabilitation or promotion of the clients' health and wellness. In the case of mothers, MSDs affect not only their own health and movement but their ability to care for their children.

1.3 Defining the occupation of mothering

To gain insight into how an occupation interacts with health and musculoskeletal function, physiotherapists and other health providers interested in the health of a particular occupational group need to understand the nature of the occupation of interest and which elements of the occupation might benefit or disrupt clients' health. A multi-disciplinary approach is required to arrive at research-based knowledge into the link between occupation and health. As McLaughlin Gray (1997) suggested, determining the essence of occupation is a prerequisite to investigating the relationship between occupation and health. Insights regarding occupation and, in the case of this study, the occupation of mothering, are found within the occupational science and occupational therapy literature. Within these fields *occupation* carries a definition that is broader than the standard dictionary one. It encompasses more than just paid employment, to which it is mostly limited in the medical and health and safety literature. Rather, occupations are seen as "groups of activities and tasks of everyday life, which are named, organised, and given value and meaning by individuals and cultures" (CAOT, 1997, p. 3). In this context the word occupation denotes

“everything people do to occupy themselves including looking after themselves (self-care), enjoying life (leisure), and contributing to the social and economic fabric of their communities (productivity)” (CAOT, 1997, p. 3). It has also been defined as a person meaningfully engaging their resources of time and energy in self-care, productivity or leisure in the context of their physical or social environments (Christiansen & Baum, 1997). By these definitions ‘occupation’ encompasses everything one does and it is seen as a function of the person and his or her environment.

These concepts are important to the foundation of this study which has been undertaken with these broader definitions of *occupation* in mind. This is because mothering as an occupation is a unique and complex phenomenon for which there is no universally accepted definition. It is only by taking a broader view of this occupation when trying to define mothering, that a satisfactory definition can be reached. Although mothering has traditionally been defined within a biological construct, linked directly to a woman’s reproductive capabilities, this view is now seen as outdated by social scientists and many contemporary family researchers view mothering as a social construct with historical and cultural variations (Francis-Connolly, 2000; McMahon, 1995). In this discourse, mothering is broadly conceived as the work women do in caring for and nurturing children. Mothering, for the purposes of this study, will be defined as *a woman engaging her resources of time and energy in actions directly or indirectly related to the care or nurturing of a child to whom she is a mother, in the context of her physical or social environment*. Defining the occupation of mothering in this way enables the relationship between the occupation of mothering, its physical demands and the MSDs that mothers experience, to be explored with the same validity that is given to exploring the connection between paid employment and MSDs.

1.4 Mothers and musculoskeletal disorders

Consultation of the literature to locate knowledge specific to mothers who have MSDs related to the occupation of mothering reveals that there is little evidence-based information from which health providers might devise their treatment and rehabilitation strategies and prevention advice. From the small amount of literature that does make specific references to mothers and MSDs, it would appear that there is widespread concern among health

providers that mothers are in fact at risk of pain, discomfort or injury as a result of this occupation. Advice for expecting or new mothers regarding the prevention of pain or injury was found in a variety of locations: medical websites (American Academy of Orthopaedic Surgeons (AAOS), 2005; Mayo Clinic, 2005; Methodist Rehabilitation Center, 2006), parenting magazines or newsletters (Eller, 2001; Pathways, 2005), and a prominent international physiotherapy organisation (APTA, 2006). This information links the occurrence of musculoskeletal pain or disorders to postural techniques, lifting, lack of abdominal and arm strength (Pathways Center, 2005), placing children in and out of equipment (Eller, 2001), and other specific tasks such as breast feeding (AAOS, 2005). In other words, the literature makes similar links between the occupational tasks of mothering as mothers anecdotally report.

However, the basis of the advice given by such sources is not explicitly referenced and when further investigation of the scientific literature was carried out it became clear that only two studies exist that have examined which factors related to specific childcare occupations might cause musculoskeletal symptoms in mothers (Griffin & Price, 2000; Sanders & Morse, 2005). Hence it seems most likely the advice given to mothers has hitherto been derived either from industry-related knowledge about the link between tasks and MSDs or from clinical or personal experience and observational reasoning – not from research specifically investigating mothers. The industry from which knowledge can best be drawn is that of the paid childcare industry and there does exist a small body of scientific research into MSDs and their causes in childcare workers (Brown & Gerberich, 1993; Calabro, Bright, Cole, Mackey, Lindenberg, & Grimm, 2000; Grant, Hebes, & Tepper, 1995; King, Gratz, & Kleiner, 2006; King, Gratz, Sheuer, & Claffey, 1996; Kumagai et al., 1995; Owen, 1994; Shimaoka et al., 1998; Taloni, et al., 2004). Even so, the knowledge base is small and research only began in earnest in this area in the 1990s. Perhaps because these studies have been published in the health and safety arena as opposed to the medical field they are not specifically referenced in the readily available literature giving advice to mothers and health providers. It is therefore also likely that health providers treating mothers rely on prevention and treatment information that is generalised and employ rationalist clinical reasoning to provide advice to these clients

when trying to help them minimise the effect of their daily occupations on their musculoskeletal symptoms.

Despite a lack of specific research, it is nevertheless clear – from the above discussion and from the small body of research that does exist – that mothers do experience musculoskeletal symptoms; that they perceive these symptoms to be related to the physical demands of childcare tasks integral to the occupation of mothering; and that there is preliminary indication in relevant literature that there may be some correlation between specific tasks or task-related factors and the musculoskeletal symptoms reported. It is therefore plausible that the tasks performed while caring for children create physical stresses which have the potential to expose this population group to an increased risk of MSDs.

1.5 Significance of the study

1.5.1 Universality of mothering

Having established that mothers are at risk of MSDs related to the occupations they perform as mothers, it is necessary to consider the significance of this issue if research is to be undertaken. It might be argued that the universality of the occupation of mothering is in itself enough to make mothers' health, and the way in which the occupation of mothering affects it, important issues in all societies. Mothering as an occupation is linked to us all – most of us have been mothered, work with mothers, are friends with mothers and have family members who are currently mothering. A large majority of the female population is or will become mothers. The size of this population group alone suggests that health issues faced by mothers should be a priority. Census data collected for New Zealand show that in 2001, 29% of women aged 15 years and over were parents in a two-parent family and 11% of all women aged 15 years and over were a sole parent, meaning 40% of all women over 15 years of age (or 592,800 women) were mothers residing with their children (Statistics NZ, 2005). This statistic is a snapshot of mothers living with children on that day, and therefore 40% is likely to under-represent the proportion of the total population who are mothers in New Zealand in any given year. The proportion of the population who are mothers reported by the United States is 56% (or an estimated 82.5 million women) and

this percentage is probably a better representation (US Census Bureau, 2005).

Nevertheless it can be said that mothers form a significant group of the New Zealand population who might be exposed to risks related to the occupations of mothering, at some point in their lifespan. They are therefore likely to be well represented amongst those who visit health providers for treatment of illness or injury, and hence health issues specific to their occupation are important.

It is also significant that the occupation of mothering has a key function in society.

Statistics show that mothers are still the primary caregivers of our future generations (Francis-Connolly, 2000; Statistics NZ, 1993a; Statistics NZ, 2001a), daily “safeguarding their children’s health, nurturing their development, and socialising them to be community members” (Larson, 2000, p. 270). In order to care for this population effectively, it is necessary to have information regarding the health issues faced by mothers. Therefore, it is surprising that the area of MSDs in mothers is relatively under-researched.

1.5.2 Burden of musculoskeletal disorders related to occupation

1.5.2.1 Describing the problem

Although the occurrence of MSDs specifically in mothers is under-researched, MSDs related to paid occupations (work) have been the focus of vast amounts of research internationally and it is well recognised in New Zealand and around the world that MSDs are health problems with heavy personal, economic and social burdens (Aptel, Aublet Cuvelier, & Cnockaert, 2002; Driscoll et al., 2004, NRC, 2001; Warren, Dillon, Morse, Hall, & Warren, 2000; WHO, 2003b). MSDs related to occupation are currently most often called work-related musculoskeletal disorders (WRMSDs) (NRC, 2001). As a large body of scientific research is available pertaining to WRMSDs, the author proposes to apply this information to the issues facing mothers with MSDs related to the occupation of mothering. It is therefore necessary to explicitly define why the body of knowledge pertaining to WRMSDs is highly relevant and why it has been a key knowledge base that the author has drawn on to inform her research.

Consulting the literature regarding WRMSDs, with the occupation of mothering in mind, it became evident that the occupation of mothering might, and arguably should, be classified

as ‘work’ and health issues regarding these ‘workers’ given the same priority as those of the paid workforce. The majority of mothers perform a culturally accepted group of productive tasks every day in order to care for their children, and time spent doing these tasks can not be separately classed as *leisure* or *self-care*. Mothers are therefore *workers* who are unpaid. Defining mothers as doing unpaid work makes explicit the rationale for applying the body of knowledge about work-related MSDs to the population under study. However, confusion might arise with the concept of mothering being labelled as work because the occupation of mothering is an orchestration and melding of multiple tasks and the transition from activities that are *work* or that are *leisure* or *self-care* is fluid (Larson, 2000). Further discussion of the nature of the occupation (work) of mothering follows later, with identification of the elements of this occupation that might predispose mothers to MSDs. The important concept here is that as long as a child is present and being cared for by their mother, the mother is performing the underlying *work* of mothering, sometimes intertwined with activities of leisure, self-care, or with other productivity roles (e.g. volunteer work, paid work). It is important to clarify that this stance does not necessarily attribute the sometimes negative associations given to the word *work*, to mothering. This stance acknowledges the idea that work can be joyful and enjoyable, but nevertheless proposes that the primary nature of the child caring activity a mother does be classed as productivity because it involves caring for another, as opposed to self, and performing activities that, while they may be enjoyed, are not undertaken purely for the purpose of leisure.

Therefore if mothers are seen as workers (albeit unpaid), it is useful to consider the burden of musculoskeletal disorders in the paid population, as this will demonstrate how significant a problem WRMSDs might also be for mothers. For that reason, let us further consider the burden of WRMSDs and the ways in which NZ and other industrialised countries are addressing this issue in order to reduce its negative effect on health.

Establishing the burden on society caused by WRMSDs is not a straightforward process. This is because, in order to establish what the costs associated with a particular health problem such as WRMSDs are, a lot of information regarding the occurrences of that problem and its outcomes is required. This preliminary process is the vital first step in

identifying and describing any health problem that health organisations hope to monitor and control, and in justifying the costs of research and intervention (Warren et al., 2000). Without accurate information, it is difficult to appropriately direct the subsequent steps in the disease intervention process. In the case of WRMSDs, there seem to be many issues concerning how feasible it is to accurately gather this information and hence there is a huge diversity in the nature of the information that is reported and how meaningful it might be in the greater context of the problem.

The information gathering process regarding WRMSDs is referred to as *surveillance*, which the United States National research council describes as the “ongoing, systematic collection, analysis, and interpretation of health and exposure information in the process of describing and monitoring work-related musculoskeletal disorders” (NRC, 2001, p. 304). As surveillance of the occurrence of WRMSDs is difficult, there are several key issues to consider if one is to study elements of this health problem. Firstly, it has been said that attention paid to the problem and hence the data collection has most often been initiated for financial reasons, by the organisations which are concerned with the medical, compensation and time off work costs caused by WRMSDs (Aptel et al., 2002). This means that in some circumstances there may be large and accurate bodies of data detailing the prevalence of WRMSDs, while in others, perhaps those where there is less financial incentive, less data is available. In the circumstances where data has been collected, it may still only reflect organisational financial costs and may not reflect individual or personal burdens caused by the WRMSD. In circumstances where the workers experiencing the health problem are unpaid (such as mothers, or volunteer workers) the data regarding WRMSDs does not seem to be available, as although WRMSDs may result in a loss of productivity and substantial personal, societal, and economic burdens, these burdens are not commonly monitored (Sanders & Morse, 2005).

Another important problem with the surveillance of WRMSDs is that this term encompasses a wide variety of conditions and associated health problems. Although the term Musculoskeletal Disorder (MSD), broadly refers to “health problems of the locomotor apparatus” (WHO, 2003a, p. 1), these health conditions might affect any structure in the musculoskeletal system (bones, ligaments, tendons, cartilage, muscles, nerves) in any

anatomical location (spine, upper or lower extremities) and have a variety of outcomes. They might result in acute (short-term) pain or loss of function or in chronic (persistent) impairments of function, or permanent disabilities. MSDs may have an easily attributable cause such as a traumatic event in which a musculoskeletal structure has been exposed to a force that exceeds its tolerance, or a cause that is obscured, either because the MSD has been caused by a complex combination of factors or because it has been caused by cumulative stresses in which the structure was repeatedly put under stress until eventually its tolerance was exceeded (Marras, 1997). In other words, MSDs might therefore be classified in a myriad of ways (e.g. according to type, anatomical location, precipitating factors, duration). Therefore to accurately record and describe the prevalence of this problem there would need to be a standardised or uniform system to code MSDs along with information about tasks, occupation and industry of the worker experiencing them. As no such system currently exists, there are significant limitations to quantifying the problem (NRC, 2001). This fact must be taken into account when considering the figures which indicate some of the financial burden to countries caused by WRMSDs.

Despite the disparity in the literature between approaches to the problem of quantifying WRMSDs and their associated burden, there are some commonalities. There is consensus in the literature that when quantifying WRMSDs, non-work factors must also always be taken into account. This is because it is not possible to eliminate factors outside the workplace when considering what has caused the MSD (WHO, 1985; NRC, 2001). The statistics regarding WRMSDs are therefore based on circumstances where occupational factors are assumed to have had a significant causal role but the influence of non-work factors has never been excluded. In other words, there are always likely to be some confounding factors and overlap between work and non-work factors.

Another common practice is to categorise WRMSDs according to body location and in this way limit the size of the research to a specific area. WRMSDs are generally divided into those affecting the Neck, the Upper Limb, Lower Back and Lower Limb. The Neck, the Upper Limb, Lower Back have received ample attention in the research and substantial quantities of data are available, but there is a paucity of research on the Lower Limb (Bernhard, 1997; NRC, 2001). Finally, as much of the literature has the aim of providing

information for future intervention, it typically examines the relationship between WRMSDs and the *factors* which may have a role in causing, aggravating, accelerating or exacerbating WRMSDs (NRC, 2001; WHO, 1985). (Theory regarding risk factors and the causation of MSDs will be discussed in detail in section 1.6.1 on page 22). This means that WRMSDs are often quantified in terms of a particular factor or particular occupational exposure (e.g. lifting).

The above discussion of how the literature depicts the problem of MSDs and the types of language and categories used is intended to demonstrate why it is a very difficult problem to address within the scope of this research and why oversimplification, or failing to understand the enormity of the topic, might lead to creating research that fails to be meaningful or to offer anything to the broader knowledge base in this area. There is an argument for standardisation of language and approaches to studying WRMSDs and their causes and this study has attempted to follow current trends in its approach to identifying risk factors for MSDs when mothers lift children.

1.5.2.2 The burden of MSDs internationally

Most industrialised countries collect data on WRMSDs and some will be used below to outline the international burden of them. The organisations that report on WRMSDs are numerous and varied, for example: occupational health and safety organisations, government and labour agencies, research organisations, insurance agencies, and health providers. Due to the diversity of the types of data collected and the sources, accurate data is difficult to find. This should be taken into account when considering the figures outlined below.

In the US the NRC (2001) reported that the total economic burden attributable to WRMSDs is likely to be as high as US\$45 to \$54 billion annually. This figure reflects not only the cost of compensation claims but also indirect costs related to lost wages, lost productivity and lost tax revenues. The NRC believed this to be a conservative estimate due to under-reporting of injuries. Of the reported WRMSDs responsible for these costs, a significant proportion of the injuries are likely to have resulted from over-exertion. In 1995, the Bureau of Labor Statistics reported that 32% of all lost-time injuries resulted from over-exertion or repetitive motion. Of the over-exertion injuries back disorders are more frequent

than disorders of any other body part (Mital, Nicholson, & Ayoub, 1997). In fact, lower back disorders may account for up to 41% of all work compensation costs (Marras, 2000). Manual handling activities, including unaided lifting, lowering, carrying, pushing, pulling and holding activities are highlighted as one of the prime causes of over-exertion injuries to the back (Cole, & Grimshaw, 2003; Marras, 2000; Rodrick, & Karwowski, 2006). Less accurate data is available regarding the cost of upper limb WRMSDs which has been described as lower than those of low back disorders, but nonetheless significant (Warren et al., 2000).

In other countries WRMSDs also carry a heavy burden. For example, in France in 1990, the cost of low back pain alone was estimated as €1.3 billion (Aptel et al., 2002); in the UK it has been estimated to cost US\$2.6 billion a year and in Australia AU\$400 million a year (Cole, & Grimshaw, 2003). As in the US, there is data from Sweden and the UK indicating that strains and sprains due to over-exertion of the musculoskeletal system, are the most common types of injuries to workers (Mital et al., 1997). Manual handling is also implicated in these countries as a major cause of over-exertion (Mital et al., 1997).

These figures demonstrate that WRMSDs are responsible for a considerable health burden internationally, that of WRMSDs, low back disorders are the most prominent concern, and that manual handling (and in particular, lifting) has been identified as an important precipitant of this burden.

1.5.2.3 The burden of MSDs in New Zealand

As in most industrialised countries, many organisations in New Zealand have an interest in monitoring health issues such as WRMSDs. The key holder of statistics pertaining to WRMSDs has been Statistics New Zealand since 2002, when it was appointed to compile comprehensive data across the agencies which monitor injury prevalence and produce injury-related data (Statistics NZ, 2007a). Prior to 2002, information regarding injury was collected and held individually by organisations such as the national insurance agency, the Accident Compensation Corporation (ACC), New Zealand Health Information Service (NZHIS) and the Occupational Safety and Health Service (OSH). Information from these agencies shows that WRMSDs are also a considerable burden in NZ. A report created by Statistics New Zealand of all work-related injuries in 2006 showed that sprains and strains

of the musculoskeletal system cost NZ\$94.5 million, making up 42% of the total work-related claims cost (Statistics New Zealand, 2006a). This does not account for injuries of gradual onset which, if included, might increase the costs substantially, to up to 60% of total claims cost if the trend was the same as that seen in the 2001-2002 report (Statistics NZ, 2007b). These figures do not include injuries sustained by unpaid workers.

Similarly, a report compiled by the National Occupational Health and Safety Advisory Committee (NOHSAC), also demonstrated that the burden of WRMSDs in this country was significant (Driscoll et al., 2004). The NOHSAC report was based on a critical and detailed analysis of peer-reviewed literature published between 1984 and 2004 on occupational disease and injury in NZ. The NOHSAC provides independent information for the Minister of Labour on the prevalence of major occupational health issues and evidence-based information on how best to address these issues. Its conclusions regarding the significance of occupational musculoskeletal injuries are important as this appears to be the most comprehensive review undertaken in this area in NZ to date. Although the review stated that literature was only available in some areas, it was still able to confirm that NZ is consistent with international trends in the occurrence of WRMSDs. It concluded that, as it is internationally, low back pain is one of the most common WRMSDs in this country. A wide range of occupations, work tasks, workplace factors and psychological factors were identified in the review as being associated with low back pain in NZ, but it was concluded that further investigation would be required to confirm the validity of these associations. Nevertheless, it was evident that the NZ workforce is equally exposed to nearly all the factors currently highlighted by the international literature as being associated with low back pain. This indicates that research undertaken internationally can also be applied to the NZ workforce. In its summary, the report also called attention to several facts from studies of note: that in one group of workers, having to *lift* three-quarters or more of the working day doubled the risk of pain progressing from acute (short-term) to chronic (long-term); that of all ACC claims over a 3 month period in 1984, low back pain rates were highest in occupations involving *manual work* such as labourers, coal miners, farmers, nurses, freezing and railway workers and that 55% of incidents occurred during *lifting*.

With regard to the WRMSDs affecting the upper limb, the NOHSAC report chose to separate upper limb conditions associated with work that have clear clinical and pathological signs, from upper limb conditions present without objective signs. It highlights that there has been controversy in NZ surrounding upper limb conditions, as the former are easier to diagnose and classify, whereas the latter are more difficult (Driscoll et al., 2004). This separation has largely occurred due to the fact that workers in NZ are covered for certain injuries by ACC and therefore diagnosis and classification has been an important factor in determining the likelihood that an injury is work-related and hence eligible for cover. Despite there being some problems with data collation, the report concluded that “virtually all occupations, tasks and exposure associated with upper limb disorders occur in the NZ workforce” (Driscoll, 2004, p. 96). This again indicates that NZ is in line with international trends in upper limb injury occurrence.

1.5.3 Burden of MSDs and the occupation of mothering

The World Health Organization (WHO) maintains that identifying the problems in the occupational health of women remains a challenge as much of women’s work remains unrecognised, uncounted and unpaid (Kane et al., 1999). They describe women’s work as being fluid and multi-dimensional with women undertaking formal paid work, informal paid work from home, or combining full-time paid work with household work and the care of children, the sick and the elderly. As a result women move in and out of the paid workforce at different points in their lifespan. Therefore, establishing the burden of MSDs in women and in particular in mothers, would be a highly complex undertaking. To date there is no country in the world embarking on the level of surveillance that would be required to quantify this burden.

However, given the prevalence of WRMSDs in the general population, it is likely that some women will have suffered one prior to becoming a mother, that some women may develop a MSD while doing the work of being a mother, and that some women will suffer a WRMSD when they return to the paid workforce and continue to mother their children. Therefore the effect on the health of women, of WRMSDs either caused by paid employment or by the work of mothering, is likely to be significant, and to be interlinked. It is therefore only by examining a combination of the effect of domestic work done by

women and their paid employment that the full occupational health of women can be understood (Blane, Berney, & Montgomery, 2001; Kane et al., 1999). Women who contract a WRMSD prior to becoming a mother may be more vulnerable to further injury while mothering, or may have a reduced capacity to perform the occupations of mothering (Franché, Pole, Hogg-Johnson, Vidmar, & Breslin, 2006). Those who develop MSDs related to the occupations of mothering may not only have their mothering capacity reduced, but may find that their physical capacity is affected when they try to return to the work-force. Or indeed, may not return to the workforce. Of individuals in a large cohort study of acute low back pain patients, female single parents were shown to be more likely than other individuals to not return to work (Dixon & Gatchel, 1999).

Therefore, although the financial burden directly associated with the work of mothering is unknown, it can be concluded from the preceding discussions that if mothers develop MSDs there will be associated medical costs and loss of productivity, social costs associated with a reduction in their mothering capacity and personal loss of function, and potentially long-term consequences for their health. Because they are unpaid, and because the occupation of mothering is mostly a long-term commitment, it will generally be mothers and their families who absorb this burden (Kane, 1999).

1.6 Addressing musculoskeletal disorders related to the occupation of mothering

1.6.1 The role of risk factors in addressing MSDs

As outlined above, WRMSDs are a complex issue responsible for a substantial global burden. This has led to WRMSDs being the focus of much research, in the hope of preventing or reducing the burden they cause (Cole & Grimshaw, 2003). The scientific community, work organisations, and health providers have laboured toward identifying the causes of WRMSDs and what intervention strategies might be effective. Addressing such a complex and widespread issue requires collating a phenomenal amount of information. Recognising this fact, the US Congress commissioned the United States National Research Council (NRC, 2001) to thoroughly evaluate and collate the current evidence in the scientific literature regarding MSDs related to work. The report that the NRC produced as a

result, was a comprehensive 374-page publication. It included evidence regarding types of MSDs (diagnosis and classification), theories of causation, prevalence, prevention and intervention knowledge and research gaps (NRC, 2001).

Preceding the NRC report, the United States National Institute for Occupational Safety and Health (NIOSH) had published an influential and extensive review of the literature describing the epidemiology of musculoskeletal disorders of the back and upper extremities (Bernard, 1997). The review focused on the causal links between physical activities and psychosocial factors in the work place and MSDs, and provided a firm foundation for the NRC report. These works now appear to be well-recognised internationally and they are commonly cited in the recent literature which pertains to WRMSDs. They are used as a valuable source of expertise to inform guidelines and research in this area. The purpose of the current study is to investigate which risk factors for MSDs are present when mothers lift children. The focus is not on investigating WRMSDs themselves, but on factors related to causation, in a specific occupation. It was not within the scope of this study to perform an independent comprehensive review of the literature on WRMSDs. Therefore, the seminal report by the NRC, and the NIOSH review, provided an important base of current knowledge regarding WRMSDs. The major limitation of relying heavily on any publication is that the conclusions drawn within it might be biased toward the authors' personal views. The NRC report and NIOSH reviews were undertaken by panels of experts from different scientific backgrounds (biomechanics, epidemiology, hand surgery, human factors engineering, internal medicine, nursing, occupational medicine, physical medicine and rehabilitation, physiology, psychology, quantitative analysis and rheumatology) and rigorous protocols were followed, which helps to ensure a neutral stance. Nevertheless, for the current study, relevant primary articles were also consulted where appropriate. The NRC report will be used to outline key concepts and theory related to how risk factors relate to addressing WRMSDs. The approach taken by this study toward identifying what risk factors for MSDs are present when mothers lift their children in the home environment follows a path guided by the conclusions of the NRC report.

The NRC report was guided by two underlying principles. The first was to “approach musculoskeletal disorders in the context of the whole person rather than focusing on body

regions in isolation” (NRC, 2001, p. 5). The second was “to draw appropriate scientific inferences from basic tissue biology, biomechanics, epidemiology, and intervention strategies to develop patterns of evidence concerning strength of the relationship between musculoskeletal disorders and the multiplicity of work and individual factors” (NRC, 2001, p. 5). These principles were important when choosing to use this document to guide the methodology of the current study. Firstly, it was important for the current study to take a holistic approach to the MSDs experienced by mothers. This is because the research in this area is in its infancy, and considering the whole person would make the findings not only in line with international trends but also more valuable to improving the health of mothers. Secondly, the current study wished to follow the NRC approach and look at the role various workplace and individual factors would have in mothers developing MSDs. This approach would allow a variety of factors to be considered and again allow a wider net to be cast when beginning to examine which factors are present that might give rise to musculoskeletal injuries when mothers lift children in the home.

The NRC (2001) developed a model as an analytic framework to organise the wide and diverse body of knowledge addressing the work-relatedness of MSDs. This model can be seen in Appendix A, and its components will be discussed in more detail in the Literature Review chapter, with regard to the model for the current study, which it was used to develop (see Figure 1 in section 2.1). In summary however, the model is organised into two broad categories: workplace factors, and factors related to the person, that might affect the development of MSDs. Within these categories, various relationships between different elements that might influence the development of a musculoskeletal disorder are outlined. The NRC intends to depict various pathways within the workplace-person system that might lead to the outcomes of pain, discomfort, impairment or disability in the worker. Rodrick and Karwowski (2006) provided an excellent example of how the model can be interpreted with regard to the development of Low Back Disorders (LBD):

The model focuses on a potential causal pathway to musculoskeletal disorders related to a load-tolerance relationship of human tissue. The biomechanical system responds to workplace and individual conditions through the systematic recruitment of muscles that result in body movements and the application of forces outside the body needed for task/job performance. The muscle co-contractions also result in subsequent loading of the structures within the

torso. If the internal loading due to task demands exceeds the tolerance of a tissue within the torso, there is potential to stimulate pain receptors (nociceptors) and/or cause structural damage ..., which can lead to an injury Individual factors (such as age, conditioning, personality, etc.) can modify the coactivity response of the trunk muscles, affect the tissue tolerance (through altered tolerance or adaptation, and/or influence the outcomes of pain or injury. Workplace factors can also influence the injury pathway. Physical loads imposed by the work demands ..., organizational factors ..., and social context ... have all been shown to influence the recruitment of trunk muscles. (p. 821)

An added consideration when choosing this approach is that it is also the approach that ACC, the major injury compensation body in New Zealand, has chosen to take (ACC, 2007a). This is evidenced by the approach taken within the section of their injury prevention unit aimed at addressing what they label ‘Discomfort, pain and injury’ (DPI). On their website, they promote the contributory factors approach to DPI and highlight the fact that it is a combination of factors (including individual, organisational, environmental, task and load related factors) which are significant in the occurrence of DPI (ACC, 2007b).

Considering the worker and workplace as a system is the approach taken by the field of ergonomics. Ergonomics can be broadly defined as a specialist field that studies and intervenes in work and work systems “to establish compatibility among the worker, the job and the work environment” (NRC, 2001, p. 303). Ergonomics knowledge areas include (but are not limited to) cognitive processing, psychology, environmental issues, design processes as well as physiology and anatomy (Edwin, Wood, & Parker, 2006). The field uses ‘macro’ (whole system) as well as ‘micro’ approaches (Edwin et al., 2006). It is a field of knowledge concerned with the safety, productivity and health impact associated with occupations. The range of professionals who work within the field or draw from this field for their work, reflect the variety of factors connected with these concerns. Ergonomics embraces researchers and practitioners from medicine, epidemiology, psychology and industrial engineering and other health-related, technical/engineering and behavioural disciplines (NRC, 2001). Given the goals of the professions of physiotherapy and occupational therapy (outlined in sections 1.2 and 1.3), it is not surprising that therapists who specialise in working with clients with WRMSDs use principles of ergonomics in the rehabilitation process (to help maximise a client’s ability to function in their occupation),

and to inform injury prevention strategies (Brown & Gerberich, 1993). This area of interaction between the rehabilitation professions and ergonomics has been called ‘rehabilitation ergonomics’ and carries its own scope of expertise overlapping – but not synonymous with – the field of ergonomics itself (Vieira, 2006). This melding suggests increasing support for the multidisciplinary approach to the problem of WRMSDs, which is also evident in scholarly discussion in the field of occupational health (Thornbory, 2005). Therefore it is appropriate for the methodology of the current study to draw on the existing ergonomics knowledge base regarding the factors that might give rise to musculoskeletal injury when mothers lift their children in the home. By taking this approach, all the factors in the worker-workplace system can be addressed. In this study this means factors related to: the mother (worker); the child (the primary load); and the home (workplace). It considers the risk for MSDs in relation to physical and psychosocial factors in the home, the context of the mother’s life, including her social support systems and physical and psychosocial stresses outside the work of caring for her child, and her individual responses to pain and coping mechanisms.

It has therefore been established that it is possible to identify relationships between certain elements of occupations and of persons, and the risk of developing MSDs. In particular a number of specific physical exposures are strongly associated with specific MSDs when exposures are intense, prolonged, and particularly when workers are exposed to several risk factors simultaneously (Bernard, 1997). Hence it is useful to outline the conclusions of the NRC (2001) and NIOSH (Bernard, 1997) reviews regarding the factors considered to date to be the most significant in contributing to the development of MSDs affecting the lower back (section 1.6.1.1) and upper limb and neck (section 1.6.1.2). The inter-relationship of specific factors related to the occupation of mothering will then be discussed in detail in the literature review.

1.6.1.1 Summary of generally accepted risk factors for disorders of the lower back

A comprehensive and detailed critical review of over 40 articles by Bernard (1997) assessed the levels of evidence regarding the relationship between low-back disorder and five physical workplace factors. Bernard’s review gave the epidemiologic evidence of work-relatedness one of four ratings: strong evidence of work-relatedness; evidence of

work-relatedness; inadequate evidence of work-relatedness; and evidence of no effect of work factors. The conclusions of the review are as follows:

- There was strong evidence that low-back disorders are associated with work-related lifting and forceful movements. These relationships were considered to be consistent with biomechanical and other laboratory evidence regarding the effects of lifting and dynamic motion on back tissues.
- There was evidence that work-related awkward postures are associated with low-back disorders.
- There was strong evidence of an association between exposure to whole body vibration (WBV) and low-back disorder.

The NRC (2001) review likewise concluded that there was a clear relationship between back disorders and the physical load imposed by manual handling tasks such as lifting, awkward work postures such as frequent bending and twisting, physically heavy work, and WBV.

1.6.1.2 Summary of generally accepted risk factors for disorders of the neck and upper limb

Bernard (1997) drew the following conclusions regarding the evidence for causal relationships between MSDs of the neck and upper limb and risk factors.

- There was evidence for causal relationships between neck-only and combined neck-shoulder MSDs and highly repetitive work (defined as “work activities which involve continuous arm or hand movements which affect the neck/shoulder musculature and generate loads on the neck/shoulder area” (p. 2-1)), forceful exertion, work with high levels of static contraction or prolonged static loads, and extreme working postures involving the neck/shoulder musculature.
- There was evidence for positive associations between shoulder-specific MSDs and (1) highly repetitive work and (2) repeated or sustained shoulder postures involving greater than 60° flexion or abduction of the shoulder joint.

- There were strong associations between elbow MSDs and (1) forceful work and (2) exposure to a combination of risk factors (e.g. force and repetition, and force and posture).
- For hand and wrist MSDs, there were associations were between carpal tunnel syndrome and highly repetitive work or combined exposures, and between a risk for hand/wrist tendonitis and combined risk factors (e.g. highly repetitive, forceful hand/wrist exertions).

The NRC (2001) review similarly indicated that repetition and force were strongly associated with incidence of WRMSDs of the neck and upper limb. However, it did not find convincing evidence concerning the association between postures of the neck and upper limb and MSDs, and in addition highlighted vibration as an important risk factor.

1.7 Summary of introduction

This Chapter has shown that the occurrence of MSDs in mothers is a noteworthy problem and that the findings of research in this area would be relevant to most health providers but especially to the rehabilitation professions (physiotherapy and occupational therapy). In this Chapter it was argued that the occupation of mothering should be acknowledged as being work which is unpaid. Therefore the same attention should be given to addressing the acquired MSDs experienced by mothers, as is given to the MSDs experienced by the paid work populations. The problem of work-related MSDS (WRMSDs) in the general population was recognised in this Chapter as being a difficult problem to address, due to its size and complexity. Similarly the problem of MSDs in mothers was shown to also be complex. The widely accepted approach of basing WRMSD prevention and intervention on addressing contributory risk factors was described and a summary of the key risk factors for WRMSDs was given. In conclusion, it can be said that acquired MSDs related to performing the occupation of mothering have the potential to be a substantial health problem for women. There is therefore good evidence to support undertaking the current study to identify the risk factors for MSDs when mothers lift their children.

2. LITERATURE REVIEW

2.1 *Introduction*

This chapter presents the existing knowledge base in the area of risk factors which might give rise to musculoskeletal disorders (MSDs) when mothers lift children. The discussion will be organised around the model below (see Figure 1), which was created for this study by adapting the NRC model (2001) to the occupation of mothering. It is a conceptual model that shows how various factors in a dynamic system involving the mother, the child and the work of mothering interact to result in outcomes of pain, discomfort, impairment or disability related to MSDs. (The original model is given in Appendix A.) Using this model to organise the concepts, the primary literature addressing work-related MSDs (WRMSDs) specifically in childcare occupations (paid and unpaid) is reviewed and the risk factors for MSDs related to the worker (mother), load (child), the task, organisational and social context will be discussed. Key risk factors relating to each area are identified from the literature.

The purpose of this literature review is to present an understanding of the physical work of mothering and the risk factors for MSDs inherent within. As stated by the World Health Organization (WHO), it is only by having a greater understanding of the work women do, and in what circumstances, that it will be fully possible to understand their health in the context of occupation (Kane, 1999). Given the paucity of literature examining the connection between the physical demands of the occupation of mothering and its impact on health, the foundation for this study is best laid by exploring the nature of the occupation of mothering on the road to establishing associated health risks. An occupational analysis of the work of mothering, by the author, informs the discussion that follows, supported by available multi-disciplinary literature.

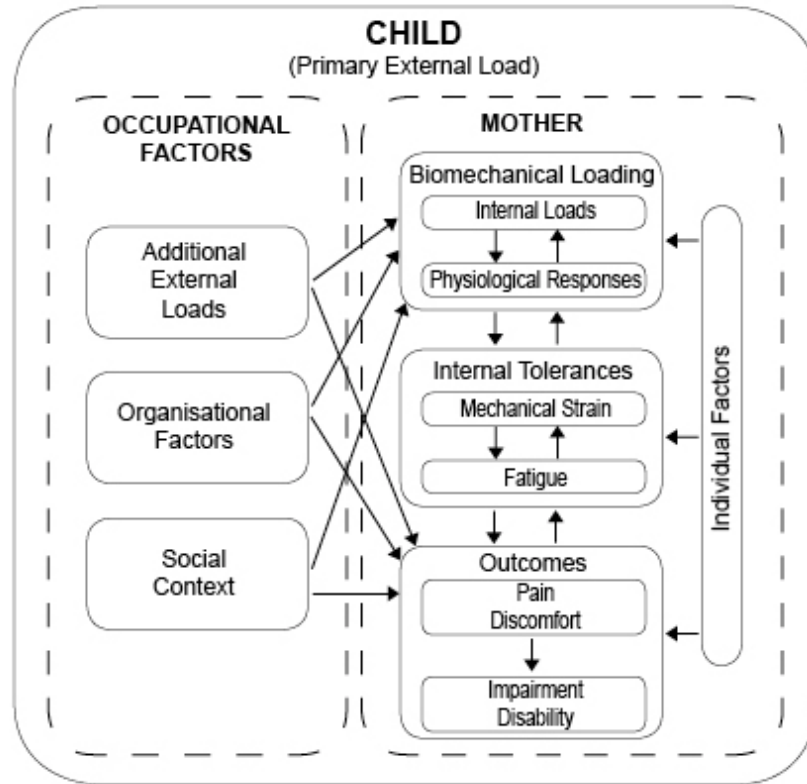


Figure 1: Conceptual model of the possible roles and influences that various factors may play in the development of musculoskeletal disorders in mothers (adapted from NRC, 2001, p.3; the original model is reprinted in Appendix A).

2.2 Prevalence of MSDs in mothers: Outcomes of pain, discomfort, impairment or disability

As discussed in the introduction, the progression from being exposed to a hazard to developing a MSD is complex and can be influenced by any or all of the factors outlined in Figure 1. The outcomes may vary in type, location and severity from one individual to another, depending on the complex interplay of these factors (NRC, 2001). In Chapter 1 it was proposed that due to a lack of surveillance data in this area, it is hard to accurately quantify existing levels of pain, discomfort and disability experienced by mothers as a result of acquired MSDs related to the occupation of mothering. This notwithstanding, it was suggested that the burden of MSDs experienced by mothers might be expected to be significant. The following paragraphs will describe the level of pain, discomfort, disability or impairment described in the research to date.

Following an extensive literature search only two studies specifically aimed at examining MSDs related to the physical demands of the occupation of mothering were located (Griffin & Price, 2000; Sanders & Morse, 2005). Only one of these studies, undertaken by an associate professor of occupational therapy and an associate professor of occupational health and environmental medicine, provides quantitative data regarding the prevalence of MSDs (Sanders & Morse, 2005). Sanders and Morse, concerned that few studies had examined the physical risks associated with caring for children at home, undertook a study to identify the frequency, type and severity of musculoskeletal symptoms in parents of children less than 4 years old. They used a seven-page survey instrument to collect self-report data from 130 parents. The survey was developed from field observations of childcare tasks, focus-group feedback, the existing literature, pilot surveys and expert review. It collected demographic and anthropometric information, information about the family social circumstances, time-use, and the parents' performance of high-risk childcare practices. This data was then analysed to determine if there were any significant associations between any of these factors and the incidence of musculoskeletal symptoms.

It is significant that 92% of the parents who responded to the survey were mothers (n=120), making the results and methods highly relevant to the current study. The results showed that the parents in the sample were experiencing notable levels of symptoms, with 66% of the sample (n=88) reporting musculoskeletal pain. Almost half of all parents (48%) had low back pain, and 44% of parents indicated that they had neck, upper back or shoulder pain. Knee, finger, wrist, or hip pain was less common, each occurring in 10% or less of parents. Specific conditions had been diagnosed in those participants who had been seen by a medical doctor (n=33) and diagnoses included: low back strain, sciatica, shoulder tendonitis, knee pain, neck pain, wrist tendonitis, de Quervain's tendonitis, carpal syndrome and hip tendonitis. From their results Sanders and Morse concluded that "a high number of parents, primarily mothers appear to be at risk for developing some kind of musculoskeletal pain as a result of caring for children under 4 years of age" (p. 292).

With regard to the limitations of their data, the authors acknowledged that an instrument that is self-report and cross-sectional in nature may result in a response bias, as it might be the most affected parents who are motivated to take part. They also acknowledged that the

instrument used a physical-stress rating scale that was non-standardised. Hence, although this study was thorough in providing an indication of the physical stresses of childcare and recorded the presence of musculoskeletal pain, care must be taken regarding the generality of the results. However, the authors' expertise and thorough approach to the tool development suggest that their findings could be used as preliminary evidence that mothers are at enough risk of developing MSDs for this issue to warrant further study.

The study by Sanders and Morse is the only piece of research that has quantified the MSDs occurring specifically in mothers. Nevertheless, further support for the argument that mothers are at risk of these disorders can be derived from research into paid childcare workers. Paid childcare workers are a population who can be said to be exposed to similar physical and psychosocial demands as mothers as a result of their occupation. They are also predominantly female and represent a cross-section of the female population comparable to that of mothers in terms of anthropometrical and demographic factors (Brown & Gerberich, 1993; Gratz & Claffey, 1996; Gratz, Claffey, King & Scheuer, 2002; Sanders & Morse, 2005; Statistics New Zealand, 2001). Therefore it is likely that mothers might experience similar outcomes as paid childcare workers. It is however important to note two possible differences between these populations. First, in some situations the ratio of children to carer might be higher for paid childcare workers (Gratz & Claffey, 1996). Second, the duration of a work day for paid childcare workers typically ranges from 8-11hrs, whereas some full-time mothers might be expected to perform childcare tasks on and off over a 24hr period (Gratz & Claffey, 1996). Bearing these differences in mind, the data from the paid childcare research is a valuable source of knowledge.

Research into the physical demands of childcare is relatively recent, and many of the studies discussed below examined different aspects of the problem, measured different outcomes, and used a variety of methods. There are therefore discrepancies in the frequency and nature of the musculoskeletal symptoms reported (Sanders, 2004). Concern regarding WRMSDs in paid childcare workers is evident in the Japanese literature from 1977 (Endo, Suzuki, & Sasaki, cited in Shimaoka et al., 1998). However, this problem was not given recognition in the US until 1983, when the Childcare Employee Project surveyed the health and safety concerns of childcare workers in 20 states. They reported that 48% of

respondents had experienced back strains from lifting children (CCEP, 1983). Ten years later, Brown and Gerberich (1993) published data analyses from the Minnesota Department of Jobs and Training and Department of Labour case files of injuries incurred by childcare centre workers (n=440), and also a sub-analysis of back injuries incurred by female workers. They reported an overall injury rate for the six-year period of 1.08 per 100 workers. Of the injuries, 34% involved the lower back, 20% the lower extremities and 12% the upper extremities. Sprains accounted for 69% of the back injuries. The authors expressed concern at the possibility for persistent disability among the workers, and identified a mean cost of US\$3,759 for childcare worker injuries, which they felt was likely to be a conservative estimate, given the limited data available to calculate this figure.

Lower rates of musculoskeletal problems were reported by Gratz and Claffey (1996) who performed a survey of 446 randomly selected childcare professionals. Their results did confirm, however, that childcare workers are subjected to physical demands that the workers associate with symptoms of back pain (17%). The incidence of symptoms was perceived by respondents to have dramatically increased since working in childcare (i.e. to be associated with occupational exposures). Another smaller study (n=22) also recorded musculoskeletal symptoms in childcare workers, again at different rates. Grant, Habes and Tepper (1995) included a questionnaire in their study into the possible causes of back and lower extremity pain. Questionnaire responses indicated that back pain or discomfort was experienced by 61% of respondents, neck or shoulder pain by 33%, lower extremity pain by 33% and hand or wrist pain by 11%.

In summary, there is clearly variation in the way the literature has addressed the prevalence of acquired MSDs in women performing childcare occupations. Studies vary in the ways that they: indicated prevalence (e.g. injury rates per year versus a percentage for a given period); labelled the type of MSD (e.g. musculoskeletal symptoms of pain or discomfort, versus injury or disorder); defined body site (e.g. back pain, versus neck and low back pain separately, or generic upper limb pain versus individual joints); and collected data (e.g. self-report surveys, observations, interviews). However, despite such variance, there is still reasonable evidence to suggest that both mothers and female paid childcare workers – two populations who perform similar occupational tasks – are incurring MSDs. The statistics

indicate that these are most commonly affecting the lower back, but are not negligible in other anatomical sites including the neck, shoulder, wrist, hand and lower extremities.

2.3 Tasks and occupations of mothering

This section discusses the nature of the tasks and activities that mothers perform as part of the work of childcare. In particular, the discussion is focussed on the tasks and activities that have been identified in the literature as having a higher potential to cause MSDs in mothers. It has been well established in the general occupational health literature, and similarly in the studies of childcare occupations described in section 2.2, that there is a relationship between manual handling activities and the incidence of MSDs (Bernard, 1997; Mital, Ayoub, & Nicholson; 1997; Roderick & Karwowski, 2006). Hence the focus of this section will be on identifying the tasks and activities within the occupation of mothering that involve manual handling and that have been identified as being ‘high-risk’ as a result.

All the tasks under consideration form part of the work of mothering, which to recap, for the purposes of the current study is defined as *a woman engaging her resources of time and energy in actions directly or indirectly related to the care or nurturing of a child to whom she is a mother, in the context of her physical or social environment*. A broader description of the activities of mothering was published by occupational therapist Francis-Connolly (2000) from her qualitative study examining two motherhood stages. Mothers in that study described the main activities of mothering as enfolded nurturing, teaching and daily-care tasks. *Nurturing* includes such things as rocking, snuggling, cuddling, soothing, and comforting their children and is enmeshed in care-taking tasks. *Teaching* includes actions intended to assist the child to learn things, such as rules of behaviour, language and numbers. *Care-taking* includes such tasks as feeding, changing the baby’s nappy, bathing and transporting. Alongside these, mothers perform associated household tasks and other unassociated self-care, productive or leisure tasks. Taking a broad view such as this, allows the complexity of mothering work to be appreciated.

Conventionally, it would appear that the empirical studies into risk factors for MSDs associated with childcare, list and separate tasks in a way that does not fully acknowledge the interweaving of tasks into a meaningful whole. The current study wishes to recognise

that, more often than not, mothering involves tasks and activities that combine care-taking, nurturing, and teaching, in a complex way. For instance: a task labelled as ‘changing a child’s nappy’ may involve care-taking (changing the soiled nappy), combined with teaching (e.g. simultaneously playing a game with the child that involves learning colours or counting) and nurturing (e.g. affectionately cuddling the child as the child is picked up from the change table). This is described by anthropologist Bateson (1996) as ‘enfolding’. Bateson warns that dissecting the activities of an occupation into categories can result in the devaluing of that occupation. The occupation of mothering is particularly at risk of being devalued in this way, as although the individual tasks involved in mothering a child may appear simple, they are woven together to create a complex entity. Therefore, although the discussion that follows discusses particular tasks and activities individually, the reader should be aware, that in the real work of mothering it is not easy to dissect these tasks or activities in this way. The added meaning given to tasks as a result of the process of enfolding might change the way a mother performs a manual handling task, as it changes the end-goal of the task. This might add to the challenge of fully addressing risk factors for MSDs in this population.

The high-risk childcare practices specifically within the occupation of mothering are identified first; then the findings from the paid childcare literature are used to further highlight tasks and activities of interest. The largest study to examine physically stressful or high-risk childcare practices performed by parents was that of Sanders and Morse (2005). They defined high-risk childcare practices as: carrying a child in a car seat; carrying a child on one hip; carrying a child while bent down; lifting a child up to or off a changing table; lifting a child into or out of a crib with high sides; lifting a child up from the floor; standing bent over to wash a child; changing a child on the floor or changing a child in a crib or playpen; opening baby food jars and cans; pushing a child on a seated toy; and breast feeding or bottle feeding in an awkward position. These definitions were based on job analyses of paid childcare work conducted by King et al. (1996) and Owen (1994); a focus group; and pilot study feedback. The survey created by Sanders and Morse asked parents to give each of 50 tasks a physical stress rating between 0 and 9. This method appears to have been based on that originally used by Owen (1994). Chi-square statistical analyses found significant and strong associations between the performance of high-risk

practices and the presence of musculoskeletal pain ($p = 0.001$). The parents who performed greater numbers of high-risk practices indicated the presence of pain more frequently.

This is the only study to date that has quantitatively studied this association in mothers. A much smaller qualitative study by Griffin and Price (2000) asked nine mothers to identify the daily tasks that involved the most lifting and handling of their child but did not ask the mothers about whether they perceived these activities to be associated with musculoskeletal symptoms. The activities they identified were meeting their children's feeding and hygiene needs, play, and housework. The tasks that they highlighted as being most physically demanding were similar to those described by Sanders and Morse. For example: changing nappies, dressing, lifting children in and out of cots and on or off toilets, picking up toys, lifting the children onto swings, and pushing children on bikes. The mothers also perceived tasks done more frequently as more physically demanding.

Several of the studies into paid childcare work give further evidence of the types of tasks that may be linked to MSDs. Three studies used a job analysis approach to identify high-risk tasks (Grant et al., 1995; King et al., 1996; Owen, 1994). The study by Owen asked 27 childcare workers in 5 childcare centres in the US to rate the perceived physical stress associated with the childcare tasks they performed (using the rating system later adopted by Sanders and Morse, 2005, which was mentioned above). From the findings, she ranked the 10 tasks perceived to be most physically stressful. Owen also interviewed the workers and performed on-site observations. Tasks involving lifting were identified as the primary issue. Specifically, these were: lifting from the floor to a changing table, lifting in and out of a push cart, lifting in and out of a crib or onto the toilet. However, tasks involving the body postures of bending and stooping were also listed among the top 10 most physically stressful. Comparably, the study by Grant et al. used both self-report and observation methods to analyse the physical demands of paid childcare work. Their participants also identified tasks involving awkward or heavy lifts and awkward working postures as primary issues. To assess the risk associated with lifting, they went a step further than Owen; they used the well-validated NIOSH (National Institute for Occupational Safety and Health) lifting equation to analyse two lifting tasks. The results of this calculation provided

additional evidence that workers who handle small children might be at risk of lifting-related back pain. With regard to working postures, their results agreed with those of Owen, in that workers spend significant periods of time bending at the waist (stooping). They added the observation that workers also spent a lot of time in extreme postures while sitting on the floor, squatting or kneeling. The third study, by King et al., likewise identified lifting and tasks involving trunk flexion as primary concerns. Sitting on the floor and using child-size furniture were also noted as problematic. In addition, the authors commented that tasks requiring reaching above shoulder height or working at inadequate work heights were noteworthy concerns.

In summary, it can be said that the studies which examined MSDs associated with paid childcare work, consistently link the occurrence of MSDs to the physically demanding tasks performed by the participants. From the literature presented above, it is clear that there is a pattern of evidence that suggests that lifting and low back pain (LBP) are prominent concerns. Lifting was linked to low back pain early in the research in this area by the findings of Brown and Gereberich (1993). Their large epidemiological study of injuries in paid childcare workers demonstrated an association between the occurrence of LBP and lifting in 48% of injured childcare workers. Since then several smaller studies have provided evidence to support these findings and have also brought to the fore additional concerns about work postures and MSDs.

2.4 Risk factors for MSDs and the occupation of mothering

The key contributory factors associated with increased risk of low back, neck and upper limb pain were outlined in sections 1.6.1.1 and 1.6.1.2. From section 2.3, it is clear that the tasks that mothers perform include some of these elements. In the following sections factors (as outlined in Figure 1) which may contribute to the occurrence of MSDs when mothers perform childcare work are discussed. Factors with the potential to either have a causal association with MSDs or to act as confounders when examining associations are considered.

2.4.1 Risk factors related to the person

The mother is the primary biological entity in the system shown in Figure 1 and is the person performing the task or activities of mothering. Therefore factors that are related to her as an individual that might affect whether she develops a MSD are outlined below. This includes the biomechanical loading and physiological demands she is subjected to as the primary biological entity, and various individual physical and psychological features that influence biological, clinical or disability responses (NRC, 2001).

2.4.1.1 Individual factors

Although the literature that addressed MSDs related to childcare occupations did report some of the individual attributes of the participants, very little was identified with regard to the effect of these individual attributes on the risk of developing MSDs. Therefore prominent authors from the general ergonomics literature are referred to in the discussion that follows, as their work provides a foundation for discussing the effect of pertinent individual attributes. Mital, Nicholson and Ayoub (1997), in their internationally respected guide addressing the design of manual handling tasks, recommend that the following individual factors be considered: age, gender, anthropometry, physique, strength, physical fitness, psychophysical factors/motivation (Rodrick & Karwowski, 2006). By understanding the contributions of individual factors to overall risk of developing MSDs, one can better understand how much risk is solely attributable to work (Rodrick & Karwowski, 2006). Individual factors have the potential to both independently cause or to modify (confound) the likelihood a MSD will occur (NRC, 2001). The NRC stated that individual factors that might act as confounders should be measured and taken into consideration when the data is analysed. The confounders selected for consideration depend on “the types of exposures studied, the types of outcomes measured, and the detail on potential confounders that can be collected on a sufficient number of study subjects” (p. 89). The individual factors to be discussed below were chosen as they were identified by the NRC as being important to research into occupation-related risk factors for MSDs.

2.4.1.1.1 Age

It is necessary to consider the age range of mothers of young children before investigating whether this might affect whether they develop a MSD. The ages of mothers of young children will vary, however it is possible to identify common age ranges from data published by Statistics New Zealand (2007b). In 2007 in New Zealand, 89% of newborns had a mother aged between 20 and 39 years. The mean age of women giving birth was 30 years and mean age of women giving birth to their first child was 28 years. The highest fertility rates were in women aged 30-34 years. This suggests that mothers of young children in NZ could be expected to be predominantly aged between 20 and 39 years.

There is conflicting evidence as to whether age can be expected to have an effect on manual handling capability and hence susceptibility to MSDs. Mital et al. (1997) stated that although aging results in biological changes that might be *expected* to affect lifting capacity, their 1997 review of the empirical research led them to conclude that there is insufficient evidence to say that between the ages of 18 years and 65 years, age has any effect on manual lifting capacity. Other reviews have come to similar conclusions (Kingma, 1998; Marras, 2000). It is therefore not surprising that Sanders and Morse (2005) found no statistically significant relationship between age and developing an MSD in their sample of parents. They did however find that parents of 40 years of age or older reported fewer MSDs but they also reported performing high-risk childcare practices with less frequency.

Age ranges of women performing paid childcare work appear to be comparable. The mean age of paid childcare workers in the large survey conducted by Brown and Gerberich was 32 years. Participants in a study by King et al. (1996) were aged 20-42 years old ($\chi=25$) and in the study by Owen (1994) the mean age was 22 years. The sample in the study by Gratz and Claffey (1996) was also predominantly younger adult women. Only the study by Brown and Gerberich noted any association between age and incidence of MSDs. They reported that the greatest proportions of back injuries were in the 20-29 year age group. The literature just described, guided the choice of including mothers aged 20-40 years in the current study because the sample would then reflect the general mother population and also because the risk of MSDs may be a lesser concern in mothers over the age of 40, hence including mothers over 40 might confound the results.

2.4.1.1.2 Gender

Gender has been described by Mital et al. (1997) as the most critical worker attribute as it divides the working population into two distinct groups. Mital et al. argued that due to differences in anthropometry, anatomy and physiology, men and women should be treated differently. Based on empirical evidence, they suggested that the manual handling capacity of women can generally be expected to be substantially lower than that of men, due to women having 60-70% less muscle strength.

It is not only anthropometric differences between the two sexes that might influence manual handling differences. At least one empirical study has shown significant differences in movement patterns between the sexes which affected how manual handling tasks were performed. Lindbeck and Kjellberg (2000) recorded kinematic data for 10 male and 12 female participants during the performance of a stoop lift and a squat lift. They reported significant differences between men and women in several lifting parameters, having controlled for confounding anthropometric factors (which might otherwise explain differences). Another empirical study demonstrated that gender was a mediating factor in the effect of psychosocial stress on spinal loading during the performance of a manual handling task. Marras, Davis, Heaney, Maronitis and Allread (2000) reported that women's spinal antero-posterior shear forces increased in response to stress but men's decreased. Differences in muscle co-activation accounted for these stress reactions. Hence, despite the limitations of these studies only having small numbers of participants and being performed in very controlled laboratory environments, they do provide some support for taking into account gender differences related to risk factors related to manual handling tasks. Both groups of authors argued that there is still insufficient research regarding gender differences and that men and women need to be considered separately in the evaluation of work techniques in manual handling tasks.

It is therefore interesting to note that not all the studies into childcare reported the gender of their participants in their publications. This failure to identify the gender of participants could indicate a variety of assumptions. For example, that gender is not significant, or that childcare workers might be assumed to female. Of the studies that did report the gender of participants, the percentage of females was generally extremely high (93% in Brown and

Gerberich, 1993, 99% in Gratz and Claffey, 1996, 100% in King et al., 1996). In the studies that did have male participants, their data were not analysed separately to that of the females, and this may have affected the accuracy of the overall findings and underestimated risk.

The significance for the current study is that age and gender have the potential to be confounding factors when studying risk factors associated with an occupation such as mothering. Therefore female specific guidelines and research needs to be applied with regard to the risk factors for MSDs, otherwise risks might be underestimated or overlooked. It also supports the focus of the current study being on mothers alone (as opposed to parents) as this reduces the risk of gender confounding results and also because male and female parents may have different risk variables. For instance, a 2005 study of Quebec workers found that neck pain was substantially higher among women and went as far as to recommend that future prevention for neck pain should focus especially on women (Leroux, Dionne, Bourbonnais, & Brisson, 2005). Gender combined with age may also have implications for the health of the paid workforce, in that a majority of females in paid work who are aged 20-39 years are likely to be mothers and are potentially being exposed concurrently to MSD risk factors at work and at home (Franche et al., 2006).

2.4.1.1.3 Anthropometry

With regard to anthropometry, Mital et al. (1997) indicated that taller, less muscularly strong, or obese individuals are at greater risk when performing manual handling tasks. Therefore factors associated with height, physical capacity and body mass index (BMI) may contribute to mothers developing MSDs, or they may act as confounding factors when other factors are being studied (NRC, 2001). In the literature pertaining to the childcare occupations, the implications of anthropometric factors such as these with regard to MSDs, has not been a primary focus. The most that some of the studies have done, is provide anthropometric measurement of the participants in their findings (Shimaoka et al., 1998; Taloni et al., 2004). This allows some normative statements to be made about the populations caring for children and allows the sample in the current study to be compared with populations in existing research, but does not provide guidance as to how these factors might influence the likelihood of a mother developing an MSD. In their study comparing

physical workload in Japanese and Swedish nursery schools Shimaoka et al. reported that the mean height for the Japanese sample (n=58) was 157cm and for the Swedish sample (n=15) it was 163.9cm. The mean BMI values were 21.2 (Japanese sample) and 24 (Swedish sample). Taloni et al. reported a mean height for their sample of Italian nursery workers (n=5) of 161.4cm and a mean weight of 53.8kg. None of the three American workplace studies reported anthropometric measurements (Grant et al., 1995; King et al., 1996; Owen, 1994).

Therefore, although none of the published literature to date has found significant associations between anthropometrical factors and reduced manual handling capacity or incidence of MSDs, the anthropometry of their samples is nevertheless useful. This is because, although mothers in the current study may vary in height and weight, their mean measurements can be compared to those in existing research. The fact that mothers whose measurements fall outside the average range might have a different susceptibility to MSDs than those that fall within, can be taken into consideration. Gathering anthropometric data also provides future research with an accumulating pool of data regarding the individual attributes of child-carers.

2.4.1.1.4 Physical fitness or capacity

There is currently no conclusive evidence that a physically fit individual will be less susceptible to MSDs than others. However, based on expert opinion and reasoning, Mital et al. (1997) suggested that a physically fit individual has a better outlook and may be better prepared to undertake physical work than a less fit individual. This reasoning would appear to be based on the premise that physiological processes in response to biomechanical loading can influence the ability to tolerate load without injury (NRC, 2001). For example: individuals with higher cardiovascular capacity have greater endurance and hence are subject to less physiological strain with repeated effort than those who are less cardiovascularly fit, or that tissues that are regularly loaded through physical effort with adapt with time to become more tolerant to load (up to a point) (NRC, 2001).

Mothers can be expected to have an individual level of physical capacity and level of physical coordination and confidence or skill. There is enough evidence currently to argue

that researchers who are performing large empirical studies on workplace risk factors for MSDs should aim to measure physical capacity and assess its contribution to risk of MSDs assessed (NRC, 2001). However in a smaller study such as the current one reliable measurement of physical capacity is not feasible. Nevertheless, ideally some indication of physical fitness should be obtained. For instance, self-reports of physical activity levels might be used as an accessible method to obtain such information.

2.4.1.2 Biomechanical loading and physiological factors

This section presents the physical factors (biomechanical and physiological) that have been identified as affecting female workers who perform childcare occupations. The main goal of biomechanical studies is to suggest tolerances or limits within which work situations are acceptable. To achieve this goal, the physical demands of the childcare occupations have been evaluated using several different approaches drawn from the ergonomics research. It was therefore necessary for the author to have an understanding of the theoretical approaches behind the methods used to evaluate lifting and to use this foundation of ergonomics knowledge to interpret the studies related to childcare and later to build her own research method. The theoretical approaches that were relevant were: the *epidemiological* approach (linking certain variables related to lifting to incidence of MSDs); the *biomechanical* approach (using empirical research to quantify criteria for the body's tolerance to external forces); the *psychophysical* approach (establishing and using databases based on scientific research to determine the level of exposure to a variable that is acceptable to the majority of workers), and the *physiological* approach (concerned with the physiological responses of the body to the physical task) (Rodrick & Karwowski, 2006). These approaches will be referred to in the discussion that follows.

Section 2.3 presented the perceptions of parents and paid childcare workers with regard to biomechanical risk factors associated with childcare tasks. The evidence was principally epidemiological in nature, gathered using self-report methods. It highlighted that the biomechanical risk factors that were the most problematic were those associated with lifting (Brown & Gerberich, 1993; Griffin & Price, 2000; Gratz & Claffey, 1996; Grant et al., 1995; King et al., 1996; Owen, 1994; Sanders & Morse, 2005). Data collected using self-report methods are useful to indicate the existence of potential problems but further

scientific investigation is then required to determine what specific cause and effect relationship different variables might have. It is the more detailed empirical studies that are considered to provide the strongest evidence for which variables should be addressed by intervention strategies.

In the general industrial work population, epidemiological evidence has led to countless studies using other approaches (biomechanical, psychophysical and or physiological) to quantify the biomechanical risk factors associated with lifting in more detail. A wide variety of facets of lifting have been evaluated regarding their potential to cause WRMSDs. For example, lifting has been studied with regard to: the movement patterns required to lift; the effect of movement occurring in different planes (e.g. frontal or sagittal); the effect of movement occurring at different speeds; the effects of various types of loads or different load weights; and the effect of body postures (Rodrick & Karwowski, 2006). Evaluation of lifting has focussed on how a variable, or multiple variables affect the human body as a whole (e.g. metabolic changes or energy expenditure) but also on how variables affect particular anatomical sites (Rodrick & Karwowski, 2006). Methods used to record data about variables have included such things as observation, video analysis, and biomechanical 3D modelling (Brown & Gerberich, 1993; Grant et al. 1995; King et al., 1996; King et al., 2006; Kumagai et al., 1995; Marras, 2000; Neumann, 2006; Owen, 1994; Rodrick & Karwowski, 2006; Shimaoka et al., 1998; Taloni et al., 2004).

Some attempts have been made within the paid childcare population to more closely examine biomechanical risk factors identified using epidemiological methods (Grant et al. 1995; King et al., 1996; King et al., 2006; Kumagai et al., 1995; Owen, 1994; Shimaoka et al., 1998; Taloni et al., 2004). Three studies used job analysis and observation as methods of examining the biomechanical risks associated with childcare (Grant et al. 1995; King et al., 1996; Owen, 1994). These studies were discussed in section 2.3, as they primarily recorded the presence of high-risk tasks as opposed to measuring the effect of particular elements of tasks (independent variables) on the worker (dependent variable). These studies offered rationales for how a high-risk task might affect workers but did not actually measure the effect.

Two studies into paid childcare workers were located that used biomechanical methods to examine the potential effect of risk variables on workers (Kumagai et al., 1995; Taloni et al., 2004). In 1995, Kumagai et al. evaluated the load on the low back of nursery school teachers, using video recording analysis of the basic activity, working posture, and child-lifting of two teachers from each of the 0, 1, 4 and 5 age classes. They also measured trunk inclination (TIA) continuously during full work-shifts for 20 teachers using a trunk inclination monitor. Their postural analysis showed that time spent in non-neutral postures (standing bent forward, squatting, kneeling) accounted for a third of the work-shift in the 0-1 age class. They therefore concluded that nursery teachers are subjected to considerable postural load. From the TIA data they found that nursery teachers spent 43% of their time with a TIA of more than 20°, which has been associated with an increased risk of low back pain. They were also able to report the frequency of movements involving the trunk, finding that nursery teachers lifted their trunk from a severe forward bending position about 600 times during a work-shift. They found that frequencies of child-lifts were also high, with a mean of 46 child-lifts per hour in the 0-1 age class (this was with a ratio of 1 teacher to two children). This study provides substantial support for the argument that biomechanical risks for MSDs are present when children are cared for. As do the findings of Taloni et al. (2004) who performed a biomechanical study of trunk inclination angle in paid childcare workers. The purpose of their study was to develop a method that would allow the risk of developing a low back disorder to be calculated using a formula (called the “nursery index”) and single frames extracted from video analysis. Their study examined trunk inclination angle (TIA) in the sagittal plane, based on the assumption that while performing lifts childcare workers assumed a series of different static postures characterised by the TIA. The authors created an index for predicting risk of low back pain developed from well validated existing formulae for calculating limits within which lifting was acceptable (MAPO, NIOSH, OWAS and RULA). To test this index they used measurements taken from video observation of lifting postures to calculate the risk index for a task and then compared it to the risk that was identified from computerised three-dimensional (3D) biomechanical modelling. Data showed a good correlation between the risk level indicated by the index and the one indicated by the computerised modelling. The results of their study not only validated their nursery index but also demonstrated that in their sample, antero-posterior shear forces acting on the spine (reflected by increasing index

scores) were inversely proportionate to decreasing knee flexion (i.e. as the participants increased their trunk flexion or TIA the shear forces on the spine increased).

In the mother population, biomechanical risk factors have only been measured via self-report and not examined using any other approaches. Recognising this fact, Sanders and Morse (2005) commented the most notable limitation of a study such as theirs was that a survey does not record the biomechanical practices of the participants and the frequency and duration of the more physically demanding tasks (lifting and carrying). They commented that there was a lack of research providing information about the high-risk elements within childcare tasks rather than only naming the tasks that are high-risk and considered that further research was needed to address this deficit.

Only one study of paid childcare workers examined physiological load and associated it with performing childcare work (Shimaoka et al., 1998). Shimaoka et al. compared general and local physical workloads between 58 Japanese and 15 Swedish nursery school teachers. The most pertinent physiological finding was related to heart rate (HR) measurements. They performed continuous measurement of HR throughout the day and then converted it to a heart rate increase compared to rest, with a HR increase of greater than or equal to 30% signifying a strenuous workload (and greater risk of causing a MSD). Eight childcare tasks were seen to be strenuous in both groups: outdoor play or nurture, care in feeding, indoor play or group nurture, care in napping, changing clothes, changing diaper, tidying rooms and garden, and toilet care. A further nine tasks were rated as strenuous in the Japanese group. Compared to other jobs in European studies, the average HR increase compared to rest was higher than that of sedentary workers (e.g. administrators) and lower than occupations categorised as physical work (e.g. dairy farmers), making it similar to those categorised as mixed physical and mental work (e.g. nursing). The relevance of this for the current study is that physiological work is not insignificant when mothers perform childcare tasks and the fact that more strenuous tasks create a higher level of risk of MSD, needs to be considered.

2.4.1.3 Individual psychosocial factors

In the paid working population, psychosocial factors related to WRMSDs appear to have received less attention than physical factors. There is recognition given to the fact that they

potentially have a significant role to play in MSDs but so far there is not been enough investigation to be clear about the exact significance of particular factors and how they should be described or labelled. In 1997, Bernard made the comment that there was a 'state of confusion' regarding the contribution of psychosocial factors to MSDs and stated that 'psychosocial' appeared to be a 'catchall term' used to describe factors associated not only with the job and work environment, but also with the extra-work environment and with characteristics of the individual (p. 7-1). Despite this, the NRC review in 2001 managed to tease out the existing research in this area and established that there was a fairly robust association between psychosocial risk factors and low back, neck or upper extremity disorders. However, the NRC again emphasised that despite much research being done into psychosocial variables and their association with MSDs, few studies had penetrated the way in which these variables contributed. There is evidence that psychosocial factors may act as confounders when the effect of physical work exposures is studied, but also that the psychosocial factors might be independently related to the onset of MSDs. The NRC therefore encouraged the development of theoretical models to guide further empirical and longitudinal research. They commented that until these models have been developed and tested, care should be taken when making inferences regarding the presence of such risk factors.

The cross-sectional or retrospective nature of much of the research included in the NRC review did not allow clear causal inferences to be made (NRC, 2001). Therefore, more recently prospective studies were undertaken to determine if the presence of adverse psychosocial factors can predict the likelihood of MSD onset. In one such study of 829 participants from 12 diverse occupational groups, certain work related psychosocial factors and individual distress were associated with the subsequent reporting of MSDs and this effect was common across several anatomical sites (Nahit et al., 2003). Therefore, the researchers concluded that it was important not only to include these factors in studies into WRMSDs but to undertake further prospective research. The interconnectedness of the physical and psychosocial factors has also been supported by other research. The authors of a 2005 study, which surveyed 9, 496 workers in Quebec with a view to estimating the associations between physical and psychosocial work factors, also strongly suggest that these variables always be considered together with regard to WRMSDs rather than

focussing on one or the other alone (Leroux et al., 2005). In 2007 a similar recommendation was made by authors of a study into 939 call centre employees, who found that psychological strain contributed to the development of MSDs (Sprigg, Stride, Wall, & Holman, 2007).

There is therefore assorted evidence that both psychosocial variables related to the individual and to the workplace may contribute to MSDs. For the purpose of this study, this section will focus on those psychological or social variables (psychosocial) that might be categorised as being associated with an individual mother. Other factors which are psychosocial, but that are related to the context of the home as an organisation in which the mother performs her work or to the wider socio-cultural context, will be discussed in section 2.4.3.2.2. This structures the discussion to fit with the model in Figure 1 - to again bring the emphasis on separating the 'work' of mothering from the woman as an individual as befits the mothering/work model - thereby not defining women only by their role as mothers, but also as women who are performing the work of mothering.

The individual psychosocial variables identified in the review by Bernard (1997) and by the NRC (2001) are: depression or anxiety, psychological distress, personality factors, fear-avoidance coping, pain behaviour, and job dissatisfaction. The results of these reviews show that psychosocial factors have a contributory role at all stages of the MSD process from the development of a disorder to its transition from being an acute health problem to a chronic one. The NRC described individual psychosocial variables as having four components: cognitive (represented by attitudes, beliefs, and thoughts concerning pain, disability, and perceived health); emotional (depression, distress and anxiety); social (family and work issues); and behavioural (coping, pain behaviours and activity patterns).

Individual psychosocial variables in women working in the childcare occupations and how they might contribute to onset and chronicity of MSDs has not been addressed by any of the research on paid childcare workers to date. Conversely, the two studies which specifically addressed MSDs in mothers did address psychosocial variables and provided some evidence that individual psychosocial variables might be important to the development of MSDs in this population (Griffin & Price, 2000; Sanders & Morse, 2005). Sanders and Morse found that the perception that caring for a child was highly demanding

was significantly associated with increased incidence of MSDs in their sample. Griffin and Price linked individual psychological strain experienced by mothers to the heavy sense of responsibility mothers feel when caring for their children; for example feeling a sense of helplessness and lack of control when their children were sick. They did not demonstrate how this might impact on MSDs. Individual psychological factors such as perceived job demand and perceived job control have been linked to MSDs in general populations, which provides additional support for the fact that the presence of these variables might increase risk for MSDs in mothers (Burton, Bartys, Wright & Main, 2005).

In research addressing the general health of mothers (as opposed to MSDs), individual psychosocial variables have been acknowledged as having an important association with mothers' health (Brown & Lumley, 2000; Brown, Lumley & Astbury, 1994; Francis-Connolly, 2000; Gratz & Claffey, 1996; Hartrick, 1997). It is recognised that becoming a mother and performing the work of mothering can result in considerable psychological strain for some women and that this can impact on health (Figes, 1998). For example, Kitzinger (1992) highlighted that becoming a mother and taking on the responsibility of caring for another human being who is wholly dependent, can emotionally exhaust mothers. They often find themselves in this position of responsibility with a reduced feeling of control (Figes, 1998). The most recognised consequence of failing to cope with the psycho-emotional challenges associated with becoming a mother is the development of psychological distress, anxiety and/or depression – variables which have been identified above as pertinent to the development of MSDs. In a large study of 1,336 Australian mothers, 16.9% of women were identified as suffering from depression at 6 months post-partum (Brown & Lumley, 2000). In a follow-up study 30% of the women were found to be still depressed, or depressed again when their child was 2 years old. The women with depression reported less practical and emotional support from their partners, less social support overall, more negative life events and poorer physical health. They perceived lack of support, isolation, exhaustion and physical health problems as contributing to their depression. These findings suggest that levels of depression in mothers of young children are notable and they provide further support for the fact that individual psychosocial variables should be considered when studying MSDs occurring when mothers lift children

in the home. This is because the presence of adverse psychosocial variables may influence the prevalence of MSDs independently of the lifting.

Mothers might also experience stress related to paid work demands which then impacts on their work as a mother, and these should also be taken into account. In the study by Sanders and Morse (2005), a greater number of MSDs was reported in mothers who worked outside the home. This might be due to physical paid work exposures but could also be related to the stress of having dual roles as a paid worker and a mother (Franch et al., 2006).

2.4.1.4 Medical history and pregnancy

The NRC (2001) reported that there is epidemiological evidence that pre-existing physical conditions, or ill health add to risk of acquiring a WRMSD. Within the literature pertaining to MSDs and childcare occupations, the effect of pre-existing injury or concurrent ill-health has not received much attention. In studies regarding acquired MSDs in general industry, previous back injury has been shown to be a noteworthy risk factor (Marras, 2000), but this was not measured in studies on child carers. Although King et al. (1996) cited the work of Calder (1994), which stated that data on pre-existing conditions that might increase the risk of injury were important and currently missing from the literature, they did not report any data of this nature from their 125 symptom surveys of childcare workers. This suggests that despite recognising a need for it, they did not measure it. The effect of pre-existing injury or illness was similarly not mentioned in most of the other studies which recorded hazards associated with performing childcare occupations (Grant et al., 1995; Owen, 1994; Sanders & Morse, 2005). One of the two studies on mothers, Griffin and Price (2000), did state that none of the 9 mothers in their sample had back pain prior to becoming a mother. Gratz and Claffey (1996) were the only paid childcare researchers that provided a comparison between the child-carers' health status prior to working with children and their current health status. They found that child-carers in their sample (n=446) perceived that they got sick more often since working in childcare. In particular they reported increased incidence of stomach acid, backaches, fatigue, headaches and muscle strain. The child-carers particularly noted an increase in illness in their first year of work. As it was a retrospective study, Gratz and Claffey were not able to determine the participants' exact health status prior to working in childcare, only the perception that it had been adversely affected. It is

therefore possible that those child-carers who noted a reduction in health status were less resilient due to other pre-existing factors. This possibility provides an example of how information regarding pre-existing health conditions is important when making inferences regarding the association between work-related risk factors and adverse health outcomes.

One other study reported data regarding health status among paid child care workers, but did not make any comment about the workers' health status prior to working in childcare (Clabro et al., 2000). Calabro et al. reported that 57.6 of their sample (n=240) reported that they had experienced illnesses related to their contact with children at sometime during their professional career. Therefore, there is some evidence that perhaps mothers, like childcare workers, may be at risk of contracting systemic illnesses which they are exposed to through their children (who may contract it from other children). This would then need to be taken into account when assessing risk of injury related to the performance of physical tasks as the mothers may be less resilient due to the presence of systemic illness.

In populations which are predominantly female and in their child bearing years, pregnancy must also be considered as a potential contributory factor to acquired occupational MSDs (Gratz & Claffey, 1996), due to postural changes and hormonal changes affecting the connective tissues (Tapp, 2003). Drawing from existing empirical research, Tapp (2000) provided a detailed rationale for increased risk for MSDs related to performing manual handling tasks while pregnant. The postural effects are predominantly present later in the pregnancy as they are due to the increasing size of the woman's abdomen, which creates a change in the way that she can interact with her environment and carry out tasks. Changes in the last trimester of pregnancy, Tapp concluded, can result in a pregnant woman: having further to reach to lift objects, a need for altered work surface heights, a change in centre of gravity that affects balance, additional trunk weight to move during lifting, retaining fluid which affects the tolerance of joints for repetitive movement, and an altered standing posture. Despite the potential effect of pregnancy on manual handling capacity, Gratz and Claffey (1996) were the only researchers to report data regarding pregnancy, with three child care workers (out of a sample of 368) reporting at least one pregnancy during their childcare work.. Therefore the data collected through observation of childcare workers does not identify whether any of the workers were pregnant at the time, and what affect (if any)

this may have had on their findings. Similarly, neither Griffin and Price (2000) nor Sanders and Morse (2005) make any comment on whether the mothers in their samples were pregnant.

2.4.2 Risk factors related to the primary load – the child

The child in the current study is the primary load being lifted by the mother. The first distinction of a child as a load is that it is living. Living loads are described by Occupational Safety and Health (2000) as inherently having more risks. A child as a load has other unique attributes: for instance; there is the emotional bond with the mother, the child's vulnerability and fragility, and the fact that a child grows and therefore changes in size and shape. The contribution of child-related variables identified in the childcare literature on MSDs will be discussed below.

2.4.2.1 Age and weight

Age, behaviour and weight of the child are factors associated with the child that are thought to affect manual handling. The actual age of the child provides an indication of the expected weight of the child as a load, but also the child's developmental stage with regard to behaviour. Several authors in the literature examining the physical nature of childcare have made inferences regarding the effect that age, behaviour or weight of the child might have on situations where the child has to be handled (Grant et al., 1995; King et al., 1996; Kumagai et al., 1995; Sanders & Morse, 2005; Shimaoka et al., 1998). However there has not been a standardised approach to assessing this effect. This may be due to the lack of research in this area, which means that researchers are assessing the combined effect of multiple factors and therefore do not provide a detailed examination of the effect of the load. Nevertheless there is some evidence that these factors should be taken into consideration in research where a child is the primary load.

Two authors reported that the incidence of MSDs amongst child carers varied with the age of the child (Grant et al, 1995; Sanders & Morse, 2005). Grant et al. found that there were higher levels of back pain among childcare workers caring for children aged between 6 weeks and 3 years, than those caring for children aged 3 or 4. Similarly, Sanders and Morse found that parents of children aged 0-2 years had higher levels of musculoskeletal pain than

those of children aged 2-4 years. They linked the higher occurrence of MSDs to the fact that younger children are less mobile and require more lifting.

Several authors have also attributed increased risk to the biomechanics of working with specific age categories (Grant et al., 1995; King et al., 1996; Kumagai et al., 1995; Sanders & Morse, 2005; Shimaoka et al., 1998). Their results have been introduced in section 2.4.1.2 with regard to biomechanical risk factors but are re-iterated here with a specific focus on the age of the child. Kumagai et al. found that childcare workers in the 0-1 year age group spent more time in non-neutral postures (e.g. bent forward, squatting, kneeling) and experienced a greater frequency of extreme flexion of the spine. Similarly, Grant et al. found the frequencies of time spent in non-neutral posture was greater for child carers working with younger children, and that infants and small toddlers were lifted more often than older children. Owen (1994) also observed that children older than 3 years required less lifting, holding and carrying. Sanders and Morse reported that the highest overall biomechanical stressors in their sample appeared to be in parents of children aged 1-2yrs. Similar to Owen, they concluded that this was because at 1-2 yrs of age, the children are at a weight that constitutes a hazard but still require frequent lifting, carrying and holding. Sanders and Morse reported the mean weight of children in their sample to be 11.86kg (range of 3.6kg-20.5kg). The weight of the children in Owens study was similar (9.1kg-18.2kg). None of the other literature reported the weight of the children involved in the study, despite load weight being recognised as important risk factor in the general research (HSE, 2004).

Researchers have found that the age of the child can affect the type of physical workload the carer experiences. In younger children, Shimaoka et al. (1998) found that the highest musculoskeletal stress was experienced by carers of 0-2 year-olds. However those working with 3-5 year olds experienced a higher general physical workload, which reflected the greater physiological endurance required to keep up with the more mobile older children. King et al. (1996) also reported that physical endurance was the biggest challenge associated with caring for the older preschoolers (2.5-5 years).

2.4.2.2 Shape and movement

There is a small body of evidence that suggests that children are a load which is more difficult to handle because of their size, shape and ability to move (Brown & Gerberich, 1993; Grant et al., 1995; Owen, 1994). Owen observed that children were difficult to handle as they were not compact packages. Similarly Grant et al. observed that the size and shape of a child makes it difficult to get a good grasp or grip, especially if the child was moving. Likewise Brown and Gerberich, and Owen stated that children often moved during handling and that their movement could be unpredictable.

2.4.3 Risk related to occupational factors

2.4.3.1 Additional external loads

There is some evidence within the literature that mothers are exposed to hazards related to handling additional external loads while performing childcare tasks. Mothers may be required to lift or handle childcare equipment, clothing, toys, furniture or various other items while simultaneously carrying a child (Griffin & Price, 2000; Sanders, 2004; Sanders & Morse, 2005).

2.4.3.2 Organisational factors – physical and psychosocial aspects

The NRC (2001) stated that organisational factors “may affect the external demands of work and the individual’s response to these demands” and that they may “influence external loads in terms of the organization of tasks, work pace, characteristics of interpersonal interactions, and the utilization of ergonomic principles to modify tasks so as not to exceed the physical capacity of the worker” (p. 33). It is therefore recognised that there is a relationship between the structural and cultural attributes of an organisation and the health of the people working within it. This is because the organisational culture strongly influences whether psychosocial and physical workplace factors have a positive or negative on the worker (Calabro et al., 2000). The *culture* of an organisation has been described as consisting of the “values and beliefs that define what the organization does and why and how it does it. This culture includes the prevailing “organizational norms, values, beliefs and attitudes” (Peterson & Wilson, 1998, p. 4).

The following sections describe how organisational factors might affect the way mothers manually handle their children and therefore affect their risk of developing a MSD. For the purpose of the current study, in which mothering has been defined as ‘work’ (albeit unpaid), the organisational factors have been defined as those factors associated with the home, because it is the mother’s base and primary workplace, and with the wider socio-cultural context in which her ‘organisation’ or home operates. Therefore section 2.4.3.2.1 discusses the home as an organisation, viewing it as a physical workplace with its own unique physical environment, and with a unique combination of household members, policies, practices, and culture. As an organisation, each home has a distinct pattern of interactions between members and of division of control or power. Section 2.4.3.2.2 will discuss the wider socio-cultural context, viewing it as being the overriding organisation within which the household operates. This stance is taken because mothers perform the work of mothering in the home, but also on a daily basis out in the community and world. They are therefore liable to also be affected by the organisational attributes of the community and world around them with regard to the way they care for and lift their children.

2.4.3.2.1 The home as an organisation

2.4.3.2.1.1 Physical environment of the home

The factors associated with the home as a work place or organisation can be divided into physical and psychosocial. As a physical environment, the home can be described as a dwelling that is most commonly designed for adults who mostly mobilise upright on two limbs. It is designed to serve several functions including providing a place to prepare and eat food, to sleep, to bathe and toilet, and to undertake recreational activities. Most households with children have adapted the fittings of the house to accommodate the needs of children who initially do not walk, but must be pushed in a pram or carried and then who become mobile but must negotiate an environment which is primarily fitted for adults. This is an important consideration because the layout will be designed to meet the needs of adults. For instance: the space provided to manoeuvre around the home and the height of work surfaces (e.g. of benches, basins and toilets) is that required by one adult individual. When caring for children, mothers help the child negotiate this space and this may add

manual handling challenges. For example; mothers might have to manoeuvre down narrow stairs carrying children, or lift children onto toilets or to basins to wash their hands.

2.4.3.2.1.2 Equipment

Another important consideration is the physical equipment that is added to a previously adult space as part of caring for children. The equipment used in the home when caring for children might include a crib, changing table, baby bath, pram, highchair, child size furniture (e.g. table and chairs), child safety gates, mobility aids (walker, trolleys to push, ride on toys), child bouncer seat, indoor swing, toys, and breastfeeding chair (Grant et al, 1995; Griffin & Price, 2000; King et al., 1996; Sanders, 2004; Sanders & Morse, 2005). Therefore the home absorbs a reasonable amount of extra equipment to adapt to the needs of a child. The addition of equipment reduces the overall free space available and adds potential obstacles, which may affect the risk of injury.

The physical equipment itself has also been identified as being a potential source of problems. From an ergonomics perspective, the equipment would ideally promote the safety of both the child and the mother. However, Sanders (2004) identified a number of ergonomic design problems associated with childcare equipment which increase the risk of injury for the mother. From her summary it is evident that almost all of the equipment listed above has the potential to be problematic and hence the design is important. It is therefore interesting that Griffin and Price (2000) reported that “choosing equipment for ergonomic reasons was not a priority” (p. 17) for the mothers in their study. Choices were based on cost, aesthetics or convenience.

2.4.3.2.1.3 Psychosocial factors associated with the home as an organisation

The physical considerations associated with the home as a workplace are linked to psychosocial factors. This is because the ‘organisational culture’ of a household will influence what priority is given to making the home a safe workplace for both mothers and children and will also influence whether the mother chooses equipment for ergonomic reasons. Therefore the psychosocial factors associated with the organisation will now be discussed.

The occupational (as opposed to individual) psychosocial factors that have been shown to have an association with WRMSDs are the intensity of the workload, the degree of job control, whether the work is monotonous, and the degree of job clarity (Bernard, 1997). The occupation of caring for children has been reported as being centred on meeting a child's needs to a level that threatens carers being able to adequately meet their own needs (Griffin & Price, 2000; Tardy, 2000). Hence it is the child's needs which might dictate to a large extent the intensity of the work of caring for children. Work intensity is measured by indices of perceived time pressure, workload, and work pace (Bernard, 1997). Within the child care occupations, meeting the basic needs of a child (feeding, hygiene, physical and emotional comfort, stimulation) has in itself been recognised as a substantial workload (Kitzinger, 1992; Sanders, 2004). Time pressure is often felt by mothers because they feel the need to also complete associated household work (e.g. laundry, grocery shopping, cleaning and tidying the house), meet the needs of other family members and meet their own needs (Erlandsson & Eklund, 2003; Sanders, 2004). Mothers also experience a large number of unexpected occupations which place additional demands on their time (Erlandsson & Eklund, 2003).

Feelings of time pressure in some mothers are increased by having to balance dual roles of caring for family and working in paid employment (Biernat & Wortman, 1991). Results of the 1996 census in New Zealand showed that mothers of 61.3% percent of children in two-parent families were in paid work (Statistics New Zealand, 2006b). Nevertheless women still had higher participation in all forms of unpaid work within their own household than males (Statistics New Zealand, 2006b). This could result in a greater total workload for women than men in New Zealand. The difference in unpaid work did vary with age. The most notable difference between the sexes was in the 35-39 year old age group, in which 71% of females were caring for a child living within their household in the week preceding the census, compared with only 55% of men. The effect of having a greater overall workload might be that mothers increase their work pace, as they are trying to complete a number of obligatory tasks within a limited period of time as well as tasks that are added to their life for enjoyment or to enhance meaningfulness. Despite causing an increase in overall workload, it is important to note, that for some women working outside the home has positive aspects such as providing stimulation, financial security, a sense of

achievement and social contact and therefore can promote well-being (Biernat & Wortman, 1991; Erlandsson & Eklund, 2003; Tardy, 2000).

Psychosocial stress is also affected by the level of perceived job control that a mother has (Bernard, 1997). Perceptions of job control influence whether the mother copes with her workload and the pace of her work, by determining whether she feels that she has the power to change the intensity of the work to a level acceptable for her. As mentioned above, women often feel that the needs of the child create an external locus of control by dictating the pattern of the day's tasks (Figes, 1998; Griffin & Price, 2000; Kitzinger, 1992; Tardy, 2000). The child's needs also dictate that many childcare activities must be repeated frequently throughout the day and might introduce an element of monotony. Work which lacks stimulation or variation might contribute to mothers experiencing MSDs (Bernard, 1997). Expectations of the mother in terms of how she should perform her role could be viewed as affecting the mother's level 'job clarity'. Mothers who feel conflicted about how they should fulfil multiple roles (partner, mother, homemaker, paid worker) might experience less 'job clarity' and hence more psychosocial stress related to their occupation as a mother.

The two paragraphs above discussed the indices of work intensity, job control, monotonous work and job clarity with regard to the occupation of mothering. A key influence over whether any of these variables are present when mothers care for children in the home is the relationships within the home, which are dictated by the norms, values, beliefs and attitudes of the family – defined above as the organisational culture. This will influence the relationship between adults in the home (if there is more than one adult) and affect the distribution of power and how much say in a mother has in decisions regarding the home. Such decisions might pertain to the layout of the physical workplace, buying of childcare equipment, organisation of the day's activities, division of labour within the household, which activities are considered an acceptable use of the mother's time (e.g. paid work, childcare, personal hobbies, exercise), and how to care for and raise the children in the family. The level of communication within the home is also affected by the organisational culture and dictates whether or not the mother can make her needs understood with regard to organising her workload to optimise her own health and well-being, as well as that of her

children. The relationship between the mother and the children will also be a function of the organisational culture within the home and might affect the mother's workload. For example, the family's attitudes to parenting affect what methods a mother uses to elicit co-operative behaviour from her children and potentially affect how much she handles the children during the day.

The organisational culture within the family will also influence how much social support a mother has. Social support has been shown to be an important influence on the occurrence of MSDs in the workplace (Bernard, 1997). Mothers receive social support from partners, family, friends, and their community (Griffin & Price, 2000). A lack of social support might affect the psychosocial well-being of a mother but might also directly affect the amount of manual handling that a mother does (Brown et al., 1994). If a mother does not have a social network that can provide her with practical support then the result is likely to be that she spends more time performing the physical tasks involved with childcare and has a greater level of exposure to risk factors which might give rise to MSDs.

2.4.3.2.1.4 Health and safety

The health and safety culture of an organisation have also been shown to have an effect on the incidence of WRMSDs (Calabro et al., 2000). Attitudes toward health and safety are known to have an effect on the incidence of injury in general work populations, with favourable health and safety culture resulting in lower injury rates (Mearns, cited in Calabro et al., 2000). However, Calabro et al. found that this was not the case in a sample of 240 paid childcare workers. Instead, their findings showed that despite having a favourable perception of the health and safety culture in their workplace, the childcare workers were reporting frequent work-related illness and injury. The authors therefore inferred that this showed a high level of acceptance towards illness and injury among the workers. They did not explain why this might be the case. The relevance of this research to the current study is that it should not be assumed that mothers who live in a household where health and safety practices are viewed positively will be at less risk of developing MSDs. It may be that prioritising health and safety in theory does not translate into practice, because like paid childcare workers, mothers might accept a certain level of

discomfort associated with their work. Alternatively, mothers might find it unacceptable to modify their childcare methods to protect their personal safety.

Another consideration with regard to health and safety culture within the home is that mothers performing the occupation of mothering are not covered by formal health and safety legislation and therefore do not have the systems and structures in place to ensure that they are protected from injury. For example, in New Zealand paid workplaces are obliged to comply with legislation governing the health and safety with regard to new and expectant mothers at work (OSH & Department Of Labour, 1998). However, in the home, new and expectant mothers find their own way in terms of the safe performance of childcare work. They generally do not have access to health and safety advisors and information in the way that they might in the workplace. In addition, knowledge regarding safe lifting and work practices that they learnt in the paid workplace is not always transferred to childcare activities (Griffin & Price, 2000). This suggests that there are obstacles to the transfer of this knowledge.

2.4.3.2.1.5 Economic factors

A final consideration of the home as an organisation is the influence of economic factors on the work of the mother. Economic factors have been shown to affect how mothers choose equipment for childcare and might conceivably have an influence of other factors which could contribute to the development of MSDs (Griffin & Price, 2000). For example, the financial status of the family would affect how much paid childcare the mother can afford to use, or the level of dispensable income she has available for leisure activities, hobbies, self-care activities and so forth. However, to date, the literature in this area has not addressed the effects of economic factors on the incidence of MSDs in the childcare occupations.

2.4.3.2.2 *Wider socio-cultural context*

The home exists within the wider socio-cultural context which has the potential to affect the occupational factors which were described above. The socio-cultural context exerts its influence on mothers through the social expectations that mothers are conditioned by or respond to, and by the value given to the occupation of mothering. Some of the expectations described within the literature are: prioritising the needs of the child above all

else; having a child which is healthy, safe, well-fed, clean, suitably clothed and developmentally stimulated; and being a mother who is involved, a competent caregiver, attentive partner, emotionally composed and who has a social network (Bell, 2004; Francis-Connolly, 2000; Kaplan, 1992; Kedgley, 1996; McMahon, 1995; Meggitt, 1999; Phillips, 1988; Society for Research on Women, 1991; Tomson, 1995). It can be argued that these social expectations might influence whether a mother chooses to stay at home with the child or work, the tasks she undertakes as part of her mothering role, how much time she spends on these, how she performs them, and what value she perceives tasks related to caring for children to have. As a result, this might affect the way that her work is organised and hence the potential for MSDs to be acquired.

The value given to the occupation of mothering by the society and culture in which she lives might also affect whether mothers are susceptible to MSDs. One way to illustrate the impact that the wider socio-cultural context might have on the work mothers do, is to consider the effect of politics and social policy on mothers. It has been proposed that many of the problems facing mothers are social in origin and require social and political solutions such as paid parental leave, tax incentives or wages for full-time mothers and post-natal support (Kedgeley, 1996). An example of a current policy which affects mothers will be given below.

In May 2007 the NZ government passed a child discipline bill that disallowed parents the right to use “reasonable force” when disciplining their children (The New Zealand Herald, 2007, May 16). In other words, it was no longer legal to smack a child in any way. This then created an expectation of how parents (mothers) might behave toward their children. As an alternative to physically disciplining a child parents are encouraged to adopt alternative strategies such as *time-out*. Time-out requires removing the child to a designated thinking area to cool down. This might involve lifting a resistant child who is angry or even hysterical to place them in time-out. Lifting a child under these circumstances has the potential to create a much higher risk of injury for the mother. This is not to suggest that smacking is a better alternative but simply to demonstrate the way in social policy can affect the performance of childcare tasks.

2.5 Summary of literature review

The literature review began by introducing a conceptual model around which the literature was to be organised (see Figure 1). The model showed how factors in a dynamic system involving the mother, the child, and the work of mothering, might interact to result in a mother developing an MSD. The existing knowledge regarding the prevalence of MSDs in mothers was then presented, accompanied by information regarding the prevalence of MSDs in paid childcare workers. A rationale for the relevance of research evidence from studies into paid childcare workers was provided. Low back disorders were highlighted as the most common MSD among these populations but disorders in other areas of the musculoskeletal system were not insignificant. The review then presented the tasks and occupations of mothering that might be considered ‘high-risk’ and the evidence concerning which tasks were most associated with MSDs. Tasks involving lifting received the most mention. Then the complex sets of risk factors that might contribute to mothers acquiring MSDs were discussed. This included risk factors related to: the person (individual factors such as age, gender, anthropometry, physical fitness/capacity, biomechanical loading and physiological factors, individual psychosocial factors, medical history and pregnancy); the child (age, weight, shape, movement); and the occupation (additional external load, organisational factors in the home or wider socio-cultural context). The importance of each of these factors, either as a primary risk factor or as a confounding factor, was discussed and methodologies used to identify risk factors were presented.

It was noted that research in the area of mothers and occupation-related MSDs is in its infancy and hence the body of existing knowledge in this area is small. Therefore the various methodologies identified in the review were critiqued with regard to their usefulness for exploring an area of research that is fairly new, such as the current one. It is concluded that for the current study using a combination of methodological approaches would provide a wider variety of information than using a single approach, and would produce more useful data.

2.5.1 Study objectives

It has been shown that mothers experience MSDs that they associate with caring for their children (Sanders & Morse, 2005). There is evidence in the literature presented in this Chapter to support the presence of risk factors that might give risk to MSDs when mothers lift children in the home. To date, the physical demands of childcare, as experienced by unpaid child-carers such as mothers, have only been researched using interviews or surveys (Griffin & Price, 2000; Sanders & Morse, 2005). In contrast, in paid childcare populations, the physical demands of childcare have been researched using the above methods in combination with observation. Therefore, to fulfill the objective of the current study to identify risk factors that might give rise to musculoskeletal disorders when mothers lift their children in the home, it was decided that both self-report (survey) and structured observation (checklist) would be used. A multi-factorial approach was chosen so that information regarding both primary risk factors and potential confounding factors can be gathered and presented. The intention of the study is to provide descriptive information regarding the factors identified, which future researchers can use to direct studies toward the factors that most warrant attention. It is not within the scope of this Masters Thesis to provide evidence of causal relationships between various risk factors and incidence of MSDs in mothers due to: the complexity of the research topic, the number of risk factors involved, the lack of existing well-validated and reliable research tools appropriate for this area, and the sample size that is feasible for the project.

3. METHODOLOGY

3.1 Introduction

This chapter describes the methodology used in this study. It consists of two sections. The first describes the general methodological process, including the study objectives, study design, participants and recruitment, data collection process and data analysis process. Two data collection tools were used in the study: a survey and a structured observation tool. The second section describes the development process that the tools were subjected to prior to use and details how components of the tools were modified or constructed. While it is not within the scope of a Masters thesis for a new or heavily modified tool to undergo rigorous testing for reliability and validity, through careful consultation of the literature and provision of evidence for all the components of the tools the author hopes to demonstrate that the tools she developed were well grounded in existing literature. Tool development involved the expert review of the tool by Dr Mark Boocock, an internationally respected ergonomist based at Auckland University of Technology. The tool development section is divided into Part A (the survey) and Part B (the structured observation tool).

3.2 General methodological process

3.2.1 Study design

A quantitative descriptive design was used. Data relevant to identifying factors which might give rise to musculoskeletal injury in mothers were collected using two methods.

Firstly, the participants completed a 9-page, short-answer survey. This survey was adapted (with the authors' permission) from 'The Ergonomics of Caring for Children' survey (Sanders & Morse, 2005). (A fuller description of the adaptation of the survey is given in Section 3.3.). The adapted survey collected data which could not be easily observed but might contribute to understanding factors involved in MSD development. Mothers were asked for information relating to: demographics; their social circumstances; their time-use and participation in childcare activities; their perception of the occupational demand of mothering; musculoskeletal symptoms they attributed to childcare activities; and their

knowledge of safe lifting practices. As part of the survey they rated the physical stress of 50 childcare activities on a scale of 0-9.

Secondly, mothers were observed in their home performing childcare tasks involving lifting. This was a structured observation process and data were recorded about relevant risk factors using a modified structured observation checklist based on the New Zealand Manual Handling Hazard Control Record (NZMHHCR) (OSH, & ACC, 2001). The NZMHHCR was extensively modified through careful consultation of current literature to allow the observer to assess the load, posture, psychosocial and environmental contributory risk factors, and to assign a rating of low, medium, or high risk to each factor (the development of the structured observation tool is fully described in Section 3.4).

Ethical approval for the research was granted by the Auckland University of Technology Ethics Committee (AUTECH).

3.2.2 Study participants

Twenty-five mothers of children weighing between 9 and 14kg took part in the study. The number of participants was determined by the scope of the study and was discussed with AUT statistician John Pemberton prior to commencing data collection. It was his expert opinion that 25 participants would yield useful descriptive data while remaining feasible for a Masters thesis, as it would involve processing 25, 9-page surveys and data from 50 observation hours.

3.2.2.1 Participant recruitment

All the mothers who took part were volunteers who had responded to an advertisement, written in both English and Maori, which invited them to take part in the study (see Appendix B). A snowball method of recruitment was used. The advertisement was distributed to contacts well known to the author, who gave them to mothers who fitted the selection criteria. Contacts included an antenatal instructor, nurse, midwife, Plunket committee member, pre-school teacher, thesis supervisors, and the author's extended family and friends. Some mothers who took part had been given an advertisement by a friend who had taken part. The mothers contacted the researcher via an 0800 number which connected with her cell phone.

Participants were given a verbal description of the study at initial contact and were sent a written information sheet explaining the research process and their rights as participants (see Appendix C). Prior to commencement of data collection, they signed an informed consent form (see Appendix D). To maintain confidentiality participants' data sheets were assigned an ID number and stored separately to their consent forms.

3.2.2.2 Participant selection

To be included mothers were required to be aged between 20 and 40 years, to be without serious mental or physical health conditions, and to have a child (or children) without special needs weighing between 9 and 14kg. A 'serious mental or physical health condition' was defined as an injury, illness or impairment or mental or physical condition for which the mother was currently receiving treatment from a health provider and which affected her ability to perform normal daily tasks on 1 or more days of the week. 'Special needs' was defined as the child having any developmental delay (physical or mental) that had resulted in the child having increased needs in terms of childcare. The participants were asked screening questions when they contacted the researcher to ensure that they fitted the inclusion criteria.

3.2.3 Data collection process

Interested potential participants were sent the information sheet, consent form and the survey. They were then contacted within 2 weeks to confirm that they were willing to take part and to arrange a time to perform the observation visit. They were asked to complete the consent form prior to filling out the survey and were advised that both would be collected at the observation. The time for the observation visit was arranged as often as possible at the most convenient time for the participant and their family, taking into account their daily routines. The participants were reminded that participation was voluntary and to contact the researcher should they wish to reschedule the visit or to withdraw from the study.

To protect her own safety, prior to the home visits, the researcher left a sealed envelope containing the location of the observation with her mother, whom she had arranged to telephone at the end of the visit. If she did not call, her mother would take appropriate steps

to confirm she was alright. The researcher collected and destroyed the envelopes at the end of each visit.

For the observation visit, the researcher arrived promptly at the scheduled time at the participant's home. Having introduced herself fully to the mother and family, she then confirmed that the mother understood how the observation would take place and reviewed the consent form and the survey with the mother, answering any questions which arose. Anthropometric measurements were then taken of the mother and her child or children using a standard tape measure and set of home scales brought by the researcher. The weight measurement was confirmed three times on the scales. For practical reasons, a set of calibrated scientific scales could not be used, but the same home scales were used to measure all the mothers, to ensure consistency. Co-operation with measurement and observation was elicited from children using play strategies led by the mother. The mother was then observed as she performed several childcare tasks involving lifting that she needed to perform in that time period, or that she performed most commonly. From two to five tasks were observed for each mother. Observation was limited to 2 hours. Data regarding the contributory risk factors were recorded on the structured observational checklist developed for this study (see Appendix E). The researcher followed the protocol developed with the checklist to rate the level (low, medium or high) of risk associated with each factor observed to be present (see protocol in Appendix F). This was to ensure she was as consistent and objective as possible. The researcher also wrote down any extra information relevant to the physical aspects of childcare that the mothers volunteered. Many mothers were enthusiastic about discussing the work that they did and all consented for this information to be noted. At the end of the visit the researcher checked the data for accuracy prior to leaving and offered the mother a small koha (i.e. a gift to acknowledge her contribution to the study).

Immediately afterward the data were checked again thoroughly to ensure that information regarding the factors had been recorded clearly and that the rating scale had been used correctly. The data from the survey and observational checklist were then entered into a Microsoft Excel spreadsheet. Data collection took place over a five-month period between March and August 2007. To ensure that she continued to evaluate the risk level of factors

consistently, the researcher checked the data of later observations against that of earlier observations for consistent rating decisions.

3.2.4 Data analysis

Data analysis was performed using Microsoft Excel and Minitab 15 statistical software.

John Pemberton, a statistician at AUT, provided statistical advice concerning the choice of analyses.

3.2.4.1 Survey data

A coding method for the survey data was developed with the advice of the statistician and all survey data was coded prior to being entered into Microsoft Excel. Descriptive statistics were then able to be generated for demographic data (characteristics of mother, the family, and children weighing between 9 and 14kg); and for mothers' responses to questions about perception of occupational demand, musculoskeletal symptoms, and time use.

The purpose of the statistical analysis of the physical stress ratings that mothers gave to the 50 childcare tasks in the survey was to identify which tasks were perceived to be most physically stressful. In other words, the aim of analysis was to group the activities according to physical stress. The analytical process for this data needed to allow for two assumptions: that not all mothers would have the same threshold for physical stress (i.e. some mothers might consistently rate all activities higher/lower than other mothers); and that some activities were in fact found to be more physically stressful than others (i.e. not all activities were rated as equal). First, therefore, to take into account the overall differences in rating between individuals, a stress ratio was used instead of the raw stress scores. The stress ratio was calculated by dividing the stress rating given by a mother to a particular activity, by the mother's average stress rating for all activities reported. Then, to determine if some childcare activities were rated more physically stressful than others, a one-way ANOVA (analysis of variance) was performed using the stress ratios. The transformed data met the normality assumption required to use ANOVA.

The creators of the original survey, Sanders and Morse, analysed relationships between pertinent variables in the survey data (age of parent, BMI of parent, time-use etc.) and the presence of musculoskeletal pain. The current study data was therefore screened for such

relationships using scatter-plot graphs. This process demonstrated that factor analysis would be unsuccessful due to the small sample size. Factor analysis was therefore abandoned.

3.2.4.2 Observational checklist data

The purpose of the analysis of the observational checklist data was to ascertain in what percentage of lifts each category of risk level for a particular risk factor, was present (e.g. unstable centre of gravity of the load was present at a high level in 25.3% of all lifts observed). Therefore, observational checklist data for all lifts observed was collated. Pie graphs were generated to demonstrate the percentage of lifts in which the risk factor in question was present and at what level.

3.3 Development of research tools: Part A: Adapting the survey

3.3.1 Origin of the survey

The original survey was created by Sanders and Morse (2005) and was a combined project of the Quinnipiac University Occupational Therapy Department and the Ergotechnology Center at the University of Connecticut Health Center. Martha Sanders was contacted by email to ask permission to use the survey in the current study and permission was granted. Her email confirming permission is in Appendix G. The original survey was 8 pages long and contained 6 unnumbered sections which were headed: Background Information; Information About Your Child or Children; Information About You; Childcare Practices; Bodily Discomfort or Pain; Daily Activities in Childcare That May Cause Physical Discomfort.

3.3.2 Modification of the survey

Changes were made to the Sanders and Morse survey to adapt it to the New Zealand context (which involved substitution of familiar language for American terms); to ensure that it complied with the requirements of the ethical committee (AUTECH); to format it in such a way that would enhance usability; and to make small additions to adapt it to the participant group. The changes made to each section are briefly outlined below. The final version of the survey used in the current study is presented in Appendix H.

3.3.2.1 Background information

The AUT logo and participant number label were added according to AUTECH requirements. Acknowledgement was included of the source of the survey and the permission given by the original authors for its use. The final paragraph reminding participants to read the information sheet and sign the consent form was included to ensure that informed consent was obtained prior to mothers completing the survey.

3.3.2.2 Information about your child or children

The questions in this and all subsequent sections were numbered. The age category used by Sanders and Morse (2005) of under 3 years-old was changed to ‘weighing between 9 and 14kg’ for the current study. The category of ‘walking’ or ‘not walking’ was added as the child’s mobility has the potential to affect the manual handling situations experienced by mothers. A question asking if the children have special needs was removed as this was excluded in the screening questions for the current sample.

3.3.2.3 Information about you

Gender was removed as male participants were excluded. The measurement was added next to age (years), weight (kg) and height (cm) to ensure consistency among responses. A question was added asking the mothers with which ethnic group they most identified to enable the demographics of the sample to be compared to those of the wider population.

Occupations were categorised according to the New Zealand Standard Classification of Occupations (NZSCO) so that they could be quantified more easily in the data analysis. The NZSCO has a wide variety of users, including: the government, employers, the careers service industry, demographers, sociologists, policy analysts, market researchers and insurance providers (Statistics New Zealand, 2007c). It therefore provided a useful standard which would allow comparison with demographics from other sources, if required.

A question regarding household income was moved to this section from the Bodily Discomfort or Pain section, where it may have been misplaced due to a formatting error. The option to choose not to disclose household income was added for ethical reasons.

On advice from the statistician the time-use questions were changed from categorical answers to providing a number in hours and minutes. This was to make statistical analysis easier because the sample was small.

3.3.2.4 Childcare practices

Words written in American English in the descriptions of childcare tasks were changed to their New Zealand English equivalent in this, and subsequent sections. Examples of changes made are: crib to cot, tub to bath, stroller to pram, diapers to nappies, zippers to zips, and pails to buckets.

3.3.2.5 Bodily discomfort or pain

The instructions for noting bodily discomfort or pain on the body map were changed to simplify the process, while obtaining the same data. The anatomical labels on the picture were redone before photocopying as they were clearly legible.

3.3.2.6 Daily activities in childcare that may cause physical discomfort

For the current study, the scale (0-9) was added on each page under the stress rating label to remind mothers that they were rating from 0-9 not 1-10.

3.3.2.7 Lifting

The current study added a sixth section to obtain information about the mothers' perceptions of how safe they considered the lifting they do to be, what they perceived to be 'safe lifting', and how they learnt about 'safe lifting'. It was considered appropriate to gather this data to make the findings more useful to future research looking at interventions to reduce injury risk in this population group.

3.4 Development of research tools: Part B: Development of a structured observation checklist for observing mothers lifting their children in the home (the OMLITH)

Structured observation was chosen as the method most appropriate to provide a broad variety of data regarding factors which might give rise to musculoskeletal injury when mothers lift their children in the home. This is because there is a paucity of existing

research in the area to be studied. The method therefore needed to be broad rather than be specific in its focus. This would then reduce possibility of overlooking a key element in the injury process and provide information for future research about possible confounding factors.

Structured observation requires the use of an observation tool to assist the observation process. Without a structured tool, observations would be too subjective to provide data which could be quantitatively analysed (Denis, Lortie, & Bruxelles, 2002). One study of the reliability of workplace observations was particularly relevant to the current study, in that it involved a workplace observation and compared the reliability of observations performed by six experienced ergonomists and six untrained observers (Denis et al., 2002). Three of their findings supported the methodological approach of the current study. They found that observation could be a reliable process; that the reliability of the observations did not depend on the experience or training of the observers; and that reliability was most affected by the observer having clear criteria for how to rate variables. Although experts in the field do perform observations and analysis of occupations and tasks without a structured observation tool, this was not considered reliable enough for the current study for the following reasons. First, the researcher would need clearly defined criteria in order to perform observations reliably. Second, the data produced by free description would be qualitative rather than quantitative in nature. Third, the method would be harder to reproduce for future research. In other words a checklist would increase the standardisation of the observation process and makes the assessment more reliable.

Because observation to assess tasks involving lifting (manual handling) is usually performed in the field of ergonomics, this is the origin of much of the evidence used to guide the production of the observation tool for this study. As described in Section 1.6.1 the aim of ergonomics is to design systems or products which minimise physical effort and discomfort and maximise efficiency (Collins English Dictionary, 2005). Observation can be used in this field as a means of identifying potential causes of injury (contributory risk factors) to persons performing the tasks. The process of ergonomic assessment involves first identifying tasks which are linked to workers sustaining injuries, and then analysing those tasks to identify what might be causing the injury. A variety of methods are available

to assess which tasks might be linked to injury and to analyse them. The type of assessment is chosen to fit the outcome required and so it can be subjective – such as a survey of workers’ perceptions of which work-related factors contribute to injury – or objective – such as recording data using standardised checklists or close analysis in a lab of a particular task using computerised biomechanical models (Neumann, 2006). In this study both a subjective method (self-report survey) and objective method (structure observation using a checklist) were used.

Initially it was thought that an existing standardised observational checklist tool might be used to assess the injury risk factors present when mothers lift children in the home. Therefore the existing available tools were assessed for suitability. Internationally, occupational health and safety regulations now make it compulsory for employers to minimise health risks to workers and this applies also to manual handling tasks. As a result there is a wide range of inspection tools available to help employers assess injury risks and develop solutions. Many of these tools contain checklists to assist with the observation process. Neumann (2006) compiled a comprehensive inventory of tools for ergonomic evaluation for the Swedish National Institute for Working Life. Neumann has a PhD in ergonomics and has presented papers on ergonomics and workplace evaluation at international conferences throughout Scandinavia and in the US. He has also published papers in leading ergonomics journals. The inventory was developed through literature and web searches as well as through Neumann’s contacts in research and practitioner networks. In this inventory 19 tools are listed that can be used for workplace evaluation. The author for the current study evaluated the key tools among these for assessing tasks involving lifting. In choosing a tool on which to base the observational checklist for this study the following needed to be considered:

- The population to be observed – mothers in the socio-cultural context of New Zealand and in the working environment of the Auckland home.
- The researcher and scope of research – the observation would be performed by a Masters student who is a registered physiotherapist but not a trained ergonomist, i.e. an advanced layperson. Data needed to be able to be collected reliably, using minimal

equipment. As it is the first study to observe mothers lifting in the home, a range of factors needed to be included for observation.

- Data analysis – the data generated needed to provide an indication of the presence of risk factors for MSDs when mothers lifted children in the home. Data needed to be able to be collated and analysed quantitatively.
- The type of tasks to be analysed – the observations would be of manual handling situations involving lifting a child (a live load) during childcare tasks (tasks related to the nurturing, feeding, dressing, transporting, hygiene and growth of the child).

In summary, the tool needed to be able to be used reliably with minimal training by a physiotherapist and to provide quantitative data regarding the risk factors when children (live loads) are lifted during childcare tasks, by their mothers (female workers) in the home.

A broad literature search was conducted to locate tools currently used internationally to assess risk associated with manual handling tasks in the work environment, and to assess whether they could be used for the current study. The following well-known checklists for workplace evaluation were considered:

- MAC (The Manual Handling Assessment Chart) – developed by the Health and Safety Executive (HSE) in the UK for use by health and safety inspectors to assess manual handling situations. When evaluated for reliability and usability it was found to be easy and fast to use, with a logical structure and scoring system (Lee & Ferreira, 2003).
- Manual handling of loads assessment checklist – published by the HSE in their guidance publication on manual handling operations regulations (HSE, 2004).
- MANTRA (Manual Tasks Risk Assessment) – developed by University of Queensland to allow health and safety inspectors to assess any industry for exposure to musculoskeletal risk factors associated with manual tasks in the workplace (Burgess-Limerick, Straker, Pollock, & Egeskov, 2004).
- NIOSH (National Institute of Occupational Safety and Health) equation – developed in the US to allow the calculation of a ‘maximum’ permissible load for different lifting

circumstances (Neumann, 2006). The NIOSH equation was evaluated in-depth when it was revised (Waters, Putz-Anderson, Garg, & Fine, 1993).

- REBA (Rapid Entire Body Assessment Tool) – developed to assess working postures that involve the whole use of the body and where manual handling may occur (Coyle, 2005).
- New Zealand Manual Handling Hazard Control Record (NZMHHCR) – released with by OSH and ACC in NZ with the code of practice for manual handling and designed to assess a wide range of contributory factors associated with injury risk (OSH & ACC, 2001).

All of these tools had the same purpose but used different approaches to evaluate risk, and placed the emphasis on different risk variables. The NZMHHCR was chosen as a base for a checklist tool because it was considered the best tool to use to assess a broad range of contributory risk factors (related to load, environment, person and task), and because it was designed with the New Zealand context in mind and to be used in the field by a lay person (the original NMHHCR can be found in Appendix I. It could also be used with adaptation to assess tasks involving a live load, whereas some tools (such as the MAC) were not appropriate for live loads (HSE, 2004). However, the NZMHHCR was not designed to provide specific ratings of risk for each of the contributory factors – only to provide an indication of whether factors were present or not. The process used by the NZMHHCR involves calculating a ‘risk score’ as a screening step, to indicate whether contributory factors need to be assessed. In the contributory factors assessment, the level of risk is not rated. At the end of the contributory assessment the NZMHHCR provides a rating system (using low medium or high) for the overall task to help the assessor to interpret the significance of the contributory factors. This was a notable limitation of the tool and may have been the reason why the tool did not seem more than twice in the published literature. Rating each individual factor was considered by the current author to be a more rigorous approach for research.

Nevertheless, the two articles that did report using the tool in their research were positive about the benefits of the tool despite noting the limitations (Coyle, 2005; Lloyd & Thomas,

2004). Coyle (2005) compared the NZMHHCR with the REBA (described above) for assessment of manual handling hazards in the supermarket industry. Her critique of the NZMHHCR noted its lack of specificity and objectivity. However, she stated that the advantage of the NZMHHCR was that it assessed a wide variety of contributory factors, and therefore was useful when more comprehensive data was needed. It also provided controls for the factors identified and hence guided the user toward recommendations based on the assessment process. Support for the comprehensive nature of the NZMHCCR was also given by Lloyd and Thomas (2004). They used it successfully in a collaborative project undertaken by ACC and Montana Wines aimed at reducing serious back injuries (Lloyd & Thomas, 2004). They similarly found that the easy progression from assessment to identifying controls for hazards was an advantage. Their main reservation regarding the tool was that due to a lack of definition of the terminology it was important to train staff in the correct use of the tool. The comments of these authors indicate that developing the tool further and providing clearer descriptions of how to assess each factor would be beneficial if using the tool for quantitative research.

The process of using the NZMHHCR in the current study started by completing the first section – calculating the ‘risk score’ to determine if the occupation of mothering met the criteria for performing a contributory factors assessment. The ‘risk score’ was calculated using values that reflected an average day performing the occupation of mothering. These values were created by the author based on knowledge of the childcare occupations gained in the literature review. The ‘risk score’ was calculated using a load score for 10-14kg, a posture and workplace layout score for jobs that required end-range postures in awkward positions and restricted workspace, and a time score of 40 repetitions of lifting per shift. This provided a risk score of 44, which is interpreted as meaning “Injuries are possible for trained and fit people. Workplace redesign is recommended to control contributory factors identified” (OSH & ACC, 2001, p. 46). Hence it was concluded that it was appropriate to further assess the contributory factors associated with injury risk in mothers performing manual handling tasks.

The development process to create a structured checklist for use in the current study was then begun. The steps of development for the checklist for observing mothers lifting in their

home environment (OMLITH) are outlined below. At several stages in the process, AUT ergonomist Dr Mark Boocock was consulted for feedback on the content and rating scales, as he was experienced in workplace assessment and research in this area. Dr Boocock was consulted after the initial draft was developed, after revision of this draft and after the pilot test of the tool.

- The 58 factors in the NZMHHCR were reduced to 25 by eliminating those considered to be inappropriate or redundant and by combining those that were assessing the same biomechanical risk. The factors that could not be observed (such those in the section titled ‘Management’) were removed as they covered items that would be assessed in the survey in the current study.
- Each factor maintained its original label from the NZMHCRR so that it was possible to easily link the information back to the suggested controls in the manual for discussion or future research.
- A rating scale of low, medium or high was developed for all 25 remaining factors. Developing the rating scale involved consulting the guideline document in the NZ Manual Handling Code of Practice, but also drawing on ratings given to factors by the other tools discussed above. Using a rating system with three levels (low, medium, high) is common among workplace assessment tools but these ratings often use different criteria to nominate the risk level (HSE, 2004; Monnington, Pinder, & Quarrie, 2002; OSH & ACC, 2001; Taloni et al., 2004). Not all factors in the protocol were assigned a ‘low’ as a possible rating, because the presence of this factor was considered in itself as leading to a moderate or high level of risk.
- A protocol document for rating each factor was developed and used when performing an observation to ensure that the checklist was used reliably by the current researcher and might be used by others in the future if the tool performed well.
- A pilot observation using the checklists and protocol was performed and then further modifications made.

The full protocol for rating the factors on the checklist is given in Appendix F. The next section provides the rationale for the low, medium and high ratings.

3.5 Development of protocol for rating contributory risk factors

The protocol for rating each factor is presented a box, followed by an outline of the rationale for the ratings.

3.5.1 Load

3.5.1.1 L.1. Weight of load handled

To calculate the risk associated with the weight of the load handled, the psychophysical tables compiled by Mital (1997) will be used to determine the ‘population percentage’ for the weight handled in the circumstance being observed. The risk will then be based on the population percentage considered at risk.

Low – population percentage of 75% to 90%

Moderate – population percentage of 50% to 75%

High – population percentage of 50% or less

The term ‘population percentage’ refers to the percentage of the population who could perform the task without risking injury. For instance, if the weight of the load to be lifted is evaluated as having a population percentage of 75%, it means that 75% of the population could perform the task, with that load weight, without risk of injury. The population percentage is calculated using psychophysical tables produced by Mital et al. (1997). For the current study weight limits were calculated and collated into a table to guide the assignment of low, medium, or high risk, depending on how much the load weighed and how far it was lifted vertically (see Table 1). The rationale and means of calculating the values in the table is given below.

There are various approaches available to assess whether the weight of a load may contribute to risk of injury. The psychophysical approach is the most widely accepted approach to assessing risk associated with load weight, with prominent researchers in ergonomics contributing over several decades to the creation of a database of tables of acceptable weight limits based on variables associated with the lifting situation (Ayoub & Dempsey, 1999; Webster, Ciriello & Bangs, 1999). Mital et al., in particular, have been recognized internationally for the work they have done to enhance the validity of tables

produced by preceding ergonomics researchers by applying biomechanical and physiological design criteria to psychophysical data. Their tables, specifically pages 65-68, were used to develop the weight recommendations and ratings for the current study because they were well grounded in evidence from empirical research.

Table 1: Weight ranges (kg) used to determine low, medium, and high risk ratings for lifts, categorized by vertical lift distance (derived from Mital et al., 1997)

Risk Level	Floor to 80cm	Floor to 132cm	Floor to 183cm	From 80cm to 132cm
Low	8.6-11	7.0-9.0	6.3-7.8	9.4-11.0
Medium	11.1-13.4	9.1-11.0	7.9-9.4	11.1-13.4
High	13.5-15.7	11.1-14.9	9.5-11.8	13.4-14.9

The tables provide a recommended weight limit for a percentage of the population. For instance: 75% of the population could lift 14kg but only 50% of the population could lift 17kg safely for a particular set of lifting conditions. For the current study, the original weight limits in the table were modified following Mital et al.'s instructions using 'multipliers'. These reduce the recommended weight limit to take into account other hazardous factors. These multipliers were: an asymmetrical multiplier of 0.924 (allowing for an average of 30-60 degree turn during lift: a couplings multiplier of 0.925 (allowing for poor quality, limited or slippery hold) and a working duration multiplier of 0.920 (allowing for a work day for mothers of 12 hours). This created a total multiplier of 0.786. These multipliers were deemed to be appropriate for most tasks within the occupation of mothering based on conclusions from the literature presented in Chapter 2

3.5.1.2 L.2. *Bulky, unwieldy*

Low – one of the following factors

Moderate – two of following factors

High – three or more of following factors

- Infant is holding objects that combine with the child to create an unwieldy shape or large size
- Infant's clothing/blankets increase its bulk
- Body posture adopted by infant or necessary to perform task makes child difficult to hold (e.g. full nappy)
- Infant is greater than 75cm in length.

The size and shape of the load dictates whether it is considered bulky or unwieldy. A bulky or unwieldy load may cause the handler to adopt awkward postures of the joints or spine

(HSE, 2004; OSH & ACC, 2001). Children are living and moving loads and change their dimensions or ‘shape’ and ‘size’ frequently. Therefore their shape at the time of lifting can vary according to the situation (e.g. they might be standing, sitting up, crawling away, or bent over). In general, the assumption was made from reading the literature reviewed in Chapter 2 that the least demanding way to lift a child is under the arms when the child is facing the lifter and sitting or standing. This would mean that the heavier end of the load (the head) is vertically aligned with gravity and the shape of the load is a variation on a vertical rectangle (i.e. the centre of gravity of the load is positioned centrally, HSE, 2004). When the child presents a ‘shape’ which is more curved (e.g. curled up in a ball, or crawling) or is in a position where the head is harder to orient safely during the lift, for the purpose of this study it was considered ‘unwieldy’, as these ‘shapes’ might adversely influenced the mother’s posture. Similarly, hazards such as a full nappy were considered likely to increase risk as they dictated the ‘shape’ of the load during carrying and again made the child ‘unwieldy’ to handle. Objects or clothing were considered with regard to whether they made the child ‘bulky’ to handle. The HSE guidelines indicate that if any dimension of a load exceeds 75cm its handling poses an increase risk of injury and hence this was included as a factor. The risk was considered to be a function of the number of these adverse circumstances that were present.

3.5.1.3 L.3., L.4. & L.5 Unpredictable, unstable, uneven weight distribution or unbalanced

Low – some sudden or uncontrolled movement by infant or change in the infant’s centre of gravity (child awake and moving but co-operative, child alert but calm)

Moderate – moderate level of sudden or uncontrolled movement by infant or change in the infant’s centre of gravity, or child’s weight distribution (child awake and only partially co-operative, child leans out, or child asleep (non-rigid load))

High – high level of sudden or uncontrolled movement by infant or change in the infant’s centre of gravity (child awake and resisting, child agitated or distressed)

These factors were originally separate in the Code of Practice but were combined here as they are assessing the same biomechanical risk (OSH & ACC, 2001). They are concerned with the stability of the child’s centre of gravity while being lifted. The purpose of assessing this factor is to ascertain whether the child moves during the manual handling causing a change in the centre of gravity of the load, and therefore creates a force that

requires the mother to compensate (HSE, 2004). Compensation may result in overloading her musculoskeletal system (OSH & ACC, 2001). As a live load a child can move unpredictably and generally the mother will react to maintain the safety of the child, but as a result, might place her body at risk of injury (Griffin & Price, 2000). If the child is moving but calm, the risk is low because the mother is likely to be able to accommodate the changes in the load's centre of gravity. If the child is asleep or slumps and becomes a completely non-rigid load, this increases the force required to complete the lift and hence the risk. If the child is resisting handling, the risk is high as the mother must use extra muscle force to complete the task and also because the child's movement becomes highly unpredictable.

3.5.1.4 L.6. Hindrance to vision

Low – some hindrance of mother's vision during handling by load handled or obstacles

Moderate – moderate hindrance of mother's vision during handling

High – full blocking of mother's vision during handling

Obstruction of the mother's vision creates added risk as it adds the chance the mother will slip, trip, fall or collide with obstructions, or adopt awkward body postures in order to be able to see (HSE, 2004; OSH & ACC, 2001).

3.5.1.5 L.7. Difficult to grip, greasy, slippery

Actual grip to be considered for how it deviates from 'good' grip standard as per NIOSH coupling guidelines: wrists neutral, fingers flexed approximately 90°, thumbs in mid position (e.g. underarm grip of infant from front of handler's body)

Moderate – when the infant can not be gripped with both hands equally sure of grip, when fingers are not flexed close to 90°, or if surface factors (wet, greasy) make the grip somewhat unsure

High – if grip is outside midrange for wrist or thumb, if surface factors make the grip highly unsure (very wet, greasy), if hand can't wrap around contact area, if load can't be balanced evenly between the two points of grip, or if the grip changes during the handling

Good grip is essential to providing safe coupling between the worker and the load being handled (Mital et al., 1997). The ratings for risk associated with grip were derived from the coupling classification developed for use with the NIOSH lifting equation. This was because these provided a clear set of well-validated guidelines regarding grip (Waters et al., 1993). A rating of low risk was not included because it was considered that if the grip

deviated from the NIOSH guidelines it would create a situation of at least moderate or high risk. This is due to the significant influence that coupling has on the force required to lift (OSH & ACC, 2001). The condition of the load's surface (surface factors), or changing grip during the lift, create situations which require greater force generation and increase risk the load will be dropped. Hence they create a high level of risk (HSE, 2004).

3.5.2 Environment

3.5.2.1 E.1. *The floor is slippery, uneven or cluttered*

Low – some obstacles present but easily avoided and floor surface dry and in good condition

Moderate – obstacles present and require change in handling strategy to avoid, floor wet or worn/uneven (floor in poor condition), or mother's footing unsure, loose carpet/matting

High – combining of multiple factors or significant risk from one factor, e.g. floor very cluttered and difficult to navigate, wet and or worn/uneven and or mother's footing unsure, or avoiding a moving obstacle

The floor surface can affect risk level by making it easier for the mother to slip, trip or fall during handling and can hinder smooth movement or increase unpredictability (HSE, 2004; OSH & ACC, 2001). The ideal is a flat, well maintained surface that is obstacle-free and slip resistant (HSE, 2004; Mital et al., 1997). The ratings were derived from how far the floor surface deviated from the ideal and the likelihood that this would adversely affect handling. The focus is on the sureness of the mother's footing and how floor surface factors affect this.

3.5.2.2 E.2. *Area slopes or has steps*

Low – there is a gradual incline of surface

Moderate – moderate incline of surface, or 1-3 steps

High – steep slope, or >3 steps

As the surface deviates from flat, the risk associated with handling increases because the force required to complete the task, and the co-ordination needed to do so safely, both increase (HSE, 2004). Rating levels were based on the effects of slope angle on push force outlined in the HSE manual handling guide (p. 35), and on the principle that steps increase the likelihood of sudden and uncontrolled movements occurring (OSH & ACC, 2001).

3.5.2.3 E.3. *Hot, cold, outdoors, windy, wet*

Moderate – handling outdoors with wind, rain, cold
High – handling outdoors with extreme weather conditions

Mothers are not generally able to avoid lifting when adverse atmospheric conditions are present and hence atmospheric conditions have the potential to affect their lifting capacity (Sanders, 2004). The most extreme atmospheric conditions that might affect mothers were assumed to be those associated with handling children outdoors. Low temperatures can impair dexterity (e.g. outside in cold rain and wind) (HSE, 2004). Alternatively, high temperatures or humidity can cause rapid fatigue or perspiration on the hands which affects grip (HSE, 2004). Lifting capacity in temperatures over 27°C has been shown to reduce lifting capacity by 20% (Snook & Ciriello, cited in Mital et al., 1997). With regard to mothers, who generally place the needs of the child first, they might alter their handling to reduce the effect of weather on the child (e.g. bend over more to stop the child getting wet) or persevere despite extremes of temperature (e.g. lift a child into a car in temperatures of 27°C or more (Griffin & Price, 2000)).

3.5.2.4 E.5. *Noisy*

Low – some noise from child or background but not sufficient to distract mother

Moderate – child or background noise that is loud and distracting mother somewhat (some of mother's attention going to noise)

High – noise that is extremely loud and is distracting mother significantly (e.g. mother is trying to address it during handling)

Noise can affect manual handling by distracting the worker or reducing the ability for the worker to communicate effectively to maintain control of a handling situation (OSH & ACC, 2001). The ratings for the OMLITH checklist were created based on how far the situation varied from the ideal, with the ideal assumed to be a quiet lifting situation. Rating level was based on the level of distraction presented by the noise in the environment and by whether the mother could communicate with the child sufficiently to co-ordinate a safe lift.

3.5.2.5 E.6. *Poor lighting, glare, gloomy*

Low – lighting reduced (not bright daylight or artificial light) but still sufficient for most activities

Moderate – lights dimmed or glare present

High – darkness or facing directly into the sun or lamp

Insufficient lighting affects vision and increases the potential for injury (Mital et al., 1997; OSH & ACC, 2001). A worker may not be able to see obstacles and might slip, trip or fall, or they might adversely change their body position to be able to see what they are doing (HSE, 2004). The ratings were based on how far the situation varied from having “sufficient well-directed light to enable [the mother] to see clearly what [she was] doing and the layout of the workplace, and to make accurate judgements of distance and position” (HSE, 2004, p. 36).

3.5.2.6 E.7. *Insufficient or confined space*

Low – movement slightly restricted by furniture, obstacles or fixtures

Moderate – movement restricted by furniture, obstacles or fixtures in such a way that the mother is required to reach out or up or to twist

High – movement restricted by furniture, obstacles or fixtures in such a way that the mother is forced to reach and twist far from the body, or perform combined reach and twist

The risk associated with the space in which the manual handling task is being performed is rated by how the spatial restrictions might adversely influence the postures adopted by the mother (OSH & ACC, 2001). Narrow and confined spaces have been shown to reduce acceptable load carrying capability (Mital et al., 1997). The level of rating increases as the effect of spatial restrictions on posture becomes more marked and is based on the MAC tool (HSE, 2004). Restrictive situations include those where the mother is lifting a child to an end destination that requires a precise placement of the child: for example, putting the child in a highchair or putting the child’s legs through a harness.

3.5.2.7 E.8. Equipment

Equipment refers to objects the mother uses during the completion of the task being observed, such as: changing tables, bed, cot, highchair, bath. It includes objects designated for child care, but also items that mothers might use in the absence of these items e.g. a bed might be termed equipment when it is being used instead of a change table

Moderate – observably increases difficulty of task performance

High – equipment broken, unsafe, unfamiliar, or unsuitable to the task

The equipment category was added in place of ‘other’ in the OSH and ACC guidelines (2001). The addition of equipment was deemed necessary from the review of the literature (Chapter 2) because in several of the paid childcare studies (Grant et al., 1995; Gratz et al., 2002; King et al., 1996; Owen, 1994) and in Griffin and Price’s (2000) study of mothers, the equipment used was found to have an effect on the way that manual handling was performed. It therefore had the potential to increase risk of injury if it increased the difficulty of the task, for example, by causing mothers to move awkwardly, or increasing the potential for uncontrolled or unexpected movement.

3.5.3 Person

3.5.3.1 P.3. Insufficient strength or fitness

The mother’s physical capacity for the task will be judged by the perceived exertion she experiences during the task. The mother will be asked to rate her exertion on the Borg RPE perceived exertion scale (Borg, 1998). This will then be given a risk level as follows:

Low – Rating of 11-12 (Light to Somewhat hard)

Moderate – Rating of 13-14 (Somewhat hard to Hard)

High – Rating of >15 (Hard (heavy) to Maximal exertion)

The Code of Practice for Manual Handling stated that “some manual handling tasks may require a degree of physical fitness, skill and strength” and that “if the task demands do not match the characteristics of the people doing it, they are at risk of injury” (OSH & ACC, 2001, p. 24). The UK manual handling guidelines similarly advised that, despite a lack of empirical evidence demonstrating an association between a worker’s fitness and strength and injury risk, they should be considered in assessments (HSE, 2004). Neither of these

tools provided an easy to use and quick method to measure strength and fitness in the field, and nor do any other workplace assessment tools.

One method used by researchers to measure the fit between the worker's physical strength and co-ordination and the requirements of manual handling tasks is the Borg Rating of Perceived Exertion (RPE) (Asfour, Ayoub, Mital, & Bethea, 1983; Borg, 1998; Dehlin, & Jäderberg, 1982). Perceived exertion can be a reliable, fast and inexpensive way to assess the physical fitness demands of a task. It assesses a person's subjective estimate of the intensity of the work being performed and correlates highly with physiological criteria (Asfour et al., 1983). The RPE was found to be a feasible tool for evaluating the severity of manual handling tasks by researchers that assessed its correlation with physiological variables in 216 different variations of lifting and lowering (Asfour et al., 1983).

The validity and reliability scale is dependent on it being used according to Borg's protocol for its correct use and hence this protocol was followed for use in the current study. The original version of the Borg RPE for exercise was used. This involves a rating scale between 6 and 20. The RPE was used according to the instructions given by Borg in his publication (Borg, 1998, p. 50). However, the wording was adapted to reflect that a manual handling activity was being performed rather than 'exercise'. The scale and instructions used are given in Appendix J. The mothers were asked to read the instructions on one side of a laminated card and then to turn the card over and provide a RPE from the scale.

3.5.3.2 P.4. & P.6 Special considerations, less resilient

Included in this category are conditions such as: pregnancy, disability, size of mother, illness, minor injury.

Low – condition has some impact on the way handling is done by the mother, mother less resilient due to a minor condition (mildly unwell, minor physical impairment that does not affect back, knees or arms)

Moderate – condition has moderate impact on the way handling is done by mother, mother less resilient due to more serious condition (systemic symptoms of illness, moderately severe injury but not to back, knee or arms)

High – condition has high impact on the handling, mother less resilient due to condition that significantly changes functional capacity (very unwell, or suffering from back pain, arm pain, knee pain)

The categories of P4 and P6 from the OSH and ACC guidelines (2001) were combined as the effect of either special considerations or reduced resilience on manual handling risk was

considered to be similar. The rationale for the risk levels assigned to this risk factor is that more serious systemic illnesses, or a physical injury to the major joints that are loaded during lifting, will have a greater effect on the mother's lifting capacity. The more unwell or injured she is, the greater the risk of her sustaining further injury. The factors to be considered might be pregnancy, pre-existing musculoskeletal pain, fever caused by viral or bacterial infection, disability, de-conditioned individuals, and individuals whose size might make lifting more difficult (e.g. extremely small, or obese individuals) (HSE, 2004; OSH & ACC, 2001).

3.5.3.3 P.5. Inappropriate footwear, clothing or personal protective equipment

Low – clothing slightly restricts movement but handling technique unaffected, footwear somewhat unsafe

Moderate – clothing restricts movement to the point where handling technique changes, footwear decreases mother's ease of handling

High – clothing extremely restrictive, footwear unstable or makes handling very difficult

The risk associated with clothing is rated according to whether it restricts the mother's movement or causes her to adopt awkward postures. The footwear she wears might affect her handling technique, but might also introduce instability or risk of tripping and falling (Mital et al., 1997; OSH & ACC, 2001).

3.5.3.4 P.8. Fatigue

The mother will be asked to use a VAS (Visual Analogue Scale) developed by the author of the current study to rate her current level of fatigue, and then her fatigue level on an 'average day'.

Low – mother is more tired than usual for her but still rates herself in the bottom half of the VAS

Moderate – mother rates herself in the upper half of the VAS (higher level of tiredness) but this is similar to her average rating (i.e. usual for her)

High – mother rates herself in the upper half of the VAS and this differs to her average rating (i.e. mother is significantly more tired than usual for her)

Fatigue is a concern as a risk factor because fatigue can adversely affect safety during manual handling tasks (Lee, Hicks, & Nino-Murcia, 1990; OSH & ACC, 2001). Fatigue is very common among mothers (Brown et al., 1994; Figes, 1998; Troy, 2003). The term fatigue can be defined from a physiological perspective (end-result of excessive energy consumption, depleted hormones or diminished muscle cell contractility) or from a psychiatric perspective (subjective state of weariness) (Lee et al., 1990). It can be therefore

be difficult to objectively measure fatigue in a way that can be compared between participants (Brunier & Graydon, 1996). The intention of the current study was not to examine the association between fatigue and other variables but to use a general fatigue measurement to indicate if this was an ‘average day’ for the participant in terms of her energy levels (a reflection of combined physiological and psychiatric elements). The measure of fatigue was therefore being used to determine if fatigue could be acting as a confounding factor with regard to the results. If mothers were more tired than usual, the results could be adversely affected as mothers might be performing tasks with energy conservation as a priority over safety. Conversely, if mother was less tired, risk might be underestimated.

No easy to use, single item, standardised tool exists for measuring general fatigue in mothers. A single Visual Analogue Scale (VAS) was therefore chosen to measure fatigue as it was an easy to use and well-validated reports measure (Brunier & Graydon, 1996). (The VAS used in the current study is given in Appendix K) A VAS is often used to measure the intensity of subjective sensations such as fatigue (and most commonly, pain) (Paul-Dauphin, Guillemin, Virion, & Briançon, 1999). The simplest version of the VAS is a straight horizontal line of fixed length (for the current study, 100mm) with descriptions (anchors) of extremes of sensation at either end (Brunier & Graydon, 1996). The anchors for the current study were “No tiredness at all” at the left end and “Complete exhaustion” at the right end. The wording of the VAS, and the instructions given to the participant, has been shown to affect validity of the VAS (Paul-Dauphin et al., 1999). Therefore the VAS for the current study was tested and modified using two mothers (not participants in the final sample) to improve its validity. During this small trial mothers were asked to give feedback regarding ease of use between the VAS given in Appendix K and a five-item numerical scale taken from the ‘Lack of energy’ subscale of the Swedish Occupational Fatigue Inventory (SOFI) (Leung, Chan, & He, 2004). Both mothers decidedly preferred the single-item VAS and the wording of the VAS, and found the wording of the SOFI difficult to relate to.

The rating of fatigue therefore is intended to reflect when mothers are more tired than usual. This is based on the assumption that a short-term increase in tiredness may impact on

manual handling performance adversely as the mother has not had time to adapt her handling strategies to accommodate the change in her energy level.

3.5.4 Task

3.5.4.1 *Introduction to analysing task-related risk factors*

The tendency in the past has been for literature regarding task analysis to focus on the technique used to perform a task that involves lifting (Giat & Pike, 1992; Straker, 2003; van Dieën, Hoozemans, & Toussaint, 1999). The lifting techniques evaluated with regard to injury prevention were the squat lift (back remains as erect as possible and knees are flexed), stoop lift (the trunk is flexed forward and the knees are straight or only slightly bent) and semi-squat lift (uses a posture midway between the squat and stoop) (Straker; van Dieën et al.). The squat technique until recently was the most commonly advised technique and was the focus of the 1986 ACC injury prevention campaign that used the catch phrase “Don’t use your back like a crane” (ACC, 1998). This was based on biomechanical research from the preceding decades. More recently however, the focus of the literature has changed. It has been demonstrated that there is not sufficient evidence to support the use of one particular technique and therefore the focus is now on contributory elements (such as the horizontal load distance from the body) rather than whole body postures (Giat & Pike; Straker; van Dieën et al.). This requires each task to be considered individually. For example: in some situations it might be easier to bring the load close to the body by using a stoop method, however in other situations a squat lift might provide better leverage (e.g. when the load is low-lying) (Giat & Pike). Therefore rather than refer to lift technique, the observation checklist rates the elements within the task for their contribution to the risk associated with the manual handling task.

3.5.4.2 *T.1. Horizontal reach*

Low – upper arms angled slightly away from the body *or* trunk bent slightly forward
Moderate – upper arms straight or nearly straight *and* trunk bent significantly forward
High – upper arms angled away from the body and trunk bent significantly forward (combined)

In the OSH and ACC Manual Handling guidelines, horizontal distance and vertical distance were combined (OSH & ACC, 2001). The OMLITH checklist follows the trend of other

well-validated workplace assessments and separates the horizontal and vertical distance risk factors (HSE, 2004; Monnington et al., 2002).

Studies have shown that lifting capability decreases with increases in horizontal distances of the hands from the spine (Monnington et al., 2002). Regardless to the handling technique used, the stress on the body will increase if the load is not kept close to the body, and the load will become more difficult to control (HSE, 2004). The current study used trunk and arm position to reflect the separation distance of the hands from the body and associated risk. The body positions and associated risk level were derived from those used in the MAC (Monnington et al., 2002, p. 8), the UK manual handling guidelines (HSE, 2004, p. 22) and the German Federal Institute of Occupational Safety and Health guidelines for the assessment of manual handling tasks (BAUA, 2001).

3.5.4.3 T.1.1. Vertical lift distance

The vertical lift distance will be rated according to the number of lifting ‘zones’ that the load passes through during the lift. The zones are: from floor to knuckle height, from knuckle height to shoulder height, shoulder height and above.

Moderate – load passes through two zones

High – load passes through three zones

The vertical lift distance also affects the stress experienced by the body during the lift (Rodrick & Karwowski, 2006). The zones referred to in the OMLITH checklist rating are taken from the lifting and lowering diagram on page 55 of the UK manual handling guidelines (HSE, 2004). If the load travels through two zones it represents a notable vertical distance of travel against gravity; if it travels through three zones, the vertical distance forces the handler to undergo a substantial change in posture to achieve the lift distance. It is designed to reflect the *distance travelled* vertically, not the challenges associated with lifting up high or down low.

3.5.4.4 T.2. Reaching above shoulder or below mid thigh

Moderate – arms are partially extended over shoulder height during handling, or below mid thigh but above shins during handling

High – arms are fully extended overhead during handling, or to below the shins

This risk factor reflects the danger associated with lifting loads in postures where the body's ability to produce the necessary forces required is compromised (HSE, 2004; OSH & ACC, 2001). If these situations occur during lifting they are considered to generate enough risk to the body to be rated moderate or high and for a low rating not to be included (Mital et al., 1997).

3.5.4.5 T.3. Handling over long distances

<p>Low – 2-4m Moderate – 4-8m High – >8m</p>

Manual handling capability decreases as carry distance increases. Carrying loads over long distances creates the potential for injury as it forces muscles to contract continuously and may result in fatigue or overload of tissues (OSH & ACC, 2001; HSE, 2004). The carry distances used in the rating scale for the OMLITH checklist are adapted from the HSE MAC tool (Monnington et al., 2002). The lower limit for the risk rating was chosen because a carry distance less than 2m is considered negligible (Monnington et al., 2002). The rationale for adjusting the upper limit from 10m down to 8m was that carrying to perform childcare tasks is likely to be without resting intervals, and the mother's hands are likely to be at or above elbow height (Sanders, 2004). The UK manual handling guidelines recommend adjusting criteria in these circumstances (HSE, 2004).

3.5.4.6 T.5. Awkward, or twisted postures

<p>Low – rotates or side-bends spine <45° during handling</p> <p>Moderate – rotates or side-bends spine >45° during handling, or combines the two irrespective of the amount of rotation</p> <p>High – rotation or side-bending combined with reaching</p>

Awkward and twisted postures are associated with asymmetrical lifting or asymmetry of the load itself (Mital et al., 1997). There is consensus within the manual handling assessment literature that asymmetrical postures involving twisting or bending to the side are associated with a higher risk of injury (BAUA, 2001; HSE, 2004; Mital et al., 1997; Monnington et al., 2002; OSH & ACC, 2001). Performing childcare tasks will often involve asymmetrical lifting situations because of the characteristics of the child as a load and the type of tasks involved in childcare. If the mother twists or side-bends the trunk at

all during the lift then an increased element of risk is introduced. The threshold for a rating of ‘low’ was chosen based on the UK manual handling guidelines filter for acceptable load weights, which indicated that from 0-45° of trunk twist or side-bend only reduces lifting capability by 10% (HSE, 2004). The ‘medium’ rating reflects the increased risk caused by combining side-bending and rotation of the trunk or by performing either movement beyond 45° (Burgess-Limerick et al., 2004; Mital et al., 1997). The highest level of risk is caused by combining rotation of the trunk or side-bending with substantial forward flexion as such postures place the most stress on the joints (Burgess-Limerick et al., 2004).

3.5.4.7 T.7. Unpredictable, fast or unexpected movements

Low – a small sudden, unexpected, or uncontrolled movement by the mother

Moderate – a moderate sudden, unexpected, or uncontrolled movement

High – very sudden, unexpected or uncontrolled movement

This risk factor refers to movements of the mother as she performs the task (e.g. suddenly swerving to avoid an obstacle), not movement of the load. Fast, sudden, or uncontrolled movements can involve rapid accelerations and decelerations of the body and therefore contribute to a higher risk of musculoskeletal injury (Burgess-Limerick et al., 2004). The rating scale assigns a ‘low’ rating to small perturbations of the mother’s centre of gravity, which would be expected to have minimal impact on how she is handling the child. ‘Moderate’ is assigned to more obvious perturbations of her centre of gravity which visibly alters the performance of the task. A ‘high’ level of risk is reserved for situations which involve an obvious and substantial acceleration or deceleration of the mother’s body while she is handling the load (Burgess-Limerick et al., 2004; Lavender & Li, 1999).

3.5.4.8 T.8. Work pace

Low – small element of pressure: mother appears relaxed but is working quickly

Moderate – pace of task likely to cause mother to lift for convenience: mother appears under pressure, is very task orientated and moving quickly

High – pace of work extremely likely to cause the mother to disregard her personal safety: mother is rushing, moving urgently, safety of child is at risk

The work pace can influence how a mother might perform a task, it can also affect safety by influencing whether the mother performs fast lifts with less control, as well as influence the level of fatigue that the muscles experience (OSH & ACC, 2001). If the mother cannot change the rate of work then fatigue within some muscle groups may be more pronounced, as pauses which allow recovery do not occur (HSE, 2004). The rating scale for the OMLITH differentiates between when the mother is working quickly but is still in control of the pace, and when she is working quickly because there is external pressure to do so. The assumption is that the more the pace is externally controlled, the greater the risk of injury.

3.5.4.9 T.10. Handling in a seated position

Low – handling in a seated position with arms in ideal zone (between shoulder height and waist, elbows angled to 90°)

Moderate – handling in a seated position with the arms outside the ideal zone, any side-bending *or* twisting while handling in the seated position

High – any combination of bending, side-bending, extending and twisting while handling in a seated position

The forces that the body can safely exert when seated are less than those for standing and therefore lifting capacity is reduced and risk of injury increased (OSH & ACC, 2001). The zones used to determine the ratings for risk for seated handling are based on the zones that appear in Figure 25 of the UK manual handling guidelines (HSE, 2004, p. 58).

3.5.4.10 T.11. Squatting, kneeling or crouching

Low – symmetrical handling from a balanced low squat or crouch

Moderate – handling from a deeper squat or crouch position or with an element of asymmetry

High – handling from unbalanced deep squat/crouch, or while kneeling, asymmetrical lift causing combined trunk movements, or prolonged squat prior to lift

The considerations for risk when handling is performed in squatting, kneeling and crouching positions are the potential for the position to be unstable, the increased level of metabolic work in these postures (due to increased muscle activity), and the extreme flexion potentially experienced by the spine and lower limbs (Mital et al., 1997; OSH & ACC, 2001).

4. RESULTS

4.1 Introduction

This chapter will present the findings of the current study. In section 4.1 the results from the ‘Ergonomics of caring for children’ survey will be presented, including: the characteristics of the children weighing between 9 and 14kg (the primary load); the characteristics of their siblings; and the mothers’ demographics, time-use characteristics, musculoskeletal symptoms, and knowledge of ‘safe’ lifting practices. Then the results from the data collected using the observational checklist (OMLITH) will be presented. This will include the characteristics of the lifts observed and the occurrences and level ratings for each of the 25 risk factors on the checklist.

4.2 Results from the ‘Ergonomics of caring for children’ survey

4.2.1 Sample characteristics

The final sample included 25 healthy Auckland mothers, aged between 28 and 40 years of age with at least one healthy, normally developing child weighing between 9-14.5kg.

4.2.1.1 Characteristics of children weighing between 9-14kg (the primary load)

The loads of interest in the current study were children in the family who weighed between 9 and 14kg, referred to as the ‘primary load’ in the conceptual model (see Figure 1). Of the 25 mothers in the sample, five had two children weighing between 9 and 15kg which were included in the observation process. Therefore, in total, there were 30 children who fitted the weight criteria for inclusion. The mean age of those children was 17 months, and mean weight was 11.6kg. The mean activity level of children was 5.7 on a 100mm VAS scale. A rating of 5.7 represents a moderate activity level, with intermittent spurts of busy and quiet play. Characteristics of the children who were the primary load are summarised in Table 2 below.

Table 2: Characteristics of children who are the primary load (n=30)

Child characteristic variable	Range	Mean
Age (months)	5-36	17.2
Weight (kg)	9-14.5	11.6
As percentage of mothers	11.1-21.3	17.1
Activity level (VAS 0-10)	1-8.3	5.7

4.2.1.2 Family characteristics

In seven instances mothers were only caring for 1 child (the primary load child). In addition to the children weighing 9-14kg, 13 of the mothers had one additional child, 1 of the mothers had 2 additional children, 2 had 3 additional children and 1 had four additional children. In total there were 25 siblings with the average age of siblings being 5 years and 4 months. Siblings were fairly equally divided between male and female. Sibling characteristics are summarised in Table 3 below.

Table 3: Characteristics of siblings of children who are the primary load

Sibling characteristic variable	Value
Total number of siblings	25
Age (yrs)	
Range	0.25-14
Mean	5.36
Gender	
Female	14
Male	11

4.2.1.3 Mother characteristics

The average age of mothers in the sample was 34.6 years. The average Body Mass Index (BMI) value was 24 demonstrating that the average body weight of the sample fell within the 'normal' range (CDC, 2007). The height of the mothers was 1.69cm. The age, BMI and height characteristics of the mothers are presented in Table 4.

Table 4: Age, BMI and height of mothers

Mother characteristic variable	Range	Mean
Age (yrs)	28-40	34.6
BMI	19.2-33.6	24.2
Height (cm)	1.57-1.85	1.69

A summary of demographic variables is shown in Table 5. From this table it can be seen that 20 of the mothers were married and 5 were living with a significant other. Therefore all the mothers were in two-parent families. Within the family, the partner was rated as ‘frequently’ providing help with childcare by 13 mothers and ‘always’ providing help with childcare by 12 mothers.

The household incomes for the sample were all above the New Zealand national average income for June 2007 (NZ\$34, 684, Statistics New Zealand, 2007d), with 13 of the households earning between NZ\$40, 000 and NZ\$90,000 and 8 earning more than \$100,000. Four mothers chose not to disclose the household income. Of the 25 households, 12 had one income as the mothers were not working. Three of the households had two incomes as the mothers were working full-time and in 10 of the households the mothers worked part-time. The professional classification of the mothers who were working (n=13) was predominantly Professionals (n=6), followed by Legislators, Administrators and Managers (n=3), then Service and Sales (n=2), Technicians and Associate Professionals (n=1) and clerks (n=1). The majority of the sample made use of childcare (n=20). NZ European was the reported ethnicity for 24 mothers, with one mother reporting a mixed ethnic background of Maori and Asian.

Table 5: Marital, support, and income status of mothers

Demographic factor	Number(%)
Marital status	
Married	20 (80%)
Living with significant other	5 (20%)
Time partner helps with childcare	
Never	0
Occasionally	0
Frequently	13 (52%)
Always	12 (48%)
Income (\$NZ)	
40-59,000	3 (12%)
60-79,000	5 (20%)
80-90,000	5 (20%)
100,00 or >	8 (32%)
Not disclosed	4 (16%)
Working status	
Not working	12 (48%)
Part-time	10 (40%)
Full-time	3 (12%)
Occupations (NZSCO Classification)	(n=13)
1. Legislators, Administrators, Managers	3 (12%)
2. Professionals	6 (24%)
3. Technicians and associate professionals	1 (4%)
4. Clerks	1 (4%)
5. Service and sales workers	2 (8%)
Ethnicity	
NZ European	24 (96%)
Other	1 (4%)
Use of childcare	
Use	20 (80%)
Don't use	5 (20%)

4.2.2 Mothers' time-use

The time-use characteristics of the mothers in the sample is shown in Table 6. Mothers averaged 6.8 hours of sleep a night (n=25). Twenty-two of the mothers reported exercising regularly and the average exercise per week for these mothers was 2.9 hours (24.9 minutes per day). The majority of the mothers who exercised, performed cardiovascular exercise (n=20). Taking part in hobbies was reported by 19 mothers, with a variety of hobbies

recorded (see Table 6 below). The mean time spent on hobbies per week was 2.2 hours. All of the mothers (n=25) did housework, with the average time spent on housework per week totalling 14.9 hours. Twenty-two mothers spent some time (average 4.3 hours/week) watching the T.V. or using a computer at home and 18 mothers gardened or did home maintenance tasks (average 2.9 hours/week).

Table 6: Time-use characteristics of mothers

Activity	Number (%)of mothers who did activity	Mean (hrs)
Sleep per night	25 (100%)	6.8
Exercise	22 (88%)	2.9
Cardiovascular	20 (80%)	
Strength	3 (12%)	
Flexibility	2 (8%)	
Racquet sports	2 (8%)	
Team sports	1 (4%)	
Hobbies	19 (76%)	2.2
Arts & Crafts	6 (24%)	
Baking or Cooking	3 (12%)	
Reading or Writing	9 (36%)	
Music or Drama	2 (8%)	
Tramping	1 (4%)	
Shopping	1 (4%)	
TV or Computer	22 (88%)	4.3
Housework	25 (100%)	14.9
Garden/Home Maintenance	18 (72%)	2.9

4.2.3 Mothers' perceptions of the occupational demands of being a parent

As can be seen in Table 7, mothers' perceptions of the occupational demands of being a parent were mixed. Fifteen mothers felt that they had enough time to get done what they needed to do and 9 felt that had sufficient time for hobbies and meaningful activities. In

contrast, 10 did not agree that they had enough time to get done what they needed to do and 16 felt they did not have sufficient time for hobbies and meaningful activities. Twenty mothers (80% of sample) agreed that caring for their children requires a lot of physical effort.

Table 7: Mothers' perceptions of the occupational demands of being a parent

Job statements	Agree	Disagree
"I have enough time to get done what I need to do"	15	10
"I have sufficient time during the week to perform hobbies or other activities that are meaningful to me"	9	16
"Caring for my children requires a lot of physical effort"	20	5

4.2.4 Presence of musculoskeletal symptoms

The most common site of musculoskeletal pain in the current sample was the Low Back, with 16 mothers experiencing pain in this region, followed by 8 mothers experiencing pain in each of the Neck, Shoulder and Upper back regions. All anatomical sites were reported as a source of pain by at least one mother. Symptoms of musculoskeletal discomfort are summarised in Table 8.

Table 8: Symptoms of musculoskeletal discomfort by body location

Body Location	Neck	Shoulder	Upper Back	Elbows	Low Back	Wrist/ Hands	Hips/ Thighs	Knees	Ankles/ Feet
Number(%) of mothers with pain	8 (32%)	8 (32%)	8 (32%)	1 (4%)	16 (64%)	3 (12%)	4 (16%)	5 (20%)	1 (4%)

4.2.5 Mothers' knowledge of 'safe' lifting practice

Table 9 provides a summary of what the mothers in the sample perceived to be important when performing a 'safe' lift. These are based on the responses from question 6.2 in the survey asking them to 'Briefly describe what you consider safe lifting'. The key phrases

used by mothers were grouped according to categories that became evident once the responses were collated. Twelve mothers identified using the abdominals as important, 8 mothers identified not stooping during a lift (bending back with knees straight), 6 mothers identified maintaining symmetry and stability, 4 mothers identified that the load should be kept close to the body, 3 others identified not twisting and one mother identified lifting the head up or lifting the child without added objects.

Table 9: Characteristics perceived by mothers to be important in a 'safe' lift

'Safe' lift characteristic	Number of mothers
Use abdominals	12
Don't stoop	8
Maintain symmetry/stability	6
Keep load close to body	4
Don't twist	3
Lift with head up	1
Lift child without added objects	1

The sources from which mothers learnt about what they perceived to be 'safe' lifting are shown in Table 10. Mothers responded to question by ticking one of four choices (work-related formal training, experience through lifting at work, heard from other people, pamphlets/brochures/advertisements) or ticking 'other' and adding an explanation. Mostly mothers had gained their knowledge of 'safe' lifting from pamphlets/brochures/advertisements (n=14) but lifting at work (n=8), health professionals (n=4), from a course (n=2) and from their own experience (n=1) were also mentioned. The categories of health professionals, from a course and from their own experience were added by mothers under 'other'.

Table 10: Sources of mothers' knowledge regarding 'safe' lifting

Source	Number of mothers
Advertisements	14
Work	8
Health Professional	4
Course	2
Own experience	1

4.2.6 Physical stress ratings of activities

The following results were obtained from the ANOVA performed using the stress ratios derived from the physical stress ratings given to the childcare activities (for complete method of analysis refer back to section 3.2.4.1). The results show that mothers in this sample did differentiate to a statistically significant degree ($p=0.000$) between activities when rating physical stress associated with the activity. The low p value demonstrates that there was a large actual variation in the average stress ratios across the tasks despite the small sample, which gives support to the fact that some tasks were rated significantly more stressful than others by the mothers in the sample.

Mothers consistently gave 'Bending while carrying a child' a significantly higher physical stress rating than their average rating. Typically it was rated almost twice as stressful as the average rating. A number of categories were also rated significantly above the average stress rating, including: 'Use of a backpack to carry infant/child', 'Use of a baby jogger', 'Carrying a child on your shoulders', 'Standing bent over to wash child in bath or sink', 'Lifting child into or out of cot', 'Prolonged squatting or stooping while playing with a child', and 'Placing a child in car seat or removing child from car seat'.

Conversely, posing little problem to mothers were the following: 'Opening and removing nappies from packaging', 'Opening baby food jars', 'Dressing or undressing a child or fastening clothes', 'Buckling child into car seat', 'Turning neck while driving to view child', 'Drying a child', 'Bending to pick up toys', and 'Sitting playing on floor'.

4.3 Results from the observations: Incidence of risk factors when mothers perform childcare tasks

4.3.1 Lifts observed

A total of 87 childcare tasks which involved lifting were observed. Each of the 25 mothers was observed performing between two and five childcare tasks (mean of 3.48 tasks). The tasks observed differed for each mother and were classified into 16 groups as follows: lifting child in or out of cot (n=18), lifting child into or out of car-seat (n=12), changing a nappy on the floor (n=12), holding a child on the hip and bending (n=7), lifting child in or out of bath (n=7), lifting child in or out of highchair (n=6), changing a nappy on a change table (n=5), dressing child (n=4), lifting child onto knee while seated (n=4), lifting child in or out of play equipment (n=3), lifting child on or off furniture (n=2), breast or bottle feeding child (n=2), lifting child into stroller (n=2), lifting child into bed (n=1), lifting child upstairs to put in time out (n=1), physical play (n=1).

Just under half of the lifts observed (48.3%) fell into one of the first three categories (lifting a child in or out of a cot, lifting a child into or out of a car-seat and changing a nappy on the floor). The other half of the tasks predominantly involved lifting a child into or out of a piece of equipment (e.g. bath, highchair, stroller, toy) or onto or off a surface (changing table, knee, couch, coffee table, hip).

The data obtained from the OMLITH checklists are depicted in the pie graphs below (Figure 2, Figure 3, Figure 4, Figure 5). The pie graphs are accompanied by interpretation which refers back to the risk rating protocol developed for the OMLITH. White areas in the pie graphs represent lifts in which the risk factor was not present.

4.3.2 Risk factors related to the load

The highest levels of risk were presented in the areas of load weight, load stability, and load grip (see Figure 2).

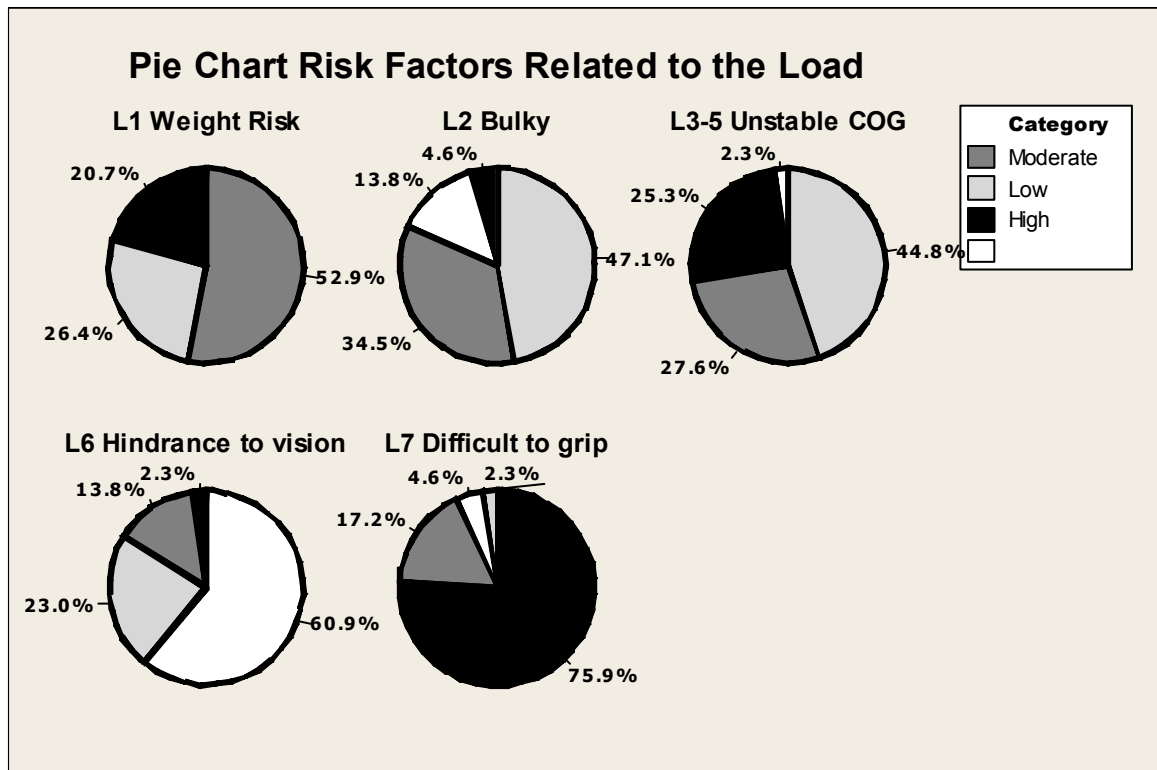


Figure 2: Pie chart of contributory risk factors related to the load

4.3.2.1 Weight of load

The weight of the child presented a moderate level of risk in 52.9% of the 87 task situations observed. In this study, a moderate level of risk signifies that 25-50% of the female population would be at risk of injury while performing the task (see rating protocol for the OMLITH in Appendix F). The weight of the child presented a high risk in 20.7% of tasks, signifying that 50% or more of the female population would be at risk of injury when completing this task.

4.3.2.2 Load stability

The centre of gravity of the child (COG) was evaluated as being present as a risk in 97.7% of tasks. In other words the load was assessed as being unpredictable, unstable, having uneven weight distribution or being unbalanced in these situations. In 44.8% of tasks the rating was 'low' risk, which represents some sudden or uncontrolled movement by the infant or change in the infant's COG. For example, a child that is awake and moving but co-operative or calm. In 27.6% of tasks the rating was 'moderate' risk, signifying a

moderate level of sudden or uncontrolled movement by infant or change in infant's COG. For example, if the child were awake but not fully co-operating, or if the child was asleep and hence was a non-rigid load (in which case the COG is less easy for the mother to instinctively accommodate). In 25.3% of tasks the child had a high level of sudden or uncontrolled movement or a notable change in COG and hence a 'high' risk level was assigned. For example, the child may have been awake and excited or agitated or resisting movement.

4.3.2.3 Grip

The grip required to lift the child in 75.9% of tasks was rated as 'high' risk. This signified that one of the following was present: the grip was outside mid-range for the wrist or thumb; the grip was very unsure due to surface factors (e.g. wet child); the hand couldn't wrap around the contact area; the child's weight couldn't be balanced between points of grip; or the grip changed during handling. In 17.2% of tasks the risk assigned was moderate.

4.3.2.4 Shape and size of load

In 81.6% of tasks the child was assessed to be a bulky or unwieldy load because one ('low') or two ('moderate') of the following factors were present: the infant was holding extra objects at the time of lifting; was lifted while in bulky clothing or blankets; had to be carried in body posture that was difficult to hold (e.g. horizontal); or was greater than 75cm in height (see Figure 2).

4.3.2.5 Obstruction of vision

The child presented an obstacle to the mother's vision in only 39.1% of tasks and mostly commonly a 'low' rating was assigned (23%) (see Figure 2).

4.3.3 Risk factors related to the environment

The factors in the environment which presented the most risk were those associated with the surface the task was performed on, noise in the surrounding environment, the space available in which to perform the task, and the equipment involved (see Figure 3).

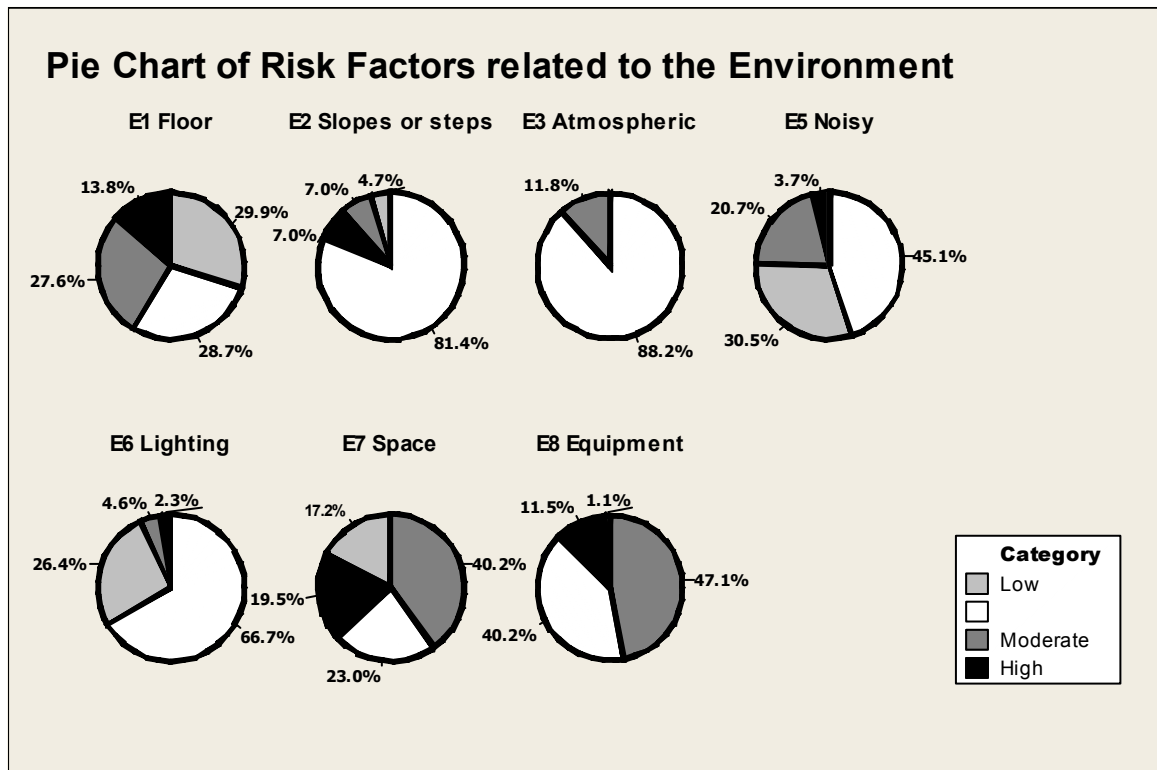


Figure 3: Pie chart of contributory factors related to the environment

4.3.3.1 Floor surface

The floor surface was rated a 'high' risk in 13.8% of tasks as a combination of risk factors were present, such as obstacles on the floor (e.g. clutter), and an unsafe surface (e.g. slippery, uneven), or because the mother's footing was unsure or there were moving obstacles in the space (e.g. another child or an animal). In 27.6% of tasks the risk level was rated as 'moderate', signifying only one of these factors was present. In 29.9% of tasks the risk level was rated as 'low', which indicated that there were obstacles on the floor (e.g. toys) but that the surface was otherwise safe.

Slopes or steps were present in only 18.7% of the tasks observed but when present more often introduced a 'high' or 'moderate' level of risk

4.3.3.2 Noise

Noise was rated as a risk factor for 54.9% of the tasks observed. It was most commonly rated at 'low' (30.5%) and 'moderate' (20.75) levels of risk. This indicated some noise in

the environment but it was not a notable distraction to the mother, or it was only taking some of her attention of the performance of the task (e.g. another child yelling or dropping something). In 3.7% of tasks the noise risk was rated as 'high' as the mother was notably distracted by it.

4.3.3.3 *Space*

Insufficient or confined space was identified in 77% of tasks. A 'high' risk rating was given to 19.5% of tasks because the mother's movement was restricted by furniture, obstacles or fixtures in such a way that it forced her to reach and twist far from the body or to flex and twist in combination. In 40% of tasks a 'moderate' level was assigned as the mother's movement as restricted due to space but to a lesser degree. A rating of at least 'low' was given if slight restriction of the mother's movement was evident, which occurred in 17.2% of tasks.

4.3.3.4 *Equipment*

In 47.1% of tasks the equipment involved in the task (e.g. child's cot, car-seat, highchair, changing table) was rated as increasing risk to a 'moderate' level because it observably increased the difficulty of task performance (for example, car-seats that were rear-facing that had straps between the mother and the child, highchairs where the food tray couldn't be pulled out which made it difficult to get the child's legs down past the seat). In 11.5% of tasks the equipment introduced a 'high' risk level as it was broken, unsafe, unfamiliar, or unsuitable to the task (e.g. a cot with a side that was stuck and couldn't be lowered).

4.3.3.5 *Lifting outside*

Mothers lifted outside in 11.8% of the tasks in windy, rainy or cold conditions (see Figure 3). When lighting was reduced (33.3% of tasks) it most often only presented a 'low' risk (26.4%).

4.3.4 Risk factors related to the individual

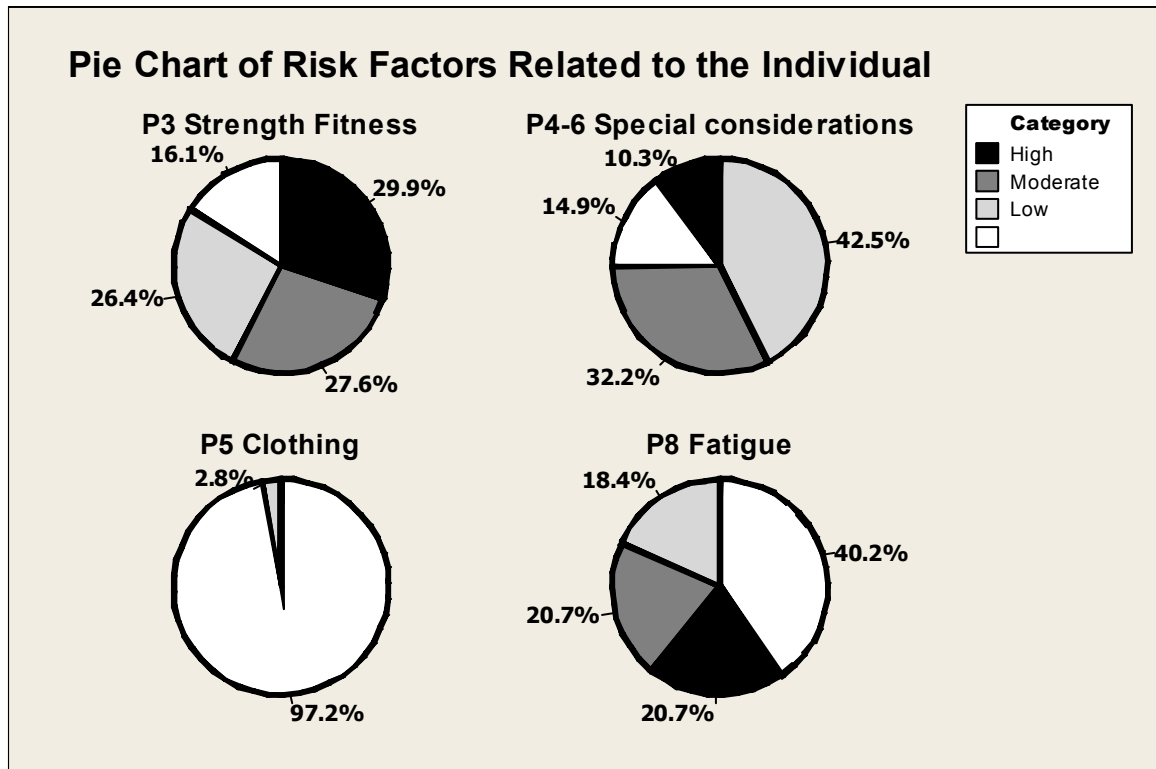


Figure 4: Pie chart of risk factors related to the individual

4.3.4.1 *Strength and fitness*

The strength and fitness of the individual was measured by asking the mothers to give an RPE value (rating of perceived exertion) for each of the 87 tasks observed (Borg, 1990). The RPE value determined the risk rating assigned for the task. For 29.9% of tasks, a risk rating of 'high' was assigned, indicating that the mother had given the task an RPE of 15 or greater (see Figure 4). At this level of RPE the mother's heart rate could be expected to be approximately 75% of her maximum resting heart rate (MRH) if she were aged 30yrs, and therefore signifies a high physiological work load for mothers aged 30yrs and older (Borg, 1990). For 20.7% of the tasks the mother gave a RPE of 13-14 which meant a rating of 'moderate' risk was assigned and therefore indicates that a 30yr old mother was likely to be working at 65-70% of her MRH. For 18.4% of tasks a RPE of 11-12 was given and therefore a 'low' risk rating assigned, indicating that the mother was likely to be working at approximately 60% her MHR, representing a moderate physiological workload. If a risk

rating was not assigned it was because the RPE was less than 11 and therefore the increase in heart rate from resting was likely to be negligible.

4.3.4.2 Special considerations

Special considerations related to the individual were identified in 85% of the observed tasks (see Figure 4). In 42.5% of tasks a ‘low’ risk rating was assigned as the mother was considered less resilient due to a minor condition such as being mildly unwell, or having a minor physical impairment that did not affect the back, knees or arms significantly. In 32.2% of tasks the risk rating was ‘moderate’ because the mother had a condition that was visibly affecting the way that the handling was done (e.g. abdomen shape and movement limitations associated with third trimester pregnancy, systemic symptoms of illness (e.g. malaise associated with cold virus, moderate injury, or if the back knee or arms were injured). The risk rating of ‘high’ was assigned to 10.3% of tasks as the mother had a condition that was considered to be having a notable impact on the performance of lifting (e.g. severe morning sickness, or suffering from levels of pain in the back, arms, or knees that was causing her to alter her movement).

4.3.4.3 Fatigue

Fatigue was identified as presenting a ‘high’ risk in 20.7 % of the tasks observed (see Figure 4). This signified that the mother rated herself in the upper half of the VAS (see Appendix K) (meaning that she was experiencing some fatigue) and that she also rated herself more tired than usual. In 20.7% of tasks the rating was ‘moderate’ which indicated that the mother was experiencing some fatigue but that it was at a level that she was used to. A ‘low’ rating was assigned to 18.4% of tasks which meant that the mother was more tired than useful for her, but still rating her fatigue in the bottom half of the VAS.

4.3.4.4 Clothing

Clothing was not considered to present a risk in 97.2% of tasks, indicating that during the majority of tasks the mothers’ clothing was appropriate and did not restrict her movement or affect her handling in any way (see Figure 4).

4.3.5 Risk factors related to the task

The task-related risk factors that were most often present were the horizontal reach associated with tasks, the vertical lift factors, twisting, and work pace (see Figure 5).

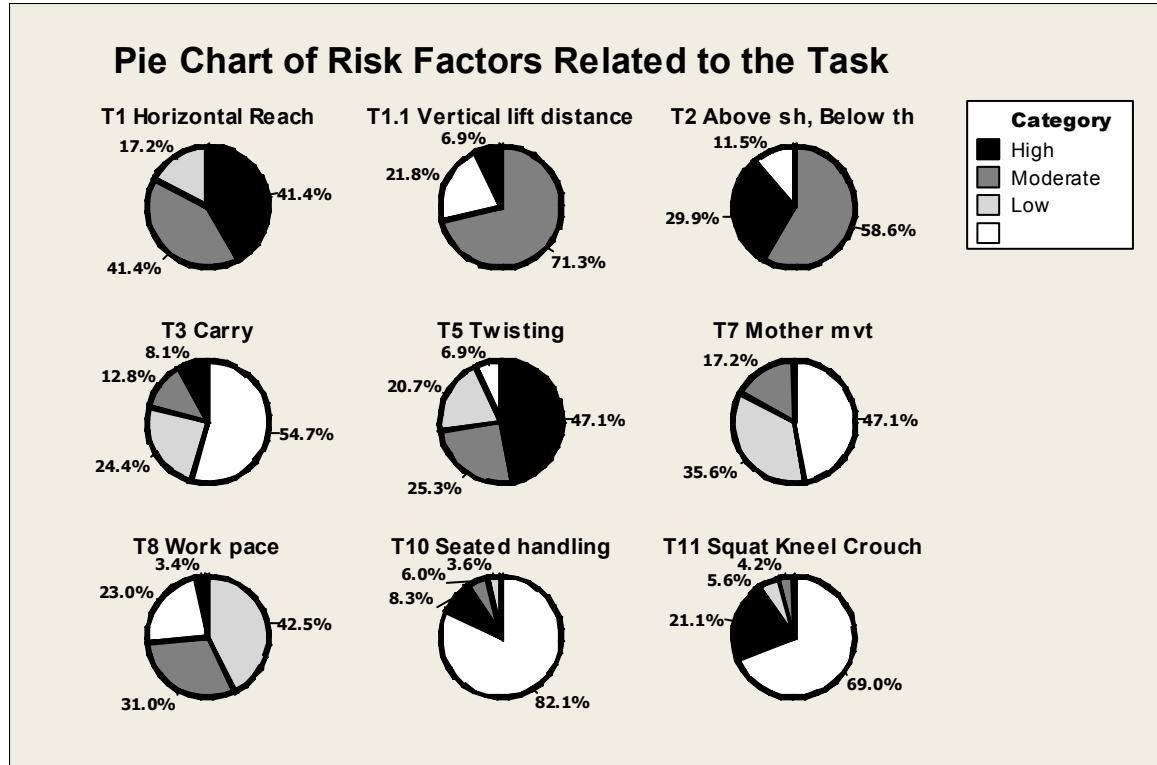


Figure 5: Pie chart of risk factors related to the task

4.3.5.1 Horizontal reach distance

Horizontal reach distance was rated as ‘high’ risk in 41.4% of tasks indicating that the mother had her arms outstretched and was simultaneously bending forward at the trunk (i.e. combined reach and trunk flexion). In 41.4% of tasks the mother *either* had her arms fully outstretched (reaching) *or* she had her trunk bent forward and therefore a rating of ‘moderate’ was assigned. In 17.2% of tasks the mother’s arm or trunk posture deviated from neutral and but only slightly and hence was given a ‘low’ risk rating.

4.3.5.2 Vertical lift factors

The vertical lift factors were the vertical lift distance, and reaching above the shoulder or below mid thigh. The vertical lift distance was rated according to the number of lifting ‘zones’ that the load passed through during the lift, with the ‘zones’ being from the floor to

knuckle height, knuckle height to shoulder height and shoulder height and above. In 71.3% of lifts the load passed through two zones, indicated by a 'moderate' risk rating, and in 6.9% of tasks the load passed through three zones, indicated by a 'high' risk rating. At some point during 29.9% of lifts the mother either had her arms fully extended overhead, or had to reach below her shins, and a 'high' risk rating was assigned. In 58.6% of lifts the risk rating assigned was 'moderate' as her arms were only partially extended overhead or she reached to below mid thigh but above her shins.

4.3.5.3 Twisting

Awkward postures due to rotating or side-bending the trunk were observed in 93.1% of tasks. A rating of 'high' was assigned to 47.1% of tasks when the mother rotated or side-bent the trunk in combination with reaching. A 'moderate' rating was assigned to 25.3% of tasks because the mother rotated or side-bent the trunk to an angle of greater than 45° or combined rotation with side-bending. In 20.7% of tasks a 'low' rating was assigned because the mother was either side-bending *or* rotating and only to an angle of less than 45°.

4.3.5.4 Work pace

Risk associated with the pace of work was observed in 77% of tasks, although it was most commonly rated as 'low' (42.5%) or moderate (31%). A 'low' rating was assigned when the mother was working quickly but appeared relaxed, a 'moderate' rating was assigned when the mother appeared to be under pressure to complete the task (the mother was very task orientated and moving quickly). In a small number of tasks (3.4%) the mother was observed to be rushing or moving with urgency and therefore a 'high' risk rating was assigned.

4.3.5.5 Squatting, kneeling or handling while seated

Mothers were observed to be lifting the child from a squatting or kneeling position in 31% of tasks. When this risk factor was present it most commonly received a risk rating of 'high' (21.1%) as the mother was lifting from an unbalanced deep squat or while kneeling, or was performing an asymmetrical lift in either of these positions.

Lifting a child while seated was only observed in 17.9% of lifts but when it was observed it was rated as 'high' risk in almost half the cases (8.3%). A 'high' risk rating indicated that during the tasks, the mother not only lifted the child while seated but performed combined bending, extending or twisting movements of her trunk. A 'moderate' risk rating was assigned to 6% of seated handling tasks because the mother's arms moved away from her body or she performed some degree of trunk rotation during the lift.

4.3.5.6 Carrying

The child was carried during the performance of 45.3% of tasks. Carrying the child further than 8m was observed in 8.1% of tasks, while carrying the child between 2 and 8m was observed in 37.2% of tasks (see Figure 5). In other words, carrying children was not a component of most observed tasks, and the carry distances introduced a 'low' level of risk in the majority of instances observed.

4.3.5.7 Mother's movement

Mothers were observed moving in an unpredictable, fast, or unexpected way in 52.9% of tasks (see Figure 5). Most commonly a 'low' risk rating was assigned (35.6%) signifying that only a small amount of unexpected or uncontrolled movement by the mother had occurred.

5. DISCUSSION

5.1 *Introduction*

The current study is an investigation of the physical demands of performing childcare occupations in a sample of healthy mothers aged between 28 and 40 years, who have normally developing children, and reside in Auckland. In particular, the aim of this study is to identify the risk factors for MSDs that are present when mothers lift children in their own home while performing childcare tasks. It is the first study of its kind in that it gathered data using both a self-report method (survey) and observations in the home. Of the existing two pieces of research pertaining specifically to the physical demands of the occupation of mothering, one used semi-structured interviews (Griffin & Price, 2000) and the other used a survey alone (Sanders & Morse, 2005). By using both survey data and observational data the current study is able to provide information regarding a wider range of potential risk factors for MSDs in mothers related to caring for their children. The survey allowed information regarding demographic and psychosocial characteristics and mothers' perception of physically stressful tasks to be obtained. This was complemented by data from structured observations of the mothers performing childcare tasks, which allows risk factors associated with the load, environment, the mother (person) and the task to be identified in detail.

The approach of using combined methods (survey or interview and observation) has been used by ergonomists to study the physical demands experienced by paid childcare workers (Grant et al., 1995; King et al., 1996; Owen, 1994). Although the current study followed the direction taken by the paid childcare research, it does nevertheless differ from the existing research. This is because the current study involved a structured observation process in using a specifically developed checklist (the OMLITH) as opposed to performing unstructured observation. This approach allowed the presence of risks to be quantified and presented graphically.

5.1.1 Summary of survey results

The results of the survey in the current study demonstrate that mothers in the sample do perceive some of the childcare tasks they do, to be physically stressful. They also demonstrate that the mothers are able to differentiate to a statistically significant degree, the level of physical stress associated with tasks. This allowed groups of tasks to be grouped according to level of physical stress. Mothers' ability to differentiate adds credibility to the fact that some tasks might be inherently more physically demanding. In particular mothers consistently identified 'bending while carrying a child' as the most physically stressful activity. However, activities such as 'using a backpack to carry a child', 'using a baby jogger', 'carrying a child on your shoulders', 'standing bent over to wash a child in a bath or sink', 'lifting a child into or out of a cot', 'prolonged squatting or stooping while playing with a child', and 'placing a child in a car seat or removing them from a car seat' were also above average in terms of physical stress.

5.1.2 Performance of the 'Ergonomics of Caring for Children' survey

The 'Ergonomics of Caring for Children' survey proved a valuable tool for collecting demographic data, time-use data and ratings of perceived physical stress. However, it did have limitations. One limitation was that although it collected information regarding the MSDs experienced by mothers, it did not include a time frame for these, or ask about the mothers' musculoskeletal history prior to having children. It would have been useful to include questions about pre-existing musculoskeletal injuries or symptoms and also about co-existing health conditions such as illness or pregnancy that might have affected the mothers' resilience to MSDs. The addition of the questions regarding 'safe' lifting provided a helpful indication of mothers' understanding of current injury prevention advice.

The most notable limit of using the survey was that it did not provide adequate psychosocial information to allow other risk factors (that were reported or observed) to be fully interpreted or explained. Therefore, although it might be time consuming, a future study could include a semi-structured interview to provide additional insights into how psychosocial factors influence the physical demands of caring for children. A combination of a survey, semi-structured interview and observations would provide a fuller picture of how the contributory factors interweave and might also illustrate how the 'enfolded' nature

of childcare tasks effects the physical strain on the mothers and the incidence of MSDs. For example, the semi-structured interview could ask mothers to explain what it was about a task that made them give it a high risk rating in the survey. In the current study, some of the activities were rated consistently less stressful than others and this may signify that these activities could be eliminated from future studies to shorten the survey and allow more time for in depth exploration of the activities that present a higher risk.

5.1.3 Summary of OMLITH results

Eighty-seven observational checklists (OMLITH) were completed from 50 observation hours of mothers performing childcare tasks involving lifting. The researcher observed a range of activities, however, ‘lifting a child into or out of a cot’ (n=18), ‘lifting a child into or out of a car seat’ (n=12) and ‘changing a nappy on the floor or on a change table’ (n=23), made up 60% of the lifts observed, and therefore made a notable contribution to the data. The data obtained from the observations shows that in the current sample, risk factors related to the load, environment, person and the task, which might give rise to MSDs, were present during all 87 observed tasks. Risk factors were frequently present at levels that were rated as presenting a medium to high level of risk. The level of risk was assigned according to a protocol developed for the checklist tool that drew on current literature regarding acceptable levels of risk for each variable.

5.1.4 Performance of the OMLITH tool

The OMLITH performed well in providing a broad overview of the risk factors that are present when mothers lift children in the home environment. The strength of the tool was that it was able to provide information about four categories of risk factors in relation to the childcare activity observed: the load, the environment, the mother, and the task. It was easy to use in that the researcher had no difficulty assigning a rating of each factor due to the rating protocol. However, even for the tool developer, the protocol proved to be a necessary ‘aide memoir’. The researcher always referred to the protocol to make rating decisions, and it is suggested that making an observation of multiple factors would be difficult without a structured tool and rating protocol. This is because there are many factors present simultaneously and so it is easy to overlook some while focussing on others. The

alternative to a structured checklist would have been to have videoed the task, which would then have allowed repeated viewing. However, this is difficult to do with one researcher; involves more expensive equipment; involves time-consuming analysis of the footage; and the camera could be invasive or distracting in the home environment. Therefore, the OMLITH checklist was considered a good alternative, and its performance in this study warrants its use in similar studies in the future and its further development. It is envisaged that with a larger sample the factor analysis that was not possible in the current study (see section 3.2.4) would be possible and associations between different variables could be identified.

The checklist was ambitious, however, in that it rated 25 factors and this made it complicated to use. The high number of factors meant that the researcher could not easily memorise the written protocol and had to repeatedly refer back to it. It also made data entry and analysis time-consuming. The results of the current study suggest that the following factors might be removed from the checklist or combined with other factors to simplify the process: ‘hindrance to mother’s vision’, ‘lighting’, ‘atmospheric conditions’, ‘clothing’, ‘carrying’ and ‘vertical lift distance’. A possible explanation for why the first four of these factors did not appear to be an issue is that the presence of those risk factors also presents a risk to the child’s safety or comfort and hence mothers tended to avoid these occurring. For example: mothers probably make sure that they can see (vision not obstructed, lighting adequate) so that they do not fall and hurt their child or bang the child against anything, they tend to maintain the home atmosphere to be comfortable for the child, and they wear appropriate clothing at home so that they can move comfortably and safely with the child (e.g. not wearing high heels as they are unstable). The ‘carrying’ factor could be removed because when carrying was observed, the risk associated with the carrying was no higher than that already present in the lift required to start the carry. Finally, the ‘vertical lift distance could be removed’ as the key elements of risk associated with vertical lift are extremes of movement, and these are covered by the ‘above shoulder, below thigh factor’. Use of the tool in future studies with larger samples would assist in determining whether there is value in retaining these factors.

Another limitation of the OMLITH tool was that the assessment protocol used for the risk rating had not been tested or standardised. The researcher would recommend implementing the changes suggested throughout the discussion that follows, prior to further testing or use of the tool. One way of testing the OMLITH would be to compare it to other contemporary methods used to assess risk associated with manual handling in the workplace. Some of these methods were identified in the methodology chapter. Further testing of the measurement tools used to assess physical fitness/capacity and fatigue is also needed to determine if they are valid or reliable. For example, the RPE tool could be compared with heart rate measurements and the fatigue scale could be compared with existing fatigue measurements.

A final suggestion for researchers interested in using the OMLITH is to consider observing each mother perform the same selection of childcare activities (e.g. each mother is observed changing a nappy, lifting a child in and out of a cot, and lifting a child in and out of a car-seat). This would allow statistical analysis to be performed using groups of activities and allow the combination of risk factors associated with one group to be compared to another. The benefit in the current study of not limiting the activities in this way was that a wider selection of tasks was observed. In future, researchers may want to focus on the activities that were identified from the survey results as having a higher risk level.

5.2 Risk factors that might give rise to MSDs when mothers lift children in the home environment

Having summarised the results of the current study, and outlined the strengths and weaknesses of the tools used to collect data, the following sections discuss the key findings presented in Chapter 4, in more detail. The discussion is organized around the four categories of contributory risk factors associated with manual handling tasks which were included in the observations checklist (OMLITH). The categories are: the load, the physical environment, the mother, and the task. In addition, organisational factors are discussed. The discussion draws together the data obtained from both the surveys and the observations to identify the contribution that variables in each of the categories might make to mothers

acquiring childcare-related MSDs. Variables that might be regarded as key contributory risk factors, and also those that might act as potential confounders of results are both included. Information offered by mothers during the observation process regarding their childcare experiences, noted at the time (with the mother's permission), is used to provide examples. This information is identified by quotation marks, to show that it is derived from mothers' comments. The additional qualitative information is used to enhance the interpretation of the observations, but should not be considered as evidence in itself, as it was gathered through informal discussion and not a standardised interview technique. Therefore the information may be biased. The performance of the tools used to collect data has been summarised above, but further critique of the measurement of specific variables will also be incorporated into the discussion.

The reader is reminded that the intention of the current study was to highlight the presence of potential risk factors that warrant further investigation. It was not within the scope of the current study to make causal inferences regarding relationships between particular contributory factors or between these and the presence of MSDs in the current sample. This is due to the fact that the data was descriptive in nature and due to the small sample size. Rather, the current study aimed to contribute to knowledge in this area by providing information that would allow future researchers to construct more useful hypotheses on which to base research into causal relationships between variables, or on which to base intervention studies.

5.3 Load

The most notable feature of lifting a child is that the mother is lifting a living being, and therefore the load-related risks associated with the lifting are different to those associated with an inanimate object. Children must be considered as having unique load-related properties that affect the way that they can be lifted or handled during childcare tasks. The current study demonstrates that there are additional risk factors associated with lifting children. The presence of 'high' risk ratings for many of the load-related risk factors in the current study provides evidence to support the hypothesis that when mothers lift children they prioritise the safety and comfort of the child, as suggested by Griffin and Price (2000). This can be inferred from the fact that despite the presence of factors which added risk (e.g.

heavy child, bulky clothing, moving distressed child, difficulty with gripping) the mothers performed the childcare tasks that were needed to protect, feed, clean, transport, teach, nurture or stimulate their child, disregarding the risk to their own body. They were not observed to and did not report, limiting the performance of childcare tasks to reduce the associated risk. However, neither of these tools were able to measure how mothers balanced the need to perform a task and the physical strain on themselves – or how much they took into consideration their own needs versus the needs of the child. In the current study information regarding whether they do this came up in conversation with the mothers. One mother in the current study commented that she “carried her two children at once across a car-park to make sure they were safe from cars” which is an example of the mother prioritising the safety of the children. In future research it would be valuable to ask mothers about the ways that lifting a child is different to other objects using similar methods to Griffin and Price (2000) (semi-structured interviews). This would provide better information about the extent to which the fact that the mother is lifting a child influences her willingness to accept risks. Knowing what motivates mothers to accept such risks might assist in the development of effective intervention strategies. The following sections will discuss the results of the current study regarding other attributes of the child as a load.

5.3.1 Weight and age

The results of the current study show that in the 87 tasks observed, the weight-related risk associated with lifting the children was notable. The weight of the children in the current study ranged from 9 to 14.5 kg, with a mean weight of 11.86kg. At this weight, the associated risk was calculated to most often be moderate to high. The results therefore demonstrate that the weight range chosen for the current study was an appropriate choice and are consistent with other studies that have suggested that children in this weight range should be considered a ‘heavy’ load from an ergonomics perspective (Owen, 1994; Sanders & Morse, 2005). Despite this, mothers may not be aware of the risk. Griffin and Price reported that mothers in their study did not class their children as ‘heavy’ and that this then influenced their choice of lifting technique. As one mother said “she’s not very heavy, she’s only about 12 or 13 kilos if she was a big box or something you’d bend your knees” (p. 13).

The risk associated with the child's weight can not be reduced as the child's weight is an independent variable. Therefore, the presence of high risk ratings associated with the weight of the children, in itself, provides evidence that further research is necessary to establish what steps can be taken to minimise likelihood that mothers will develop MSDs associated with lifting children in this weight range.

Weight is associated with the age of the child. Male children are expected to reach 9kg of weight at approximately 9 months of age and to reach 14.5kg at approximately 3yrs (figures based on US CDC growth charts, cited by the APEG, 2008). These figures are for the 50th percentile of children. Female children are expected to reach these weights slightly later (9kg at 10months, 14.5 kg at >3yrs). Therefore children could weigh between 9-14.5 kg for 27 months (2.25 years), and mothers caring for children are exposed to hazards associated with handling this weight of load for a considerable period of time. Manual handling associated with caring for children older than 3yrs of age has been shown to have less association with MSDs (Grant et al., 1995; Sanders & Morse, 2005), be less frequent (Griffin & Price, 2000; Owen, 1994), and is associated with less time spent in awkward postures (Grant et al., 1995; King et al., 1996; Kumagai et al., 1995; Simakoa et al., 1998). In the current study, the age of the children ranged from 5months to 3 years, and hence in all the tasks observed the children were in an age category that has been associated with higher risks. This may explain the higher rates of MSDs reported by mothers in the current study when compared to Sanders and Morse (2005), as Sanders and Morse included parents of children up to 4yrs of age, and reported that the parents of the older children experienced less MSDs.

5.3.2 Child development

As a child grows and develops his or her mobility and behaviour change. The youngest child in the current study was 5 months old and weighed 11.6kg. At 5 months old he was able to sit and hold the weight of his own head, but not mobilise (crawling). He was still being fed a bottle, but was also receiving some solids. He needed his nappy changed 5-7 times a day. His car-seat was still a baby capsule, and transporting him involved carrying him in the capsule out to the car. For stimulation he enjoyed being placed in toys that would allow him to practice pushing through his legs (jolly jumper) and like to be moved

from room to room in his bouncer seat so that he could see what his mother was doing. Therefore, if the physical demands associated with carrying for this child are considered, it can be seen that he needed to be lifted any time he needed to be moved as he was not mobile, his ability to sit allowed him to be picked up under his arms from the sitting position but he was not able to assist with the lift by holding his mother and gripping her with his legs, he needed to be lifted and carried to the change table and back for changing of his nappy 5-7 times a day, the need for a capsular car-seat meant that his 11.6kg weight was carried in conjunction with the weight of the car-seat, his need for active play meant that he needed to be placed in and out of equipment that would encourage his movement as he was not yet old enough to get in and out by himself, and to allow him to interact with and be stimulated by his mother, he was moved from room to room in his bouncer seat as he could not yet crawl. This analysis shows how the developmental stage of the 5 month old affected the lifting and manual handling of the child done by his mother. This example can be compared with the needs of the oldest child in the study who was 3yrs old and weighed 13.5kg. This child was independently mobile on two legs and could move himself around the house to access most activities. He was able to use the toilet by himself and climb into his car-seat by himself. Although he was sometimes in a stroller when he and his mother went out, he could climb into it by himself. He needed help climbing into the bath and sometimes had to be lifted into his bed when asleep. However overall, he was lifted much less frequently and when he was lifted he was able to use his arms and legs to grip to his mother and assist her to take his weight. It can therefore be seen that the development of the child has a substantial influence on the physical strain experienced by the mother. As stated in section 5.3.1 the existing literature has observed that different physical challenges are presented by different age groups. Although age can be used in this way (to indicate the expected behaviour and physical demands associated with a group of children) it may be more effective for future injury prevention studies to focus on the developmental stage of the child, in combination with the child's weight, rather than focus on age alone. Children might be grouped according to key developmental milestones (such as sitting, crawling, gripping with legs during the lift, eating solids, etc.) rather than age. This might result in more specific advice regarding how to cope with the challenges presented by the child at different stages. It would also take into account the risk associated with having a different

combinations of these variables such as having a heavy young child that isn't mobile, versus a lighter young child, or a child that is mobile.

5.3.3 Child behaviour – effect on load stability

It is not only a child's developmental stage and weight that are constantly changing. An associated variable that also changes constantly is the child's behaviour. Whether the child is a stable load to lift or carry is greatly affected by his or her movement and behaviour. Children are able to destabilize themselves as a load by moving suddenly or unpredictably. The mother's body is then placed under greater strain. In the current study load instability or movement was observed as a risk in 97.7% of tasks and in 44.8% of tasks it presented a 'moderate' to 'high' risk. This key finding shows that the effect of the child's behaviour on the risk to the mother during lifting warrants further investigation.

Although the child's behaviour was observed to be an important variable, the survey in the current study, only asked one question about the child's behaviour. This was the question about the child's activity level. The results of this question indicated a mean activity level amongst the children in the study which was moderate, with intermittent spurts of busy and quiet play. This indicates that they had an activity level that is within a normal range. Therefore the presence of unpredictable and or uncontrolled movement is likely to be common when mothers lift children in this weight range. This question does not provide insight into what was the cause behind the unexpected or uncontrolled movement in terms of the child's behaviour. The results from the OMLITH do not elucidate this either. Therefore, it is recommended that in future studies further information is obtained regarding the influence of the child's behaviour on lifting. The comments that mothers in the current study made about how behaviour can affect lifting were "harder to carry the child when he did the 'flopping fish' and went limp", "child would often arch her back and swing away from mother", "child would grizzle and resist being put down", and "child liked to play and swing on mother". The child's temperament was also identified by mothers as affecting the lifting: "have to carry her all the time when she grizzles", "older child liked to be carried more than younger one did", "distressed child is harder to handle", "putting child in time out when he was angry was hard as he would kick and resist". Griffin

and Price (2000) also found that the mothers in their study identified that they lifted differently when the child was crying or upset.

5.3.4 Grip

The effect of grip on whether a worker or parent could safely lift a child was only briefly discussed in the existing literature, but children were identified as being difficult to grasp, especially when moving (Grant et al., 1995; Owen 1994). The current study was able to provide a more detailed assessment of whether children are difficult to grasp as suggested in the literature. The results of the current study demonstrated that in 75.9% of tasks that when mothers grasped their child: their hands were well outside the ‘ideal’ grip advocated by NIOSH, they couldn’t get a good grip around the contact area, the two hands were not equally sure of grip, they were required to change their grip on the child during the lift or the child was difficult to grip due to such things as being wet. It can be inferred that these results are in part due to the shape and living nature of children. They can not be grasped anywhere on their body (as many inanimate objects can) as some body-parts are more fragile. They are commonly grasped under the arms, allowing a symmetrical two-handed grasp with the mother’s hand in a mid-range position, but this is not always possible. Unlike a box, children must often be orientated in a particular direction during the lift – such as head up, facing in or out etc. – and also must be oriented in a particular direction at the destination. This means that mothers will commonly have to move their hands and change their grip during the lift to orientate the child correctly. For example, when a child is lifted into a car seat they start facing the mother who is standing next to the car and they finish in the car seat facing forward, so the child has turned 90°. The results are also due to the fact that a child is often moving and therefore the mother has to adapt her grip accordingly. For example, if the child moves away from the mother as she goes to lift, it can mean that she doesn’t get a good grip and has to readjust her grip to make it safer.

The paragraph above describes the complexity of gripping a child. Because it is complex, and because changes often happen quickly during the lift, it is also difficult to observe in detail. Therefore the OMLITH tool only provides an indication that there are challenges when gripping a child and that these challenges introduce risk of MSDs. The OMLITH is not detailed enough to provide information on which solutions can be based. These would

require further research where gripping children was analysed in detail using video analysis or computerised modelling. Given the percentage of tasks in which the tool rated the grip as introducing a 'high' level of risk, further research of this nature is clearly warranted.

5.4 Mother

5.4.1 Sample demographics

The current study used a modified version of the 'Ergonomics of Caring for Children' by Sanders and Morse (2005) to collect demographic data about the sample. Sanders and Morse had a sample of 130 parents of which 120 were mothers, whereas the current study had a sample of 25 mothers. Nevertheless, the demographics of the current sample were comparable to the sample of Sanders and Morse. The mean age of the current sample was 34.6yrs and in their study it was 33 yrs, all the families in both studies had incomes close to, or above the mean average for the geographic region, 52% of the current sample indicated that their partner 'frequently' helped with childcare and 48% reported that their partner 'always' helped with childcare compared with 42% 'frequently' helping and 42% 'always' helping in the study by Sanders and Morse. In the current study 48% of mothers did not work outside the home, 40% worked part-time and 12% worked full-time. In the sample of Sanders and Morse there was a more even distribution between not working (31%), working part-time (34%) and working full-time (35%). Parents averaged 6.8hrs of sleep per night in the current study and 6.4hrs in the Sanders and Morse study. Therefore in most variables except working status, the two samples appear very similar.

When the demographics of the current sample are compared to Auckland population as a whole, however, there are some limitations of note. The ethnicity of the current sample was not representative of the diverse ethnic mix in Auckland. Ninety-six percent of the current sample (n=24) identified themselves as New Zealand European. European people only make up 65.7% of Auckland's population, with 8.4% being Maori people, 13.7% being Pacific Island people and 18.7% being Asian people. The ethnic mix of the Auckland region also differs from the rest of New Zealand and can differ within different areas of Auckland also. Therefore the results of the current study may not reflect the general

population of mothers in Auckland. Caution must therefore be used when applying the results to mothers from an ethnic background that was not included in the current sample. The homogeneity of the current sample is likely to have been a result of using the snowball recruitment method as opposed to performing a random selection of mothers. Larger studies would be advised to use a different recruitment method to ensure that the sample reflected the population as a whole, for instance, a random sample created using a regional database.

5.4.2 Musculoskeletal symptoms experienced by mothers

Many of the mothers in the study had musculoskeletal symptoms, despite reporting themselves as ‘healthy’ in response to the screening questions. The symptoms survey used in the current study was that from the “Ergonomics of Children Survey” of Sanders and Morse (2005). A summary of the percentage of mothers experiencing musculoskeletal symptoms by anatomical location is presented in Table 11 below, along with the symptoms reported in the study by Sanders and Morse.

Table 11: Musculoskeletal symptoms

Musculoskeletal symptoms	Neck	Shoulders	Upper Back	Low Back	Knees
Current Study	32%	32%	32%	64%	20%
Sanders & Morse, 2005	17%	11.5%	16%	48%	10%

As can be seen in the table, the percentage of mothers that reported musculoskeletal discomfort in the neck, shoulder, upper back or knees was almost double that reported by Sanders and Morse. The percentage of mothers that reported low back pain was also higher. This may be due to the age of the children in the current study being younger, as discussed in section 5.3.1. Or it might be due to a greater degree of responder bias in the current study; mothers with more discomfort may have been more motivated to take part. Equally, it might reflect a difference between the frequencies of MSDs in mothers in NZ versus mothers in the US. However, variability among the rates of MSDs reported in the childcare research is common. Therefore, better surveillance data regarding MSDs in mothers would

be needed to explain these differences (Brown & Gerberich, 1993; Grant et al., 1995; Gratz & Claffey, 1996). Despite the limitations of the data, the current study provides further evidence that mothers are experiencing MSDs and that the lower back appears to be the most common anatomical site for symptoms.

The current study was subject to the same limitation as previously reported studies (Grant et al., 1995; Owen, 1994; Sanders & Morse, 2005) in not formally ascertaining the MSD history of the sample. Nevertheless mothers in the current study did converse with the author about the effect that pre-existing conditions (e.g. occupational overuse syndrome caused by work, knee problems from sports) had on their ability to perform childcare tasks. This suggests that they are relevant when investigating MSDs in mothers related to childcare. Therefore, as others have commented, in future studies more information needs to be collected about the timing of the onset of MSD symptoms, the severity of MSD symptoms and the effect that MSD symptoms have on function (King et al., 1996). This is especially important in view of the fact that pre-existing injuries have been suggested to affect how mothers performed lifting tasks (Griffin & Price, 2000). Despite this, it was nevertheless valuable to use the presence of MSD symptoms as an indicator of increased risk during the performance of the tasks observed. However, little can be said about how or if these symptoms modified the mothers' manual handling performance.

5.4.3 Physical fitness and capacity

Reported RPEs (Ratings of Perceived Exertion) were used to assign risk ratings to reflect risk associated with the physical fitness or capacity. In over 57.5% (or over half) of the task situations, the mother's heart rate would have increased from resting to 65-75% of her maximum heart rate (MHR). It could be assumed that an individual who had a greater physical capacity for the task (and hence be less at risk performing the task) might give a lower RPE, as they would experience a smaller increase in heart rate and therefore perceive less exertion. Therefore this result suggests that there was a mismatch between the types of tasks that the mothers were required to perform to care for their children, and their level of fitness or physical capacity. This inference must be regarded with caution however, as the RPE measurement used in the current study has not been empirically tested and may not be an accurate representation of the physiological workload mothers are experiencing. There is

also a possibility of test anxiety when mothers perform tasks in front of a stranger, which might cause them to rate the perceived exertion higher because they are experiencing a higher heart rate (Borg, 1998). Despite these limitations, the findings from the current study provide support for the need to quantify the physiological workload associated with mothering to assess what level of fitness and strength might be required to safely complete a work day caring for children in the home. Future research into MSDs in mothers which are related to childcare activities would be encouraged to follow the lead of Shimaoka et al. (1998), who measured heart rate during the performance of childcare tasks.

5.4.4 Individual psychosocial factors

In the literature review, it was suggested that individual psychosocial factors might influence the manual handling done by mothers, the incidence of MSDs in mothers, or the ability of mothers to adapt to or recover from MSDs. The individual psychosocial factors outlined were: depression, anxiety, psychological distress, personality factors, a 'fear avoidance coping' technique, pain behaviour, or job dissatisfaction (Bernard, 1997). A limitation of the current study was that it was not possible to fully assess the degree to which these psychosocial factors were present. The three questions in the 'Ergonomics of Caring for Children Survey' that addressed psychosocial factors were based on the Demand-Control Model of stress, and were aimed at assessing the mothers' perceptions of the level of demand they perceived to be associated with performing childcare activities (Sanders & Morse, 2005). Sanders and Morse, the originators of the survey, found that there was a strong association between the mothers who indicated that caring for children was a highly demanding occupation, and the presence of musculoskeletal pain. The sample size in the current study was too small to statistically test for this association. However 80% of the current sample did indicate that caring for their children required a lot of physical effort, 65% indicated that they did not have sufficient time to perform hobbies or other meaningful activities, and 40% indicated that they did not have enough time to get done what they needed to do. This suggests that the mothers in the current study were experiencing mothering to be a demanding occupation and it may be one of the reasons that mothers were experiencing the levels of MSDs reported. However, despite the fact that these questions are valuable, in that they indicate that important psychosocial factors are

present, they do not explain why mothers gave these answers or how this perception then affected their physical childcare behaviour. Further information is required from other methods to assess the individual psychological status of the mothers and how psychosocial demands effect the way mothers perform the physical tasks of childcare. Some of the comments made by mothers in the current study also indicated that there is a relationship between psychosocial factors and the performance of childcare and associated MSDs. For example some mothers commented that their parenting style (which is a function of their personality and individual beliefs, attitudes and values) affected the physical strain they experienced “being consistent and eliciting co-operation can prevent child-care situations becoming more demanding”, “being a parent who is more ‘hands off’ means less handling”, “if she is grizzling and tired I just leave the washing until later rather than carry her around”. Mothers’ coping styles also affect the physical work that they do. Some mothers worked on having strategies to reduce the work that they do (such as getting child to climb into cot, highchair or stroller, using distraction techniques, eliciting co-operation, being prepared to have a nap). Other mothers talked about stress and how it affected them. For example: “stress and tiredness affects my neck”, “stress and reactions to children are affected by tiredness”, “when I’m under pressure sensible lifting goes out the window”.

For future studies to evaluate this further an interview process or detailed survey would need to be developed. This may not always be feasible. However, the author recommends that mothers are at least screened for symptoms of depression using a well validated tool such as the Edinburgh Postnatal Depression Scale (EPDS), because depression has the potential to confound results demonstrating associations between other factors and MSDs and also because depression in itself may be a primary risk factors for MSDs (Lumley et al., 2003; Lumley et al., 2006).

5.4.5 Knowledge of safe lifting practice

The literature review identified that what constitutes ‘safe lifting’ has changed over the recent decades; in particular there has been a change from a technique-focused approach to an approach that focuses on addressing contributory factors. In order to assess if mothers were aware of these changes, the author included questions about what mothers perceived to be ‘safe lifting’ in the survey. The results showed that the mothers had a variety of

perceptions of what contributed to a 'safe' lift. The strategies reported by mothers included some that were based on lift technique (don't stoop, n=8) but most of the mothers identified contributory components to be important (use abdominals, n=12, maintain stability, n=6, keep load close, n=4, don't twist, n=3, lift with head up, n=1, and lift child without added objects, n=1). This would suggest that the mothers in the current sample have taken on board some of the more recent approaches to 'safe lifting' that focus on contributory factors as opposed to lift technique. The author also asked mothers where they had learned about safe lifting. Mothers predominantly identified pamphlets/brochures/advertisements (n=14) as the main source of information. They also identified work (n=8), and health professionals (n=4). This suggests that mothers might be receptive to written advice regarding lifting. However, caution must be taken when using written guidelines as a lifting training method without first empirically testing the effect of the guidelines. Barker and Atha (1994) found in their study written guidelines for lifting, such as those commonly used in industry, resulted in a poorer lifting performance (determined using biomechanical analysis and Borg RPEs) than allowing people to lift in their untrained state. This might explain why the mothers in the current sample reported having knowledge of safe lifting practice, but were still reporting a high incidence of MSDs – it may be that the written information had not been effective.

It is interesting to note that only one mother identified having learnt how to lift safely from her experience. The reason for this could be that although mothers are learning from experience they are not aware of it and therefore do not report it, or it could be explained by mothers not transferring what they learn in one task to other tasks, as was found by Griffin and Price (2000). Whether mothers have the skills and knowledge to analyse and learn from their own occupational performance of tasks is an important issue. This is because mothers are their own 'health and safety' officers. They therefore need to be able to identify risks and develop strategies to minimise them.

The reader may note that in this discussion the author has purposefully avoided making inferences regarding the effect of particular lifting techniques. Existing literature has made reference to mothers performing activities with 'incorrect lifting techniques' which expose them to biomechanical strain (Griffin & Price, 2000). However, as explained in the

methodology chapter in section 3.5.4.1, an approach involving the risk associated with contributory factors is now more widely accepted (Giat & Pike, 1992; Straker, 2003; van Dieën, Hoozemans, & Toussaint, 1999). Griffin and Price (2000) reported that the mothers in their sample preferred a stoop lifting technique. The current author would argue that in some situations a stoop lift might be more appropriate as it enables the child to be brought closer to the mother's body (reduces the horizontal distance during the lift). For example, it may be a more stable lift if the child is moving and could destabilise a mother who is crouching. The current study provides support for applying contemporary approaches to mothers, as opposed to advocating a particular lift technique. The lift technique approach may have been preferred in the past because it is simpler to teach. However, the current author would argue that it might be more effective to teach simple principles (e.g. bringing the load close to the body, aiming to lift symmetrically, aiming to be stable during the lift, planning ahead and practising minimising extremes of movement by activity design and child co-operation strategies) rather than a particular technique that mothers might dismiss immediately if they perceive it to be impossible or inappropriate. This is supported by the comment of three mothers in the interviews performed by Griffin and Price (2000) who had tried to use correct lifting techniques but found that that was hard to accomplish and therefore felt that it was not always appropriate to use correct techniques.

5.4.6 Co-existing conditions

The findings of the current study showed that mothers frequently had other co-existing conditions like pregnancy that could potentially reduce their resilience to MSDs. The mothers in the current sample were not specifically asked if they were pregnant but they consistently offered this information without being asked. Given the rationale presented in the literature review regarding the effects of pregnancy on physical performance, it would be valuable to include a question in the survey asking the mothers whether they are currently pregnant, and if so, how many weeks and whether the pregnancy is affecting their ability to perform childcare tasks. For example, the two mothers in the current study who were pregnant and in the first trimester reported being affected by fatigue, whereas the two mothers in the third trimester were observed as having adverse changes to body shape affecting their lifting, which is in line with the findings of Tapp (2000).

The potential for mothers to be also experiencing major health problems is also high when one considers the findings of Brown and Lumley (2000) and Lumley et al. (2003, 2006). These authors have reported that a large of percentage of mothers might experience perineal pain, mastitis, urinary or faecal incontinence in the first year after child birth. This evidence, as well as the findings of Gratz and Claffey (1996), shows that women who care for children are particularly susceptible to illness in their first year of childcare. Therefore more information about the general health status of mothers is needed to assess this has an association with incidence of MSDs in this population. It is recommended that future research uses a standardised measurement of health status, such as the SF-36 (Short Form 36, Health status measure) used by Lumley et al. (2003, 2006)..

5.4.7 Fatigue

Fatigue was measured using a VAS scale that was developed for the current study that had not been tested or standardised. The scale was used primarily to gain an indication of how the mother's fatigue on the day she was being observed compared to her level of fatigue on an average day. The left anchor of the scale represented the ideal – no tiredness at all and the right anchor represented the opposite extreme – complete exhaustion. The value of obtaining this data is that it allows some inferences to be made regarding how fatigue might have acted as a confounding factor, by changing the way the mother performed the task. For example: the mothers in the study by Griffin and Price (2000) commented that “when they were tired, especially at the end of the day, they really did not care how they lifted” (p. 9). This would mean that on a day when they were tired, a different result might be seen. The results showed that in approximately a fifth of the tasks the mother not only rated herself as fatigued (in the upper half of the VAS) but also rated herself more fatigued than usual. This suggests the possibility that fatigue was an influencing factor with regard to other variables observed, or comments made by the mother. For example: the mother may have been performing a task in an energy-conserving manner which increased the risk rating given to other variables (Griffin & Price, 2000), she may have been easier to distract causing increased risk, or may have not have had the energy to plan and guide the task so that it was achieved efficiently. The mothers in the current study volunteered a notable amount of information regarding their perception of fatigue. It appeared that asking them to

rate fatigue prompted a conversation about why they felt they were fatigued. The comments they made highlight the fact that fatigue is a theme that was common among the mothers. Factors that were perceived to increase fatigue levels by mothers in the current study were: “lack of sleep or interrupted sleep”, “having to give children constant attention”, “stress”, “a lack of practical support” (from partner, paid help or family), “not being able to have a nap”, “having a new baby or more than one child” (especially twins), “being hung over”, “recovering from a caesarean”, “a lack of stimulation” (boredom), “number of feeds given during night”, “not being able to co-ordinate or organise the day to pace activities” and “grieving for a dead family member” (these comments were offered by mother during the observation visit and noted down). Being fatigued was recognised as being an issue with regard to lifting as it “caused stress and neck or back pain”, “affected ability to think things through clearly or elicit co-operation from child”, and “affected ability to discipline child” (mothers’ comments during observations).

Another limitation of the fatigue measurement in the current study was that it used a scale that reflected a general level of fatigue, without specifying a source. It combined fatigue that may have been caused by physical, emotional or psychological stresses. The comments of the mothers reflected a mixture of these stresses as the cause of their fatigue.

Nevertheless, although the current study did not measure fatigue in a standardised way, the results of the fatigue assessment are useful. They provide an indication that the results of the study might reflect risk factors present when *fatigued* mothers lift children in the home, as fatigue was present at some level during 59.8% of tasks observed. However the fact that fatigue was so common also suggests that fatigue may be more likely to be present than not when mothers lift children, and hence warrants more detailed investigation. Fatigue may also influence whether mothers have the energy to take part in activities that may be protective in other ways like exercising, taking part in hobbies, socialising and so forth. The effect of fatigue should therefore be studied in future research. Qualitative methodologies might assess the psychosocial influences of fatigue more appropriately, while quantitative methodologies could be used to assess physiological fatigue. It would be useful to develop standardised tools to assess fatigue so that fatigue experienced by mothers could be compared to other populations exposed to frequent lifting.

It is notable that within the paid childcare literature, fatigue was not addressed. Similarly, mothers in the study by Sanders and Morse (2005) were not asked about fatigue. They were asked how many hours of sleep they averaged per night ($\chi=6.4$ hrs) but this can not be assumed to indicate the level of fatigue the mothers were experiencing. In the current study the mothers reported a similar average number of hours sleep per night ($\chi=6.8$ hrs) to the mothers in the Sanders and Morse's study, but despite this they were also experiencing high levels of fatigue.

5.5 Task

5.5.1 Childcare tasks

5.5.1.1 Survey

This sample of mothers reported performing tasks classified by the survey developers as high risk, such as 'carrying a child on one hip', 'carrying a child while bent down', 'lifting a child up to or off a changing table', 'lifting a child in or out of a cot with high sides', 'standing bent over to wash a child' and 'changing a child on the floor' (Sanders & Morse, 2005). However, the current study results also identified other activities that were perceived as significantly more physical stressful by this group of mothers, such as using a backpack to carry the child, or using a baby jogger, carrying their child on their shoulders, performing prolonged squatting or stooping while playing with their child, or lifting their child into or out of the car seat. It is possible that these differences in the activities that presented as more physically stressful were associated with characteristics associated with the sample, such as a difference in lifestyle patterns between the current sample and that of Sanders and Morse. However, inferences regarding the actual difference between the two studies' results could not be made with the data available. Demographically the two samples were similar but it is possibly that their daily activities and routines differed in a way that meant that they were exposed to different activities or equipment. For example, a difference between the vehicles and car seats commonly used in the US and in New Zealand might account for a different perceived physical stress when placing a child in or out of a car seat; the difference in physical stress associated with backpacks might be due to it being less common for mothers in the US to use backpacks to carry children. Again, it is not possible

to say, without further research being undertaken. Future studies that use the ‘Ergonomics of Carrying for Children’ survey might want to ensure that mothers have to identify that they *do not* do an activity using a symbol (e.g. putting a cross) so that the mothers are sure to rate all the activities that they *do* do – even when they feel it is not physically stress (indicated by a rating of zero). It is possible that some mothers left a blank rather than providing a zero and that this could have provided a different result between the two studies with regard to statistical analysis.

Some differences can be seen between the activities identified in the literature addressing the physical demands of paid childcare and those identified in the current study or in the studies by Griffin and Price (2000) and Sanders and Morse (2005) who also studied mothers. In particular, the activities of bathing children and putting children in and out of car-seats are not generally performed by paid childcare workers, but are important activities for study as mothers rated them as presenting a high level of physical stress. Therefore it is not adequate to rely on research based on paid childcare workers for providing insight into the work of mothers, despite there being many similarities. Other important differences between the paid childcare work and mothering that affect the nature of their activities are; that childcare centres often have child-sized furniture and modifications to promote child independence, such as low toilets and basins, and steps up the changing table; that mothers have a different duration (over a 24hr period if at home full-time) and organisational structure of their work day, which often involves combining childcare with other activities around the home, interwoven with social and leisure activities. These examples are intended to provide support to the argument that mothers need research that specifically addresses their occupation.

5.5.1.2 Observations

The tasks observed varied across a range of activities (lifting a child in or out of a cot, a highchair, a car-seat, play equipment, stroller, bed a bath; lifting a child onto or off a change table, furniture, the mother’s hip, the mother’s knee while seated), but when compared to activities described in the literature they represent a realistic cross-section of what parents of young children do in a day (Francis-Connolly, 2000; Griffin & Price, 2000; Sanders & Morse, 2005). Therefore even though the results are collated, they still are

likely to provide a reasonable assessment of risk. The activities were predominantly those that had been recognised in the literature as being potential causes of physical stress, or that the individual mother identified as a cause of physical stress for her. The benefit of assessing activities that have been highlighted as problematic was that the current study could then confirm that activities that were perceived by mothers and researchers to cause a higher level of physical risk did in fact expose the mothers to notable levels of risk factors for MSDs. This finding adds another layer of evidence to support the need for further research in this area.

Within the activities themselves, a classification of activities involving lifting a child ‘into or out of’ versus those that involve lifting a child ‘on or off’ distinguishes itself. This is valuable because placing a child ‘into’ and ‘out of’ a piece of equipment requires more precision and has been mentioned in the UK handling guidelines as presenting higher risk than when precision is not required (HSE, 2004). However, when the load is a child, safety can add to the risk when on/off tasks are involved because the child is not contained and could fall, so the mother has to control the child’s movement at the origin or destination if he or she is up off ground. Future research could look at the difference between precision tasks (into/out of) and on/off tasks which are less precise and the effect of perceived danger of falling i.e. on mother’s movement patterns/risk of injury.

Although these tasks have been grouped to make it easier to discuss them, they were not performed uniformly by the mothers and although they have the same task as a base (e.g. put the child into the highchair) the contributory factors associated with the individual situation combine together in a unique way to increase or decrease the risk. Nevertheless, the OMLITH provided a way to assess the key elements across all tasks that contributed to risk of the mother developing an MSD. When a multi-factorial approach is taken, each risk factor is considered not only for its own potential to contribute to the development of MSDs but also its contribution to the combined risk that the mother faces from all factors during the task. For example, mothers were frequently required to perform tasks while reaching away from the body. This risk factor by itself may not result in injury but when other risk factors are present during the task such as the child is moving, the space is restricted, the mother twists, the mother is pregnant and the equipment is awkward to use,

then the situation becomes more hazardous. Therefore a tool such as the OMLITH is a more comprehensive way of assessing tasks. However, the OMLITH was designed with the intention of analysing a group of collated risks from multiple tasks (n=87) and does not provide a risk profile for a single task. It could nevertheless be easily further developed to be used in this way clinically, to assess a mother and provide a basis for discussion. This is because it was based on an original tool (NZMHHCR) that provided controls for risk factors that were identified. If another protocol that included controls for each of the risk factors identified was created, clinicians would have information to draw on when helping mothers to devise strategies to reduce the effect of the risk factors.

In the literature review, it was argued that separating out elements of a task in the way just discussed had the potential to overlook the enfolded nature of the activities within the occupation of mothering. It was argued that mothers perform care-taking tasks in combination with nurturing (e.g. cuddling, soothing) and teaching (assisting the child to learn things) their children. This enfolding adds meaning to the care-taking activities. The researcher in the current study found that the OMLITH tool did not record information about the meaning within the task for the mother. For example, a mother may have picked up a child a particular way because it was more soothing to the child even if it presented a higher risk bio-mechanically. Understanding the meaning associated with a task is important, as it can provide information about why a mother was motivated to perform a task in a certain way. In order to obtain information about the meaning, the researcher engaged the mothers in conversation about the task as they performed it, and noted their responses. From these notes, she concluded that mothers are commonly performing enfolded occupations. This is not ideal, however, and again is a limitation of the current study. In the future, the researcher would recommend that the semi-structured interview process already suggested above, be designed to capture information about the meaning associated with tasks which will be useful when designing intervention studies. The existing studies into the demands of paid childcare work or mothering did not address this directly or use the term enfolding but those researchers also recognised that caring for children often involves some form or other of multi-tasking (Calabro et al., 2000; Grant et al., 1995; Griffin & Price, 2000; King et al., 1996). The current study proposes that given the embedded meaningfulness of the occupation of mothering, the concepts of enfolded

occupation and meaning are important to incorporate into future research via qualitative methods.

5.5.2 Biomechanical and physiological risks

Similar to the existing research in this area, the current study identified that activities involving lifting, or prolonged awkward postures, provided the greatest physical demand for mothers (Brown & Gerberich, 1993; Griffin & Price, 2000; Gratz & Claffey, 1996; Grant et al., 1995, King et al., 1996; Owen, 1994; Sanders & Morse, 2005). Mothers were observed to bend far forward (performing arm and trunk flexion), reach above shoulder height and below mid thigh at levels that presented a high risk. This suggests that mothers are exposed to biomechanical loading of the spine similar to that of the childcare workers in the studies by Kumagai et al. (1995) and Taloni et al. (2004). Other awkward postures of note in the current study were twisting, and lifting while seated, squatting, or kneeling. These postures not only create adverse biomechanical loading of the spine but also load the lower limb. As yet, however, they have not been studied in the childcare literature.

Physiologically, using the RPE scale as an indicator, mothers in this study appeared to be experiencing increased heart rates of 30% or more associated with childcare activities, as was found in the study of Shimaoka et al. into paid childcare workers (1998). However, in the current study, this was measured indirectly using RPE measurements. Although the RPE only provided a rough estimate of physiological workload, it does provide support for future research into the metabolic workload associated with mothering activities.

Currently there are no studies using a sample of mothers and children that have employed the biomechanical methods used in studies involving paid childcare workers, such as inclination monitors, video analysis, computerised 3D modelling and heart rate memory devices. These could provide valuable information about which lifting principles might be appropriate and effective, to incorporate into future 'safe lifting' advice for mothers.

5.6 Organizational factors

5.6.1 The home as workplace

5.6.1.1 Physical environment

In the current study, the risk factors associated with the home as a physical workplace were evaluated by observation using the OMLITH. The results from the OMLITH showed that the spaces that mothers worked in within the home often restricted their movement, that the floor surfaces were often cluttered or varied in type, that there were often moving obstacles and the environment was often noisy. Mothers were also observed lifting both indoors and outdoors. The findings suggest that in New Zealand, the main priority of home design does not seem to be to create a safe working space for mothers and children. If it were a priority the following might be seen: bathroom design with a lay out that makes it easy to manoeuvre the child in and out of the bath, help a child get on and off a toilet, or help a child wash their hands at the basin; kitchen design that incorporates room for a high chair and space to manoeuvre around it, steps to climb up into the highchair, and kitchen storage that children can't access; living areas on a single level, with one type of surface (e.g. carpet, not wood and mats), with child-proof spaces and toy storage systems that make toys easy to manage/contain. Although some of the mothers in the current sample had adapted their homes using such strategies, it was not always possible to do this, especially if the layout or structure of the home did not allow it. Conversely, in paid childcare centres, the space *has* often been adapted for the children (Grant et al., 1995; King et al., 1996; Owen, 1994) but often to only meet the needs of the child (e.g. child-sized furniture, child height toilets and basins). This results in the carer having to adopt awkward positions. A compromise seems appropriate, where both the child and the mother are considered. Research into this by ergonomists specialising in design, would be valuable. Until this is available, it is suggested that mothers be encouraged to recognise the hazards in the physical environment of the home and formulate strategies to address them.

5.6.1.2 Equipment

The current study found that childcare equipment was contributing to risk at 'moderate' to 'high' levels in 58.6% of tasks. These findings are consistent with other authors who have

evaluated the effect of childcare equipment on the manual handling performed by parents (Griffin & Price, 2000; Sanders, 2004; Sanders & Morse, 2005).

The equipment that was observed to create ‘moderate’ to ‘high’ risk was that which was faulty or notably obstructed performance. For example: a cot with the side up, child car-seats, especially rear-facing, some toys that that child had to be put into, strollers that had a bar across the front for child to hold onto. Mothers were not asked about why they chose equipment in the current study. Griffin and Price (2000) found that mothers chose equipment for a variety of reasons (including aesthetics, durability, cost, and safety). Future research in the field or ergonomics could draw on mother’s feedback and findings such as those in the current study to emphasise the need for child-care equipment that is designed to meet all the expectations of mothers and is safe for both the mother and child.

5.6.1.2.1 Mothers’ time-use

One of the most important organisational factors that might affect mothers’ exposures to risk factors for MSDs is how the mothers use their time. Mothers’ time use is strongly influenced by the ‘organisational culture’ of their home – a concept that was introduced in section 2.4.3.2, which refers to the values and beliefs that define what the organisation does and how it does it (Peterson & Wilson, 1994). The organisational culture in the home influences what the mothers and their families see as acceptable and valuable uses of the mothers’ time, and determine what the mothers feel is a priority and whether they prioritise their own needs and safety. How the mother uses their time influences the intensity of the childcare workload and the degree of time pressure that mothers experience, as well as the perceived job control, the monotony associated with childcare, and job clarity.

In the current study the time-use data collected in the survey enables some inferences to be made regarding these issues, despite the fact mothers were not directly asked about these organisational psychosocial factors. The majority of the mothers in the current study took part in most of the following activities on top of childcare: exercise, hobbies, TV or home computer use, housework, and garden or home maintenance. If an average total time spent by a mother per week on each activity is calculated using the mean times for the sample, these activities account for 34 hours (20%) of the total week (168hrs). The mothers who worked in the current study averaged 22.5hrs of work per week. If this is added to the time

spent on the activities listed above, it brings the total hours spent on all these activities to 54.5hrs (32.4%). This provides a picture of how mothers' time is spent outside childcare activities, but a notable limitation that the results do not show the amount of time the mothers actually spent on childcare. It would be valuable to ask mothers how much time they believed that they spent on childcare as this would then allow the mothers' time-use to be analysed fully and more useful inferences to be made.

In the absence of this data, national sources of time-use data can be used to aid the discussion. In a report presented by Statistics New Zealand in 2001, New Zealand women aged between 25 and 34 were shown to be spending 3 times longer caring for children per day than men, despite the fact that the total work (paid and unpaid) was the same overall. If the time that mothers spent on childcare was added to the total calculated above, it would possibly demonstrate why mothers report experiencing time pressure. It is also likely that childcare would take up the greatest percentage of time during their child-bearing years, unless they were working full-time.

It is difficult to compare the time-use data from the current study to that of Sanders and Morse (2005) due to differences in the way the data were analysed. However it is valuable to note that in that study, a significant negative association was found between musculoskeletal pain and hobbies, with participants who engaged in hobbies for just one hour or more per week, having fewer complaints of musculoskeletal pain. This means that hobbies had a protective effect. However, in the current study, mothers reported musculoskeletal symptoms at higher levels than in the study by Sanders and Morse, despite spending an average of 2.2hrs per week on hobbies. This would suggest that these associations need further investigation through factor analysis in a larger sample. This would allow associations between specific hobbies or pass-times to be analysed, because it may be that some hobbies or pass-times contribute to, rather than protect from, the occurrence of MSDs. Mothers in the current study also reported high levels of other factors that might be considered to reduce their susceptibility to MSDs, such as partner support, exercise, and use of paid childcare. The inference that could therefore be made is that without these protective factors, the incidence of MSDs might be higher, and hence the results of the current study might under-represent the incidence of MSDs in mothers.

The results showing the ways in which mothers use their time reflect what the mothers in the current study found to be important and how they chose to organise their week. It can be seen from the results that mothers included a variety of activities in their week on top of childcare. The results of the survey and OMLITH did not directly measure the occurrence of most of the psychosocial organisational factors (such as time pressure, job-clarity, job-control, monotony) as mothers were not asked about these and they are not observable. The comments that mothers made to the researcher did provide some indication that mothers were experiencing time pressure (“normally in a hurry”, “always rushing to get things done”, “speeds up tasks when child is crying”, “I have to do things quickly because can’t leave other child unattended”, “feels busy, can’t get everything done”), sometimes experienced stress associated with a lack of job control (“organised days were less stressful”, “unpredictable tasks increase stress”, “has to flexible and factor in contingencies”), and that mothers sometimes experienced monotony (“boredom contributes to fatigue”, “quieter days are harder because there is less stimulation”).

Therefore, given this information from the mothers, and the recognition in the general literature that psychosocial organisational factors can have an important primary or mediating role in the MSD process, and that there is currently a paucity of research into this area, these factors also need to be the focus of future research in unpaid working populations such as mothers.

5.7 Summary of recommendations for future research

- Continue the development of the OMLITH tool – compare the performance of the tool to the performance of other workplace assessment tools, test the validity and reliability of the RPE scale, develop a fatigue scale that indicates the type of fatigue experienced, remove the factors from the OMLITH that are considered redundant, test the use of the OMLITH with a larger sample of mothers and determine if factor analysis is possible when a larger sample is used, observe the same selection of activities for all mothers.
- Recruit mothers for a larger study from a national database to increase generalisability of results.

- Continue the development of the ‘Ergonomics of Caring for Children Survey’ – consult with the originators of the survey to determine if further questions might be included to assess the mothers’ musculoskeletal symptoms in more detail, determine if the mothers are pregnant and whether this affects their physical capacity, ask the mothers how much time they spend on childcare, and develop a way to classify a child’s developmental level.
- Develop a semi-structured interview to use in conjunction with the OMLITH and ‘Ergonomics of Caring for Children Survey’ in future projects.
- Undertake research to assess how psychosocial factors might affect the incidence of MSDs in mothers.
- Consider using validated health assessment tools such as the SF-36 and the EPDS (Edinburgh Post Natal Depression Scale) to assess mothers’ general and mental health and investigate whether there is a relationship between either of these and MSDs.
- Perform detailed biomechanical studies into specific risk factors such as load movement, grip, and horizontal reach distance during childcare tasks, using video analysis and computerized modeling.
- Undertake research to determine how children’s behaviour affects the risk associated with lifting them.
- Undertake ergonomics research into work-space and equipment design to maximize the safety of both the mother and child during childcare activities.

5.8 Summary of risk factors that might give rise to MSDs that are present when mothers lift children in the home

When mothers lift children aged 5 months to 3 years and weighing between 9 -15 kilograms, they are lifting a **load** weight that can be classified as ‘heavy’ for the type, duration and frequency of tasks that mothers perform. As a load, children are challenging;

they can move in unpredictable or uncontrolled ways and commonly require a grip that is not ideal.

Mothers experience MSDs despite taking part in activities that are considered to be protective, such as exercise or hobbies, and having some knowledge of safe lifting. The level of fitness required to perform childcare activities sometimes exceeds the physical capacity of the mother despite her taking part in regular physical exercise. Some mothers are less resilient to MSDs due to fatigue, co-existing health problems, injury, or pregnancy. Most mothers perform multiple roles – working part-time or full-time as well as performing the unpaid work of caring for their children. As a result they are exposed to risk factors for MSDs both at home and at work. Mothers can be subject to psychosocial stresses that affect their performance of manual handling tasks and their resilience to developing MSDs or their ability to recover from MSDs.

Childcare **tasks** require mothers to perform extremes of movement (e.g. reach out, overhead, to the floor), lift asymmetrically and twist or side-bend, and to lift while kneeling, squatting, or while seated. Many mothers are aware of ‘safe lifting’ practices but this does not necessarily provide protection against MSDs. This is because mothers often ignore hazards during task performance while they focus on their child, and are also occupied by enfolded multiple mothering activities into a care giving tasks (such as showing affection, teaching).

The physical **environment** that mothers’ lift in can place mothers at risk by being cluttered, having varying surfaces, restricting movement, or being excessively noisy. The equipment that mothers have access to sometimes interferes with safe task performance.

5.9 Clinical implications

It is important for health care providers to be aware that risk factors that might give rise to MSDs are present when mothers lift children in the home environment. Furthermore, the results in the current study suggest that the development of MSDs in mothers is a complex process and is multi-factorial. Therefore caution needs to be applied, as currently there is insufficient research on which to base handling guidelines for mothers. Therefore advice

provided to mothers regarding manual handling, may not have the desired injury prevention effect. Further research is needed to produce empirical data on which injury prevention strategies and advice, targeting specific risk factors, can be based. Until this is available it is suggested that health providers take a different approach to providing 'safe lifting' advice when working with mothers. The approach advocated here, is one based on clinical reasoning using occupational and functional analysis. This would involve working collaboratively with individual mothers to educate them about the risks that they are exposed to when lifting their children (summarised in section 5.8), and helping them to identify which of the risk factors identified in this study need to be addressed in their circumstances. Strategies would be based on modifying occupational performance in a way that incorporates the needs of the mother and the child, and reduces the effect of potential risk factors. This requires health providers to have a working knowledge of the factors which can contribute to the development of MSDs and to use information gained from the collaborative occupational analysis to highlight possible risks. Approaching the problem of MSDs related to occupation in this way (using contributory factors) is in line with the contemporary approach taken by ACC (2007b).

List of Abbreviations

AAOS	American Academy of Orthopaedic Surgeons
ACC	Accident Compensation Corporation
ANOVA	Analysis of variance
APTA	American Physical Therapy Association
AUT	Auckland University of Technology
AUTEC	Auckland University of Technology Ethics Committee
BAUA	Federal Institute of Occupational Safety and Health (Germany)
BMI	Body mass index
CAOT	Canadian Association of Occupational Therapy
CCEP	Child Care Employee Project
CDC	Centers for Disease Control and Prevention (US)
COG	Centre of gravity
DPI	Discomfort, pain and injury
EPDS	Edinburgh Postnatal Depression Scale
HR	Heart rate
HSE	Health and Safety Executive (UK)
LBD	Low back disorders
MAC	Manual handling assessment chart
ManTRA	Manual Tasks Risk Assessment
MAPO	Movement and Assistance of Hospital Patients
MRH	Maximum resting heart rate
MSD	Musculoskeletal disorder
NIOSH	National Institute for Occupational Safety and Health (US)
NOHSAC	National Occupational Safety and Health Advisory Committee (NZ)
NRC	National Research Council (US)
NZ	New Zealand
NZHIS	New Zealand Health Information Service
NZMHHCR	New Zealand Manual Handling Hazard Control Record
NZSCO	New Zealand Standard Classification of Occupations
OMLITH	Observation Checklist for Observing Mothers Lifting in the Home

OSH	Occupational Safety and Health Service (NZ)
OWAS	Ovako Working Posture Analysis System
REBA	Rapid Entire Body Assessment Tool
RPE	Rating of perceived exertion
RULA	Rapid Upper Limb Assessment
SF-36	Short-form Health Survey
SOFI	Swedish Occupational Fatigue Inventory
TIA	Trunk inclination angle
UK	United Kingdom
US	United States
VAS	Visual analogue scale
WCPT	World Confederation for Physical Therapy
WHO	World Health Organization
WRMSD	Work-related musculoskeletal disorder

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Appendix A: NRC model (2001)

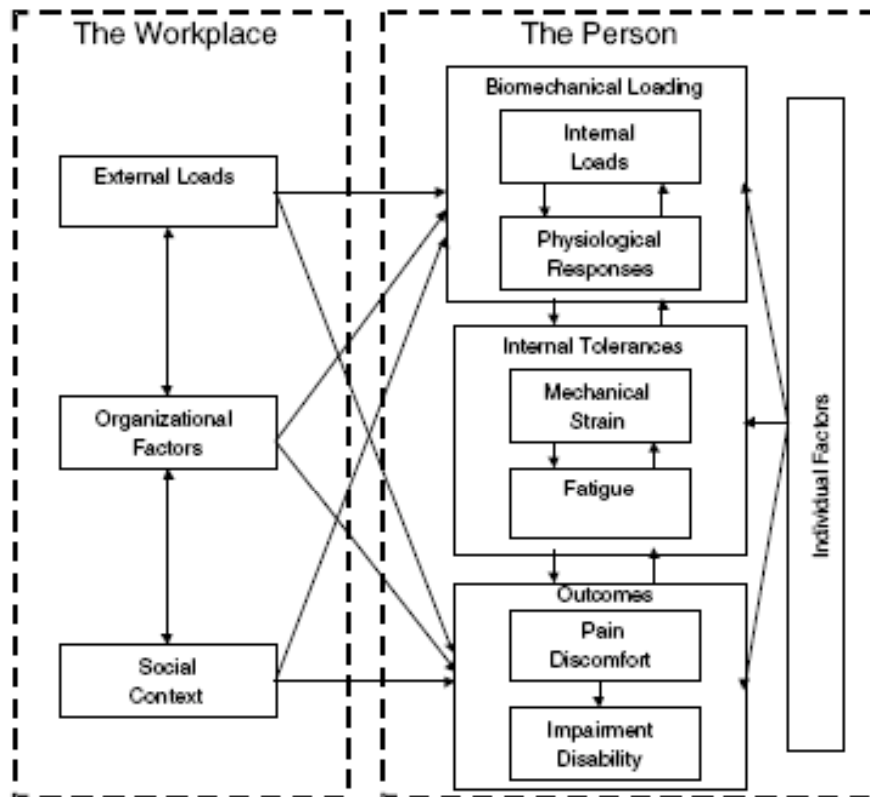


FIGURE ES.1 A conceptual model of the possible roles and influences that various factors may play in the development of musculoskeletal disorders. The dotted box outline on the right indicates the possible pathways and processes that could occur within the person, including the biomechanical load-tolerance relationship and the factors that may mediate the load-tolerance relationship, such as individual factors and adaptation. Outcomes may be a result of this relationship and may be influenced by individual factors, such as conditioning or psychological state. The dotted box on the left indicates the possible influences of the workplace on the sequence of events that can lead to musculoskeletal disorders in the person. Arrows between “the workplace” factors and “the person” box indicate the various research disciplines (epidemiology, biomechanics, physiology, etc.) that have attempted to explain the relationship. For example, epidemiology typically searches for associations between external loading characteristics and reported outcomes, whereas the relationship between external loads and biomechanical loading is usually explored via biomechanical studies (adapted from National Research Council, 1999b).

Figure ES.1 “Musculoskeletal Disorders in the workplace: Low Back and Upper Extremities,” by the National Research Council. Panel on Musculoskeletal Disorders and the Workplace. Commission on Behavioral and Social Sciences and Education. Copyright 2001 by the National Academy of Sciences. Model reprinted with permission of the author.

Appendix B: Participant recruitment advertisement



Mothers are invited to take part in a research project studying childcare tasks in the home.

The purpose of the research is to identify the risks associated with lifting children who weigh between 9 and 14kg. To participate you need to be a mother in good health, aged between 20 and 40 years.

This project has been approved by the Auckland University of Technology Ethics Committee.

So if you have a child in this weight range and are interested in taking part, or would like further information, please contact:

**Renee McKay
0800 LIFTING
0800 5438464
renmck05@aut.ac.nz**

He powhiri tenei ki nga whaea. Haere mai ki te tautoko te kaupapa rapunga korero, mo nga tamariki ramaha raua 9kg ki te 14kg.

Te putake o tenei rapunga korero, Tuatahi, kia mohiotia tatau nga tamariki taumaha ana te hiki 9kg ki te 14kg. Tuarua, koutou nga whaea e pirangi ana te hau mai ki tenei hui mehemea e 20 – 40 o tau, mehemea kei te ora tou tinana, Nau mai haere mai.

Te kaupapa o tenei hui kua whakamanatia te whare-wananga o Auckland University of Technology Ethics Committee.

He patai, kia koutou nga whaea, i te mea kei te mohio koutou ki enei tomomo tamariki, whakaatu mai o whakaaro kia

**Renee McKay
0800 LIFTING
0800 5438464
renmck05@aut.ac.nz**

Appendix C: Participant information sheet

Participant Information Sheet



Date Information Sheet Produced:

20-08-2006

Project Title

Observing mothers lifting their children in their own home to identify ergonomic risk factors.

Invitation

You are invited to take part in a research study on the lifting you do as a mother, while caring for your child at home.

What is the purpose of this research?

This research study is being conducted as part of a Masters in Health Science at Auckland University of Technology (AUT). To obtain a Masters degree, students are required to complete a piece of research and to submit a thesis on that research. The research project must first have been approved by the AUT Faculty of Health and Environmental Studies and Ethics Committee (AUTEC).

Masters student Renée McKay, who is a registered physiotherapist, will carry out this research under the supervision of Dr Clare Hocking, a registered occupational therapist and Associate Professor at AUT.

How are people chosen to be asked to be part of this research?

You have been chosen because you are a mother between the ages of 20 and 40 without any serious mental or physical health conditions, with a child who weighs between 9 and 14 kg.

What happens in this research?

If you take part, you are agreeing to:

- Complete a questionnaire which asks for information about the physical strain you experience while caring for your children, and for information about you and your social circumstances.
- Allow Renée to observe you performing childcare tasks in your home for 2 hours, during which she will record information which will allow her to analyse the lifting involved in these tasks.

Renée will contact you within the next two weeks to see if you are interested in taking part. If you choose to take part she will send you a consent form and a questionnaire to complete. She will arrange a time to come and collect these forms, and to spend 2 hours observing you doing your normal childcare tasks in your home.

What are the discomforts and risks?

Renée wishes to watch you lifting your child as part of normal childcare tasks you perform. The risk of physical injury from participating in this study is therefore no greater than that you face during your average day. Nevertheless, it is possible that you might experience some physical discomfort as you perform your normal childcare tasks.

Some people may find that they feel uncomfortable being watched or worry that the way they care for their child is being judged. They may also worry about how they will feel having a stranger in their home.

Please be assured that it is your right, while you take part in this study, to feel comfortable, to understand fully what you are taking part in, and to feel that your dignity and privacy are being respected at all times. You are therefore welcome to have a support person present, and to ask Renée for any information that would help you to feel comfortable.

How will these discomforts and risks be alleviated?

Should you experience any physical discomfort while Renée is observing you care for your child, she would like you to let her know so that she can stop the observation. If necessary, she will help you obtain care from an appropriate health provider.

As a registered health practitioner, Renée will be following the ethical guidelines of her profession, and will behave with respect towards you and your family at all times. She will be in your home as a guest, and should you feel uncomfortable, you can stop the observation at any time, without feeling that there will be any negative consequences for you. You are also welcome to contact her supervisor, Dr Clare Hocking, at AUT should you wish to find out more about Renée and her qualifications before she visits your home, or at any stage during the research project if you have questions or concerns.

What are the benefits?

By taking part in this study and by receiving feedback about its findings, you may learn useful information about the physical demands of the work that you do as a mother. Your participation will contribute to health practitioners gaining more information about the physical work that mothers like yourself do, and about what contributes to the risk of mothers becoming injured while caring for their children.

What compensation is available for injury or negligence?

If you injure yourself during the observation while you are carrying out your normal childcare tasks, then compensation is available through the Accident Compensation Corporation within its normal limitations.

How will my privacy be protected?

All communication with Renée and any information she collects about you is strictly for the purpose of her Masters research and will be kept confidential.

You will not be identifiable to anyone other than Renée or her supervisor at any stage during the research, as any information recorded about you will not have your name on it and will be kept separate from the consent form you sign. You will not be able to be identified in any material that is used to write reports on this study. The consent forms and research data will be stored securely and destroyed at the completion of the study.

You have a right to access the personal information Renée records about you, and to request changes to be made where you feel that the information is incorrect. Should you wish, Renée is happy to give you a copy of your completed questionnaire and the structured observation you participated in.

What are the costs of participating in this research?

By participating in this research you are volunteering roughly 3 hours of your time. To take part you will fill in a short-answer and tick-box survey, that will take approximately 30 minutes and you will be observed performing your normal childcare tasks for 2 hours, in your home. Following this, Renée might contact you by telephone if she finds that the data she has gathered is not complete. However, she will try to make as few demands on your time as possible.

How long do I have to consider this invitation?

Renée will contact you by telephone within the next two weeks to see if you are interested in taking part. She will be happy to answer any questions you have. If you would like further information now, please feel free to ring or email Renée or her supervisor Dr Clare Hocking (contact details at the end of this Information Sheet).

There is no obligation for you to participate in this research. If you do take part, you can change your mind and withdraw from the study prior to, or during, the observation session without giving a reason. To withdraw from the study, you simply need to tell Renée or Clare that you no longer wish to take part. This can be done by telephone or email prior to the observation session or in person, during the observation session.

How do I agree to participate in this research?

When Renée telephones you, tell her that you would like to take part. She will then send you a questionnaire and consent form to fill out. No data will be collected from you until you have given your permission by signing the consent form.

Will I receive feedback on the results of this research?

You can choose to be sent a summary of the results of the research and a copy of your individual data by ticking 'Yes' on the consent form.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Clare Hocking, clare.hocking@aut.ac.nz, 09 921 9999 ext 7120.

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTC, Madeline Banda, madeline.banda@aut.ac.nz, 921 9999 ext 8044.

Who do I contact for further information about this research?

Researcher Contact Details:

Renée McKay, renmck05@aut.ac.nz, 0800 LIFTING (0800 5438464)

Project Supervisor Contact Details:

Dr Clare Hocking, clare.hocking@aut.ac.nz, 09 921 9999 ext 7120

Approved by the Auckland University of Technology Ethics Committee on 15 November 2006, AUTC Reference number 06/124.

Appendix D: Participant consent form

CONSENT TO PARTICIPATION IN RESEARCH

Title of Project: **Observing mothers lifting their children in their own home to identify ergonomic risk factors.**

Project Supervisor: **Dr Clare Hocking**

Researcher: **Renée McKay**

- I have read and understood the information provided about this research project (Information Sheet dated 20-08-2006.)
- I have had an opportunity to ask questions and to have them answered.
- I understand that I will be observed and have information about me recorded on a form.
- I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- If I withdraw, I understand that all relevant forms, or parts thereof, will be destroyed.
- I agree to take part in this research.
- I wish to receive a copy of the report from the research: tick one: Yes ☐ No ☐
- I wish to receive a copy of my completed questionnaire and observation form: tick one: Yes ☐ No ☐

Participant signature:

Participant name:

Participant Contact Details (if appropriate):

.....

Date:

Approved by the Auckland University of Technology Ethics Committee on 15 November 2006
 AUTEK Reference number 06/124

Appendix E: Observation checklist for risk factors

<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Participant number:</div>	<div style="border: 1px solid black; padding: 2px;">Task being observed:</div>
Contributory factors assessment	
<p>Load</p> <p>Weight _____ Length _____ Width _____ Frequency of lift _____</p> <p>L1 Load weight</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>L2 Bulky, unwieldy</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>L3, L4, L5 Unpredictable, unstable, uneven weight, unbalanced</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>L6 Hindrance to vision</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>L7 Difficult to grip, greasy, slippery</p> <p style="margin-left: 100px;">M <input type="checkbox"/> H <input type="checkbox"/></p>	

<p>Environment</p> <p>E1 Floor slippery, uneven or cluttered</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>E2 Area slopes or has steps</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/> Number of steps _____</p> <p>E3 Hot, cold, humid, outdoors, windy, wet</p> <p>M <input type="checkbox"/> H <input type="checkbox"/></p> <p>E5 Noisy</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>E6 Poor lighting, glare, gloomy</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>E7 Insufficient or confined space</p> <p>L <input type="checkbox"/> M <input type="checkbox"/> H <input type="checkbox"/></p> <p>E8 Equipment</p> <p style="margin-left: 100px;">M <input type="checkbox"/> H <input type="checkbox"/></p>

Participant Number:

Task:

People**P3 Insufficient strength or fitness**L ☐ M ☐ H ☐ Rating on Borg scale _____**P4, P6 Special considerations, less resilient people**L ☐ M ☐ H ☐ Condition _____**P5 Inappropriate footwear, clothing**L ☐ M ☐ H ☐**P8 Fatigue**L ☐ M ☐ H ☐**Task****T1 Horizontal reach**L ☐ M ☐ H ☐ Distance _____**T1.1 Vertical lift distance**M ☐ H ☐ Distance _____**T2 Reaching above shoulder or below mid thigh**M ☐ H ☐**T3 Handling over long distances**L ☐ M ☐ H ☐ Distance _____**T5 Awkward, or twisted postures**M ☐ H ☐**T7 Unpredictable, fast or unexpected movements**L ☐ M ☐ H ☐**T8 Work pace**L ☐ M ☐ H ☐**T10 Handling in a seated position**L ☐ M ☐ H ☐**T11 Squatting, kneeling or crouching**L ☐ M ☐ H ☐

Appendix F: Risk factor rating protocol

A Load

L.1. Weight of load handled

To calculate the risk associated with the weight of the load handled, the psychophysical tables compiled by Mital (1997) will be used to determine the 'population percentage' for the weight handled in the circumstance being observed. The risk will then be based on the population percentage considered at risk.

Low – population percentage of 75% to 90%

Moderate – population percentage of 50% to 75%

High – population percentage of 50% or less

Moderate – moderate level of sudden or uncontrolled movement by infant or change in the infant's centre of gravity, or child's weight distribution (child awake and only partially co-operative, child leans out, or child asleep (non-rigid load)

High – high level of sudden or uncontrolled movement by infant or change in the infant's centre of gravity (child awake and resisting, child agitated or distressed)

L.6. Hindrance to vision

Low – some hindrance of mother's vision during handling by load handled or obstacles

Moderate – moderate hindrance of mother's vision during handling

High – full blocking of mother's vision during handling

L.2. Bulky, unwieldy

Low – one of the following factors

Moderate – two of following factors

High – three or more of following factors

- Infant is holding objects that combine with the child to create an unwieldy shape or large size
- Infant's clothing/blankets increase its bulk
- Body posture adopted by infant or necessary to perform task makes child difficult to hold (e.g. full nappy)
- Infant is greater than 75cm in length.

L.7. Difficult to grip, greasy, slippery

Actual grip to be considered for how it deviates from 'good' grip standard as per NIOSH coupling guidelines: wrists neutral, fingers flexed approximately 90°, thumbs in mid position (e.g. underarm grip of infant from in front of handler's body)

Moderate – when the infant can not be gripped with both hands equally sure of grip, when fingers are not flexed close to 90°, or if surface factors (wet, greasy) make the grip somewhat unsure

High – if grip is outside midrange for wrist or thumb, if surface factors make the grip highly unsure (very wet, greasy), if hand can't wrap around contact area, if load can't be balanced evenly between the two points of grip, or if the grip changes during the handling

L.3., L.4. & L.5 Unpredictable, unstable, uneven weight distribution or unbalanced

Low – some sudden or uncontrolled movement by infant or change in the infant's centre of gravity (child awake and moving but co-operative, child alert but calm)

B Environment

E.1. The floor is slippery, uneven or cluttered

Low – some obstacles present but easily avoided and floor surface dry and in good condition

Moderate – obstacles present and require change in handling strategy to avoid, floor wet or worn/uneven (floor in poor condition), or mother's footing unsure, loose carpet/matting

High – combining of multiple factors or significant risk from one factor, e.g. floor very cluttered and difficult to navigate, wet and or worn/uneven and or mother's footing unsure, or avoiding a moving obstacle

E.2. Area slopes or has steps

Low – there is a gradual incline of surface

Moderate – moderate incline of surface, or 1-3 steps

High – steep slope, or >3 steps

E.3. Hot, cold, outdoors, windy, wet

Moderate – handling outdoors with wind, rain, cold

High – handling outdoors with extreme weather conditions

E.5. Noisy

Low – some noise from child or background but not sufficient to distract mother

Moderate – child or background noise that is loud and distracting mother somewhat (some of mother's attention going to noise)

High – noise that is extremely loud and is distracting mother significantly (e.g. mother is trying to address it during handling)

E.6. Poor lighting, glare, gloomy

Low – lighting reduced (not bright daylight or artificial light) but still sufficient for most activities

Moderate – lights dimmed or glare present

High – darkness or facing directly into the sun or lamp

E.7. Insufficient or confined space

Low – movement slightly restricted by furniture, obstacles or fixtures

Moderate – movement restricted by furniture, obstacles or fixtures in such a way that the mother is required to reach out or up or to twist

High – movement restricted by furniture, obstacles or fixtures in such a way that the mother is forced to reach and twist far from the body, or perform combined reach and twist

E.8. Equipment

Equipment refers to objects the mother uses during the completion of the task being observed, such as: changing tables, bed, cot, highchair, bath. It includes objects designated for child care, but also items that mothers might use in the absence of these items e.g. a bed might be termed equipment when it is being used instead of a change table

Moderate – observably increases difficulty of task performance

High – equipment broken, unsafe, unfamiliar, or unsuitable to the task

C People

P.3. Insufficient strength or fitness

The mother's physical capacity for the task will be judged by the perceived exertion she experiences during the task. The mother will be asked to rate her exertion on the Borg RPE perceived exertion scale (Borg, 1990). This will then be given a risk level as follows:

Low – Rating of 11-12 (Light to Somewhat hard)

Moderate – Rating of 13-14 (Somewhat hard to Hard)

High – Rating of >15 (Hard (heavy) to Maximal exertion)

P.4. & P.6 Special considerations, less resilient

Included in this category are conditions such as: pregnancy, disability, size of mother, illness, minor injury.

Low – condition has some impact on the way handling is done by the mother, mother less resilient due to a minor condition (mildly unwell, minor physical impairment that is not affecting the back, knees or arms significantly)

Moderate – condition has moderate impact on the way handling is done by mother, mother less resilient due to more serious condition (systemic symptoms of illness, moderately severe injury and if back, knee or arms involved)

High – condition has high impact on the handling, mother less resilient due to condition significantly changes functional capacity (very unwell, or suffering from significant levels of back pain, arm pain, knee pain)

P.5. Inappropriate footwear, clothing or personal protective equipment

Low – clothing slightly restricts movement but handling technique unaffected, footwear somewhat unsafe

Moderate – clothing restricts movement to the point where handling technique changes, footwear decreases mother's ease of handling

High – clothing extremely restrictive, footwear unstable or makes handling very difficult

P.8. Fatigue

The mother will be asked to use a VAS (Visual Analogue Scale) developed by the author of the current study to rate her current level of fatigue, and then her fatigue level on an 'average day'.

Low – mother is more tired than usual for her but still rates herself in the bottom half of the VAS

Moderate – mother rates herself in the upper half of the VAS (higher level of tiredness) but this is similar to her average rating (i.e. usual for her)

High – mother rates herself in the upper half of the VAS and this differs to her average rating (i.e. mother rates her self 0.5cm or greater, more tired than usual for her on the VAS)

D Task

T.1. Horizontal reach

Low – upper arms angled slightly away from the body *or* trunk bent slightly forward

Moderate – upper arms straight or nearly straight *or* trunk bent significantly forward

High – upper arms angled away from the body and trunk bent significantly forward (combined)

T.1.1. Vertical lift distance

The vertical lift distance will be rated according to the number of lifting ‘zones’ that the load passes through during the lift. The zones are: from floor to knuckle height, from knuckle height to shoulder height, shoulder height and above.

Moderate – load passes through two zones

High – load passes through three zones

T.2. Reaching above shoulder or below mid thigh

Moderate – arms are partially extended over shoulder height during handling, or below mid thigh but above shins during handling

High – arms are fully extended overhead during handling, or to below the shins

T.3. Handling over long distances

Low – 2-4m

Moderate – 4-8m

High – >8m

T.5. Awkward, or twisted postures

Low – rotates or side-bends spine <45° during handling

Moderate – rotates or side-bends spine >45° during handling, or combines the two irrespective of the amount of rotation

High – rotation or side-bending combined with reaching

T.7. Unpredictable, fast or unexpected movements

Low – a small sudden, unexpected, or uncontrolled movement by the mother

Moderate – a moderate sudden, unexpected, or uncontrolled movement

High – very sudden, unexpected or uncontrolled movement

T.8. Work pace

Low – small element of pressure: mother appears relaxed but is working quickly

Moderate – pace of task likely to cause mother to lift for convenience: mother appears under pressure, is very task orientated and moving quickly

High – pace of work extremely likely to cause the mother to disregard her personal safety: mother is rushing, moving urgently, safety of child is at risk

T.10. Handling in a seated position

Low – handling in a seated position with arms in ideal zone (between shoulder height and waist, elbows angled to 90°)

Moderate – handling in a seated position with the arms outside the ideal zone, any side-bending *or* twisting while handling in the seated position

High – any combination of bending, side-bending, extending and twisting while handling in a seated position

T.11. Squatting, kneeling or crouching

Low – symmetrical handling from a balanced low squat or crouch

Moderate – handling from a deeper squat or crouch position or with an element of asymmetry

High – handling from unbalanced deep squat/crouch, or while kneeling, asymmetrical lift causing combined trunk movements, or prolonged squat prior to lift

Appendix G: Permission to use survey

From: Clare Hocking [mailto:clare.hocking@aut.ac.nz]
Sent: Wednesday, April 12, 2006 3:39 PM
To: Sanders, Martha Prof.
Cc: rmckaynz@hotmail.com
Subject: Request to access your survey: Ergonomics of Caring forChildren

Dear Martha

I am approaching you to ask whether it would be possible to access the seven-page survey you describe in your publication with Dr Tim Morse, titled The Ergonomics of Caring for Children: An Exploratory Study (The American Journal of OT, 59(3)).

The reason for my request is that one of my postgraduate students, Renee McKay, is embarking on a related study of the ergonomic risk factors for mothers of infants in New Zealand, in the course of daily occupations of child care. As you are aware, the risk factors are high but research in the area is surprisingly sparse.

Renee's intention is to gather quantitative data, using an observation tool developed by Occupational Health and Safety services in New Zealand, and to compliment that with demographic and qualitative data. It would be optimal if she could draw from your experience in this regard, as you have tested your survey measure quite comprehensively, making it the most appropriate, valid and established tool.

I am not sure of your position in relation to copyright and authorship issues. Obviously, Renee would identify yourselves as developers of the survey and provide full reference details. We would also be happy to provide assurances that we would not further distribute the survey, if you prefer that.

Looking forward to hearing from you

Clare

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>>> "Sanders, Martha Prof." <Martha.Sanders@quinnipiac.edu> 14/04/06 8:23:48 a.m.
>>>

Dear Clare,

Thanks so much in your interest in our survey. The survey is an initial attempt at gathering ergonomic information related to caring for typical children. Once you get started, I would be more than happy to share my ideas about how to improve the survey. I am also including an adapted version of the Standardized Nordic Questionnaire (that I used for another study). You may find this helpful as I would have liked more detailed information about the nature of MSDs from the parents. Your plan to gather observational data is definitely important and needed.

Again, I hope the survey helps you get started. The survey is not copyrighted, but I would appreciate reference information for myself and Dr. Morse as you suggested.

Good luck,

Marcy Sanders

Appendix H: Modified survey used in current study



Participant Number _____

THE ERGONOMICS OF CARING FOR CHILDREN

Background Information:

We understand that caring for children often demands physical tasks that can become fatiguing. This survey is designed to help us understand the physical stressors in caring for young children. The information we learn from the survey may help us in preventing physical discomfort related to caring for children.

This survey was developed by the *Quinnipiac University Occupational Therapy* department and the *Ergotechnology Center* at the *University of Connecticut Health Center*. The developers have kindly allowed it to be used in this study, with some modification.

Before filling it in, please make sure that you have read and understood the information sheet and read and signed the consent form. Thank you very much for your time.

1. Information About Your Child or Children

- 1.1 If you have more than one child weighing between 9 and 14kg, please fill out the columns starting with child 1 as the youngest, child 2 next, then child 3 as the oldest.

	Child One	Child Two	Child Three
Age			
Weight			
Sex			
Walking (W) Not Walking (NW)			

- 1.2 What are the ages and sex of *other* children in your family?

- 1.3 How would you describe your child's level of activity? Please mark an X along the continuum of activity.

Low activity level
Plays quietly most
of the time

Moderate activity level
Intermittent spurts
of busy and quiet play

High activity level
Always busy;
rarely sits still
during play

2. Information about You: Please provide the following information:

- 2.1 Age: _____ yrs
Weight: _____ kg Height _____ cm
- 2.2 With what ethnic group(s) do you most identify? _____
- 2.3 What is your marital status?
- ☐ Married with spouse at home
 - ☐ Living with significant other
 - ☐ Single
- 2.4 *If married or living with a significant other*, to what degree does this person share in child-raising tasks?
- ☐ Never participates (helps with 0% of tasks)
 - ☐ Occasionally participates (helps with 1-24% of tasks)
 - ☐ Frequently participates (helps with 25%- 49% of tasks)
 - ☐ Always participates (helps with 50% or greater tasks)
- 2.5 Are there other adults in your household who may participate in childrearing?
Please list these people and their relationship to you.

-
-
- 2.6 What is your work status?
- ☐ Not working for pay outside the home
 - ☐ Working part time: number of hours per day _____ number of days per week _____
 - ☐ Working full time: number of hours per day _____ number of days per week _____
- 2.7 If you work outside the home, what is your present occupation?

2.14 Please mark an “X” below the response that most closely describes how much you agree with the statement.

	Strongly Disagree	Disagree	Agree	Strongly Agree
I have enough time to get done what I need to do	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have sufficient time during the week to perform hobbies or other activities that are meaningful to me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Caring for my children requires a lot of physical Effort	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3.0 Childcare Practices

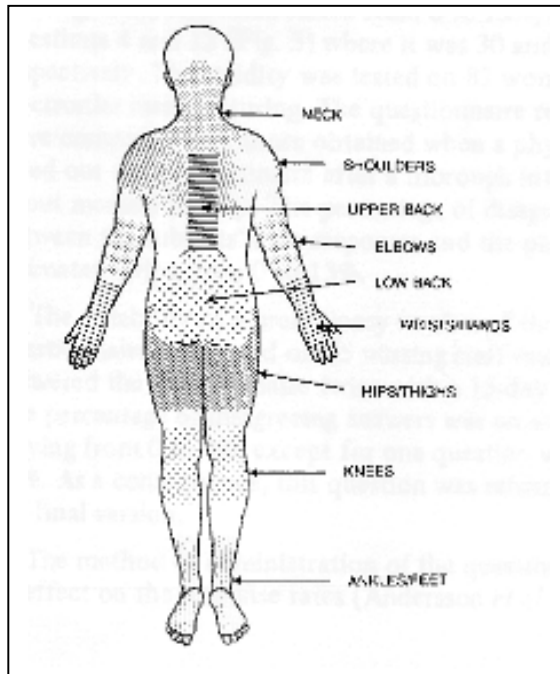
3.1 Please tick practices that you have done on a regular basis in the last month.

- ☐ Carry child in car seat while doing errands (use to transport child)
- ☐ Change your child on the floor, in cot or playpen
- ☐ Lift a child up to or off a changing table
- ☐ Lift a child into or out of cot
- ☐ Lift child up from the floor
- ☐ Stand bent over to wash your child in the bath
- ☐ Carry child on one hip while performing other tasks
- ☐ Carry a child while bending down to perform tasks
- ☐ Open baby food jars and cans
- ☐ Push a child seated on a low push toy, car or truck
- ☐ Breastfeed your child in an awkward position
- ☐ Bottle feed your child in an awkward position

4.0 Bodily Discomfort or Pain:

- 4.1 Please note areas of your body in which you have experienced pain or discomfort for either 7 days consecutively or 20 days all together in the last 3 months- ***that you think may be related to caring for your child or children.***

Please note the location of your pain on the diagram and then indicate the type of pain experienced by putting an S for sharp pain, a D for a dull ache and an N for areas of numbness or tingling. Draw an arrow towards the pain that causes you the ***most*** trouble.



S Sharp pain
D Dull Ache
N Numbness or tingling

- 4.2 Have you visited a health professional for this pain?

- ☐ Yes
- ☐ No

- 4.3 *If yes*, did you receive a diagnosis for your pain?

- ☐ Yes
- ☐ No

What was the diagnosis?

- | | |
|-----------------------------------------------|------------------------------------------------|
| <input type="radio"/> Carpal tunnel syndrome | <input type="radio"/> Shoulder tendonitis |
| <input type="radio"/> Wrist tendonitis | <input type="radio"/> Neck strain |
| <input type="radio"/> Lateral epicondylitis | <input type="radio"/> Thoracic outlet syndrome |
| <input type="radio"/> Medial epicondylitis | <input type="radio"/> Low Back Strain |
| <input type="radio"/> Cubital tunnel syndrome | <input type="radio"/> Sciatica |
| <input type="radio"/> deQuervain's disease | <input type="radio"/> Other |

If other please explain:

5.0 *Daily Activities in Childcare That May Cause Physical Discomfort*

Tick the following activities that you think may cause discomfort in the left columns. Tick all that apply for each of your children. Please make sure that child 1 is the youngest, child 2 is next and so on.

In the right column please rate how physically stressful you perceive the task to be for you on a scale of 0-9 with 0=no physical stress and 9=extreme physical stress.

5.1 Transporting Children

Child One	Child Two	Child Three		Stress Rating (0-9)
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Placing child in car seat or removing child from car seat	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Buckling child into car seat	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Placing child in pram or removing child from pram	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Carrying child in a car seat carrier while doing errands	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Turning neck while driving to view child in back seat	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Reaching arm back to rear seat while driving	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Placing child in trolleys at grocery or dept stores	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other/Comments _____	—

5.2 Changing Diapers/Toileting

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Changing child on floor or in cot or playpen	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lifting child up to or off of changing table	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Holding a child's legs up with one hand while wiping	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Opening and removing nappies from packaging	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lifting a child onto or off a toilet (if applicable)	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other _____	—

5.3 Dressing

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Dressing child- pulling shirt over head or pants over legs	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Undressing child	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Dressing and undressing for outdoor activities	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Fastening clothes (zips, buttons, snaps)	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other _____	—

5.4 Bedtime or Naptime Routines

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lifting child into or out of cot	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Supporting a sleeping child's head on your shoulder or arm	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Reading bedtime stories	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other _____	—

5.5 Feeding- Bottle and Food				Stress Rating (0-9)
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Opening baby food jars	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Opening cans of formula	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lifting the child in or out of the high chair	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Fastening the straps of the high chair or seat	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Cleaning food off the floor	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Bottle feeding in an awkward position	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Breast feeding in an awkward position	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other _____	—
5.6 Bathing				
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lifting the child <i>into</i> bath or sink	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lifting child <i>out of</i> bath or sink while wet	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Kneeling by bath to wash child	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Standing bent over to wash child in bath or sink	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Drying child	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other _____	—
5.7 Playing				
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Bending over while helping child walk	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Pushing a child seated on a low car, truck or push toy	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Sitting on the floor playing	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Bending to pick up toys (to put away)	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Playing games with child seated on ankle, foot, or back	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Carrying a child on your shoulders	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Prolonged squatting or stooping while playing with child	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Sitting on child-size furniture	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other _____	—
5.8 Performance of Daily Tasks/Chores Related to Childcare				
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Carrying child on one hip while performing other tasks	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Carrying a child while bending down to perform tasks	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lifting infant up or down to the floor	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Emptying nappy buckets	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Completing and carrying extra laundry	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Helping child wash hands	—
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Other _____	—

5.9 Leisure Activities that You Perform with Your Child

- | | | | | |
|-----------------------|-----------------------|-----------------------|---------------------------------------------------------|---|
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Use of a backpack to carry infant/child | — |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Use of a front pack to carry infant | — |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Use of a baby jogger | — |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Placing child in and removing from bicycle seat carrier | — |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Other _____ | — |

5.10 Of the physical activities you do while caring for your child, which do you think are most related to your pain?

5.11 Please tell us about any other issues or experiences in caring for your child that you feel has been related to your physical discomfort:

5.12 When you have had pain or discomfort, please tell us what activities this discomfort affects. Please tick all that apply.

- ☐ Work - paid employment outside the home
- ☐ Ability to sleep at night
- ☐ Ability to fully perform tasks related to childcare
- ☐ Ability to do household chores
- ☐ Quality of relationship with your child or children
- ☐ Personal self-care
- ☐ Safety of your child
- ☐ Your energy level
- ☐ Performance of hobbies

6.0 *Lifting*

6.1 Thinking about the lifting you do:
How would you rate the way you lift your child in terms of the risk for your body?

- ☐ Not safe
- ☐ Fairly safe
- ☐ Moderately safe
- ☐ Very safe

6.2 Briefly describe what you consider 'safe' lifting.

6.3 How did you learn about 'safe' lifting?

- ☐ Work-related formal training course
- ☐ Experience through lifting at work
- ☐ Heard from other people
- ☐ Pamphlets/brochures/advertisements
- ☐ Other _____ Please explain below.

Appendix I: Original NZMHHCR

Manual Handling Hazard Control Record

Task Details

1 Task name:

Area:

Assessor:

Date of assessment:/...../.....

Others consulted:

2 Sketch with dimensions (Optional)

3 Record the results of your:

Review of the company records: (e.g. hazard register, accident investigations, early reports of discomfort)

Figure 1: A schematic diagram of a 1D lattice chain with N sites. The chain is represented by a horizontal line with N discrete sites. The left end is labeled "Left lead" and the right end is labeled "Right lead". The sites are numbered 1 to N from left to right. The chain is connected to two leads, which are represented by dashed lines extending from the ends of the chain. The leads are labeled "Left lead" and "Right lead".

Consultation with Employees: (Talk to the people who do the task or who were injured doing it; get them to mime the task.)

[illegible]

Observation of the manual handling task: (Watch the employees doing the task, video the task. Describe the manual handling aspects of the task by writing down its steps.)

A 10x10 grid of colored dots. The dots are arranged in a pattern that is mostly uniform but has some variations in color and density. The colors include red, green, blue, yellow, and black. The pattern is somewhat abstract and does not form any recognizable shapes or text.

Task duration or cycle time:

Number of repetitions per shift:

Forces exerted (per cycle). (e.g. Lifting 16 kg bags, pushing with a force of 20 kg for 3 metres.)

[illegible]

Hazard Identification

4 Are any of these factors present in the task?

	No	Yes
Twisted, stooped, awkward, asymmetrical postures	<input type="checkbox"/>	<input type="checkbox"/>
Fixed, sustained, rigid, prolonged postures	<input type="checkbox"/>	<input type="checkbox"/>
Unvaried, repetitive movements	<input type="checkbox"/>	<input type="checkbox"/>
Sudden, uncontrolled or jerky movements	<input type="checkbox"/>	<input type="checkbox"/>
Handling or reaching away from the body	<input type="checkbox"/>	<input type="checkbox"/>
Using high or sustained force	<input type="checkbox"/>	<input type="checkbox"/>
Handling heavy or awkward loads	<input type="checkbox"/>	<input type="checkbox"/>
Whole body vibration or upper limb vibration	<input type="checkbox"/>	<input type="checkbox"/>
Handling that goes on for too long without a break	<input type="checkbox"/>	<input type="checkbox"/>

5 Is one or more of the boxes in question 4 ticked 'Yes'?

Yes ☐ go to questions 7 – 11 and find the risk score for the task

No ☐

6 If there is no evidence that there is hazardous manual handling, stop here. Review again according to your hazard review schedule.

Sign off:

Name:

Date:/...../.....

Risk Score

- 7 Find the load score:** The load score is the muscle force applied by the worker. It may be the weight of the object handled or you may need to measure the forces applied with a spring balance or a force gauge – or make an estimate. If several people do the task, the score should reflect the ability of the least able.

Men	Women	Load Score
< 10 kg	< 5 kg	1
10 - 19 kg	5 - 9 kg	2
20 - 29 kg	10 - 14 kg	4
30 - 39 kg	15 - 24 kg	7
40 +	25 +	10

Report the Load Score here → A

- 8 Find the posture and workplace layout score:** Observe the postures adopted. Take an average value if necessary or use numbers between the ones shown. **Posture Score**

• Trunk upright, no twisting, load close to body, standing or walking a few steps only.	1
• Some bending forward or twisting, load close to body, sitting, standing or walking for a longer distance.	2
• Bending far forward or close to the floor, slightly bending and twisting the trunk, load far from the body or above shoulder height, sitting or standing.	4
• Bending far forward and twisting the trunk, load far from the body, below the knees or above shoulder height, unstable posture while standing, crouching or kneeling.	8

Report the Posture/Workplace Layout Score here → B

- 9 Find the work conditions and environment score:** **Environment Score**

Good conditions, with sufficient space, no obstacles, level and solid floor surface, good lighting, able to get a good grip on the load.	0
Restricted workspace (area < than 1.5m ²), restricted postural stability (floor uneven, soft, slippery, sloping).	1

Report the Environment Score here → C

- 10 Find the time score:** Find the time score from the greatest of either the number of repetitions of the task or the time spent doing it during the shift.

Repetitions per shift	Total time per shift	Time Score
< 10	< 30 min	1
10 - 40	30 min - 1 hr	2
40 - 200	1 - 3 hrs	4
200 - 500	3 - 5 hrs	6
> 500	> 5 hrs	8

Report the Time Score here → TIME

Add the three scores in boxes A, B and C → Sum

- 11 Multiply box 'Sum' by box 'Time' to get the risk score.**

Decide the significance of the risk score. Follow the arrow and consult the table. If the risk score is 10 or more you should carry out the contributory factors assessment at question 12.

- Less than 10 ☐ Complete question 6 and you are finished, **unless** there is the risk that a single high force action could cause harm.
- 10 or more ☐ Complete the remainder of this checklist.

- 12 Tick any contributory factors that are present in the task.** Transfer each factor that you tick to Question 13. For example, if you ticked 'Handling over long distances', write 'T3' in Column A of Question 13. See the pages listed in the Code of Practice for Manual Handling for solutions for each factor.

A Load (Solutions page 30)

- L1. Heavy loads handled/high forces required ☐
- L2. The load is bulky or unwieldy ☐
- L3. The load is unpredictable ☐
- L4. The load is uneven in weight distribution ☐
- L5. The load is unstable or unbalanced ☐
- L6. The load blocks the handler's vision ☐
- L7. The load is difficult to grip, greasy or slippery ☐
- L8. The load lacks handles, or the size, position or shape of its handles makes handling awkward ☐
- L9. The load is very hot or cold, or hazardous ☐
- L10. The load is a live person or animal ☐
- L11. The load has sharp edges ☐
- L12. Other ☐

B Environment (Solutions page 31)

- E1. The floor is slippery, uneven or cluttered ☐
- E2. The area slopes or has steps ☐
- E3. It is hot, cold, humid, windy or wet ☐
- E4. The air quality is poor ☐
- E5. The environment is noisy ☐
- E6. The lighting is poor, glare or gloomy ☐
- E7. Insufficient space or confined space ☐
- E8. Other ☐

Guidance on the Meaning of the Risk Score

Risk Score	Urgency and type of control measure
<10	Injuries are unlikely unless there are infrequent high force actions. Monitor the task from time to time.
10 - 24	Injuries may result for less resilient people. Workplace redesign is recommended for them.
25 - 49	Injuries are possible for trained and fit people. Workplace redesign is recommended to control the contributory factors identified.
50 +	Injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace redesign is a priority.

Contributory Factors Assessment

C People (Solutions page 31)

- P1. There are too few staff to do the work ☐
- P2. Staff have poor skills, are untrained or new ☐
- P3. Staff have low strength or fitness ☐
- P4. Special considerations ☐
- P5. Inappropriate footwear, clothing or personal protective equipment ☐
- P6. People doing the task are of low resilience ☐
- P7. People work by themselves ☐
- P8. Fatigue can make the task unsafe ☐
- P9. There is poor employee commitment to health and safety ☐
- P10. Other ☐

D Task (Solutions pages 31 - 33)

- T1. Large horizontal/vertical reaches ☐
- T2. Reaching above shoulder/below mid thigh ☐

T3. Handling over long distances ☐

- T4. Repetitive movements with few or no breaks ☐
- T5. Awkward, twisted or restrained postures ☐
- T6. Freedom of movement restricted ☐
- T7. Unpredictable/fast/unexpected movements ☐
- T8. Uncontrolled/invariable work pace ☐
- T9. The task requires standing for a long time ☐
- T10. The task requires handling while seated ☐
- T11. Squatting, kneeling or crouching is required ☐
- T12. Handtools are poorly designed ☐
- T13. Handling requires two or more people ☐
- T14. Mechanical handling aids are used without training ☐
- T15. Personal protective equipment, special clothing or footwear make the task awkward ☐
- T16. Vibration ☐
- T17. Other ☐

E Management (Solutions pages 33 - 34)

- M1. There are insufficient rest breaks ☐
- M2. Involves piece work or other incentive schemes ☐
- M3. Shifts and/or unsociable hours are worked ☐
- M4. Too few staff are available during busy periods, when people are sick or deadlines are urgent ☐
- M5. Poor maintenance of tools, equipment, etc ☐
- M6. Staff are not involved in the selection, purchase or trialling of equipment ☐
- M7. Poor organisational communication ☐
- M8. Communication is compromised because people are separated by distance, protective equipment or by working in a confined space ☐
- M9. Task organisation ☐
- M10. Health and safety unimportant to the company ☐
- M11. Other ☐

Controls

- 13.** In column A, write the number of each contributory factor you ticked in question 12. Indicate the importance of the factor by circling one of Low Medium or High in column B. Write controls in Column C

(one to each row) and estimate their cost and impact in Columns D and E. Circle Yes or No in Column F to indicate whether or not the control measure will be actioned. Use a separate sheet if necessary.

A. Link to Contributing Factor	B. Risk (Low, Medium or High)	C. Controls: What are the possible solutions for controlling the risk posed by this factor? Transfer the control number to Column A, Question 14, if you will action it.	D. Cost of control (Low, Medium or High)	E. Impact of control (Low, Medium or High)	F. Action Yes or No
	L M H	1	L M H	L M H	Yes No
	L M H	2	L M H	L M H	Yes No
	L M H	3	L M H	L M H	Yes No
	L M H	4	L M H	L M H	Yes No
	L M H	5	L M H	L M H	Yes No
	L M H	6	L M H	L M H	Yes No
	L M H	7	L M H	L M H	Yes No
	L M H	8	L M H	L M H	Yes No
	L M H	9	L M H	L M H	Yes No
	L M H	10	L M H	L M H	Yes No

Action Plan

- 14** Starting with the most important, write the number for each control you decide to action in Column A. Indicate the term of the solution and the method of control in Columns B and C. Write the action plan, responsibilities and completion dates in the last three columns.

A. Control number from question 13, Column C	B. Term Short, medium or long term?	C. Method Will the control eliminate, isolate or minimise the hazard?	D. Action Plan Method: (How is the control measure going to be implemented and how will any related training be given to affected employees?)	E. Person assigned	F. Date for completion
	S M L	E I M			
	S M L	E I M			
	S M L	E I M			
	S M L	E I M			
	S M L	E I M			

Monitoring and Evaluation

- 15** Does the task pose a significant hazard?

Yes ☐ go to question 16
 No ☐ go to question 18

If the task poses a significant hazard, in the meaning of the HSE Act, and if you do not eliminate or isolate the hazard, you are required to monitor the health of the employees exposed to the hazard. You must take all practicable steps to obtain the consent of your employees to do this, but if they don't give their consent you don't have to do it. A Significant Hazard is one that poses a risk of Serious Harm, as defined in a Schedule to the HSE Act.

- 16** Which method of monitoring will be used to follow the musculoskeletal health of the people doing this task?

Talking with employees ☐ Discomfort reporting system ☐ Questionnaire surveys ☐ Periodic health assessments ☐

- 17** How frequently will this monitoring be carried out?

Continuously ☐ Daily ☐ Weekly ☐ Monthly ☐ Quarterly ☐ Every 6 months ☐ Annually ☐

- 18** Say how you will evaluate the effectiveness of the controls.

Control number	Type of evaluation*	Frequency	Who will confirm that the evaluation plan has been actioned?

* **Suggested methods:** Tracking: injury rates, injury severity, incidents reported, discomfort reported and sickness absence. A repeat hazard identification. General health and safety audits. Evaluating the quality of the product, the process efficiency or staff morale. Cost/benefit analyses.

Appendix J: Rating of Perceived Exertion (RPE) scale

C P.3.

I want you to rate your perceived exertion for this task, i.e. how heavy and strenuous the task feels to you. The perception of exertion mainly depends on the strain and fatigue in your muscles and your feeling of breathlessness.

Try to rate your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Don't underestimate it, but don't overestimate it either.

It's your own feeling of effort and exertion that's important, not how it compares to other peoples. Look at the scale and give a number.

6	No exertion at all
7	
8	Extremely light
9	Very Light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

9 corresponds to “very light activity”. For a normal, healthy person it is like walking slowly at his or her pace for some minutes.

13 on the scale is “somewhat hard” activity, but it still feels okay to continue.

17 “very hard” is very strenuous activity. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy and the person is very tired.

on the scale is extremely strenuous activity.. For most people this is the most strenuous activity they have ever experienced.

Appendix K: Visual Analogue Scale (VAS) for fatigue

P.8

I would like you to mark on the line below your level of fatigue (tiredness) today, right now.

No tiredness at all	Complete exhaustion
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Now I would like you to mark on the line below the fatigue you feel you experience on an 'average day'.

No tiredness at all	Complete exhaustion
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