Designing a Task Assessment Tool for Ease and Risk within the Domestic Environment

A thesis submitted for the degree of Doctor of Philosophy in the Faculty of Engineering of the University of Sheffield

by

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I. Abstract

Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) enable people to continue to live independently, as far as possible. Slowing down a person's decline or utilising equipment to maintain independence is a growing area of research. However, how we carry out daily tasks within the home can accelerate this decline. To date, little or no consideration has been given to quantifying load and the risk level associated with the performance of daily tasks within the home environment. This study evaluates and quantifies load and the risk level associated with the performance of domestic tasks which could be responsible for a person's change in behaviour in the later stages of life. In order to understand the IADL tasks, an initial survey was used to gather different people's perceptions about these tasks, and then to discover the hardest sub-task within the selected tasks. An observational study used existing ergonomic assessment methods to evaluate the postural load, and revealed that existing ergonomic tools are not enough on their own as they did not identify other risks which are associated with the performance of daily tasks.

Finally, a task assessment tool for ease and risk (AER) was developed to evaluate and quantify the risk associated with the performance of daily tasks. AER is useful in the detection of early warnings (pre-event) for healthy individuals as well as for those undergoing rehabilitation, as it can easily identify the tasks that are hardest to perform. The tool is based on three risk parameters: (1) psychological perception of the tasks, (2) adopted postures and (3) manual handling. It is capable of assessing the risk level associated with individual tasks while simultaneously assessing the domestic load over a period of time. The novelty of this work is to propose a self-assessment tool which provides the knowledge about a person's own risk associated with the performance of domestic tasks. The initial development of AER consisted of two phases: (1) development of AER and (2) evaluation of user trials, based on (a) ease of use of AER record sheet and (b) validity study. The AER trials overall used 20 healthy able-bodied participants and both trials were performed in the home environment. AER consists of a booklet and record sheets and specifically covers instrumental activities of daily living (IADL)[1] tasks but can also be extended to cover all tasks performed in the home environment. In the ease of use trial, the feedback questionnaire confirmed that AER is easy to use, free from ambiguity, applicable to almost all the tasks performed in the home environment and almost all participants agreed that AER does not require training for assessment. In the validity trials, the AER predicted risk level is measured in relation to perceived discomfort and it was found that AER has high sensitivity (78%), specificity (74%) and predictive (73% positive and 80% negative) values which revealed that AER is a sensitive and useful tool for identifying risk and perceived discomfort in performing daily tasks. It also concluded that the participants' self-assessed (IADL) exposure scores were reasonably similar as compared to the researcher's assessment and revealed that regular use of AER will help to obtain more accurate and reliable results. AER is able to assess the risk level associated with a single task and can also assess the general behaviour or domestic load over a period of time. AER is also helpful for identifying those tasks which required more caution when performed and which are responsible for someone's change in behaviour in later life. Moreover, it is believed that AER may play a vital role in the development of comprehensive and proactive strategies for the detection of problems related to the home environment and for managing them effectively before it can affect a person's quality of life.

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III. Table of definitions

The following are the definition of terms used within the thesis, taken by the author in this work:

Risk: exposure to the possibility of injury or damage as a consequence of the position in which a task is done.

Discomfort: Any slight pain or ache felt by a person during the performance of tasks.

Ease: Absence of discomfort or difficulty in performing tasks.

Exertion: Physical and mental effort required for a particular tasks.

Perceived physical demand: Understanding or awareness of the effort required to perform certain tasks or activities.

IV. Abbreviations

ADL	Activities of Daily Living
ALSAR	Assessment Living Skills and Resources
AMPS	Assessment of Motor and Process Skills
AusTOMs	Australian Therapy Outcome Measures
COPM	Canadian Occupational Performance Measure
CTDs	Cumulative Trauma Disorders
EAM	Ergonomic Assessment Methods
FIMTM	Functional Independence Measure
GNP	Gross National Product
IADL	Instrumental Activities of Daily Living
ICF	International Classification of Functioning Disability and Health
LBD	Low Back Disorders
LUBA	Postural Loading on Upper Body Limb
MSDs	Musculoskeletal Disorders
OCD	Cerviobrachial Disorders
OCRA	Occupational Repetitive Action Index
OSHA	Occupational Safety and Health Administration
OT	Occupational Therapy
OTM	Occupational Therapy Methods
OWAS	Ovako Working Postural Assessment
PC-PART	Personal Care Participants and Resources Tool
QEC	Quick Exposure Checklist
REBA	Rapid Entire Body Assessment
RSI	Repetitive Strain Injuries
RULA	Rapid Upper Limb Assessment
SI	Strain Index
ULD	Upper Limb Disorder
VAS	Visual Analogue Scale

WFOT	World Federation of Occupational Therapists

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1 Introduction

Being able to do Activities of Daily Living (ADL) and Instrumental Activities of Living (IADL) is an essential part of an independent lifestyle. The term ADL generally relates to the movements and care that a person takes of their own body. IADL is a progression from that to the life functions which are essential for an independent lifestyle. Inevitably, as time passes, changes can be noticed in people's ability to perform tasks which affect their habits. In early adulthood we can do virtually anything and perform any tasks instantly but as we grow older, we tend to need time to think and longer to perform the same tasks. According to Wiener et al., younger people may have some problems when performing everyday tasks but the prevalence rate is much higher in elderly people [2] because when people age, their bones become weaker and fragile, physical changes occur in muscle tissue, ligaments lose elasticity and joints begin to weaken [3].

Gillsjö et al., in a study which was based on phenomenography, illustrated four ways in which older adults deal with daily life and the long term pain of daily tasks at home [4]:

- *Ignore:* older adults ignore long-term pain during their busy daily lives
- *Struggle:* they continue trying to carry out tasks, despite long-term pain
- *Adjust:* they intentionally choose to adjust or reduce their activities and alter their behaviour and accept that it will include pain
- *Resign:* they stop doing certain activities and re-evaluate what can be done, which leads to some people having the attitude that it would be better to die.

This project is an endeavour to quantify the load and level of risk associated with performing daily tasks or activities as this is when most people are exposed to risks that are psychological (perception of the task) and physical (adopted postures and manual handling objects). According to Hedge et al., both occupational and non-occupational risks are responsible for musculoskeletal disorders (MSDs) [5]. Therefore, someone could exacerbate their level of risk of having MSDs by simply performing daily task or activities (non-occupational). To date little or no consideration has been given to quantifying load and the risk level associated with the performance of daily tasks (non-occupational) within the home environment. Hence, this project evaluates and quantifies load and the risk level which is associated with the performance of domestic tasks which could be responsible for a person's change in behavior in the later stages of life.

Quantifying the risk level in performing IADL tasks helps us to identify changes in habits and behaviour in the early stages of life within the IADL environment which could greatly benefit the whole population because loss of independence causes a substantial pecuniary burden on the health care system [6]. Moreover, good health and well-being ensure that an individual can lead an enjoyable and fulfilling life. Carrying out daily tasks is not easy, because in performing daily tasks people adopt various non-neutral postures of neck, arm, wrist and back which produce great strain and pain on sensitive parts of the body such as the hand, neck and back [7]. At a young age people can usually perform any given tasks easily but as they age, they start losing their muscle mass and strength [8] which causes limitations when they are performing basic activities of daily living or general tasks. The reduction in ability may increase the chances of injury or diseases such as lower back pain and arthritis. This study links two important disciplines – Ergonomics and Occupational Therapy – and it is hoped that the approaches and intervention by these disciplines will produce a positive impact on people's lives and make it possible for them to achieve their full potential.

The main concern of ergonomics is to develop the best fit between people and their tasks [9], whilst occupational therapy helps people in habilitation, rehabilitation and promotion of health and well-being [10]. The principles of ergonomics can be used to study the effects of force and awkward postures on the distal (hand and wrist [11]) and upper part of the body (shoulder, neck and back [12]) when performing IADL. So far, ergonomic assessment techniques such as the

Rapid Entire Body Assessment (REBA) [13], Rapid Upper Limb Assessment (RULA) [14, 15] and Postural Loading on Upper Body Limb (LUBA) [16] have mostly been used in industrial work environments [14, 16]. However, no attempt has been made to use ergonomic tools to evaluate activities in the home environment.

Occupational therapy enables people to carry out effectively the activities which are necessary for independent living and increases satisfaction in all facets of life. This therapy uses various tools and assessment to develop strategies of care of individuals and has developed many ADL and IADL assessment tools that are currently available to evaluate the degree of independence in patients. They are generally used as rehabilitation tools after the occurrence of a specific incident (post-event). However, they are not meant for the identification of the risk. In contrast, the ergonomics assessments are based on current practices and provide information about the risk, thereby enabling injury to be prevented before it happens (pre-event). This leads in to the purpose of the study, to implement ergonomics assessment techniques (REBA, RULA and LUBA) in analyzing daily tasks such as mopping, food preparation and doing the laundry. It was concluded in this study that the ergonomics assessment tools on their own were not sufficient because although they successfully identified the hardest task through postural analysis, they did not consider other risk parameters such as psychological perception of the tasks and manual handling. There is a need for an assessment tool specifically designed for domestic tasks which could potentially address the other risks and quantify the load and risk level in daily tasks. The tool to be designed will provide risk information to the general public through self-assessment and stimulate a discussion about the tasks which are harder to perform. Having some knowledge of the risk will help to prevent injury by assisting people to stop performing tasks in a wrong way so that they can protect themselves from any injury that could otherwise happen in the future. In addition to this tool it is also helpful to compare the current risk levels with previous or future risk levels and see how people are coping with the ability to perform activities of daily living.

1.1 Statement of the Problem

The problem being addressed by the PhD study can be defined as the known statement that there is an increased risk in later life of injury (and associated loss of independence) resulting from poor postural behavior in carrying out Instrumental Activities of Daily living [5, 17]. This research evaluates a person's risk of having MSDs through performing domestic tasks (non-occupational). And thus with a greater understanding of that risk put in place an assessment methodology with the aim of increasing independence by decreasing risks related to bad postures associated with the performance of IADLs. In order to identify the level of risk associated with the performance of IADL tasks and to assist individuals with those IADL tasks which are harder to perform, this research study developed a tool for IADL which will help the individual to know own risk level in performing tasks in home environment. Also the designed tool will have potential to use by product designer to develop products and tools for IADLs.

1.2 Rationale of the research

Human ageing is becoming a major research area among researchers in different disciplines such as engineering (e.g. mechanical specialties, ergonomics, biomechanics), medicine and behavioural, biological, sports, exercise and social sciences. However, the research activities based on older society have largely been overlooked in the development of products used by this group of people. In recent years, the dependency issue has risen in societies which have led to an increase in the need to link the different disciplines, within this study the scope has been limited to occupational therapy and ergonomics such that the benefits of collaboration can be explored and demonstrated. Occupational therapy seeks to maximize a person's ability to be independent and assesses the individual's ability to carry out the specific tasks in specific contexts (person, task/activity and environment). The context can be domestic or professional and the assessment can be reactive and predictive. Occupational therapists plan forward based on an individual's current ability, estimating future abilities based on health status, awareness of illness, and awareness of lifestyle and occupation. While ergonomics assessments are based on the identification of physical risk factors such as force, repetitive motion, awkward posture, contact stress and muscular fatigue etc. [18] which in turn lead to musculoskeletal disorders. There are also many assessment tools available in ergonomics which are predictive, robust, inexpensive, noninvasive, quick and easy to use [19] and rapidly assess relative risk of MSDs resulting from the performance of task in work environment [19]. Therefore the idea of interdisciplinarity [20] is used in this study.

It is known that IADL tasks are essential for independent living. There are many IADL tasks which need to be performed but often people adopt awkward postures which may cause discomfort, and if these remain unchanged, lead to permanent damage such that they may end up with disability or dependability in the future. During the performance of daily tasks people can slouch or bend to pick objects up because they feel comfortable at the time without considering the 'cost' in later years. As such they ignore the long term risk associated with poor postures for short term gain. National policy around active aging discourages inactivity [21] and encourages people to perform some daily activities such as gardening (fraught with risk of injury from bad postures) because the risks associated with inactivity (physical, emotional and mental health) are greater than risks associated with injuries from gardening. However, if these type of activities are uncontrolled or unmonitored then performing such activities and their risks might be equal or greater than inactivity risk which make them susceptible to increase risk in later life which resulting in dependency in future. Therefore it is essential to control or monitor and evaluate the bad postures and their associated risks in daily activities.

As mentioned earlier, there are many assessment tools available in both occupational therapy and ergonomics but none of them is fit for evaluation of a risk associated with the performance of domestic tasks. So, there is a need for such an assessment tool that can help ordinary people in evaluating their risk in performing the daily tasks. In addition to that, it would be possible to make the designed tool available for product designers, with a slight modification in order to inform design such that it can take account of these risks in the development products and tools for IADLs. Through the designed tool product designers would be able to analyse and identify any potential risk before then modifying the design such that it would minimise any risk due to reduced strength and ability of the end user. The developed tool will also be of use to health care professionals such that it could be used to plan a person's safe activity level based on their current ability and awareness of illness and lifestyle.

1.3 Scope of the Thesis

The important feature of this study is to discuss the increased risk in later life because person is more concern about losing their independence in later life. This study has overcome this problem by developing the tool for IADL tasks that uses the knowledge from two disciplines that are occupational therapy and ergonomics. The knowledge from other disciplines (Sports, Exercise science, biomechanics and physiotherapy) can also be used to design the tool for above mention problem but for this study we can stuck with occupational therapy and ergonomics.

In this study the scope of the design tool is also limited to domestic environment and this tool is used by ordinary person and helps those people who involved in designing product and tool for IADLs. There are many other professions (occupational therapy, physiotherapy and designers etc.) in which this tool can be used but it requires some modification and introducing some other multipliers such as age and strength etc. Therefore customization of this tool for other professionals is out of the scope for this thesis, however some recommendation can be found in future work section.

1.4 Aim and objectives

This study has both a “global aim” and a “specific aim”. The global aim of this study is to increase the independence by decreasing the risk related to bad postures associated with IADLs and this global aim is achieved through the specific aim which is developing the tool for an individual (so that they can evaluate their own risk in performing daily activities) and make the tool available for IADL product designers, so that they rapidly assesses ergonomic injury risk associated with IADLs, such that these designers can minimize such risks. In order to achieve this aim, the study incorporates the following objectives:

1. Based on the definition of IADLs given by Lawton [1], This study will determine which IADLs are most associated with a loss of independence and increased risk of injury.
2. Identify and compare different task/activity assessment methods from occupational therapy and ergonomics in order to quantify load and understand risk. Also assess the appropriateness of the identified assessment methods to assess the risk of injury associated with IADLs.
3. Identify the key parameters within tasks and activities within the home environment and potential methods for their assessment.
4. Propose an assessment tool for domestic tasks that quantifies load and risk.

2 Background of the study

Ageing is an individual process [22] and represent the accumulation of changes in a person's physical and psychological behaviour over time [23, 24]. However, one aspect that is very clear is that a variety of problems come with ageing, such as losing independence, which is normally due to musculoskeletal disorders (MSDs) [25]. Ageing can affect person's mobility which results in limitations in performance of activities of daily living. It can be interfere with the person's physical ability to perform the tasks by decreasing muscles strength and hand related ability (dexterity) which may result in loss of independence in later life [26]. Aging leads to decrease of muscles strength and flexibility, as it is mentioned in literature that normally person's muscles strength peaks around the age of 25 years, plateau through the age of 35 or 40 years and then shows an accelerating decline with 25% of peak force by the age of 65 years [27]. A researched conducted by Rocha, Santos et al. showed that muscles strength is an important predictor of functional ability of a person (especially in elderly people) during the performance of daily tasks [28]. Therefore loss of strength impedes person's ability to perform simple daily activities such as carrying the 5kg grocery bag, to open a bottle of medicine and even to lift the body weight from a toilet seat. Postures adopted by a person during the performance of tasks has the major impact on the expression of human muscles strength [27] because adaption of good postures involve in distributing the force of gravity evenly through our body so that no individual body part or joint is overstressed, as a consequent person feel ease or comfort in performing their tasks. While those have habit to adapt bad postures, then their body parts or joint is out of alignment and the weight distribution around that body part or joint is uneven and will put unnecessary strain on muscles, bones and joints [29] which increases the chance of injuries or disease such as neck and low back pain in later stages of life.

The elderly population is increasing around the world as the birth rates fall. The proportion and number of people over sixty years of age in the developed countries has been gradually increasing. In the UK, there are now 15, 11.6 and 1.5 million people aged over 60, 65 and 85 years or over [30] and this trend is expected to continue due to enhanced medical conditions, which results in longer life expectancy, and are also expected to propel the proportion further. In other countries such as Germany and Japan ageing is increasing rapidly whilst in others such as the UK it is not growing as rapidly [31]. According to the International Business Times, the growing elderly population is putting an immense strain on countries infrastructure and also affecting other important services such as health, education, and housing [32]. However, according to Tim Brown, "in England, there is likely to be a tenfold increase to 1.8 million older and vulnerable people by 2028" [31]. Therefore, it is necessary to consider and reduces the dependency issues within society, which might help researchers and practitioners to remove the barriers and undue effort from elderly people's lives and enable them to live independently in their homes for as long as possible and to participate happily in their daily or social activities.

Musculoskeletal problems in the UK are common and are a major cause of disability [33]. Musculoskeletal pain is widespread throughout the population and has a substantial influence on quality of life [34], especially in older adults [35]. Research conducted by Myers, Thomas et al. showed that hands are the most common site of pain [36]. Musculoskeletal pain is also one of the common causes of disability and its symptoms are common within the elderly community [37]. The musculoskeletal pain is complex and can affect the hands, shoulders, neck, back, knees, hips or feet [38]. The common causes of musculoskeletal pain, which lead to disorders, are: excessive force; awkward postures; and excessive bending, reaching or twisting. The risk factors associated with musculoskeletal pain which lead to disorders are related to work activities as well as non-work ones [39]. The prevalence of musculoskeletal pain significantly impacts the older adult population, affecting their quality of life and ability to live independently [40]. According to Urwin, Symmons et al., musculoskeletal symptoms are widespread in adult communities with more than 8.3 million adults suffering from musculoskeletal disorders in England [37], further these disorders are largely recurrent [41]. The prevalence of physical disability due to musculoskeletal disorders increases with age. Similarly, work done by Thielke, Whitson et al. showed that musculoskeletal pain slowly and steadily progresses with age [42, 43]. The General Household Survey conducted in 1995 [44] showed that, musculoskeletal disorders were the most frequent self-reported illness [37] and the prevalence rate was higher in women [37, 44] as compared to men. Therefore, the physical disability and pain due to musculoskeletal conditions can affect a person's social functioning and make their daily life more miserable [45].

The problem being addressed by this work is the "increased risk in later life of injury (and associated loss of independence) resulting from poor postural behaviour in carrying out Instrumental Activity of Daily Living". Therefore, this interdisciplinary project [20]develops something new by crossing the boundaries and thinking enhancing understanding about the particular problem [20, 46]. Knowledge from occupational therapy, ergonomics, sports and exercise science, biomechanics and physiotherapy will all be applied to this problem in order to fulfil the aim. This wide range of knowledge is needed to develop a self-assessment for the domestic environment and through that tool it will be possible to analyse daily tasks and risk level associated with them. The two key disciplines are "Occupational Therapy" and "Ergonomics". As occupational therapy assessment methods are effective for evaluating person's independence level and used as a rehabilitation tool to restore the person's ability to perform daily tasks independently while the ergonomics assessment methods successfully evaluate the risk of injury related to performing any tasks and activities. In the past, there are many assessment methods developed by researchers in different disciplines, these tools are very efficient in their specific context but none of the existing assessment tool is fit for assessing or evaluating risk of injury associated with the performance of daily activities within domestic environment. Table 2-1 shows some commonly used assessment methods in different disciplines.

Table 2-1 Assessment methods used in different disciplines

S. No.	Disciplines	Assessment methods used	Sources
1	Occupational Therapy	1. Katz ADL Index 2. Lawton Brody IADL scale	[1, 2]
2	Ergonomics	1. Strain Index (SI) 2. Rapid upper limb disorder (RULA) 3. Rapid entire body assessment (REBA)	[47-49] [12, 13]
3	Sports and Exercise Science	1. Athletic Ability Assessment (AAA) 2. Posture Assessment 3. Acceleration and Agility 4. Push-up/pull-up Challenges	[50, 51]
4	Physiotherapy	Clinician completed: 1. American Foot & Ankle Score 2. Mayo Wrist Score 3. Modified Cincinatti Rating System (Knee) 4. UCLA Shoulder rating Scale Patient completed: 1. Knee injury & osteoarthritis outcome (KOOS) 2. Foot & ankle disability index 3. Disability of arm, shoulder & hand score (DASH) 4. Oswestry low back pain score	[52]

Apart from the methods discussed above, another set of methods used by occupational therapists and ergonomists are subjective assessment scales , used to analyse parameters such as perceived fatigue, anxiety, depression and discomfort [53]. Two methods are commonly used as subjective scales are as follows: (more detail on these scale found in section 3.3.7)

1. The Visual Analogue Scale (VAS)

2. Borg Scale of perceived exertion

Similarly, there are many previously developed assessment methods within a work context that have been developed by different researchers, table 2-2 shows the brief explanation on recently developed ergonomics assessment methods. More detail on this can be found in section 3.3.8. However none of the existing assessment methods are suitable to fulfil the entire aim of this study.

Table 2-2 Brief description of recently developed ergonomics assessment methods

Assessment methods	Developed by
WERA: An observational tool develop To investigate the physical risk factors associated with WMSDs [54]	Rahman, Rani et al. in 2011.
Assessment of repetitive tasks of the upper limbs (the ART tool) [55]	Health and safety executive (HSE) in 2009
Novel ergonomics postural assessment methods (NEPRA) using product-process computer aided engineering ergonomics work place design [56]	Sanchez-Lite, Garcia et al. in 2013
ROSA: Rapid office strain assessment [57]	Sonne, Villalta et al. in 2012
A Manual Tasks Risk Assessment tool (ManTRA) was developed as part of a research collaboration between The University of Queensland, Curtin University of Technology, and the Queensland Division of Workplace Health and Safety. The tool assess the level of risk of injury associated with specific workplace tasks [58].	Burgess-Limerick, Egeskov et al. in 2000
Ergonomics screening tool [59]	The ergonomics centre North Carolina in 2012

As mentioned earlier, that this study links two important disciplines (ergonomics and occupational therapy) and it is hoped that the approaches and intervention by these disciplines will produce a positive impact on people's lives and make it possible for them to achieve their full potential. To achieve the aim, techniques such as conducting surveys and observational study are used within the respective context (see table 2-3). Therefore, the focus of this project is to design the self-assessment tool which evaluates and quantifies load and the risk level which is associated with the performance of domestic tasks which could be responsible for a person's change in behaviour in the later stages of life. Once the tool has designed, then the tool will make available for product designers (after slight modification) who involved in designing products for IADLs, so that they rapidly assesses ergonomic injury risk associated with IADLs, such that these designers can minimise such risks.

Table 2-3 Project further details and the research techniques used

Position in thesis	Title in the thesis	Procedures	Techniques used
Chapter 6	Investigation into IADL tasks	Investigation based on 8 research questions: Section 1: contain 2 research questions Section 2: contain 2 research questions Section 3: contain 4 research questions	Conduct Survey through a questionnaire
Chapter 7	Experimental work	Mopping task	Simulate in lab
		Food preparation	• Conduct survey • observational study
		Laundry	• Conduct survey • observational study
Chapter 8	Development of task assessment tool for ease and risk within domestic environment	Development of tool is based on the selection of following parameters and criteria: 1. Psychological perception • Perceived physical demand • Perceived complexity 2. Adopted postures 3. Manual handling 4. Duration and frequency of a task	• Subjective rating scale and traffic light system • Assessment criteria (based on ergonomics literature [55]) of different body parts used in tasks performance • Assessment criteria (based on ergonomics literature [60, 61]) of manual handling of loads during the performance of tasks

3 Literature review

This section looks at the relevant literature surrounding the problems faced by people in performing activities of daily living, current practice surrounding this and potential methods that could be utilised. This literature review is divided into three sections: the first section discusses the literature review process and methods. The second section discusses interdisciplinary techniques and disciplines which could be used in this study, and helped to select appropriate discipline among many disciplines for this study. The final section discusses the research methods or methodology used in the study. Table 3-1 shows the detail structure of the literature review chapter.

Table 3-1 Detailed structure of literature review chapter

Literature review	Topics discussed	Details of topics covered in this chapter	Comments
Section 3.1	Literature review process and methods	-Criteria for Selection and Review of Articles -Literature search methods (databases used) -Keywords used	Explained the whole process so that it can be repeated easily
Section 3.2	Interdisciplinary disciplines	-Occupational Therapy -Ergonomics -Sports and exercise science -Physiotherapy -Biomechanics	Discuss different disciplines and decided which disciplines and their assessment methods is good for addressing the problem studied
Section 3.3	Research methods or methodology	-Experts Interview -Survey -Observational based studies -Subjective assessment methods -Previously developed self-assessment tools -Validation techniques used	

3.1 Criteria for selection and review of articles

In planning this literature review, the author has set the specific criteria for the selection of articles for the epidemiology review:

1. The articles address the loss of independence explicitly due to the performance of domestic tasks. For that, inclusion and exclusion criteria (see figure 3-1) have decided based on the topics covered in respective disciplines.
2. The article that discusses the health outcomes based on the special conditions (such as musculoskeletal pain and disorders of neck, back, and upper extremities associated with the daily domestic activities) and their eligibility were measured by clearly defined inclusion and exclusion criteria (see figure 3-1 based on topics) before writing the literature review.
3. The articles from different disciplines (interdisciplinary) is also considered in this literature review, but measured their eligibility with predefined inclusion and exclusion criteria.
4. The articles which discussed the state of the art assessment methods in selected disciplines also incorporated in this literature review.
5. Preferably the articles were published in English language.
6. Prefer those articles which were peer reviewed.
7. Preferably, consider those studies which were done within the last 30 years.

3.1.1 Literature search methods

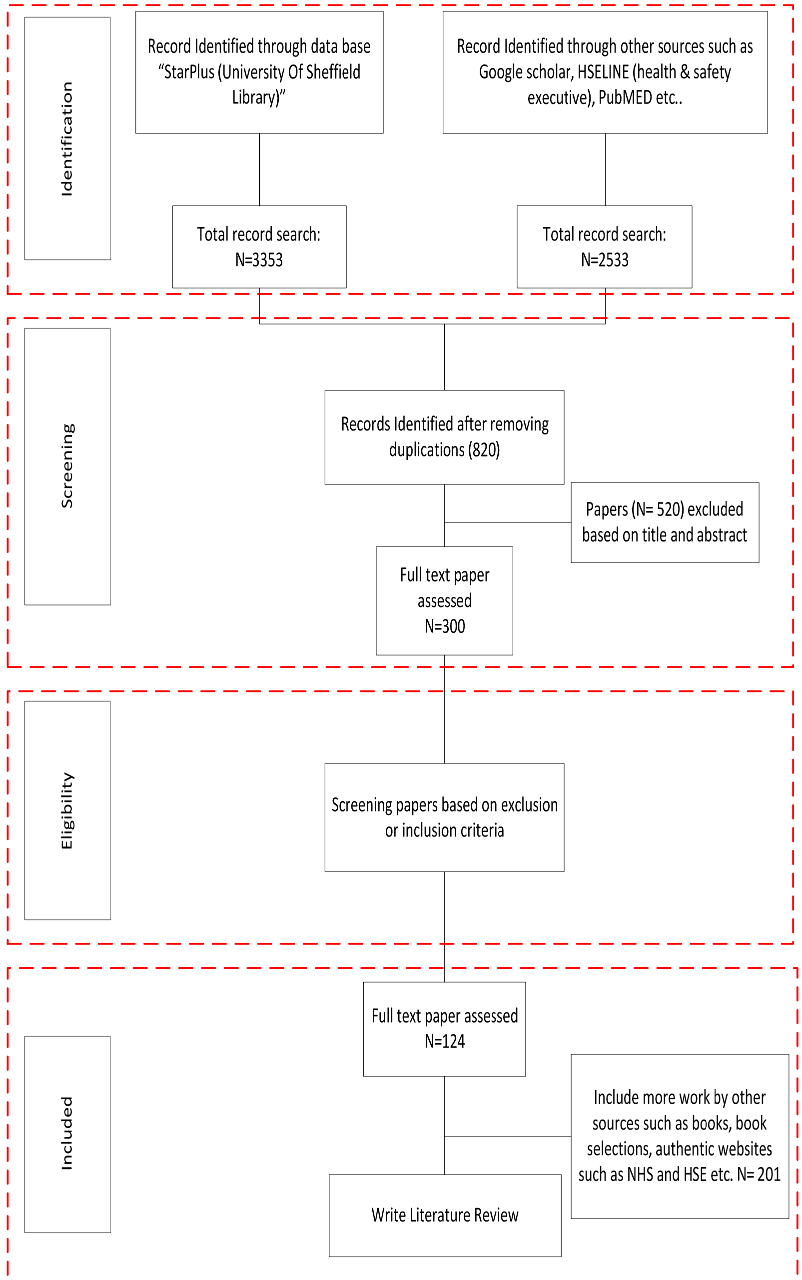
This literatures reviews were conducted using computer based databases, with StarPlus (University of Sheffield library database) a component of all literature search. Additional database included Google scholar, HSELINE (health & safety executive, UK) and PubMED etc. For inclusion in this review, a candidate list of papers were established by using above mentioned database and systematically screened in order to determine which papers met the strict criteria. Therefore, each process substantially reduced the list of papers. Initially, 820 papers were identified after removing the duplicates. 520 papers were excluded by simply screening through the titles and abstract and rest of the paper (300) were screened through the pre-defined inclusion and exclusion criteria, finally 124 papers were found to be eligible for this literature review. Similarly, some more work (N=201) also included by the other source such as books, books selection and authentic websites (for example NHS, HSE etc.). Figure 3-1 shows the systematic literature review flow diagram.

3.1.2 Keyword used in the research

Recently researchers are using the most common methods of identifying the literature, that is through the keywords [62]. However, careful consideration required for the keywords searching because the selected terms will generate the data being reviewed. A part from that, other strategies such as Boolean operations also used to find the keywords which combine the different keywords by using words such as AND, OR and NOT etc. [62] that might elicit further information about the desired topic.

Following are the some common keywords used in this study: Ergonomics, home ergonomics, ergonomics in domestic environment, ergonomics and gerontology, ergonomics and activities of daily living, ergonomics assessment methods, ergonomics observational based methods, rapid upper limb assessment, rapid entire body assessment, strain index, postural load assessment, ovako working postural assessment system, ageing musculoskeletal pain, ageing musculoskeletal disorders, occupational therapy, occupational therapy assessment methods, activities of daily living and instrumental activities of daily living, discomfort, loss of independence in activities of daily living, dependency in activities of daily living etc.

Keyword used: Ergonomics, home ergonomics, ergonomics in domestic environment, ergonomics assessment methods, ergonomics observational based methods, rapid upper limb assessment, rapid entire body assessment, strain index, postural load assessment, ovako working postural assessment system, ageing musculoskeletal pain, ageing musculoskeletal disorders, occupational therapy, occupational therapy assessment methods, activities of daily living and instrumental activities of daily living, discomfort, loss of independence in activities of daily living, dependency in activities of daily living etc.



Exclusion criteria

Occupational therapy studies excluded based on following topics:

- Using prostheses, orthotics and splints
- Neuro-prosthesis for grasping & reaching
- Cognitive teaching approach
- Behavioural approach to rehabilitation
- Psycho-education program for active learning
- Neuro-development Therapy
- Pain management program for functional restoration
- Occupational rehabilitation program
- Evaluation of occupational therapy interventions etc.

Ergonomics studies Excluded based on following topics;

- Ergonomics design philosophy
- Cognitive skills
- Equipment design
- Human reliability & information transfer
- Organisational factors in work design
- Environmental factors (noise, temperature etc.)
- Models of the human operating equipment
- Selection, design and arrangement of controls and displays
- Medical surveillance for ergonomics program etc.

Inclusion criteria

Occupational therapy studies Included based onthe following topics:

- Basic occupational therapy techniques
- Independence in daily activities
- Assessment methods in occupational therapy
- Katz ADL index and the Lawton IADL scale
- Ageing musculoskeletal pain and disorders
- Risk factors associated with work and non work environment
- Occupational therapy adaptive interventions (e.g. housing and environmental adaptive)
- Universal design based on the need for people with disabilities

Ergonomics studies Included based on following Topics:

- Fundamentals of Ergonomics
- Basic home ergonomics
- Ergonomics assessment tools
- Ergonomics in non-occupational environment
- Individual factors and musculoskeletal disorders
- Ergonomics risk factors associated with distal and lower extremities
- Perceived discomfort
- Perceived exertion
- Universal design for elderly people
- Ergonomics in daily life
- Ergonomics for kitchen
- Muscular fatigue during daily domestic activities
- Musculoskeletal discomfort assessment
- Postural analysis during daily activities
- Methods for evaluating postural load
- Manual handling

Figure 3-1 Systematic literature review flow diagram

3.2 Interdisciplinary disciplines

Before reviewing the literature under interdisciplinary disciplines, it is necessary to discuss the need of knowledge from different disciplines and what it means in this project. As mentioned earlier that this study is based on evaluation of person's risk of having MSDs through performing domestic tasks which is associated with loss of independence in later life. According to Williams, "Risk is inherent in every situation and for every activity"[63]. Therefore, the evaluation of risk within domestic environment is also very important because "the potential risk of losing one's independence can be terrifying"[64] and the survey (title: People are more concerned about losing their independence when they get old than dying) published in 2009, has concluded that "As people contemplate their later years, it seems that what worries them most is not the end of life but the quality of their time." [65]. Unfortunately, people are facing a loss of independence at each stage of their life and become susceptible to more losses in the later years of their life. The loss of an individual's independence is often gradual and unpredictable, and can jeopardize their freedom, which causes their quality of life to be affected and decline [64, 66]. Loss of independence increases a person's anger, guilty, confusion, shame and defiance [66, 67]. To maintain independence in performing activities of daily living, researchers as well as healthcare centres and government have a vital role to play in terms of resources which will keep people healthier and remaining independent, thus enabling them to live in their own homes as long as possible [68]. According to the Chief Executive of the charity Disabled Living Foundation (DLF), "Getting older should not be a barrier to having choice and control over the quality of your life, or be a reason to move out of your own home" [65, 69]. The loss of independency issue within the society is quite recent and impacts the whole population especially in elderly people, and gained much attention from researchers and healthcare professionals. Therefore it has been decided to use the interdisciplinary techniques and their respective assessment methods to address the above mentioned problem and how we can cope with it?. For this study five interdisciplinary disciplines has selected: 1. occupational therapy, 2. ergonomics, 3. sports and exercise science, 4. physiotherapy and 5. biomechanics. The next sections provide the overreaching information and detailed academic comparison about the broader range of assessment methods in each discipline.

3.2.1 Occupational Therapy

Occupational therapy is defined as “therapy based on engagement in meaningful activities of daily life (as self-care skills, education, work, or social interaction) especially to enable or encourage participation in such activities despite impairments or limitations in physical or mental functioning” [70]. According to the World Federation of Occupational Therapists (WFOT), “Occupational therapy is as a profession concerned with promoting health and well-being through occupation. The primary goal of occupational therapy is to enable people to participate in the activities of everyday life and live a healthier lifestyle” [71, 72]. Occupational therapists attain this outcome “by enabling people to do things that will enhance their ability to participate or by modifying the environment to better support participation.” [71-73]. The primary objective of occupational therapy is to prevent disability [74] and enable people to function well and experience well-being in their day to day activities [75]. Occupational therapy aims to support not only the elderly but also young people to achieve their potential goals by getting the most from their lives [76]. It therefore enables people to carry out effectively the activities which are necessary for independent living, and increases their satisfaction in all facets of life. Occupational therapists assist people of all ages [77, 78] and treat physical and psychological problems that prevent people from performing personal care tasks and activities of daily living.

3.2.1.1 Activities of daily living (ADLs) and instrumental activities of daily living (IADLs)

People will often experience illness or injury when they attempt tasks that are beyond the limits of their physical capability. As they age, these limits change and everyday tasks that previously did not cause pain or injury may now do so. What was once a simple task requires more effort as their bodies adjust to increasing age. A person's lifestyle and the way they work dramatically affect their bodies, reducing tolerance to stresses, illnesses and injuries especially as they become older. ADL refers to those activities which are essential in order to live independently; they focus on activities requiring the movement of the body in and around the home.

ADL includes activities such as bathing, dressing, homemaking, toileting, transferring, continence, and feeding [2, 79, 80], which are necessary for living independently. The integration of the physical, social and economic well-being of our life determines our quality of life. Younger people below the age of 50 years may have some problems performing ADLs. However, the prevalence rate is significantly higher in the elderly [2]. Among this group, the prevalence in people experiencing difficulty performing ADLs increases sharply as age increases, especially for a person aged 85 and above [81]. Lawton and Brody have presented another term, IADL ("instrumental activities of daily living" [1] which is a progression of life functions that are essential for everybody to live an independent lifestyle. These include handling personal finances, doing house work, using the telephone, and taking medicines [2]. According to Pinto, Medici et al., by using ADL and IADL measurements, one can easily determine how effectively older people perform their day by day activities [82]. Table 3-2 Basic ADL and Instrumental ADL.

Table 3-2 Basic ADL and Instrumental ADL

Basic ADL [1]	Instrumental ADL [2]
1. Bathing and showering	1. House work
2. Bowel and bladder management	2. Managing money
3. Dressing	3. Shopping for groceries or clothing
4. Eating	4. Use of telephone
5. Feeding	5. Using technology
6. Functional mobility	6. Transportation within community
7. Personal device care	
8. Personal hygiene and grooming	
9. Toilet hygiene	

Source: [83]

3.2.1.2 Commonly used Occupational Therapy Methods (OTM)

Table 3-3 shows the current assessment tools which are commonly used in occupational therapy for the assessment of ADL tasks. The two basic and commonly used occupational therapy methods for assessing functional status as a physical disability are the Katz index for ADL and Lawton IADL scale [84] which are discussed in detail in next section.

Table 3-3 Summary of the current assessment tools which are commonly used in occupational therapy for the assessment of ADL tasks

Tool name	Explanation	Strengths	Limitations
Katz ADL scale [85]	It uses techniques such as interview and observation to determine ability with basic ADL and mobility tasks.	It assesses the basic activities of daily living. A clinician uses this tool to plan care for the patient accordingly. It is sensitive to change in declining health status	This tool does not consider more advanced ADLs such as such as heavy housework, shopping, managing finances and telephoning
Lawton IADL scales [86]	The scale is helpful in identifying and detecting the improvement or decline in the current functional status of a person [84].	Provides self-reported information about functional skills which are necessary for independent living.	It includes self or surrogate report method of administration rather than a demonstration of the functional task which may lead to an over or under estimate of ability.
Bristol Activities of Daily living Scale [87]	The Bristol scale is an informant-rated measure that covers 20 ADLs, both basic and instrumental. Items are rated on a four-point scale.	it measures the daily living abilities for people with dementia	It is designed for a specific condition.
Functional Independence Measure (FIM™) [88]	The FIM™ instrument is a basic indicator of patient disability. It is used to track the changes in the functional ability of a patient hospital rehabilitation care.	It measures the level of disability and indicates the level of assistance that is required by the individual to carry out activities of daily living.	The FIM score depends upon the individual conducting assessment and requires proper training and education prior to using this tool. It includes 5 items for cognition, so it may be inadequate.
Assessment of Motor and Process Skills (AMPS) [88]	The AMPS is used to measure how well a client performs familiar activities of daily living.	It is good at evaluating a person's quality of performance of personal or instrumental activities of daily living	It is not good for evaluating the presence of underlying neuromuscular, biomechanical, cognitive, or psychosocial impairments (e.g., strength, motor planning and praxis, memory, executive functions, sensory processing)

3.2.1.2.1 ADLs Scale

The basic and commonly used occupational therapy methods for assessing functional status as a physical disability are the Katz index for ADL and Lawton IADL scale [84]. Figure 3-2 shows the Katz ADL index, which was first developed by Katz et al. in 1963 [89]. This scale is used in various facilities such as rehabilitation centres, hospitals, nursing homes and home cares to administer functional assessments of the elderly. The Katz ADL is based on a dichotomous (dependent or independent) rating of six ADLs: bathing, dressing, toileting, transferring, continence and feeding [85, 89]. One of the strengths of the Katz ADL is that it helps caregivers to build an inventory about the patient's functional status in a common language which is easily understood. The Katz ADL has become well-known among health care personnel and caregivers because it was the first scale to assess functional status, although there is little evidence about its reliability and validity [84]. This index is appropriate for major changes but does not account for small increments in a person's functional status [84, 85, 89]. The ADL score ranges from 0 to 6 (dependent to independent) on a dichotomous scale. Aliberti et al. have shown a three-point rating ADL scale in their work, as detailed in Table 3-4 [90].

Katz Index of Independence in Activities of Daily Living

Activities Points (1 or 0)	Independence (1 Point) NO supervision, direction, or personal assistance needed.	Dependence (0 Points) WITH supervision, direction, personal assistance, or total care.
BATHING Points: __________	(1 POINT) Bathes self completely or needs help in bathing only a single part of the body such as the back, genital area, or disabled extremity.	(0 POINTS) Need help with bathing more than one part of the body, or getting in or out of the tub or shower. Requires total bathing.
DRESSING Points: __________	(1 POINT) Get clothes from closets and drawers and puts on clothes and outer garments complete with fasteners. May have help tying shoes.	(0 POINTS) Needs help with dressing self or needs to be completely dressed.
TOILETING Points: __________	(1 POINT) Goes to toilet, gets on and off, arranges clothes, cleans genital area without help.	(0 POINTS) Needs help transferring to the toilet, cleaning self or uses bedpan or commode.
TRANSFERRING Points: __________	(1 POINT) Moves in and out of bed or chair unassisted. Mechanical transfer aids are acceptable.	(0 POINTS) Needs help in moving from bed to chair or requires a complete transfer.
CONTINENCE Points: __________	(1 POINT) Exercises complete self-control over urination and defecation.	(0 POINTS) Is partially or totally incontinent of bowel or bladder.
FEEDING Points: __________	(1 POINT) Gets food from plate into mouth without help. Preparation of food may be done by another person.	(0 POINTS) Needs partial or total help with feeding or requires parenteral feeding.

Total Points: ________

Score of 6 = High; patient is independent. Score of 0 = Low; patient is very dependent.

Slightly adapted from Katz S, Down TD, Cash HR, Grotz RC. Progress in the development of the index of ADL. *Gerontologist.* 1970;10(1):20-30.

Figure 3-2 Katz Index of Independences in Activities of Daily Living (ADL).

Source [89]

Table 3-4 Katz ADL and Lawton scale scores

Level of dependence	Katz scale score (ADL)	Lawton scale score (IADL)
Dependent (D)	0 to 3	9 to 15
Partially dependent (P)	4 or 5	16 to 25
Independent (I)	6	26 and 27

Source: [90]

3.2.1.2.2 IADLs Scale

Figure 3-3 shows the instrument known as the Lawton Instrumental Activities of Daily Living Scale (IADL), which was developed by Lawton and Brody in 1969 [1]. The scale is helpful in identifying and detecting the improvement or decline in the current functional status of a person [84]. The

IADL tasks are more complex as compared to ADL tasks and their accomplishment is necessary in order for a person to live independently in society [84]. The IADL scale is based on the ability to perform eight types of tasks: use the telephone, go shopping, food preparation, housekeeping, laundry, use a mode of transportation, responsibility for own medicine and ability to handle finance [1]. It is easy to administer and provides self-reported information about specific tasks which is helpful for health care personnel to provide better and in depth plans for care, so that the person can remain independent. The IADL score ranges from 0 (dependent) to 8 (independent) and there is substantial evidence for IADL reliability and validity [91, 92]. Loewenstein and Mogosky suggest that the IADL scale is more suitable for women than men [92]. However, current research has recommended that this scale is good for assessing all domains for both men and women [93]. Aliberti et al. have shown a three-point rating IADL scale in their work (see Table 3-4) [90].

3.2.1.3 Commentary on Katz ADL and Lawton Brody IADL scale

Occupational therapy uses various methods to develop strategies for the care of individuals. The most commonly used methods, as mentioned above, are the Katz ADL and Lawton Brody IADL which are critically discussed below:

Katz ADL scale:

- The Katz ADL scale is based on a dichotomous (dependent or independent) rating of six ADLs, using numeric values (0 or 1) to assess the functioning status of a person.

- The Katz scale uses a dichotomous scale out of 6, so if a person scored 6/6 in all six ADLs it means that person is dependent, and conversely if they scored 0/6 it means they are independent. All the questions covered by the scale are based on "do it with no supervision" or "do it with supervision". The scale is quite rough and does not say much about the base scale.

The Lawton Instrumental Activities of Daily Living Scale

A. Ability to Use Telephone

1. Operates telephone on own initiative; looks up and dials numbers 1
2. Dials a few well-known numbers 1
3. Answers telephone, but does not dial 1
4. Does not use telephone at all 0

B. Shopping

1. Takes care of all shopping needs independently 1
2. Shops independently for small purchases 0
3. Needs to be accompanied on any shopping trip 0
4. Completely unable to shop 0

C. Food Preparation

1. Plans, prepares, and serves adequate meals independently 1
2. Prepares adequate meals if supplied with ingredients 0
3. Heats and serves prepared meals or prepares meals but does not maintain adequate diet 0
4. Needs to have meals prepared and served 0

D. Housekeeping

1. Maintains house alone with occasion assistance (heavy work) 1
2. Performs light daily tasks such as dishwashing, bed making 1
3. Performs light daily tasks, but cannot maintain acceptable level of cleanliness 1
4. Needs help with all home maintenance tasks 1
5. Does not participate in any housekeeping tasks 0

E. Laundry

1. Does personal laundry completely 1
2. Launders small items, rinses socks, stockings, etc. 1
3. All laundry must be done by others 0

F. Mode of Transportation

1. Travels independently on public transportation or drives own car 1
2. Arranges own travel via taxi, but does not otherwise use public transportation 1
3. Travels on public transportation when assisted or accompanied by another 1
4. Travel limited to taxi or automobile with assistance of another 0
5. Does not travel at all 0

G. Responsibility for Own Medications

1. Is responsible for taking medication in correct dosages at correct time 1
2. Takes responsibility if medication is prepared in advance in separate dosages 0
3. Is not capable of dispensing own medication 0

H. Ability to Handle Finances

1. Manages financial matters independently (budgets, writes checks, pays rent and bills, goes to bank); collects and keeps track of income 1
2. Manages day-to-day purchases, but needs help with banking, major purchases, etc 1
3. Incapable of handling money 0

Scoring: For each category, circle the item description that most closely resembles the client's highest functional level (either 0 or 1).

Figure 3-3 Lawton Instrumental Activities of Daily Living (IADL) scale.

Source: [1]

- The scale is good for a variety of post-event disabilities in many disabled populations who have problems such as multiple sclerosis or arthritis [84] but it does not provide any information or indicate any risk before the specific injury (pre-event) occurred.

- The scale evaluates six tasks for major changes and does not account for small increments in a person's functional status.

- The scale is based on interview or observation, so it can pose a problem for a person who refuses to perform a task and is then scale scored as dependent.

Lawton Brody IADL scale:

- The Lawton Brody IADL scale is based on a rating of eight IADLs, using numeric score ranges from 0 to 8 for women and 0 to 5 for men. In this scoring system, 0 means dependent or low function and 8 means independent or high function. The scale explains the amount of help required in performing the tasks in numeric terms (0 or 1) but does not indicate the level of risk associated with each task.

- The scale is used as a post-event self-reporting system to categorize the person's ability to perform the tasks (dependent or independent).

- The scale is based on a self-reporting system, and so it might be possible for a person to over- or under-estimate his/her abilities. The scale is used to analyse the person not the task, so it might be possible for the task to have some biomechanical restriction which forced the person to perform differently which would result in a change of that person's ability to perform that task in later life.

3.2.1.4 Evaluation of ADLs by other occupational therapy methods

As well as the Katz ADL index and IADL scale, various other methods have been developed by researchers for the evaluation of ADLs [88]. There are around 117 of these methods [94], and they are often used by occupational therapist to assess the level of independence of their patients [95]. Table 3-5 a list of other methods used in the evaluation of ADLs.

Table 3-5 A list of other methods used in evaluation of ADLs

S. No	Methods	Sources
1	Functional Independence Measure (FIMTM)	[88]
2	Assessment of Motor and Process Skills (AMPS)	[88]
3	Canadian Occupational Performance Measure (COPM)	[88]
4	Assessment Living Skills and Resources (ALSAR)	[88]
5	International Classification of Functioning Disability and Health (ICF)	[88]
6	Australian Therapy Outcome Measures (AusTOMs)	[88]
7	Personal Care Participants and resources tool (PC-PART)	[88]
9	Bristol Activities of Daily Living Scale	[87]

Source [88]

All the above-mentioned methods used observation to observe post-event incidence and used rehabilitation techniques to restore the person's ability to perform daily tasks independently.

3.2.1.5 Occupational therapy evaluation criteria and methods

Occupational therapists use the following categories in relation to their patients, in order to apply the appropriate evaluation criterion for each category [96].

- Mobility
- Maintaining and changing body positions
- Manual handling
- Self-care
- Attention

3.2.1.5.1 Evaluation criterion: Mobility

Mobility can be defined as moving around and walking during the performance of tasks. The following are the typical assessment methods used in the evaluation of mobility:

- Activities of daily living (ADL) index: This method uses techniques such as interview and observation to determine ability with basic ADL and mobility tasks. This index is useful in care and discharge planning for the patients and does not assess more advanced activities. The index is therefore inadequate for measuring small changes in ability as a result of rehabilitation of the elderly [85, 89].

- AM-PAC: The Post-Acute Care tool measures activity limitation by three basic domains: basic mobility, daily activities and applied cognitive [97].

- Modified Barthel Index: This method employs an ordinal scale to measure patient performance by using 10 variables (personal hygiene, bathing self, feeding, toilet, stair climbing, dressing, bowel control, bladder control, ambulation and chair/bed transfer)[98] for describing mobility and ADL. The method is very simple to understand and carry out, using standard assessments which do not consider individual factors among the people being assessed [99].

- Stroke Impact Scale (SIS): This method uses eight domains (strength, hand function, mobility, ADL, emotion, memory, communication and social participation) to measure stroke recovery in a patient [100]. It is a quick method to assess the physical aspect of stroke impairment but does not take into account the social or mental aspect of a stroke. However, it provides good discrimination in patients with mild to moderate stroke than other methods such as the Barthel Index [101].

3.2.1.5.2 Evaluation criterion: maintaining and changing body positions

Maintaining and changing body positions are necessary during the performance of everyday tasks and these help occupational therapists to measure various motor and process skills. The typical assessment methods used in the evaluation of maintaining and changing body positions are as follows:

- Assessment of motor and process skills (AMPS): The method is based on observational assessment to measure the quality of ADL and IADL performance [102]. The method does not require any special equipment but need a five-day training and calibration course. The method assists occupational therapist in planning treatment and documenting change, but is not suitable for the evaluation of a child under the age of 2 [103].

- Berg Balance Scale (BBS): The method is based on 14 easy tasks including positions such as sitting and standing up, to measure an individual's dynamic and static balance abilities [104]. It requires no special training and has a high level of reliability. It measures a different aspect of both static and dynamic balance. It takes rather longer to administer as compared to other balance measures [105].

- Performance-oriented mobility assessment (POMA): This method is based on task-oriented tests, which measure a person's balance and gait abilities [96].

- Timed Get-up-and-go Test: The method assesses and identifies the risk of falling of those people having gait or balance deficits [106].

3.2.1.5.3 Evaluation criterion: manual handling

Manual handling involves carrying, moving and handling objects during the performance of everyday tasks. The typical assessment methods used for this are as follows:

- Functional Reach Test: The method is simple and based on a single-task dynamic test that describes functional reach as "the maximal distance one can reach forward beyond arm's length, while maintaining a fixed base of support in the standing position" [107]. The method has good reliability and validity but less sensitivity [107].

- Action Research Arm Test (ARA or ARAT): The method measures ADLs related to arm tests, using four subtests: for grasping, gripping, pinching and gross movement. “It is an observational test used to determine upper limb function”[108]. This method has exceptional reliability and validity [109].

- The Arm Motor Ability Test: The method assess the deficits in activities of daily living (ADL), by simulating some out of 13 functional tasks (cut meat, foam sandwich, eat with spoon, drink from mug, comb hair, open jar, tie shoelace, use telephone, wipe up spilt water, put on cardigan/sweater, put on t-shirt, prop on extended elbow and turn the light on/off or open/close door) and assessing the person’s functional status and quality of movement as a result of therapy [110, 111].

- Wolf Motor Function Test (WMFT): “The method is used to evaluate upper extremity performance while providing insight into joint-specific and total limb movements” [112]. “The method can be used to track progress of a patient. Very easy to learn and administer. Not expensive to simulate in a clinic or wherever you want to use it. A patient could become very frustrated if they were not able to do well in a timed test environment” [113].

3.2.1.5.4 Evaluation criterion: Self care

Self-care during the activities of daily living includes the skills such as washing one’s face, brushing one’s teeth, combing one’s hair, getting dressed, and shaving. The following are the typical assessment methods used for this evaluation criterion:

- Cleveland Scale of Activities of Daily Living (CSALD): This is used for assessing basic ADLs in individual with dementia [114].

- Modified Barthel ADL Index: This is an index of independence in ADLs created for hospital patients but can be used in sub-acute settings [96]. The method is very simple to understand and carry out, and uses standard assessments which do not consider individual factors among the people [99].

- Activities of Daily Living Index: The method uses techniques such as interview and observation to determine ability with basic ADL and mobility tasks [96].

- Functional Assessment Rating Scales (FARS): These scales, which are used "for adult behavioural health functional assessment, are ways of documenting and standardizing impressions from clinical evaluations or mental status exams that assess cognitive, social and role functioning" [115].

- Performance Assessment of Self-Care Skills (PASS): This method is used to rate performance of different ADL functions based on individual observation either at home or in clinic settings [96].

- Executive Function Performance Test (EFPT): The method is used to evaluate the person's ability to carry out IADL tasks which are essential in order to live independently [116].

3.2.1.5.5 Evaluation criterion: Attention

Attention during activities of daily living includes the selection of information and a sustained effort over a period of time [117]. The typical assessment methods used in the evaluation of attention are as follows:

- Test of Everyday Attention (TEA): This method is used to assess the attention of adults aged between 18 and 80 years. The method assesses three aspects of attentional function: selective attention, sustained attention and attention switching [96, 118, 119].

- Short Blessed Test (SBT): The method is used to assess a person's cognitive changes associated with dementia. The method is also called the Orientation-Memory-Concentration test [96].

- D2 Test of Attention: The method is very simple and easy to administer, based on a paper and pencil test that assesses the ability of participants to focus their attention on different aspects of number and letter combinations over an epoch of time [96].

All the above-mentioned evaluation criteria and their respective methods are helpful for measuring and enhancing the patient's capabilities of performing their daily activities more effectively, which in turn enable them live independently in society.

3.2.1.6 Role of Occupational Therapy

The main role of occupational therapists is to establish a meaningful link with the patients, based on their psychosocial status, wishes, will and interests [120]. Ingrid Soderback defines the main role of occupational therapists [120] as follows:

- The therapeutic role: Occupational therapists have a responsibility to collaborate with their patients so that the latter can easily re-engage or perform purposeful and meaningful activities of daily living (ADL).

- The team-member role: Occupational therapists work with other health professionals in habitation, rehabilitation or social welfare teams in order for the patient to attain full health.

- The consulting role: they co-operate with and consult the patient's friends, family and colleagues who are significantly helping the patient in performing or achieving his or her goals. These goals involve interpersonal relationships which require occupational therapists management and cooperation to solve problems and provide ease in the patient's performance of daily tasks [120].

The College of Occupational Therapists of Manitoba, Canada has published guidelines which contain practice parameters and are used by occupational therapists to serve their clients in the practice of their profession [77]. The guidelines are based on the following five steps:

Stage 1: Initiation

a. Assessor Preparation
b. Screening the referral
c. Delineating Occupational therapy roles and responsibilities and obtaining informed consent

Stage 2: Assessment of the client

a. Determining the approach to assessment
b. Gathering information and collecting data

Stage 3: Analysis

a. Evaluating information
b. Professional reasoning

Stage 4: Documentation

Stage 5: Use of information

a. Sharing information with client
b. Sharing information with other stakeholders

The guidelines provide a proficient way to assess the clients and help them to perform the tasks in a satisfying routine of meaningful daily activities that can give them confidence and a sense of direction for a purposeful life in their homes.

3.2.1.7 Summary of findings from occupational therapy methods

Almost all the existing assessment methods focus on the ability of the person and are put in place to either modify/adopt or establish/restore ability as appropriate and are generally used as a rehabilitation tool after a specific incident occurs. Usually occupational therapy methods involve self-reporting or a caregiver report and are often based on observation of performance. The main objective of these methods is to predict the functional ability of a person and the level of dependency in performing activities of daily living. Almost all existing methods have to observe some particular activities, which can be daunting for some patients and this can affect the assessment results because of patients' anxiety at being assessed. Some methods based on a dichotomous rating system to assess the functional status of a person provide good assessment for a variety of post-event incidences and require supervision to use the methods. As well as this, some methods evaluate the number of tasks for major changes only (for instance, doing it under supervision or doing it unsupervised) and do not consider minor changes in the person's functional status [85, 89].

3.2.2 Ergonomics

Generally, ergonomics requires something to be designed to fit a person's shape or design, and so the science behind it then assesses, looks at and modifies the existing design to make it comfortable for the users. Furthermore, it is the science which provides a safe and comfortable environment to work in, either at home or in the office. Kumar mentions three goals of ergonomics: comfort, well-being and efficiency & effectiveness [121]. The term is derived from the Greek words *ergon* (work) and *nomos* (laws) [122]. Mondal defines it as "the relationship between you, the equipment and the environment for productive activity in daily living" [123]. There have been significant benefits from adopting ergonomic practices in the work environment and generating "tolerable" working conditions that do not pose any known danger to human life or health [83]. Therefore, researchers and practitioners have to identify and alleviate those risks and stresses which produce adverse effects on a person's health. As is well-known, the daily tasks people perform can lead to long term disability in later life and only by ergonomic interventions and robust design will it be possible to moderate these daily activities and the toll they take. Technological advancement in every field put lives under great stress [124] and the idea behind ergonomics is that the ergonomist, researchers and the practitioners study the risk factors related to work as well as daily activities. Pinto, Medici et al. mention in their work that the ergonomic approach may possibly improve the quality of life and activities in daily living [82]. There are three main areas of activity or ability that are important for maintaining or improving a person's standard of independent living: motion, flexibility and strength [125].

- Motion - This focuses on maintaining a healthy activity level, moving joints and preventing stiffness and excessive motion

- Flexibility - This focuses on maintaining flexibility around muscles, joints and ligaments and preventing them from being injured

- Strength – This focuses on maintaining strength for muscles, and muscles prevent joints from being injured

Similarly in the relevant literature, researchers hypothetically divide the human body into three planes: sagittal, coronal and transverse [126, 127] (see Figure 3-4). These planes help to describe the direction of body motion and location of body structures [128].

<u>Sagittal Plane</u>:

The sagittal or lateral plane divides the human body into left and right halves, perpendicular to the ground (Y-Z plane)[126].

In this connection, flexion is defined as “when the angle between two attached bone segments decreases during a movement [127]).

Extension is defined as “when the angle between the two attached bone segments increases during a movement” [127])

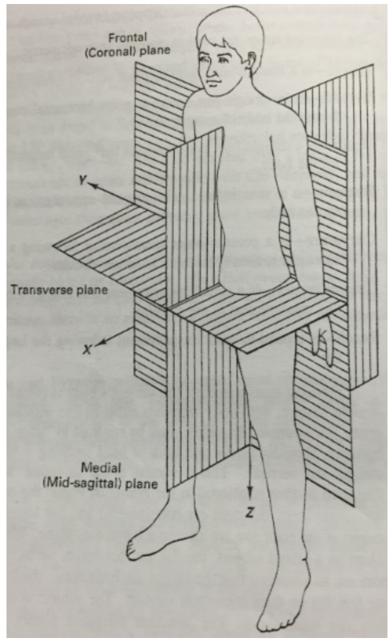


Figure 3-4 The three reference planes [83].

Coronal Plane:

The coronal or frontal plane divides the human body into front (anterior) and back (posterior) portions, perpendicular to the ground (Y-X plane)[83, 126]. The movements in the coronal plane are sideways movements called abduction and adduction. Abduction is defined as “when the movement of a limb is away from the midline of the body” [127]), while adduction is defined as “when the movement of a limb is toward the midline of the body ” [127].

Transverse plane:

The transverse or horizontal plane divides the human body into upper (superior) and lower (inferior) parts, parallel to the ground (X-Z planes) [126]. The movements in the transverse plane are based on rotation around its axis; these rotations are called pronation and supination.

Pronation rotation is defined as “movement toward the centre of the body” [127], and supination rotation is defined as “movement away from the centre of the body” [127].

Ergonomics works together with other disciplines such as gerontology in the design of new products and the environment. Gerontology is a new science which originated in the 1980s; it is the scientific study of old age, the process of age, the process of ageing, and the particular problems of old people. The main working areas are prevention, enhancement, research, compensation, and aid to caregivers. The combination of the ergonomics approach and gerontology will provide the opportunity to improve the relationship between the older user and their environment [82]. One of the important functions of gerontology is to prevent disability, and this is accomplished by using ergonomic techniques and methods to produce the best fit between the older user and their tasks. Therefore, ergonomic interventions and inclusive designs in ADL tasks will help older adults to live independently as well as reducing the risks associated with ADL tasks. Ergonomics and gerontology approaches and intervention will hence produce a positive impact on people’s lives [9].

3.2.2.1 Ergonomics assessment methods (EAM)

Numerous methods have been developed by researchers in the past to assess the exposure level to risk factors for MSDs [129] and most of these assessment methods have the ability to assess the upper part of the body such as the wrist, arm, shoulder, neck and back. Practitioners, researchers and regulating authorities are particularly interested in these assessment methods as these will later become the basis for both risk reduction and prevention programmes [129]. In the assessment of physical activity, Winkel and Mathiassen [130] propose that three dimensions of mechanical exposure – intensity of the force, repetitiveness and duration – should be used. As well as these, some other data such as postural variations, the rate of movement and psychosocial factors are also recorded. In terms of exposure assessment techniques, a number of researchers have identified and categorized the wide range of methods under three main headings: [129]

- Self-reports
- Direct measurements
- Observational methods

These same categories are conventionally used by various researchers, including, as mentioned above, Winkel and Mathiassen [130] and also Van der Beek and Frings-Dresen [131]. All three categories are explained in greater detail below.

3.2.2.1.1 Self-reports

Self-reports are mainly data from individual subjects, which are helpful in gathering exposure data due to physical and psychosocial factors. These comprise questionnaires, interviews and the person's diaries. Recently, many researchers have employed self-evaluation video films rather than requiring questionnaires to be completed [132, 133].

3.2.2.1.2 Direct methods

In the direct measurement methods, sensors are placed on the subject's body which directly measure the exposure of different variables at work. These sensors are simple hand-held device that measure different ranges of joint motions [129] such as the Lumber Motion Monitor (LMM) [134] (used to measure and assess back posture and motion); the Electronic goniometry [135, 136] (used to measure upper extremity postures angular displacement); the Inclinometers [137, 138] (used to measure the head, back and upper extremity postures); the EMG [139] (used to measure force and muscle tension variation); and the Cyber Glove [140] (used to measure the grip pressure of wrist, hand and finger motion).

3.2.2.1.3 Observational methods

To observe or record a person's exposure, researchers [129] have developed different simpler techniques known as the simpler observation and advanced observation techniques. In simpler observation, there is a variation in the number of exposure factors assessed: some allow the postural assessment of different parts of the body while the majority assess the numerous physical exposure factors. In this technique, the observer systematically records the person's task exposure, which is assessed by using a specially-designed pro-forma. Table 2-6 shows some of these methods including their main functions and exposure factors.

In contrast, the advanced observational technique uses advanced video-based techniques for the assessment of different postures [129] known as Video analysis (used for hand/finger posture assessment), ROTA (a computerized technique for static and dynamic task assessment) [129], PEO (a computerized technique for different tasks performed during a job) [141], PATH (a computerized technique for non-repetitive tasks) [142], and Video analysis (Video capture and body postural analysis and measuring trunk angles and angular velocities) [143].

3.2.2.2 Commonly used ergonomics observational methods

There are many commonly used techniques in evaluating the nature of several jobs, both safe and hazardous; some techniques are shown in Table 3-6. Most of these techniques are used by different researchers and practitioners within the ergonomics framework in different work scenarios to study work-related risk factors such as exerted force, awkward postures and excessive bending/reaching. These risk factors are work- as well as non-work related but little study has been done which shows the effects of these risk factors in a non-work environment such as the home environment, especially in kitchen work. According to Kroemer et al., the essential goal of ergonomics is humanization and to provide ease and efficiency [83].

Table 3-6 A summary of some simpler observational methods and their functions

Assessment Technique	Function	Exposure factors	Sources
OWAS (Ovako Working Postural Assessment System)	Analysis of whole body posture	Postures and load/force	[144]
RULA (Rapid Upper Limb Assessment)	Upper body and limb assessment	Posture, load/force and movement	[12]
PLIBEL	Used for identification of risk factors	Posture, load/force and others	[145]
The Strain Index	Used for risk assessment for upper extremity	Posture, load/force, movement, duration and others	[146]
OCRA (Occupational Repetitive Actions)	Assessment scores for different types of jobs	Posture, load/force, movement, duration, recovery, vibration and others	[147]
REBA (Rapid Entire Body Assessment)	Entire body assessment for dynamic tasks	Posture, load/force, movement and others	[13]
LUBA (Postural Load Assessment)	Assessment of postural loading on upper body and limb	Posture	[148]

Table 3-6 shows the some commonly used observational methods while the literature mentioned some other observational methods apart from above mention methods. Therefore, their strengths and limitations are discussed in the next section.

3.2.2.3 Postural Loading on the Upper Body

Postural Loading on the Upper Body Assessment (LUBA) [148] is a method used for postural assessment of different sitting or standing tasks by assigning the weights for the postures according to the discomfort felt in individual joints. LUBA is quite different from earlier presented approaches in its rationale to assign severity to those postures which deviate from a neutral position [149]. Its posture severity scale is based on psychophysical data of perceived discomfort and corresponds to the severity score ratio to discomfort ratio levels associated with different postures. Exigency of action will be determined by summing up all the individual scores. LUBA is based on experimental data and the assigned weights are also based on the discomfort rating of each joint posture held. The total score for posture is compared against the maximum holding time for that task which provides the action needed.

Strengths

- The LUBA score is based on physiological data
- The LUBA output consists of numeric scores which make the decision easier than a qualitative description
- The method is based on different sitting or standing tasks by assigning the weights for the postures according to the discomfort felt in individual joints

Limitations

- This method only assesses posture in pre-selected tasks and does not consider force, duration and repetition

3.2.2.4 Rapid Entire Body Assessment (REBA)

REBA is based on RULA, it evaluate certain tasks, whether the postures are dynamic or static [150]. It is based on the observation of individual body segments with respect to position, if it is deviated from neutral position means higher will be the REBA score [13]. It provides a quick postural analysis for whole body activities, gives a musculoskeletal risk action level and is a good method for health care and service industries to use [13, 151].

Strengths

- Suitable for health care and services industries
- Low cost and effective method
- Rapid to use, and very little or no training is required

Limitations

- Time consuming: both hands need to be assessed separately because there is no method to combine the data
- Low validity and reliability in relation to specific needs for ergonomic assessment
- It can be biased

3.2.2.5 Ovako Working Postural Assessment System (OWAS)

The OWAS method is used for identifying and evaluating awkward working postures [152]. The most common postures which are used in this method are back, arm, and legs. It also uses the weight of the load handled by a person. A four-digit code is used to describe the whole body posture. This method is mainly used for job evaluation and redesign.

- This method is easy to use: the calculated four-digit code can be compared against the benchmark and a decision can be made about intervention.
- Intervention effectiveness can easily be compared by the help of before and after scores for each part of the body
- This method is widely used by practitioners and researchers

Limitations

- The method does not provide a separate analysis for right and left upper extremities
- It does not provide information about repetition and duration of the postures
- It does not provide information for the elbow or wrist
- Time-consuming: proper training is needed for the observation techniques

3.2.2.6 Quick Exposure Check (QEC)

QEC was developed to assist health and safety practitioners to undertake assessments of the exposure of workers to work-related musculoskeletal risk factors [153]. It assesses the four main parts of the body (back, shoulder, wrist and neck) for the risk of developing MSDs [154]. For each body part, different variables are put into a lookup table to obtain a progression of sub-scores that will then produce a single score for that body part.

<u>Strengths</u>

- It is easy to use and appropriate for a wide of range of tasks
- Good consideration and interaction of risk factors
- Comprehensively described in literature and freely available

<u>Limitations</u>

- If there is a variation in tasks, this method is not suitable
- Exposure scores are hypothetical
- This method only focuses on physical factors

3.2.2.7 Occupational Repetitive Actions (OCRA)

OCRA is used to assess physical work exposure of hand, wrist, arm and shoulders. It includes the OCRA index and check-list and considers six primary task variables: frequency, forceful exertion, awkward postures and motions, work duration, lack of recovery time, and additional risk factors) [147, 155]. The additional risk factors include exposure to vibration, precision movements, glove use, mechanical compression, and cold stress [147]. This method is generally used for redesigning workstations and tasks [156].

Strengths

- It provides a detailed analysis of the organizational and mechanical risk factors for musculoskeletal disorders
- It contemplates all repetitive tasks involved in a job and predicts the worker's risk level

Limitations

- It can be time-consuming for complex and multiple tasks jobs
- It does not consider all the psychosocial factors related to the individual worker
- Needs trained observers, and training may take up to 3 days

3.2.2.8 PLIBEL

PLIBEL is the "method for identification of musculoskeletal stress factors which may have injurious effects" [145, 156]. It is a simple screening tool used to investigate musculoskeletal risk factors related to the workplace. It includes the time aspect, environmental factors, and organizational factors, which can also be considered as a modifying factors [156]. It is designed to serve as a rapid screening tool for evaluation of ergonomic risk factors associated with the musculoskeletal system.

Strengths

- It is a general method, not intended for any particular occupation or task
- It is used to observe either a part or the whole body, to evaluate ergonomic hazards
- It covers a broad range of risks

Limitation

- The risk is not quantified, and its validity is not shown
- Reparability is low because of subjective yes/no decisions

3.2.2.9 Threshold Limit Value for Hand Activity Level (TLV for HAL)

"The American Conference of Government Industrial Hygienists (ACGIH) established the TLV for HAL to evaluate hand-intensive jobs"[157]. TLV for HAL is used to analyse the risk factors for developing distal upper extremity disorder by using hand activity level and peak hand forces. It is intended for mono-task jobs with more than four hours of repetitive work [158]. It based on peak hand force (determined qualitatively by electromyography and a strain gauge, and quantitatively by rating the worker) and the hand activity level (determined by exertion frequency, recovery time and speed of motion) for a given task [151].

Strengths

- Rapid to use: no training is required
- It is targeted on force, repetition and recovery time: its output helps in decision-making
- No special instruments are required: HAL is rated on the VAS-scale and peak force is estimated by a strain gauge
- Video recordings can be used for assessments

- It takes less than one hour to analyse a job, and its processing time is less than five minutes

Limitations

- It does not consider other risk factors such as postures, vibration and contract trauma
- It is a subjective assessment
- It does not consider the other work place factors that increase the possibility of MSDs

3.2.3 Explicit description of ergonomics tools used in this study

This section describes in detail the ergonomics assessment tool used in thin study.

REBA

REBA is based on the observation of an individual's body segments with respect to position. Thus, if it deviates from the neutral position this means the REBA score will be higher [13]. REBA was designed in UK as a postural analysis tool for the whole body and for assessing musculoskeletal risks in different tasks in health-care and other service industries [159, 160]. However, it is evident that this tool is useful in any setting, whether the task is dynamic or static, or whether loads are being handled frequently or infrequently [159]. It is the only tool which assesses animate load handling and also considers coupling with the load handling [160]. The REBA score helps to predict the risk level and the action needed [150, 159]. In the REBA calculations for the present study, there are two groups, A and B. For the body, Group A includes neck, trunk and leg postures while Group B includes arm and wrist postures. The scores are determined from Group A (Table A) and Group B (Table B) for the observed postures. The load/force score in Group "A" is added for the account of physical force being applied and also the coupling score in Group "B" is added when holding of a load is observed. The overall risk score for the entire body is obtained from Table C with the help of Score A and B and the activity score for static, repeated actions or a major change in posture is added. This produces the final REBA score, which reveals the associated risk level and urgency of action needed. Figure 3-5 shows the REBA assessment sheet, which consists of Table A, Table B, Table C and the final score.

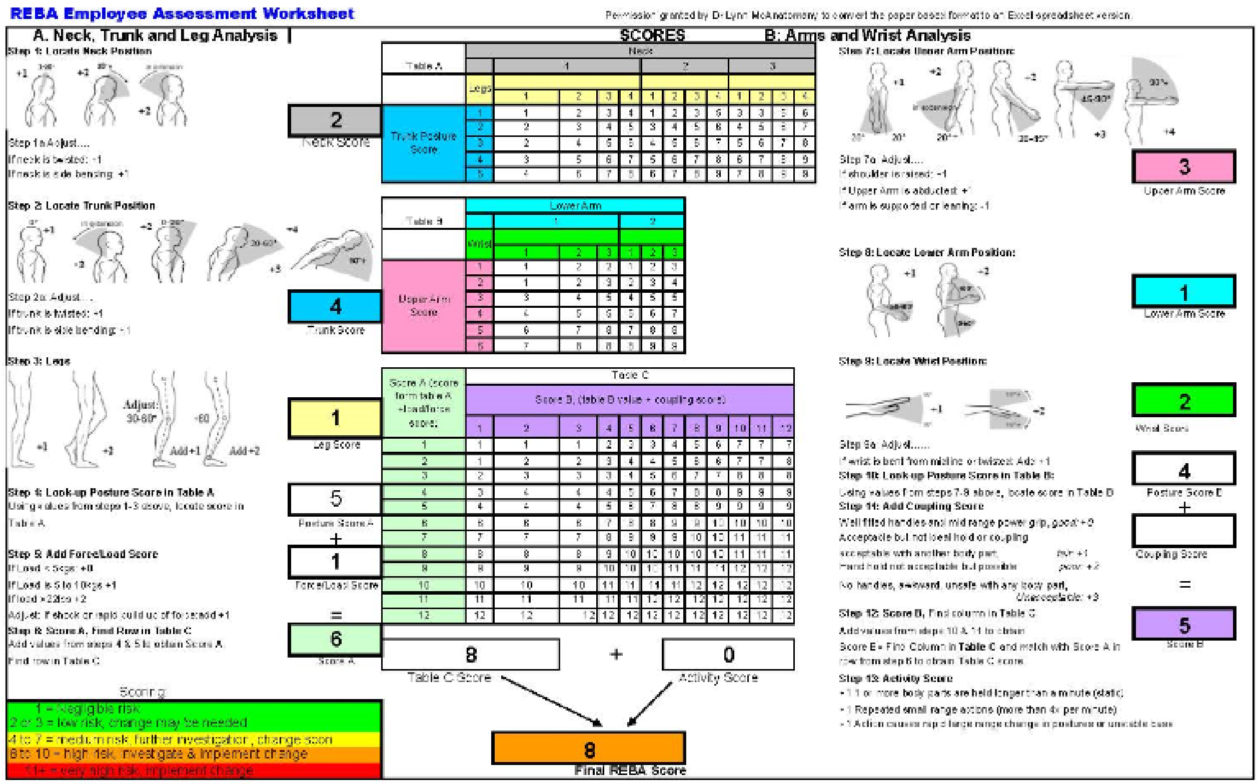


Figure 3-5 REBA assessment sheet (which consists of Table A, Table B, Table C and final score), as well as REBA scores and associated action levels (source: [13])

RULA

Rapid Upper Limb Assessment [12] is a tool used to analyse the musculoskeletal loads [161] in tasks which use the upper extremity (forearm, elbow, shoulder and neck). According to Shuval and Donchin, RULA is an authorized tool, which is used to assess the postural and biomechanical load on the upper extremity [159, 162]. Garg and Kapellusch mention that RULA is the best in classifying jobs into three levels of risk [157]. It provides output as a single number (score) which represents a combined rating of force, posture and movement for a given task. In many stationary standing or sitting tasks, RULA is certainly useful for assessing the posture, force and movement of the different tasks [157].

Rapid Upper Limb Assessment [12] is a tool used to analyse the musculoskeletal loads[161] in tasks which use the upper extremities (wrist, forearm, elbow, shoulder and neck). According to Shuval and Donchin, RULA is an authorized tool which is used to assess the postural and biomechanical load on the upper extremities [159, 162]. Garg and Kapellusch explain that RULA is the best tool for classifying jobs into three levels of risk [157]. It provides output as a single number (score) which represents a combined rating of force, posture and movement for a given task. In many stationary, standing or sitting tasks, RULA is certainly useful for assessing the posture, force and movement of the different tasks[157], and the assessment of each side (right and left arm) is done individually. In a RULA assessment, there are two groups: Group A consists of upper limb postures (lower arm, upper arm and wrist) while Group B consists of neck, trunk and legs. In Group A, the wrist, lower arm and upper arm are assessed, using Table A. By adding the muscle use score and applied force score for the arm & wrist analysis, by adding all the results the total score of group A will be obtained . Similarly, in Group B, assess neck, trunk and legs using table B. By adding the muscle use score and applied force score for the neck, trunk & leg analysis, by adding all the results the total score of group B will be obtained. The grand score is obtained by looking at the total scores from A & B in Table C (see Figure 3-6).

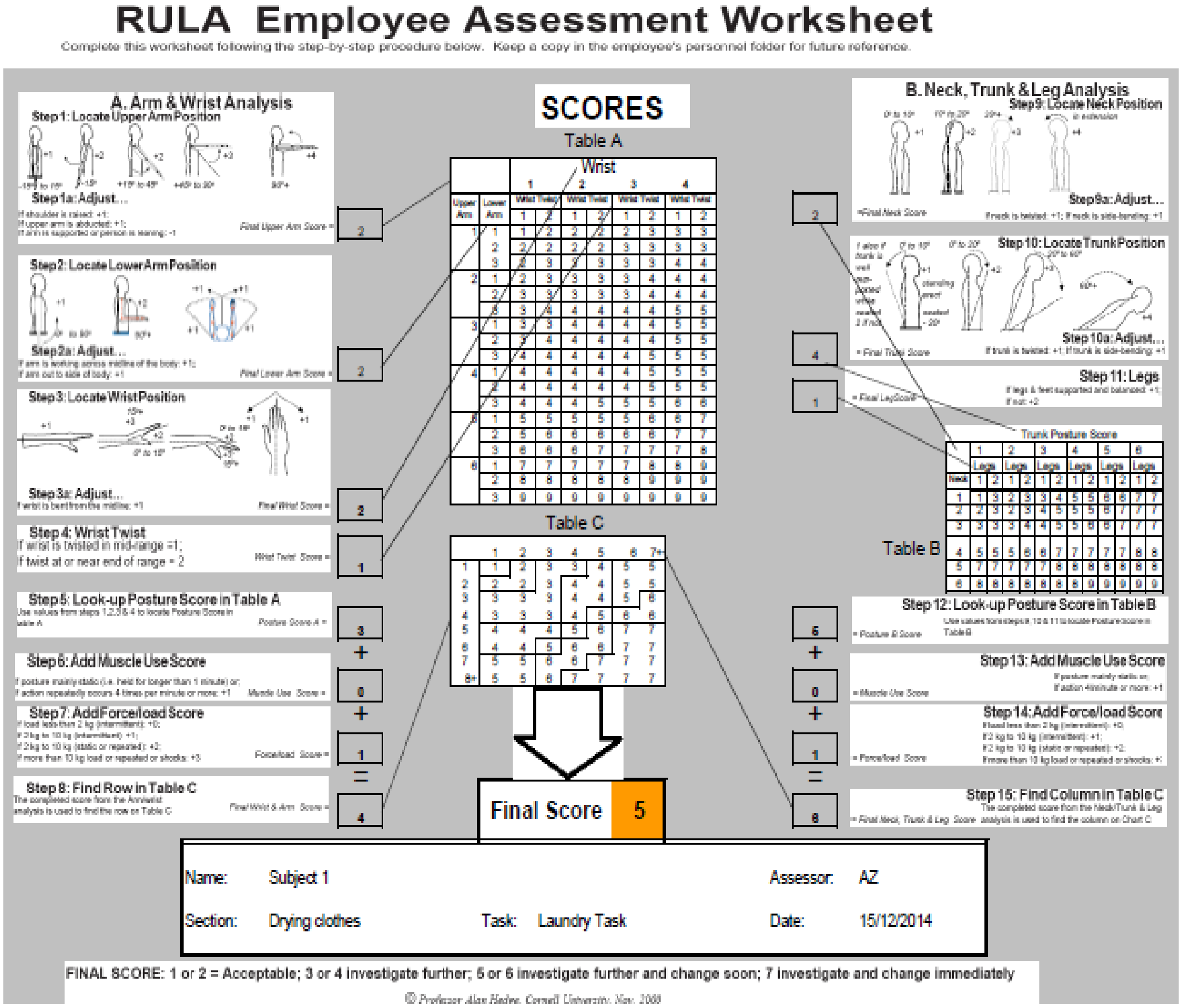


Figure 3-6 RULA assessment sheet (consisting of Table A, Table B and Table C and final score) as well as RULA scores and action levels [12].

<u>LUBA</u>

The Postural Loading on the Upper Body Assessment [148] is a method used for postural assessment of different sitting or standing tasks by assigning the weights for the postures according to the discomfort felt in individual joints. LUBA is quite different from the earlier presented approaches in its rationale to assign the severity to those postures which deviate from a neutral position [149]. Its posture severity scale is based on psychophysical data of perceived discomfort and corresponds to the severity score ratio to discomfort ratio levels associated with different postures. Exigency of action will be determined by summing up all the individual scores. LUBA is based on experimental data and the assigned weights are also based on the discomfort rating of each joint posture held. The total score for posture is compared against the maximum holding time for that task which provides the action needed. LUBA provides in-depth knowledge about postures used in different tasks. Its index or final score is based on physiological data. It also provides a number as an output score which is helpful in having a discussion as compared to qualitative output. LUBA is only used for postural assessment and therefore does not assess duration, force or repetition. The postural load index is obtained by adding the respective postures (wrist, elbow, shoulder and neck) load, which is obtained by using Figure 3-7, and the posture is evaluated by using a criterion based on the postural load index, which decides four categories of action, as shown in Table 3-7.

Table 3-7 Postural load index and action categories

S. No.	Postural Load Index	Action Categories
1	≤ 5	Acceptable
2	5 to 10	Further investigation required
3	10 to 15	Corrective action required through redesigning
4	≥ 15	Posture requires immediate consideration & corrective action.

Source: [148, 163]

Department: Task: Operator:

Analyst name: Date:

Joint	Motion	Class	Score		Motion	Class	Score	
Wrist	Flexion	0-20°	1	___	Extension	0-20°	1	___
		20-60°	4	___		20-45°	5	___
		>60°	9	___		>45°	11	___
	Radial	0-10°	1	___	Ulnar	0-10°	1	___
	deviation	10-30°	5	___	deviation	10-20°	5	___
		>30°	10	___		>20°	9	___
Elbow	Flexion	0-45°	1	___	Supination	0-90°	3	___
		45-120°	3	___		>90°	9	___
		>120°	7	___				
	Pronation	0-70°	3	___				
	deviation	>70°	9	___				
Shoulder	Flexion	0-45°	1	___	Extension	0-20°	1	___
		45-90°	5	___		20-45°	7	___
		90-150°	9	___		45-60°	12	___
		>150°	14	___		>60°	16	___
	Adduction	0-10°	1	___	Abduction	0-30°	1	___
		10-30°	4	___		30-90°	6	___
		>30°	11	___		>90°	13	___
	Medial	0-30°	1	___	Lateral	0-10°	1	___
	rotation	30-90°	4	___	rotation	10-30°	5	___
		>90°	10	___		>30°	10	___
Neck	Flexion	0-20°	1	___	Extension	0-30°	1	___
		20-45°	5	___		30-60°	9	___
		>45°	8	___		>60°	15	___
	Lateral	0-30°	1	___	Rotation	0-30°	1	___
	bending	30-45°	5	___		30-60°	4	___
		>45°	13	___		>60°	11	___
Back	Flexion	0-20°	1	___	Extension	Not included		
		20-60°	6	___				
		>60°	13	___				
	Lateral	0-10°	1	___	Rotation	0-20°	1	___
	bending	10-20°	5	___		20-30°	3	___
		20-30°	12	___		30-45°	7	___
		>30°	16	___		>45°	14	___
Postural load =								

Figure 3-7 Postural load evaluation checklist [148]

Strain Index

SI is used to assess the tasks to determine the risk upper extremity disorders [47-49]. The method depicts the hand activities, which depend on six task variables: intensity of exertion, duration of exertion, effort per minute, hand wrist posture, speed of work, and duration per day [48, 49, 146, 164, 165]. The three variables of intensity of exertion, hand/wrist posture and speed of work are estimated ones, while the other three, which relate to duration, are measured respectively [166]. The Strain Index is calculated by using the formula below [146, 164, 167] :

Strain Index (SI)= Intensity of Exertion Multiplier (IE) × Duration of Exertion Multiplier (DE) × Efforts per Minute Multiplier (EM) × Hand and Wrist Posture Multiplier (HWP) × Speed of Work Multiplier (SW) × Duration per Day Multiplier (DD)

Table 3-8 and 3-9 show each parameter used for the SI formula and their multiplier values. Table 3-10 shows the SI classifications of the tasks.

Table 3-8 Rating Values for each task variable

Rating Values	Intensity of Exertion	Duration of Exertion (%)	Efforts per Minute	Hand / Wrist	Speed of Work	Duration per Day (hours)
1	light	<10	< 4	very good	very slow	≤1
2	somewhat hard	10-29	4-8	good	slow	1-2
3	hard	30-49	9-14	fair	fair	2-4
4	very hard	50-79	15-19	bad	fast	4-8
5	near maximal	≥ 80	≥20	very bad	very fast	≥8

Source: [146]

Table 3-9 Multiplier for each task variable

Rating Values	Intensity of Exertion	Duration of Exertion (%)	Efforts per Minute	Hand / Wrist	Speed of Work	Duration per Day (hours)
1	1	0.5	0.5	1.0	1.0	0.25
2	3	1.0	1.0	1.0	1.0	0.5
3	6	1.5	1.5	1.5	1.0	0.75
4	9	2.0	2.0	2.0	1.5	1.0
5	13	3.0	3.0	3.0	2.0	1.5

Source: [146]

Table 3-10 SI classification of the tasks

Job Classification	Criterion
Safe situation	SI < 3
Uncertain situation	3 ≤ SI < 5
Some risk	5 ≤ SI ≤ 7
Hazardous situation	SI > 9

Source: [146]

3.2.3.1 Summary of findings from ergonomics assessment methods

Ergonomic assessment is good for the evaluation of the nature of tasks, whether safe or hazardous, before the incidences occurred and provides an insight into future problems regarding the tasks. Almost all the ergonomic assessment methods use physical risk factors regarding the tasks, such as force, repetition, awkward postures, extreme bending & twisting contact stress and vibration. Table 3-11 shows the summary of the current assessment tool which are commonly used in ergonomics. These types of physical exposure are also considered to be the risk factors for musculoskeletal disorders (MSD) [168]. Similarly, more or less all ergonomic assessment methods make it obligatory for the person to adopt neutral postures and they provide a comprehensive analysis of all parts of the body by using various methods (for instance, the REBA focuses on parts of the body such as the trunk, neck, legs, knees, upper and lower arms, and wrists [13]). It is also observed that all the ergonomic methods are good for a working environment for a variety of industrial tasks, but domestics tasks are different from industrial tasks because in a domestic environment the person is involved in tasks which require the adopting of postures and manual handling of objects simultaneously over a period of time and no one is supervising that person, so they are performing those tasks in whatever way they like. Therefore, the person is exposed to other risk factors apart from the ergonomic ones, such as psychological risks (dexterity, anxiety, fatigue, depression and so on). Although the ergonomic methods are good for analysing both short and long duration industrial tasks [169], none of these methods analyse the person's postures and manual handling of an objects simultaneously, and therefore it is concluded that domestic tasks are harder than industrial tasks.

Table 3-11 Summary of the current assessment tool which are commonly used in ergonomics

				Strengths				
Tool Name	**Purpose**	**Developed by**	**Developed Date**	**MSD Risk Factors Considered**	**Body Region Considered**	**Type of Job Appropriate**	**Type of Job Not Appropriate**	**Limitations**
Strain Index (SI) [146]	Risk assessment for distal upper extremity	J. Steven Moore and Arun Garg	1995	Force, repetition awkward posture, duration	Hand, wrists forearm and elbow	Hand intensive, repetitive	Static tasks and awkward posture tasks	Not consider, Contact stress cold temp, hand-arm vibration.
Rapid Upper Limb Assessment (RULA) [12]	Risk assessment for upper limb disorder	L. McAmney, E.N. Corlett	1992	Repetition, awkward postures, force	Upper arms, lower arms, wrists, trunk, neck, legs	involving multiple body regions, standing or sitting or combination	None	Some factors weighted equally no matter to what degree they exist .
Postural Loading on the Upper body (LUBA) [148]	postural assessment and discomfort felt in individual joints	Dohyung Kee, Waldemar Karwowski	2001	Awkward postures, discomfort	Upper arms, lower arms, wrists, trunk, neck, legs	Jobs involving multiple body regions, standing or sitting	used only for pre selected tasks	Force duration and repetition not considered.
Rapid Entire Body Assessment (REBA) [13]	postural analysis system sensitive to musculoskeletal risk in variety of jobs	S. Hignett and L. McAtammey	2000	Awkward postures, load/force, coupling, activity level	Trunk, neck, legs, knees, upper and lower arms, wrists	Jobs involving multiple body regions, standing or sitting or combination	None	Some factors weighted equally no matter to what degree they exist .
Occupational Repetitive Action Index (OCRA) [147]	repetitive tasks performed by upper limb	Enrico Occhipinti	1998	Repetitiveness, force, awkward posture and movements	Upper limb	Repetitive tasks where upper limbs are used	Jobs uses lower extremities	Does not consider vibration, contact stress, shoulder disorders.
Ovako Working Postural Assessment System (OWAS) [144]	identifying and evaluating poor working postures	Ovako Oy	1973	Force, awkward posture	Upper limb and lower limb	Jobs involving back, arm, and legs	_	Does not consider repetition and duration of the postures .
Quick Exposure Checklist (QEC) [153]	Provide physical exposures and predict risk for MSDs	Peter Buckle and Guangyan Li	1998	Repetitive movements, force, awkward postures, duration, vibration	Neck, shoulder, hand, wrist, arm, back, and legs	Manual handling, repetitive tasks, static tasks, dynamic tasks, seated and standing	None	Focus is on physical factors and hypothetical scores .

3.2.4 Sports and exercise science

As a discipline, sports and exercise science is based on the theoretical knowledge and practical application of scientific principles relating to psychology, physiology, biochemistry and biomechanics to maximise and improve the sports performance, general health and wellbeing through exercise [170]. It is the basic science on sports medicine which include the professionals like exercise physiologists, biomechanics, and sports medicine physicians [171]. The main goal of sport science is to enhance mental and physical preparation, performance and overall experience of competitive sports participants while exercise science is to enhance physical activity levels, experiences and benefits in general population [172]. Sports and exercise science contain three main sub-disciplines which are psychology, physiology and biomechanics [172], each sub-discipline within sports and exercise science briefly describe below.

Sports and exercise psychology

The main purpose of adapting psychology within sports and exercise is to "understand, explain, predict and change people's behaviours, emotions and thought processes" [172]. The sports and exercise psychologist, investigate the athlete through key question which addressed psychology issues, which helped them to achieve optimal mental health and to improve their performance in a particular sport [173]. Following are the main questions in which sports and exercise psychologist are interested in [172]:

1. "What psychological strategies will help an athlete to stay focused during competition?"
2. "How can we develop cohesion in competitive sports team?"
3. "What motivates teenage girls to do physical activity and exercise?"
4. "Can exercise help to prevent mental ill health, such as anxiety and depression?"

Sport and exercise physiology

Physiology is the scientific study of the normal function of biological systems [174]. In this sub-discipline physiologists are interested to know how the athlete body responds to physical activity and exercise, what limits the athlete physical performance, and how physical training can be used to improve athlete's health and performance [172]. Following are the main questions in which sports and exercise physiology are interested in [172]:

1. "How can an individual changes their diet to improve their health and their ability to compete in sport?"
2. "How can an athlete train to improve their athletic performance?"
3. "What physical factors can limit an athlete's sporting performance?"
4. "What does an athlete needs to do stay healthy while they are training hard?"

Sports and exercise biomechanics

Biomechanics is the application of laws and principles used to study the biological phenomena in the human body [126]. In this sub-discipline bio-mechanists involved in clinical and applied biomechanics in order to understand or analyse forces and its effects on athlete's body. Following are the main questions in which sports and exercise bio-mechanists are interested in [172]:

1. "How can we analyse the techniques used in different sport skills to help athletes become quicker and more powerful?"
2. "How can we increase efficiency of human movement so that elderly people are steadier on their feet?"

3. “How do we design sports equipment such as golf club that make the ball travel further with less human effort or football that travel through the air with less resistance?”

3.2.5 Assessment methods and tests

There are many assessment methods and tests developed by the researchers to assess or understand the exercise capabilities, enhanced performance and exercise tolerance of athlete who are under test procedures [175]. Assessments and testing is an essential part of an athlete’s training programme and should be conducted on regular and frequent basis, so that investigator should have a complete understanding about the mechanism of energy released during the sport or activity [175]. Bird and Davison, 1997 mentioned the specific reason for undertaking tests and assessments, which are as follows [175, 176]:

1. “Evaluate the effectiveness of a training programme to see if performance or rehabilitation is improving and intended physiological adaptations are occurring”.

2. “Provide an initial evaluation of strengths and weakness of the participant in the context of the sport or activity in which they participate. This information can be used to inform the design and implementation of a training programme”.

3. “Evaluate the health status of an athlete or exerciser. This might be part of a joint programme with clinical staff”.

4. “Provide an ergogenic aid. Often, in the setting of short-term goals for the improvement of fitness for example, the prospect of being tested often acts as a motivational influence”.

5. “Assist in selection or identify readiness to resume training or competition”.

6. “Develop knowledge and understanding of a sport or activity for the benefit of coaches, future athletes and scientists”.

The next sections are discussed some assessment methods used within sports and exercise science.

3.2.5.1 Athletic Ability Assessment (AAA)

The athletic ability assessment (AAA) tool is used for evaluating the changes in functional movement ability over time and provide the reliable movement assessment protocol that address particular sporting population [177]. AAA movement evaluation protocol based on three parameters: 1. Exercise, 2. Selection rationale, and 3. Scoring criteria. AAA has been tested on female football players in real-time and via video on two different occasions in order to estimate inter-tester reliability and found the high agreement and high correlation between real time scores and video scores. It is concluded that AAA is a reliable assessment tool and help researchers in future to examine the relationship between movement ability, injury risk and sports performance.

3.2.5.2 Posture assessment

Postural assessment is an essential tool which can be used to assess the causes behind various injuries to a person in sports, because the repetitive activities during sports forced athlete to adapt certain postural alterations, which eventually results in cause pain and injury [178]. Researchers has developed various postural assessment methods used for evaluation of postural abnormalities such as the visual observation, plumbline, goniometry, photographic, radiographic, photogrammetric, flexiruler, electromagnetic tracking device etc. [178]. Table 3-12 shows the summary of the current postural assessment tools available in sports and exercise science.

Table 3-12 Summary of the current postural assessment tools which are commonly used in sports and exercise science.

Postural assessment tool	Benefits	Limitations
Visual Observation method	• Common method used in clinical environment • No special equipment needed • Assess almost whole body	• Minor postural deviation cannot be detected • Quantitative data cannot be obtain through this tool • It has a poor inter-rater agreement • Required experts to analyse (Kinesitherapists)
Plumbline method	• Evaluate athlete postures with a postural grid • Low cost and simple to use	• Quantitative data cannot be obtain through this tool
Goniometry	• It measure joint ROM and posture assessment [179] • Having good to excellent reliability	• Provide relative angular data, not absolute angles • It requires an excessive length of time to fit and align
Photographic and digitization method	• The anterior and lateral views of subjects were photographed through digital camera then obtained images were analysed by posture analysis software	• It occupies systems resources which easily crashes the system. • The system respond slowly due to heavy software • System needs extra plug-ins to install the software
Radiographic method	• It is one of the latest methods available to analyse postures • This methods is describe as "gold standard" in the literature	• Its cost and exposure to harmful radiation forced practitioners and researchers to use non-invasive methods for postural analysis
Posturometer	• It is an electronic measuring diagnostic device which determine posture asymmetry at all levels and axes	• These device is costly and not ubiquitous
Flexiruler	• This technique was discovered almost fifty years ago, now-a-days this technique is widely used in sports science to measure the spinal curvatures, named as Kyphosis and lordosis [180] • Flexiruler is a secure, easy to use and economic method as compared to other methods mention above [181]	

Source: [178]

3.2.5.3 Acceleration and agility

Agility and quickness are the main sporting skills that contain both physical and cognitive aspects and through this test coaches evaluates the athlete's acceleration, quickness and ability to change direction efficiently [182]. This test available for short duration no longer than 30 minutes at most [51]. Normally, experts in sports and exercise science classify this test into three components: 10-Yard sprint, spider agility test and 5-10-5 pro agility [51]. The 10-Yard sprint is a self-explanatory test. In this test experts record time taken by athlete to run 10-yard straight ahead, and analyse athlete's acceleration and agility. Table 3-13 shows the acceleration and agility test which are commonly used in sports and exercise science.

Table 3-13 Brief summary of acceleration and agility test which are commonly used in sports and exercise science.

Acceleration and agility tests	Explanation
10-Yard sprint test	The 10-Yard sprint is a self-explanatory test. In this test experts record time taken by athlete to run 10-yard straight ahead, and analyse athlete's acceleration and agility,
Spider agility tests	This test as described by national strength and conditioning associate (NSCA), it involves running in a star or fish like or zigzag or any other (especially design) pattern, in order to evaluate speed and agility of an athlete.
5-10-5 pro agility test	In this pro agility test, experts evaluate athlete's ability to accelerate, de-accelerate, utilization of speed, change direction and reaccelerate as fast as possible. This test is highly reliable test to assess acceleration, quickness, quality of change of direction and stability of athletes.

Source: [51]

3.2.5.4 Push-up/pull-up challenges

In this test expert measures how many quality push-ups and/or pull-ups can an athlete do in a certain amount of time [51]. This test is very good for measuring muscular strength and endurance of athletes [51, 183].

3.2.6 Physiotherapy

Physiotherapy or physical therapy [184] is a scientific study that helps to “restore movement and function when someone is affected by some injury, illness or disability” [185]. Physiotherapists diagnose diseases that affect the person’s muscles and nerves, they also look for the factors that may have contributed or worsen the person’s condition and advise them or aware them how to minimise the risk of same thing (injury, illness or disability), so that same condition won’t happening again [186]. There are many assessment methods within the physiotherapy context, some methods are completed by clinician and some are completed by patient himself. Table 3-14 shows the summary of the physiotherapy assessment methods which are commonly used in sports and exercise science.

Table 3-14 Summary of the physiotherapy assessment methods which are commonly used in sports and exercise science.

Physiotherapy assessment methods		Explanation
Clinician completed methods	American Foot & Ankle Score	This tool is developed by American Orthopaedic Foot and Ankle Society, it uses numerical scale to address both subjective and objective factors which describe pain, alignment and function in the foot and ankle [187].
	Mayo Wrist Score	Mayo wrist scoring system evaluates the following parameters: level of disability in the wrist, assessing wrist pain, functional status (able to work or not), grip strength and range of motion [188].
	Modified Cincinatti Rating System (Knee)	It is a subjective scale which provides clinicians and practitioners information about patient’s functional and clinical status after knee surgery [189].
	UCLA Shoulder rating Scale	It is the one of the oldest shoulder rating scale developed in 1981 by The university of California, used for shoulder arthritis which undergoing a shoulder arthroplasty. Also use this tool for rotor cuff disease or shoulder instability [190, 191].
Patient completed methods	Knee injury & osteoarthritis outcome (KOOS)	The KOOS is a self-administered and assesses knee related quality of person’s life by assessing 5 outcomes which are pain, symptoms, activities of daily living, sports and recreation function [192].
	The Foot & ankle disability index (FADI) score	FADI scale was designed for all patients with foot or ankle dysfunction. It assesses four regions on specially designed scales, including ankle-hindfoot, midfoot,

	hallux metatarsophalangeal, and lesser metatarsophalangeal-interphalangeal scales [193]. Through this scale patient easily records information about pain and function in each region [193].
Disability of arm, shoulder & hand score (DASH)	DASH is a questionnaire based self-administered region-specific outcome instrument developed to measure self-assessed upper extremity disability and its symptoms. It consists of a thirty items on disability /symptom scale, provide numeric score 0 (means no disability) to 100 [194]
Oswestry low back pain score	This questionnaire based assessment tool provide information that how patient's back condition affects his everyday life. This index is an essential tool to measure the permanent functional disability in a patient [195, 196]. This index assess back related diseases and provide numeric score 0 (means no disability) to 100 (worse possible disability)[197].

Source: [52]

3.2.7 Biomechanics

Biomechanics is the discipline whose contribution is found in almost all fields. It deals with the principles of physics, in order to comprehend the forces (include gravity, external forces and resistances etc.) and their effect on the human body [198]. The knowledge of biomechanics combines with other disciplines such as engineering physics (mechanics), basic medical sciences (biology and physiology) and anthropometry, in order to study the response of human body to loads and stresses placed on the human body in the work environment [126]. A main assumption of occupational biomechanics is that human body behave according to the laws of Newtonian mechanics which is stated as "mechanics is the study of forces and their effects on masses", therefore the goal of occupational biomechanics assessment is to quantitatively describe the musculoskeletal loading and the degree of risk that associated with performance of tasks or activities [199].

3.2.7.1 Biomechanical bases of ergonomics

Biomechanics is an essential and very influential tool available to ergonomists [126]. A biomechanical analysis is employed for conditions involving forces (lift, lower, push, pull, carrying and holding) and work or non-work postures that impose stresses on the body [126]. It plays an important role in considering the occupational and non-occupational health of a person; biomechanics also help to understand why some tasks or activities cause injury and ill-health and their adverse health (muscle strain, joint problems, back problems and fatigue) effect on a worker [200]. Hence, biomechanics principles help ergonomists by suggesting the ways of designing the tasks to avoid work place injuries or of improving poorly design tasks or activities within work and home environments.

Application of biomechanics within ergonomics

Following are the examples of biomechanics principles within ergonomics [200]:

1. The optimum diameter of handles of hand held tools
    - Ergonomically design pliers
    - Ergonomically design scissors
    - Ergonomically design screw drives etc.
2. Manual Material handling

Manual material handling techniques guide the person to perform their manual tasks (include lifting, lowering, pushing, pulling, carrying, moving and handling of loads [60, 61]) or activities efficiently and safely. Biomechanics is directly involved in manual handling tasks because muscles must move to carryout manual tasks. Therefore, designing to perform the manual tasks efficiently, following three questions need to be address which used three criteria because there are three broadly different reactions from the person that can occur during lifting tasks [200].

1. How much load person can be handled without damage (means muscles strain, joint problem or spinal disc injury) to the body? (this is known as biomechanical criterion) [200].

2. How much load person can be handled without overexerting the lungs? (this is known as physiological criterion) [200].

3. How much load, do people feel able to handle comfortably? (this is known as psychophysical criterion) [200].

Addressing above mentioned questions through manual handling techniques helps to determine the extent of load placed on the body and suggest or provide opportunities to practitioners for controlling and managing loads during performance of tasks or activities.

3. Posture and movements

Biomechanics principles are used to limit person's awkward postures and unwanted movements by designing the efficient work place. In this regard there are many assessment methods has been designed by researchers, through these tools one can understand physical, biomechanical and physiological factors and minimize the risk of musculoskeletal disorders associated with performance of particular tasks [198, 199]. The commonly used ergonomics assessment methods are: rapid upper limb assessment (RULA), rapid entire body assessment (REBA), postural loading on the upper body assessment (LUBA) etc. (see section 3.2.2 for more ergonomics assessment methods).

3.2.8 Justification for selecting disciplines for this study

Above mention discussion made it clear that, within the context of different disciplines (occupational therapy, ergonomics, sports and exercise science and physiotherapy) there are many efficient assessment methods are available and professionals using these methods in a respective environment to help the individual or group of people in the society. Now-a-days the impact of population aging has gained much attention and this raises a loss of independence and change of behaviour issues among the ordinary and elderly people. What does it mean to society and how can we cope with it?. How we address the loss of independence and change behaviour in the context of interdisciplinary disciplines. Because there is no existing assessment method available in different disciplines which simultaneously address the psychological and physical aspects of loss of independence and change of behaviour directly. However, the partial knowledge from the two disciplines (occupational therapy and ergonomics) can be utilized, because occupational therapy methods work with people to restore (post-event) their abilities in performing basic activities while ergonomics have potential to evaluate the risk of injury before it actually happened (pre-event) to a person.

Apart from that, ergonomics and occupational therapy are closely related to each other because both disciplines share common backgrounds [335]. According to the International Ergonomics Association (n.d.), "ergonomics promotes a holistic approach in which considerations of physical, cognitive, social, organizational, environmental, and other relevant factors are taken into account" [201]. To practitioners, these words resonate with many basic tenets of the occupational therapy profession. Moreover, ergonomics is concerned with the design of tools, systems, and environments for the wellbeing of humanity whereas the occupational therapy concerned with the ergonomically designed tools, systems, and environments for the restoration of basics skills necessary for independent and satisfactory live [335]**.** Therefore, it has been decided to use two disciplines that are occupational therapy and ergonomics. The idea for this study is to evaluate the psychological and physical risk exposure during the performance of daily tasks through self-assessment tool which assess the domestic tasks and aware the people about the risk hidden in the domestic tasks. So that, they know their own risk level in early stages of their lives, this might help them to predict their change in behaviour and might help them to stay at their homes as long as possible.

3.2.9 Comparing and contrasting EAM and OTM

As mention above that for this study the knowledge from ergonomics and occupational therapy disciplines is used. Therefore this section compares ergonomics assessment methods and occupational therapy methods.

Ergonomic assessment methods (EAM) provide information on ergonomics analysis for the general public, and are used for analysing tasks and identifying the risks associated in performing those tasks [202]. The prime goal of EAM is to identify the ergonomic risk factors around the work place, try to quantify them, and then make possible improvements in the working environment and ensure that the tasks and activities that a person performs are within their capabilities and limitations. The best way to achieve this is to use ergonomic techniques for risk identification and risk reduction based on one's objective and a scientific analysis of one's workplace. EAM provides a comprehensive analysis of a task by dividing the task into various sub-tasks, which help to identify the particular risk factors, analyse the body region and the duration of each sub-task. This method ensures the person's comfort and well-being by providing comprehensive analysis results which are used by designers and practitioners to redesign tasks and/or the environment, which may eliminate the risks and reduce the likelihood of injuries [121].

Occupational therapy methods (OTMs) provide information about a person's physical, cognitive and motor skills which enable him or her to gain full independence and participation in social activities. A variety of OTMs are used by occupational therapists to measure a person's psychological, social and environmental factors that may be responsible for that person's functional limitations [203]. Therefore, through their strategies and tactics occupational therapists can determine the key tasks to be practised within both the home and work environment which improve a person's physical, cognitive and motor skills.

Both disciplines (ergonomics and occupational therapy) have developed strong assessment methods within their environment, but for the purposes of this study a comparison has been made between EAM and OTM, as follows:

Timing of assessment

- EAMs are used to detect early signs and symptoms (pre-event) and provide caution before injury occurs.
- OTMs are used only for rehabilitation purposes after a specific injury has occurred (post-event).

Practitioners

- EAMs need little or no training, though some methods might require a specialist or inspector, in evaluating the risk level.
- OTMs need a specialist (Occupational Therapist) to observe and evaluate the degree of dependency.

Environment

- Observations are done wherever the activity take place and activity can be recorded on video i.e. no special environment is needed
- Typically observations are based in a special environment, such as a nursing home or hospital wards.

Remit

- Through EAMs, almost any task and activity in industrial environment can be observed, whether lasting for a long or short duration [169].
- Through OTMs, some specific activities are observed such as using the telephone, housekeeping, shopping etc. [1].

Purpose

- EAMs, provide early interventions and consider risk factors such as repetition, excessive bending and twisting, and awkward hand or body postures [39].
- In OTMs, attention is not paid to early signs of dependency and need for assistance such as altered habits, neglecting of personal hygiene, exhibiting inappropriate behaviour, stopping doing physical activities, exhibiting forgetfulness, mishandling finance, etc. [204].

3.3 Research methods or methodology

3.3.1 Experts interview

Experts views in studied disciplines (occupational therapy and ergonomics) are important because experts can notify the society or project members what has been experienced within the studied disciplines, on that basis, they will help project members predicts what will therefore be expected to occur in future. Similarly, expert's opinions regarding the on-going project provide a better insight in exploring the working area. Therefore, this section presents the experts experience in the field of occupational therapy and ergonomics.

3.3.1.1 Occupational therapist (OT)

This interview was conducted with Dr. Claire Craig in August 2014. She is an occupational therapist and working in Sheffield Hallam University as a co-director of Lab4Living. She was awarded a fellowship from the College of Occupational Therapy in 2012, in recognition of her contribution to the profession. This interview was supervised by Dr Jennifer Rowson and Dr Alaster Yoxall (project advisors). Following paragraphs shows the expert opinion about the occupational therapy discipline and the interviewed question is shown in appendix 17.2.

Occupational therapists assist clients in performing activities of all types, ranging from using a computer to caring for daily needs such as dressing, cooking, and eating. In order to do this occupational therapists usually provide a set of instruction or exercises to do. Being an OT rehabilitates or focuses on what person doing already and that would be the treatment medium. According to OT, if a person is engaging the same action as a part of they do every single day then the amount of recovery will have much bigger it means that you can't do things which were doing before easily. Therefore, occupational therapy interventions focus on adapting the environment, modifying the task, teaching the skill, and educating the client/family in order to increase participation in and performance of daily activities.

Occupational therapist works in every stage of intervention processes, they work in both formal (clinician and hospital) and informal (such as home) environments. Their evaluation based on both formal and informal environment and it depend upon protocol of the environment e.g. in hospital environment they like formal quantitative evaluation such as grip strength and Purdue pegboard etc. As an OT ideal assessment would be to listen somebody really enjoy doing, or if someone having specific functional problem and he referred to see the OT, then they invited them to participate in activities and observed what they are doing because they are interesting in dexterity and adopting movement patterns. Moreover, in terms of interaction with the other thing like in kitchen assessment which is really typical helpful and useful to see. In terms of assessment, their health and the ability of a person to engage with the level of how they engage so, their norm is set by their norm which is somebody can't physically do something it might be whole different range of reasons why person can't do it, it might be they never done it before, it might be always done that way, or it might be somebody get problem in that way.

Further expert said, OT initial assessments is sit down with someone and say tell me about what have being happening to you or tell me about what going on, then OT said this is what happenings, this is what going, this is what occurring and that will give them really good idea in terms of where OT focus and what OT might be do together. Apart from that OT would be interested in something at work such as any injury and sometime they won't go back to work. So the best place to see is work environment. OT usually does this, they are interested what's going on really, this would be like a screening or identification of problems. They prioritize what is important or what is less important. There is a thing like ageing and musculoskeletal conditions which results like a stroke or work accident. We will see lot of occupational history problem like repetitive strain it would be a big factor, now more and more people get involved because they are using computer more. Many people could not perform activities which they used to perform.

3.3.1.2 Interview with ergonomics expert

This online interview was conducted by Prof. Jung Yong Kim, Hanyang University, Republic of Korea. He is conducting and supervising various research projects at ErgoMechanics laboratory in Industrial Engineering & Management Department, Hanyang University Republic of Korea.

Following paragraphs shows the expert opinion/responses regarding interview questions and the interviewed question are shown in appendix 17.3.

Ergonomics is an art to design the workplace according to the capabilities of workers. A poor workplace design is the cause of injuries, accidents, and fatigue for workers which leads to increase costs, decreases efficiency, and productivity. For different working situations and environments an ergonomist should consider and study the different branches of ergonomics:

i. **Physical ergonomics:** It deals with the human anthropometric, anatomical, biological and physiological characteristics, as they associated with physical activities.
ii. **Cognitive Ergonomics:** It deals with mental processing, such as habits, reasoning, perception, memory, and motor response, as they are related to the interactions between human and the system.
iii. **Environmental ergonomics:** It deals with human interaction with working environment. Physical environment is identified by the lighting, temperature, climate, etc.

Ergonomics is the field of research of people, their work, working environment, work design, procedures, etc. the general philosophy of ergonomics is to study and design the tools, working positions, work design, and working procedures according to the capabilities of workers. Workers should be aware that ergonomics is for their betterment during work and an ergonomist assist them for continuous improvement. The integration of ergonomist and physiotherapist are very much necessary and it has been applying since long time ago, when occupational therapist recognized that they are not able to completely eliminate the hazards at workplace, but they can identify the hazards, and define the safe working postures. Occupational therapist and ergonomics can apply their expertise at workplace to eliminate the hazards in work and working environments.

Further expert said, several risks situations occurred at every step of life, risk have influence on every person sometime major and sometimes minor as per the situation of risk. Normal situations of risks are from economic, health, safety, environmental, social aspects, etc. Risk is the potential of injury, threat of damage or loss, or any other negative outcome. It influenced at every aspect of life and can be avoided by preventive actions. Also he mentioned that Psychological and physiological risk are the growing research areas this time and several psychological and physiological factors are associated with risk during daily working tasks, and the evaluation of risk on daily basis is very necessary. Evaluation of psychological and physiological risk factors can be done by different experiments as suggested by many authors.

Risk influenced at every situation of life, and risk management is very necessary to avoid any surprise in our life. Risk management is applied from crossing a road to managing a large organization, at every concerned area in order to increase performance at every step. He further mentioned that there are several assessment tools, but MSI (musculoskeletal injury) Risk Assessment is highly recommended for domestic users, as it covers all domestic activities areas.

3.3.2 Conclusion from experts interviews

Both the experts support the interdisciplinary nature of this thesis very strongly. Ergonomics expert says that ergonomics is an art, and as such hard to put hard and fast rules to, however, i have shown through my work that with clear process and analysis, one can apply known measures to reduce load/risk and as such apply the ergonomic principles to the domestic environment. It is interesting to observe his viewpoint that “psychological and physiological risk are the growing research areas this time...”. This is important because as people age, it becomes even more significant in stopping them do things, as they feel they cannot do it, or are scared of injury. Therefore, designed tool can be used to reassure/give knowledge to individuals such that they can use safe practices to continue their independent living.

3.3.3 Survey

A survey is the process of gathering information from a number of individuals in a specific manner [205]. The main goal of the survey is to provide a precise depiction of how people of different age groups feel about the selected topic and what they want to do in future. Figure 3-8 depicts the survey designing process, which consists of the following five steps [205]:

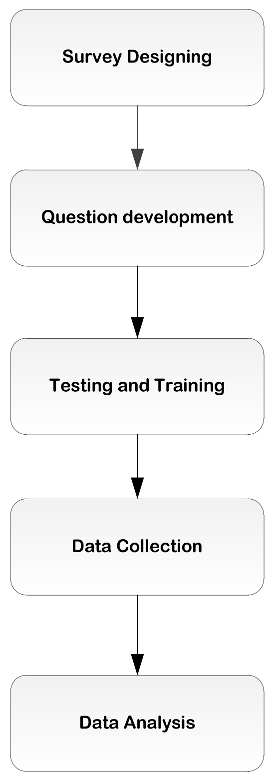


Figure 3-8 Survey designing process

3.3.3.1 Survey Designing

Surveys can be categorised into two types: (i) questionnaire (instrument based on research questions for gathering information from respondents) and (ii) interview (obtaining face-to-face information from respondents) [206]. Conducting a survey is a helpful and unbiased way to achieve good and reliable decision-making and motivates the respondents to reflect on the studied topic in a broader perspective.

3.3.3.2 Question Development

Questionnaire designing is a crucial phase of the survey development process. A well designed questionnaire is considered to be a good and reliable tool for measuring attributes that cannot be observed directly [205]. The careful design of questions in a questionnaire is a technique that is used for obtaining people's opinions about the selected topic. Fowler states that "a good question is one that produces answers that are reliable and valid measures of something we want to describe" [207]. In developing questions for a survey one should make sure that the words used in the questions are consistent with the instructive level of the intended respondents [208] and do not have an alternative interpretation or incomplete sentences which could confuse the respondent [207, 209]. In the present study the questions are designed to obtain the maximum information on the selected topic, ensuring also that the questions are understandable so that response errors are minimized and the data collected are reliable and fit for analysis. Furthermore, the length of the questionnaire is also taken into account so that the questionnaire does not appear burdensome to the respondents.

3.3.3.3 Testing and Training

Pre-tests or pilot tests help to ensure that survey tools are fit for use for the intended purpose. They evaluate the competency of the questionnaire and provide feedback on whether or not the clarity of the questions is apparent to every respondent and the true meaning and intention are conveyed to the respondent. According to Iraossi [210], there are three basic goals of the pre-test, as follows:

1. Evaluate the competency of the questionnaire.

2. Estimate the length of the survey or time needed to take the survey.

3. Determine the quality of the person conducting the survey.

3.3.3.4 Data collection

In designing the questionnaire, the most important and critical step is how to collect data which is defined as modality or mode [211]; in other words, the channel of communication with the respondents [212]. Face to face, telephone, mail, web, or mixed modes are commonly used [211], but many researchers prefer the mixed mode approach because it diminishes cost, reduces error and gathers more data [213]. Veilleroy and Hoogstoel [212] classified the survey modes into two categories: Administrated modes (including face-to-face and telephone conversations with respondents) and Self-Administrated modes (which include letter post, online (e.g. to social media like Facebook etc.) and e-mail). Table 3-15 shows a comparison between the different factors and modes used in surveys [211] and indicates the ease of use in the selection of the different modes used in the survey. It can be seen that among all the available modes of survey, the most convenient one is web based, because it is the cheapest and fastest and carries the least risk of bias in a respondent's replies. In addition, in a survey-based study the respondent's response plays a very important role in analysing the data. Most surveys use a term called the response rate ("The percentage of people who respond to your survey" [214]), to obtain an idea about how many people answered the survey. From the literature review, it was found that an adequate response rate of a sample size of 200 to 300 is 169 [215]. The response rate can be calculated by using the following formula [214]:

$$\text{Response Rate} = \frac{\text{Number of Complete Surveys}}{\text{Number of Participants Contacted}}$$

Table 3-15 A comparison between different factors and modes used in surveys

Factors	Face-to-face	Phone	Mail (letter post)	Web (email or social media etc.)
Cost	Costly	Moderate	Cheap	Cheapest
Speed	Slow	Fast	Moderate	Fastest
Response rate	High	Moderate	Low	Low to moderate
Length of survey	Long	Moderate	High	Moderate
Researcher control	Variable	Variable	None	None
Respondent burden	Low	Moderate	High	Moderate
Length of response option	Moderate	Moderate	Short	Short
Chance of interviewer bias	High	Moderate	None	None
Open-ended responses	High	High	Poor	Moderate

Source: [211]

3.3.3.5 Data Analysis

The analysis of the survey provided the way for further research to be undertaken, we use SPSS data analysis software to record and analyse the response to each participants.

3.3.4 Designing Rating scales for surveys and observational study

Rating scales play a central role in empirical studies and are ubiquitous in contemporary surveys designed to measure subjective phenomena such as attitude and belief [216]. In order to design an accurate and effective rating scale, one must define the following [216]:

1. How long a rating scale will be and whether the rating scale will include a centre point
2. Whether to include verbal labels on all points or to label some with numbers only

There is lack of an alternative approaches in designing rating scale, therefore most of the researchers or questionnaire designers design their rating scale based on their intuition [216] and end up using very different procedures for designing the rating scale [216]. For designing rating scales researchers must specify the number of points on the scale [217]. Therefore, researchers used different rating scales having different number points in their research, detailed for this is shown in table 3-16.

Table 3-16 Rating scale used by researchers in different studies

Name of researchers	Rating scale used	Source
Likert (1932)	5 point scale (often)	[218]
Osgood, Suci, and Tannenbaum's (1957)	7 point scale	[219]
Thurstone's (1928)	11 point scale (equal intervals)	[220]
Miller (1982) (The American National Election Study surveys	2,3,4,5,7,and 101 point scales	[221]
Robinson, Shaver, and Wrightsman's (1999)	2,3,4,5,6,7,9 and 10 point scales	[222]
Morin, (1993); Sussman, (1978) (measure public approval of the U.S. president's job performance)	2 to 5 point scales	[223, 224]

Source: [217]

By investigating table 3-16 it seems to be that there is no standard for number of points on rating scale and the common practice regarding to the number of point on the rating scale varies widely among the researchers [217]. However some literature suggested long scales (more points on the scale) are preferable to maximize the reliability and validity [217]. The other thing which is essential for designing the rating scale is labelling the points (how to label the points on rating scale?) and several studies mentioned that the rating scale reliability is higher when all the points on rating scales are labelled with words [225]. A study mentioned that verbally labelled scale points express greater satisfaction of respondents [226]. Therefore, this study overall use five rating scales: ease of use, physical demand required and complexity of the tasks, perceived discomfort and fatigue severity scale in surveys and observational studies.

3.3.5 Rating scales used in this study

This thesis used surveys and observational based studies, so it is necessary to define all 5 rating scales. Table 3-17 shows the details of five rating scale and their explanation regarding to the respective points used in each scale.

Table 3-17 Explanation of rating scales used in this study

Rating scale	No. of point used in rating scale	Points description	Used in
1. Ease of use scale	4	**1. Ease:** feel no difficulty in performing the task **2. Minor effort:** feel less difficulty in performing the task **3. Moderate effort:** feel difficulty in performing the tasks but within person's capability limits **4. Significant effort:** Feel great amount of difficulty in performing the task	Food preparation and Laundry survey
2. Physical demand required	4	**1. None:** no or very less physical demand required to perform the tasks **2. Minor:** less amount of physical demand required to perform the tasks **3. Moderate:** physical demand required to perform the tasks but within the person's physical capabilities **4. Too much:** an intolerable or exhausting physical demand required to perform the tasks	Food preparation and laundry survey and observational study
3. Complexity of the task	5	**1. Not at all:** the tasks perceived as simple to perform. **2. Slightly:** the tasks perceived as little bit complicated to perform. **3. Somewhat:** the tasks perceived as complicated to certain degree (more than slightly and less than moderately). **4. Moderately:** the tasks is perceived as reasonably complicated but performed happily. **5. Extremely:** the tasks perceived as highly complicated and having problems in performing efficiently.	Food preparation and laundry survey and observational study
4. Perceived discomfort scale	5	**1. No discomfort:** barely noticeable, most of the time you don't think about it **2. Mild:** annoying, nagging and bearable or gentle pain or ache feels by a person, but doesn't really interfere with the performance of daily tasks **3. Moderate:** manageable pain or ache feels by a person during the performance of tasks (tasks can be ignored for time being to manage pain) **4. High:** sever pain or ache feels by a person during the performance of tasks **5. Worst possible:** extremely sever or un manageable	Food preparation and laundry observational study

		pain or ache feels by a person during the performance of tasks	
5. Fatigue severity scale	5	**1. No fatigue:** no physical tiredness feels fresh and easily perform tasks **2. Mild:** less tiredness and not feeling fresh but still perform tasks **3. Moderate:** starting to feel tiredness and the performance of tasks are not as they were before **4. Severe:** intensely feel tiredness and the tasks are hard to perform. **5. Worst possible:** absolutely tired and the performance of tasks is almost impossible.	Food preparation and laundry observational study

3.3.6 Observational studies

In an observational study, researcher observes behaviour in an organised manner without influencing or interfering with behaviour [227]. According to Gorman and Clayton, observation studies are those that "involve the systematic recording of observable phenomena or behaviour in a natural setting" [228, 229]. Similarly, Becker and Geer explained this study as either covert or overt activity "in which the observer participates in the daily life of the people under study . . . observing things that happen, listening to what is said, and questioning people, over some length of time"[229, 230]. Normally, observational study involves two types of observation: naturalistic (natural environment is used to observe participants behaviour) or laboratory (laboratory environment is used to observe participants behaviour) observation [227]. In order to observe people in naturalistic or laboratory setting researcher has to adopt variety of roles as described by Baker (2006) [229]. Table 3-18 shows the four roles researcher can play during the observational study [229].

Table 3-18 Researcher role during observational study

Researcher roles during observational Study	Description
1. Non-participation	In this role researcher is not present (not on the scene) in front of participants but make observation from an entirely different environment. For example, observer can use transaction log analysis (TLA) for his observation.
2. Complete Observer	The researcher is present on the scene and does not interact or participate in the study, researcher role here is to listen and observe the participants.
3. Observer-as-Participant	In this role, the observer is known to participants and observer is present on the scene and has some interaction with the participants but this interaction is limited.
4. Participants-as-observer	In this role, the observer is a part of a group or team being studied. Observer is involved with participants in their tasks but observer participation is partial.

Source: [229]

Therefore this thesis used observational study for two tasks (food preparation and laundry) and during these study researcher played complete observer role.

3.3.7 Subjective Assessment Methods

Apart from the methods discussed in both areas (occupational therapy and ergonomics), another set of methods used by occupational therapists and ergonomists are subjective assessment scales, used to analyse parameters such as perceived fatigue, anxiety, depression and discomfort [53]. Subjective measurements are based on what people actually experience during the performance of a task, irrespective of how well they performed the task. Through these assessment methods techniques one can easily predict the psychological load associated with the performance of a certain task. For example, in a food preparation task a person can easily predict his/her fatigue level by using a simple fatigue level scale (marked from 1 to 10 with different levels of fatigue). The main benefit of using subjective assessment methods is that they are low-cost and very easy to use but they have a disadvantage, which is that the person's perceived opinion about the task may be influenced by biases.

In a subjective assessment, two methods are generally used: the Borg Scale (or Rating Perceived Exertion – RPE) and the Visual Analogue Scale (VAS). Perceived exertion experienced by a person is measured by the Borg scale [31], while VAS is also used to measure to perceived exertion among respondents through surveys [231]. In a comparison, both scales (Borg and VAS) show similar sensitivity and reproducibility [232].

3.3.7.1 Perceived discomfort

According to the Cambridge dictionary, "Discomfort is a feeling of being uncomfortable physically or mentally "[233]. It is also described as physical or mental distress" [234] and as something that disturbs or interferes with comfort and has a mild pain effect [235]. Everybody tries to avoid discomfort by adopting different postures. According to Cameron, discomfort is related with physical activities and, the level may be mild, moderate or high [236]. He suggests that "discomfort is a phenomenon of perception related to pain and fatigue" [236]. The Visual Analogue Scale (VAS) is to be used in this study to measure the perceived discomfort [159]. The simplest form of VAS is a 10 cm straight line whose ends are defined as extremes of the parameters to be measured [237]. Figure 3-9 shows the discomfort assessment visual analogue scale (VAS).

In ergonomics intervention, perceived discomfort plays an important role. Perceived discomfort is generally revealed as a short term effect of any physical activity and used as a subjective indicator [238]. In one study, it was conclude that perceived discomfort helps us to predict future musculoskeletal pain at work [238]. Another study also shows the association between discomfort and risks of musculoskeletal disorders [239]. Thus, it is necessary to study the effects of perceived discomfort not only in work environments but also in non-work environments.

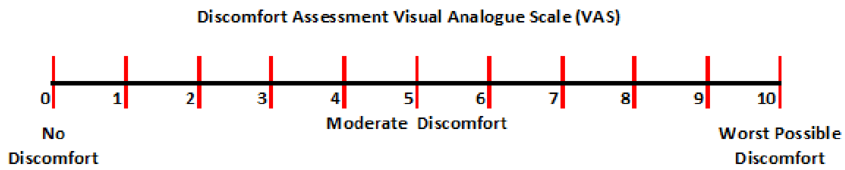


Figure 3-9 Discomfort assessment visual analogue scale (VAS)

3.3.7.2 Perceived exertion

Exertion is an estimation of the force required for a particular task which reflects the muscular effort and biomechanical stress on the muscles [146]. According to Borg, perceived exertion is the best indicator of physical strain [31]. In the work environment, the perceived exertion and fatigue felt by a person is used as an indicator of musculoskeletal stress [240]. Physical strain is associated not only with heart rate, but also with other risk factors such as arrhythmias, blood pressure evaluation, depression, body temperature changes, blood lactate level, and hormonal excretions [240]. See Table 3-19 Borg 10-point rating of Perceived exertion scale

Table 3-19 Borg 10-point rating of Perceived exertion scale

RPE	Description
0	Nothing at all
0.5	Very, very light
1	Very light
2	Fairly light
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Very, very hard (Maximal)

Source: [241]

3.3.8 Previously developed ergonomics assessment methods

There are many assessment tools developed by researchers within the working environment. These tools mostly analyse ergonomics risk factors (repetition, force, awkward postures, contact stress and vibration) and provide caution to workers so that they will perform their job(s) in an efficient way. Table 3-20 shows some recently developed ergonomics assessment methods.

Table 3-20 Brief description of recently developed ergonomics assessment methods

Assessment methods	Developed by	Assessing parameters	Scoring system
WERA: An observational tool develop To investigate the physical risk factors associated with WMSDs [54]	Rahman, Rani et al. in 2011.	Physical risk factors within working environment: body postures, force, vibration contact stress and task duration	Evaluate three risk level: Low, medium and high
Assessment of repetitive tasks of the upper limbs (the ART tool) [55]	Health and safety executive (HSE) in 2009	Physical risk factors within working environment by using subjective scales: frequency and repetition movements, force, awkward postures, and additional factors.	Evaluate three risk level by using traffic light system to grade the risks in low, medium and high
Novel ergonomics postural assessment methods (NEPRA) using product-process computer aided engineering ergonomics work place design [56]	Sanchez-Lite, Garcia et al. in 2013	Physical risk factors within working environment: postures analysis, muscles use score and force/load score	Final score base on three risk levels: low, medium and high
ROSA: Rapid office strain assessment [57]	Sonne, Villalta et al. in 2012	Tool assess the postures score related to using the office equipment such as chair, monitor, telephone, keyboard and mouse	ROSA base on scoring system adopted by RULA and REBA. ROSA score greater than 5 is considered as high risk and the workstation need immediate consideration
A Manual Tasks Risk Assessment tool (ManTRA) was developed as part of a research collaboration between The University of Queensland, Curtin University of Technology, and the Queensland Division of Workplace Health and Safety. The tool assess the level of risk of injury associated with specific workplace tasks [58].	Burgess-Limerick, Egeskov et al. in 2000	The tool assess the risk factors associated with the manual tasks in the workplace to prevent work related MSDs	Scoring is based on cumulative sum of risk exposure of each body region.

Ergonomics screening tool [59]	The ergonomics centre North Carolina in 2012	The tool rates motion, force and postures associated with the tasks for ten major body parts and assign body priority ranking as low, moderate and high	Tool used traffic light system to rate three parameters (motion, force and postures) as low, moderate and high.

The table 3-20 mentioned the assessment methods which identify and assess risks associated with tasks/activities and abilities to carry out tasks/activities. To fulfil the aim, this study designed a self-assessment tool whose initial designed is based on “ergonomics screening tool” designed by “the ergonomics centre North Carolina” in 2012 [59] as shown in figure 3-10.

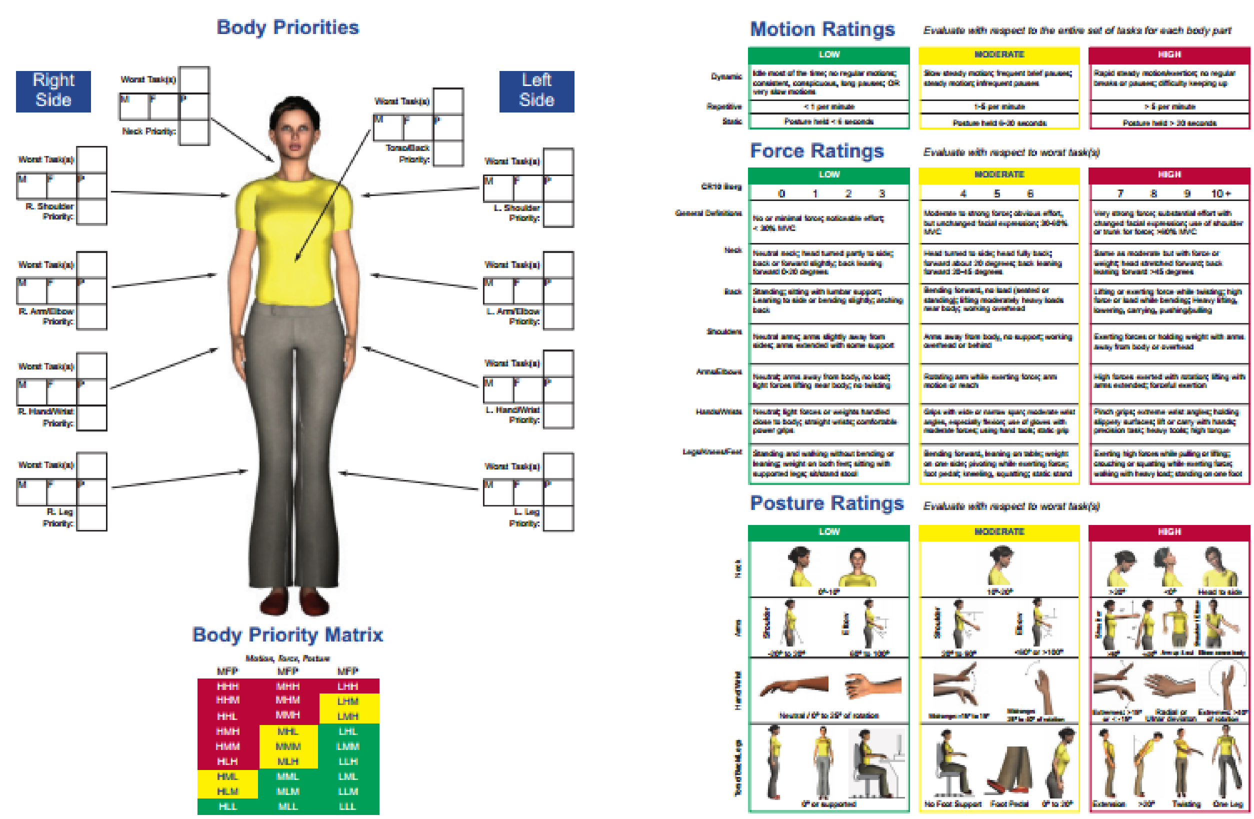


Figure 3-10 Ergonomics assessment tool developed by the Ergonomics Centre of North Carolina [59]

3.3.9 Validation techniques

An assessment tool is an instrument based on certain procedures which administered to individual to measure the person's competencies to perform job related tasks. The accuracy with which person or worker assessment scores can be used to forecast performance on the workplace is the tool's most significant characteristic which is referred to as predictive validity of assessment tool [242]. Therefore, the researchers are testing the validity, reliability and usability of their designed tool so that they know the accuracy level of designed assessment tool. Table 3-21 mentioned some of the assessment methods and the techniques used for the validation. It is revealed from the table 3-20 that many studies validate their tools against body part discomfort. Therefore the same technique is used in this study for validating the designed tool.

Table 3-21 Assessment methods their brief description and the techniques used for validation.

Assessment methods	Description	Technique used
WERA [54]	Measure WERA body parts score against body part discomfort survey. Validity testing of WERA used 130 construction workers. Reliability & Usability testing of WERA used 33 peoples which consist of OSHA practitioners and industrial managers.	**Validation:** WERA score against body part discomfort using survey **Reliability:** Inter-observer reliability **Usability:** Feedback questionnaire survey
ROSA [57]	Measure the ROSA final score against the total body discomfort in computer work in office environment. ROSA final score for the 72 office were analysed against the body part discomfort. ROSA inter-observer reliability is assessed by three trained observers who evaluated 14 workstations in the participation industry.	**Sensitivity and specificity** analysis of ROSA final score against the mean discomfort level **Reliability:** Inter-observer reliability **Cornell University Discomfort Questionnaire (CUDQ):** Also used to tested ROSA and found high validity and reliability.
An improved musculoskeletal discomfort assessment tool [243]	This tool used as proactive surveillance instrument to assist people to early identification of musculoskeletal discomfort. This tool was used by ergonomics	**Discriminant (sensitivity and specificity) analysis:** is used to accurately categorize individuals into three zones for an employ to seek treatment for

	experts to analyse 797 employee of public utility company in order to predict whether or not worker reportedly sought medical or therapeutic treatment for work related discomfort.	musculoskeletal discomfort.
Assessing the predictive validity of the UAW-Ford ergonomics surveillance tool [244]	There are many job risk factors for MSDs found in automotive industry. United automobile workers (UAW)-Ford Ergonomics Surveillance Tool (EST) has developed to screen the jobs and segregate them into low, moderate or high risk for work related MSDs which affect distal upper extremity, lower back, neck and shoulders. To check the predictive validity through sensitivity and specificity analysis study team used modified WISHA checklist to identify jobs in 4 automotive plants.	The tool's **predictive validity** is measured with the help of sensitivity and specificity analysis
Checklists for WMSD hazard evaluation [245]	The checklist for MSDs is developed for assess work related musculoskeletal discomfort in manufacturing industry and tested in semiconductor manufacturing industry. 122 participants from 6 industries participated in Nordic Musculoskeletal Questionnaire (NMQ) to check the sensitivity, specificity and positive predictive value of MDSs checklist.	**Sensitivity and specificity** values is calculated against prevalence of physical discomfort in various body parts and concluded that this checklist is proactive surveillance instrument for early identification of musculoskeletal discomfort.

3.4 Summary

It is accepted that as people age there is a tendency for them to lose their independence, and tasks become harder to carry out as their ability reduces. Slowing down a person's decline or utilising equipment to maintain their independence is a growing area of research. How the tasks are carried out within the home can accelerate this decline, and also the number of tasks that an individual must be able to do in order to maintain their independence is significant. It is known that discomfort leads a person to suffer musculoskeletal pain, which in turn leads to musculoskeletal disorders and then disability [238, 246]. Once musculoskeletal pain develops into a musculoskeletal disorder, the effects cannot be fully reversed, as lasting damage will have been done. Furthermore, the damage (musculoskeletal disorders) increases dramatically as the person ages, which in turn increases their likelihood of dependency.

There are many methods developed by researchers for the evaluation of activities of daily living ADLs [88], and they are often used by occupational therapists to assess the level of independence of their patients [95]. The most common occupational therapy methods are the Katz ADL scale, the Lawton IADL scale and the Bristol Activities of Daily Living scale. In each of these methods the person is analysed and a decision is made about whether they are able to live independently or whether they are now dependent in their daily living activities and will need support to complete their tasks.

From an ergonomics perspective the key risk factors are repetition, force and awkward positions, as these can lead to musculoskeletal disorders. Research has shown that these risk factors are also present within a home environment [171] and so activities within the home may also contribute to musculoskeletal disorders. Within the ergonomics there are many methods developed by which researchers assess the potential risks associated with industrial tasks. The most common methods are the Strain Index (SI) [146], Rapid Upper Limb Assessment (RULA) [12] and Rapid Entire Body Assessment (REBA) [13]. The potential application of these methods to a domestic setting may give significant insight into similar risks within the home. However, the different nature of the tasks within the two environments is such that care and thought will be needed when applying current ergonomic methods. For example, most tasks performed in a home environment are not continuously repeated, people may be involved in tasks which require them to adopt postures and the manual handling of objects simultaneously and may also be exposed to other risk factors as well as physical ones; therefore, using these tools directly within a domestic environment may be misleading or overestimate the risk. To date, all the ergonomic methods are used within the industrial environment to improve task design and reduce the likelihood of injury. Apart from the occupational therapy and ergonomic methods, researchers also used subjective assessment methods within respective environments (occupational therapy and ergonomic) to analyse perceived fatigue, anxiety, depression and discomfort [53]. The most common subjective assessment methods used by researchers and practitioners are the Visual Analogue Scale (VAS) and Borg perceived exertion scale.

4 Methodology and Framework of the Research

Quantifying the risks in performing activities of daily living is essential for a person to live an independent life. Having identified the risk in IADL or non-occupational tasks (such as housekeeping, childcare, gardening, or home repairs) [5, 17], it is necessary to establish a healthy domestic environment and thus reduce the chance of musculoskeletal disorders (MSDs). Performing many daily activities in non-neutral positions will mean a high probability of causing injuries or disease such as low back pain and arthritis in later stages of life; therefore the presence of risks in performing daily activities must be evaluated.

As discussed previously, this research aims to develop a self-assessment tool for evaluating domestic tasks and quantifying the risk associated with performing such tasks, and so the following are the objectives of this study:

1. *Based on the definition of IADLs given by Lawton [1], This study will determine which IADLs are most associated with a loss of independence and increased risk of injury.*
2. *Identify and compare different task/activity assessment methods from occupational therapy and ergonomics in order to quantify load and understand risk. Also assess the appropriateness of the identified assessment methods to assess the risk of injury associated with IADLs.*
3. *Identify the key parameters within tasks and activities within the home environment and potential methods for their assessment.*
4. *Propose an assessment tool for domestic tasks that quantifies load and risk.*

The study initially reviewed occupational therapy and ergonomics literature and found that psychological and physical changes occur at each stage of life [27]. These changes can include altering habits, exhibiting inappropriate behaviour, neglecting personal hygiene or stopping physical activities [204]. Such changes consequently jeopardize a person's freedom and can affect their quality of life. The decline in a person's abilities can be accelerate by trauma or disease, which can cause the person irreversible damage, although they can be reversed to some extent through an occupational therapy technique called rehabilitation, which enable the person to maximize their level of functionality [247] in performing their everyday tasks. It is found from occupational therapy literature that almost all the occupational therapy methods analyse people (for example the Katz scale is based on "do it with no supervision" or "do it with supervision") rather than analysing the nature of the daily tasks which are harder for them to perform. Most of the occupational therapy methods provide information about a variety of post-event disabilities but none of them indicate any risk before the specific injury occurs (pre-event). Furthermore, some methods are used to evaluate the specific number of tasks in order to know the major changes in a person's functional status but do not pay attention to the small increments of change in that status. A method such as the Lawton Brody scale identifies the amount of help required by a person in performing their daily tasks but no tool is mentioned nor is there an indication of the level of risk associated with the performance of those tasks.

If the risk in performing daily tasks is known earlier, where particular activities are harder for an individual to perform, then it is easy for healthcare personnel to cope with these problems by using early intervention techniques in daily activities. Although, like ergonomics, occupational therapy promotes early intervention, it is based on client-centred, occupation-based services and support for children and their families [3], and unfortunately, none of the occupational therapy methods are suitable for early intervention to help people before permanent damage occurs. In contrast, the ergonomics literature focuses on the symptoms (pain, numbness, tingling sensation, stiffed joints, muscles loss, difficulty in moving and paralysis) and the physical risk factors (force, repetition, awkward postures, static postures, excessive motion and compression) and the tasks are designed according to the physical abilities of a person so that the tasks fit the person instead of the other way around. Ergonomic methods also have the potential to provide early intervention by analysing the tasks which will help the person to understand the nature of the tasks, whether safe or hazardous. To date, ergonomics assessment methods are used for assessing industrial tasks, and using these methods in a domestic environment may be misleading or overestimate the risk because industrial tasks are completely different from domestic tasks but part of these methods can be used, such as analysing the postures adopted during the domestic tasks.

3.1 Identify domestic tasks

Occupational therapy literature indicates that there are various scales (for example, the KATZ ADL and Lawton IADL) which are used to evaluate the functional status of a person. This evaluation is based on the number of tasks (KATZ is based on 6 tasks and Lawton on 8 tasks) easily performed by a person and assesses their level of independence. Therefore, in this study the identification of the case study tasks was based on the IADL tasks as defined by Lawton and Brody which consist of the ability to use a telephone, carry out shopping, prepare food, do housekeeping, do laundry, use a mode of transportation, be responsible for own medicine, and handle finance [1]. Furthermore, in this study, the focus is on ergonomic risk factors, therefore the choice of tasks focuses on the more physical IADLs performed by everyone within the home environment. In addition, a survey was carried out to identify which specific IADL tasks are perceived to be most difficult to perform. The survey showed that people struggle with many tasks but for this study it has been decided to work on general housekeeping, preparing meals and laundry.

Case study tasks:

- Mopping - mopping a set area of floor with a standard mop
- Food preparation - chopping and slicing vegetables

- Laundering - carrying a basket of washing to a washing machine and loading it in.

3.2 Potential assessment tools

The aim of the experimental work in this study is to identify the ergonomic risk factors during IADL tasks performed at home using ergonomic assessment methods. In order to do this the following will be undertaken:

- Simulate these tasks within a known environment
- Apply ergonomic assessment methods to the case study tasks
- Identify risk factors within each case study task
- Evaluate the suitability and methods used in the ergonomic assessments against the occupational therapy assessments

The plan will be to simulate a mopping task in order to study the effects of ergonomic risk factors such as adopted body postures, repetition and perceived discomfort and related chance of injury associated with these tasks. Similarly, the plans for food preparation and laundering consist of two steps: 1) Getting the people's opinions about the food preparation and laundering task with the help of a questionnaire; then 2) using the ethnography technique to understand the hardest part of food preparation and laundering activity in a real home environment and analysing the performed task by using ergonomic observational methods and subjective assessments, as shown below.

Case study ergonomic assessment methods:

- RULA
- REBA

- Strain Index (SI)

- LUBA

The rationale for using ergonomic methods in the study can be summed up by the following:

- The SI score is the most significant in evaluation of distal upper extremity disorders (hand and wrist) [47-49]. Researchers have compared SI with other ergonomic tools and found that SI is the best for distal upper extremity disorders risk prediction [248, 249].
- RULA focuses on upper limb, shoulder, neck and back, which are the most relevant parts of the body in the different types of tasks for a high occurrence of injury [12].
- REBA is the simplest and most commonly used task analysis method to determine risk associated with the entire body (forearm, elbow, shoulder, neck, back and leg) [13].
- LUBA is based on different sitting or standing tasks by assigning the weights for the postures according to the discomfort felt in individual joints. It assigns the numeric score to the discomfort felt in individual joints, which makes the decision easier than a qualitative description [148].

3.3 Analysis of the tasks

The idea for this study is to analyse each domestic task by using three parameters: psychological perception of the task, adopted postures and manual handling of objects. These parameters are investigated through brainstorming and through developing a mind map (see section 15.2, Appendix A) on "How to assess the IADL task". The parameters cover the occupational therapy and ergonomics perspective. In addition to the mind map, it is noticeable that whenever a person performs any domestic task, he or she is involved in three aspects:

1) How the tasks should be done (psychological perception of the task)

2) Using parts of the body to perform that task (adopted posture)

3) Lifting/lowering, pushing/pulling and carrying the objects (manual handling) during the performance of the tasks

Therefore, these three parameters are more appropriate for the evaluation of domestic tasks. The psychological perception of the task is measured by a subjective scale whereas adopted postures and manual handling of objects can be measured with the help of ergonomic techniques. The technique for assessing the tasks by using both occupational therapy and ergonomics is helpful in order to understand the domestic tasks.

3.4 Propose assessment tool

This study aims to develop a self-assessment tool that quantifies the load and risk associated with the performance of daily tasks. In order to do that, the knowledge of two important disciplines (Ergonomics and Occupational Therapy) has been used to propose the new assessment tool. It is hoped that approaches and intervention from both disciplines will produce a positive impact on people's lives and make it possible for them to achieve their full potential. To date little or no consideration has been given to quantifying the load and risk associated with the performance of daily tasks. No study up to now has used ergonomic assessment methods to analyse IADL tasks, although other techniques such as anthropometry [250-252] are used by researchers to design or redesign the work space in working and non-working environments [126]. Therefore, in this project an attempt has been made to investigate and understand the daily tasks, and evaluate the psychological and physical risk factors through designing a new assessment tool which quantifies the load and risk related to the performance of domestic tasks. Figure 4-1 shows the overall structure of the project.

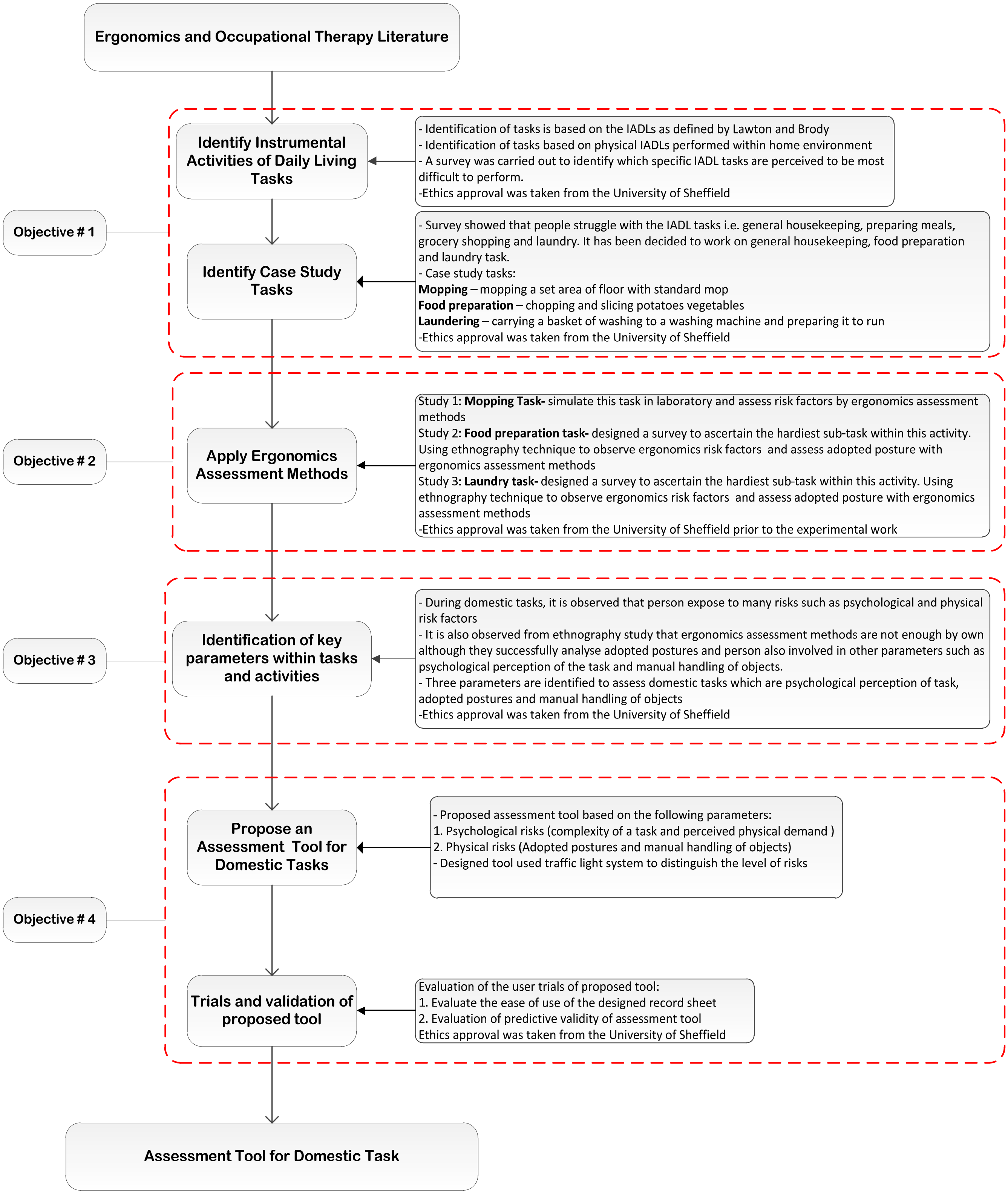


Figure 4-1 Overall structure of the project

5 Ethics for the study

Ethics is known as code of conduct. It is the scientific discipline dealing with values relating to person's conduct, with respect to the rightness and wrongness of certain actions and to goodness and badness of the motives and end of such actions [253]. Ethics can also be defined as "the norms for conduct that distinguish between acceptable and unacceptable behaviour" [254]. Ethical consideration is essential because this research involves cooperation and coordination among many people in different institutions and disciplines, ethical regulations promote the values that are necessary to collaborative work, such as trust, fairness and mutual respect. Ethical consideration in research is essential because if, it lapses in the research then it can significantly detriment human subjects, students and the public [254]. Therefor in this project ethics approval had been taken before conducting surveys and the experimental works. Table 5-1 shows the detail outline of the work conducted and respected ethic approval status in this study. Ethics applications used in this study is attached in appendix C 17.4 and 17.5, which will provide ease if one can replicate this work.

This study is based on observation of participants while performing their tasks in their usual way, that were then identified as being moderate or high risk, then aware them about potential danger of adopting posture which are not good and also provide them recommendation for controlling or lower their risk in daily life (see Appendix C 17.1).

Table 5-1 Detail outline of the work conducted and ethics approval status in this study

Work contents	Title in the thesis	Mode of conducting, sample size & age group	Ethics approval taken by University Of Sheffield
Surveys	Questionnaire on Instrumental activities of daily living	Internet based, N=181 & (18 to 90) years	Yes
	Questionnaire on food preparation task	Self-administer, N=60 (18 to 90) years	Yes
	Questionnaire on Laundry task	Self-administer, N=60 (18 to 90) years	Yes
Experimental work	Mopping task	Simulating in laboratory environment, N=20	Yes
	Food preparation task	Observational study in participant's home environment, N=1 & Age=33years, Male	Yes
	Laundry	Observational study in participant's home environment, N=2 Age=33years, Male Age=29 years, female	Yes
Experimental work Before developing assessment tool	Evaluation of duration and frequency of a tasks performed by participants in their home environment	Observational study in the participants home environment, N=7 & (28 to 35) years	Yes
Task assessment tool for ease and risk (AER) within domestic environment	User trials:		Yes
	Part-I: Evaluation of the ease of use of the record sheet	Observational study in the participants home environment, N=10, & (40 to 60) years	
	Part-II: Pilot observed trial of the AER (Validation)	Observational study in the participants home environment, N=10, & (26 to 51) years	

6 Surveys

6.1 Investigation into IADL tasks

The primary aim of conducting this study is to assess instrumental activities of daily living (IADL) and collect information about how people perform tasks differently as they age. Therefore, for the investigation into IADL tasks, critical thinking has been applied to three basic statements: how people performed and perceived IADL tasks, their ease of use in such tasks, and which sub-task(s) caused problems when IADL tasks were performed. In order to investigate the IADL tasks, this study will conduct a survey, through a questionnaire, to obtain opinions, attitudes and factual information in order to achieve the aims of the study. Thus three sets of research questions have been designed, with two questions in section 1 and 2, and four questions in section 3, in order to answer the following questions:

i. Which IADL tasks do people find it difficult to perform?

ii. How much time do people spend on performing basic daily living tasks?

People perceive and perform IADL tasks differently and become engaged or involved in many tasks simultaneously on a daily basis. There is an important link between the number of tasks they perform and the ones among them which are not easy to perform. Thoughtful and advance planning of those tasks which are difficult to perform will enhance a person's control over their daily tasks, which ultimately affect the quality of life in later stages of life. Therefore, the above-mentioned question has been designed for this survey in **Section 1**.

iii. Which IADL tasks would people modify or change when performing them?

iv. Which of the IADL tasks would people of different age groups like to be modified to make them more comfortable to perform?

People adopt a variety of body postures to increase the level of ease in the performance of their daily tasks, but unfortunately there are some tasks (such as mopping and vacuuming) which force a person to adopt awkward postures (excessive bending and reaching) which in turn produce a strain on their body and make the tasks harder to perform. Therefore, the above-mentioned questions being designed in **Section 2**.

v. Which IADL tasks require greater physical effort?

vi. Which IADL tasks cause most physical discomfort?

vii. Which parts of the body feel discomfort when IADL tasks are being performed?

viii. Which IADL tasks cause the highest discomfort level (mild, moderate or high)?

Discomfort is referred to as physical and mental distress which interferes with a person's comfort and produces different levels of pain (mild, moderate or high) in daily tasks [234]. Performing the tasks causes some degree of discomfort but those tasks which last longer produce much higher discomfort. As people tend to do several tasks simultaneously, this produces a greater magnitude of discomfort and affects different parts of the body (wrist, arm, neck and back). Therefore, the above-mention questioned has been designed in **Section 3,** so as to indicate the tasks which are harder to perform as well as the related parts of the body where people experience mild to high discomfort in performing their daily activities.

6.1.1 Rationale for using the Lawton Scale for Instrumental Activities of Daily Living (IADL)

The designed questionnaire is based on Lawton's description of IADL. It was published in 1969, and is 47 years old. One can immediately ask that many things have changed in 47 years for example introduction of internet shopping, cordless devices, microwaves ovens, a range of cleaning devices etc. However although the advance technology has a potential to maintain or promoting the person's independence in later life [255]. The emotional responses of older people towards new or advanced technology can be prohibitive to these benefits. There is reason to believe that advanced technology holds substantial promise for improving the person's quality of life (especially for older adults), however elderly people are frequently unwilling to adopt new technologies because they might think simple is better, complex might work for some other people and they also might think they do not need it [255]. Similarly, the study conducted in University of Illinois at Urbana-Champaign (2012), the researcher has mentioned the following several reasons and factors as to why various older people prefer to use simple technology or stick with older version of technology [255]:

Reason 1:

"*Many older residents expressed a sense of helplessness when faced with advanced or newer forms of technology, and as a result, they prefer to use simpler technologies*".

Reason 2:

"The older adults gave for their preference for simple technology was previous experience"

Reason 3:

"The older adults gave for preferring simple technology was compatibility with their lifestyle. Compatibility"

Reason 4:

"The older adults' preference for using simple technology was their perception that they had a decreased ability to learn new things".

Reason 5:

"The older adults' preferred simple technology was their isolation".

In addition to above mention reasons there are some other studies which show the older people attitude towards the adoption of new technology:

- Mitzner et al., 2010 has mentioned that "many older adults are unable, unwilling, or afraid to use technology" [256].
- Smith, 2010 and Adler & SeniorNet, 2006 has mention that older people are much less willing to use or take advantage of advanced technology as compared to younger people [257] [258].
- Czaja and Sharit (1998) has reported in his research that older people felt less in control, comfortable and confident when using computers [259].
- Dyck and Smither (1994) has mentioned that older people often have less experience with using of advance technology than younger people and this deficiency of experience may contribute to higher anxiety levels and a negative attitude toward advance technology [260].

Apart from the above mentioned discussion, there is speculation that older people might be reticent to take up new technology however in their lifetime they adopted new technology in the early and middle years and therefore are not completely technologically averse. This means that the older adults we are testing today are using very different devices to carry out ADLs than the older adults of 47 years ago when the ADL index was developed. Therefore, although the physical and functional components of the original tasks of 47 years ago still hold true as 'staple' actions within ADLs today; they might not be repeated so often but are still present (i.e. whilst internet shopping might reduce the burden of the shopping activity, people don't use internet shopping every single time).

Therefore it was decided for this survey based study to use simple, standard and reliable tasks which was well known to ordinary people and among the professionals (health care professionals, occupational therapists and physiotherapists etc.). So, the Lawton Scale for Instrumental Activities of Daily Living (IADL) scale provided the list of 8 tasks which analysed person's ability to cope with their daily activities and become the basis of studied survey designed.

6.1.2 Description of terms used in questionnaire

In designed questionnaire some terms are used which might have different meaning for the different user. Therefore, it is important to define these terms (what do researcher means by these terms?). Following are some of the terms used in questionnaire and their brief description:

1. Using telephone: simply make a phone call by using common household telephone.
2. Use computer/ access internet: able to use computer or access internet.
3. Grocery shopping: physically go to supermarket for shopping.
4. Preparing meal: physically involved in the meal preparation process. It means that the person carries out meal preparation steps such as gathering pans and utensils, gathering vegetable for rinse, peeling vegetables, chopping vegetables and stirring or frying.
5. General housekeeping: performed housekeeping activities such as mopping, wiping, cleaning kitchen tops, hoovering, cleaning bathrooms etc.
6. Doing laundry: physically involved in laundry process. It means that the person carries out laundry steps such as gathering clothes, sorting and pre-treatment, washing machine preparation, drying clothes and folding clothes.

6.1.3 Method

The design of this questionnaire was based on the five steps which are discussed in section 3.3.3. In this study, investigation into IADL tasks based on ability to perform the IADL tasks as defined by Lawton and Brody, which consist of using the telephone, shopping, food preparation, housekeeping, laundry, using a mode of transportation, responsibility for own medicine, and ability to handle finance [1]. The questionnaire consists of ten main questions (see section 15.1, Appendix A) which are directly related to IADL and three more questions at the end, which are designed to obtain monitoring information. The first three questions are related to the difficulty of the task, physical effort required and behaviour effect, for different IADL tasks performed in daily life. They are as follows:

1. *Please rate the following tasks in terms of difficulty to perform*
2. *Please rate the following tasks with respect to the amount of physical effort required*
3. *For each of these tasks, have you modified or changed how you perform them over the years to make them easy*

The next four questions are related to perceived physical discomfort, amount of time spent in everyday tasks and which tasks need to be modified to make it more comfortable to perform them:

4. *Which of your everyday tasks causes you the most physical discomfort and why?*
5. *Which of your everyday tasks do you feel is the most awkward to perform and why?*
6. *Which of your everyday tasks do you spend most of your time doing and how long?*

7. *Which of your everyday tasks would you most like to be modified to make it more comfortable?*

The remaining three questions after that are about assistive device, pain associated with different body regions and severity of discomfort (mild, moderate, high and extreme), as follows:

8. *Indicate any tools or assistive devices you use regularly.*
9. *Do you experience any pain or discomfort in your hand, wrist, arm, shoulders, neck or back when carrying out your everyday tasks?*
10. *How severe would you rate the discomfort as being?*

The targeted population for this survey is older people over the age of 40 but also includes various younger age groups. The entire designing process in this survey is related to activities of daily living that are essential to people being able to live independently, and especially in relation to the movement and care of their body. This survey assesses activities of daily living (ADL) and instrumental activities of daily living (IADL) for different age groups in relation to how habits alter with age and their opinions and suggestions as to which activities need to be modified.

The design of this questionnaire was based on the ability to perform the IADL tasks as defined by Lawton and Brody, which consist of using the telephone, shopping, food preparation, housekeeping, laundry, using a mode of transportation, responsibility for own medicine, and ability to handle finance [1]. The questionnaire consists of ten main questions (see section 15.1, Appendix A) which are directly related to IADL and three more questions at the end, which are designed to obtain monitoring information. The first three questions are related to the difficulty of the task, physical effort required and behaviour effect, for different IADL tasks performed in daily life. They are as follows:

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6. *Which of your everyday tasks do you spend most of your time doing and how long?*

7. *Which of your everyday tasks would you most like to be modified to make it more comfortable?*

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8. *Indicate any tools or assistive devices you use regularly.*

9. *Do you experience any pain or discomfort in your hand, wrist, arm, shoulders, neck or back when carrying out your everyday tasks?*
10. *How severe would you rate the discomfort as being?*

The questionnaire that was designed underwent two pre-test sessions: in the first session, feedback from different researchers, who possess good experience in survey design, was obtained, whereas in the second session, feedback from respondents of different age groups was solicited (four respondents were used: two male and two female). There were some reservations or uncertainties about the clarity of the questions, from researchers and initial respondents, which have been resolved by gathering more information, and the final version of the questionnaire design has been judged by the earlier mentioned (see section 3.3.2.3) three basic goals of the pre-test. The following are the reservations provided by the initial respondents:

- *Length of survey: Try to minimize or avoid unnecessary questions*
- *Inadequate options for response: Try to make the options clear and avoid confusion among the different options*
- *Ambiguity in some questions: Try to make the questions clear (use simple language) and free from ambiguity*
- *Demographics: Try to ask the demographic questions which are necessary for the intended purpose of the survey*

This survey gathered data for different instrumental activities of daily living. The data gathering was related to 10 different questions which covered all the possible activities needed for fulfilling the aim of the study. There were 181 responses that were found suitable for this survey including both male and female respondents in different group ages. The questionnaire was divided into two parts. As mentioned earlier, the first part consisted of questions related to daily living tasks and the second part was related to monitoring information. Statistical analysis was used to prioritise the IADL tasks based on number of responses received.

6.1.4 Sample size

The determination of sample size is essential for survey based study. Inadequate, inappropriate or excessive sample sizes affect the quality and accuracy of the research [261]. The target population for this study includes all healthy adults (of both genders) between ages 18-65, currently employees/students of University of Sheffield. The exclusion criteria for this study was for any adults with a diagnosis of cognitive and/or physical ill health now or previously. For this study 255 people were contacted through an email list of University Of Sheffield and of those contacted 181 responses were found to be suitable for the study. Therefore the response rate for this study is 71% (181 people).

6.1.5 Results and discussion

Table 6-1 shows the demographics of the 181 respondents who participated in the survey. This segment answers the rational statements which were mentioned at the beginning of this chapter with respect to each section and survey questions numbers respectively (see section 13.1, Appendix A).

Table 6-1 Demographics of 181 respondents

Age Groups	Male	Female	Total
(18-30) Years	37	39	76
(31-40) Years	9	10	19
(41-50) Years	7	8	15
(51-60) Years	19	10	29
(61-70) Years	10	10	20
(71-80) Years	8	5	13
(81-90) Years	6	3	9
Total	**96**	**85**	**181**

So as to see the effect of how people in different age groups performed the tasks, it was decided to divide the data into five age groups: 18-30, 31-50, 51-70, and 71-90 years, to ease in understanding and in line with previous research [262]. Table 6-2 shows the details of each age group and their responses within their group.

Table 6-2 Number of responses and proportion within each age group

Age Groups	Male	Female	Row Total	Percentage
18-30 years	37	39	76	42
31-50 Years	16	18	34	19
51-70 Years	29	20	49	27
71-90 Years	14	8	22	12
Column Total	96	85	181	100

6.1.5.1 Section 1: i. Which IADL tasks do people find difficult to perform?

In order to discover "Which IADL tasks do people find difficult to perform?", IADL survey question 1 ("Please rate the following tasks in terms of difficulty of performance") was used. The data revealed that there were three tasks ("using the telephone", "using the computer/accessing the internet" and "managing any medication") that most people found easy to perform, so the focus was placed on more physical tasks. Figure 6-1 shows the proportion of respondents who found the IADL tasks (grocery shopping, preparing meals, general housekeeping and doing laundry) difficult to perform. Figure 6-1 reveals that respondents struggled to perform four of the IADL tasks (general housekeeping, preparing meals, grocery shopping and doing laundry) but the hardest and most difficult task to perform, among all the respondents, was general housekeeping, because only 31% respondents found this task easy and 69% of the respondents rated this task as moderate to extremely hard and difficult to perform. Therefore, it can be inferred that, the most difficult task was general housekeeping.

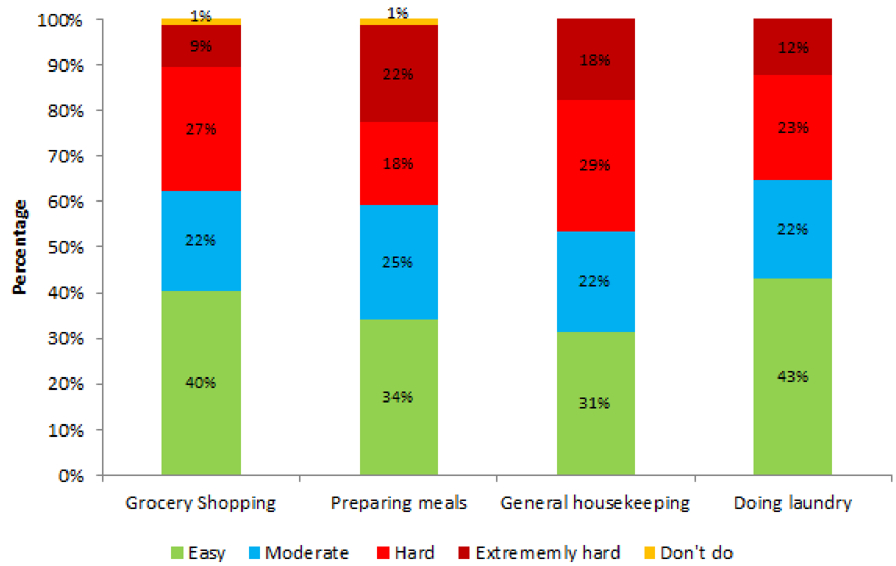


Figure 6-1 Proportion of respondents who found the IADL tasks difficult to perform

Tasks difficult to perform with respect to different age groups:

As mentioned earlier, the participants struggled to perform four tasks: general housekeeping, preparing meals, grocery shopping and doing laundry. The data is now broken down into age groups, to show more precise details. Figures 6-2 to 6-5 show the proportion of respondents in different age groups who found the tasks difficult to perform.

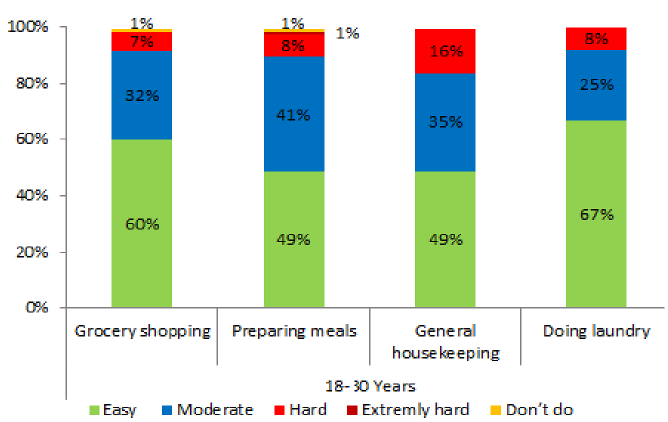


Figure 6-2 Proportion of respondents in 18-30 year olds age group

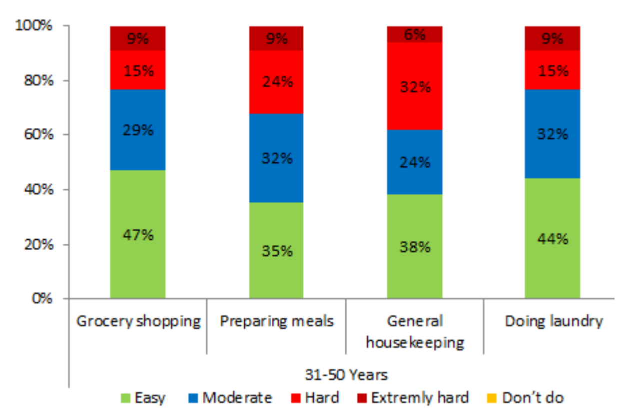


Figure 6-3 Proportion of respondents in 31-50 year olds age group

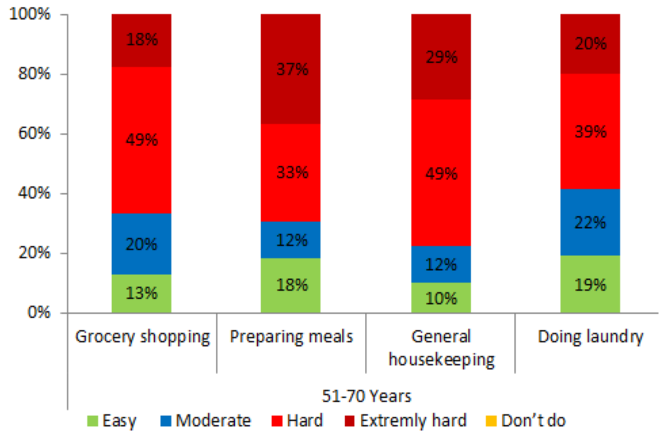


Figure 6-4 Proportion of respondents in 51-70 year olds age group

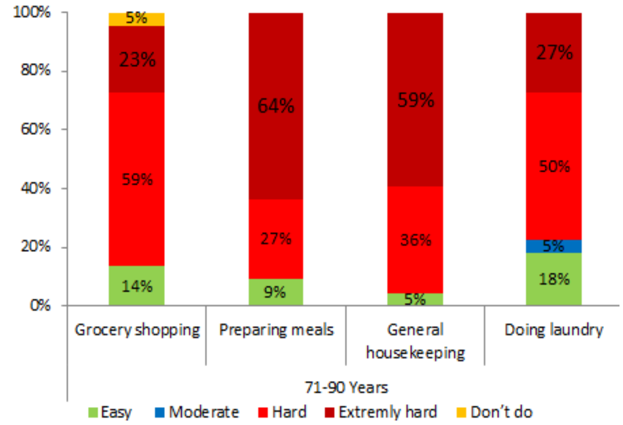


Figure 6-5 Proportion of respondents in 71-90 year olds age group

<u>18-30 years</u>:

It is interesting to observe from Figure 6-2 that 49% of the respondents in this group easily performed both preparing meals and general housekeeping, although 50% (41% + 8%+ 1%) perceived preparing meals as moderate to extremely hard while 51% (35%+ 16%) perceived general housekeeping as moderate to hard when performed. Furthermore, 1% respondents do not prepare meals and do not do grocery shopping or do not like doing so. In general, it could be inferred that respondents in this age group perceived general housekeeping (51%) and preparing meals (50%) as the first and second most difficult tasks to perform, while grocery shopping (40%) and doing laundry (33%) are the third and fourth most difficult tasks to perform.

<u>31-50 Years</u>:

It is shown from the Figure 6-3 that the respondents in this age group perceived grocery shopping, preparing meals, general housekeeping and doing laundry as moderate to extremely hard when performed but the highest proportion, 65% (32% + 24% + 9%), was for preparing meals. Furthermore, the proportion of respondents in other tasks which were perceived as moderate to extremely hard was 62% (24%+ 32%+ 6%) (general housekeeping), 56% (doing laundry) and 53% (grocery shopping) respectively. In general, it could be inferred that respondents in this age group perceived preparing meals (65%) and general housekeeping (62%) as the first and second most difficult tasks to perform, while doing laundry (56%) and grocery shopping (53%) were the third and fourth most difficult tasks to perform.

<u>51-70 Years</u>:

It can be seen from the Figure 6-4 that, the respondents in this age group perceived grocery shopping, preparing meals, general housekeeping and doing laundry as moderate to extremely hard when performed but the highest proportion, 90% (12% + 49% + 29%), was for general housekeeping. Furthermore, the proportion of respondents in other tasks which they perceived as moderate to extremely hard was 87% (grocery shopping), 81 % (doing laundry) and 82% (preparing meals) respectively. In general, it could be inferred that respondents in this age group perceived general housekeeping (90%) and grocery shopping (87%) as the first and second most difficult tasks to perform, while preparing meals (82%) and doing laundry (81%) were the third and fourth most difficult tasks to perform.

<u>71-90 Years</u>:

The respondents in this age (see Figure 6-5) group also perceived grocery shopping, preparing meals, and general housekeeping as hard to extremely hard while doing laundry was moderately to extremely hard when performed, but the highest proportion, 95% (36% + 59%), was for general housekeeping. Furthermore, the proportion of respondents in other tasks which were perceived as hard to extremely hard was 91% (preparing meals) and 82% (grocery shopping) , while a small proportion within this group (5%) either did not do or did not like to do grocery shopping at all. In general, it could be inferred that respondents in this age group perceived general housekeeping (95%) and preparing meals (91%) as the first and second difficult most tasks to perform, while grocery shopping (87%) and doing laundry (82%) were the third and fourth most difficult tasks to perform.

Comparisons of the difficulty levels of the tasks among the different age groups:

It has been noted from Table 6-3 that among the different age groups there were four tasks that were difficult to perform: general housekeeping, preparing meals, grocery shopping and doing laundry. Therefore, comparing the proportion of difficulty levels of the tasks among different age groups can give more insight into how people perceive these tasks.

An overall comparison between the general population and the different age groups is shown in Table 6-3. It also shows the classification of the hardest sub-tasks (hardest to least hard) of food preparation tasks. The classification is based on the general population.

Table 6-3 Difficult tasks for the general population and with respect to the different age groups

Difficult tasks in general population	First four difficult tasks with respect to different age groups			
	18-30 Years	31-50 Years	51-70 Years	71-90 Years
General housekeeping	General housekeeping	Preparing meals	General housekeeping	General housekeeping
Preparing meals	Preparing Meals	General housekeeping	Grocery shopping	Preparing meals
Grocery shopping	Grocery shopping	Doing laundry	Preparing meals	Grocery shopping
Doing laundry	Doing laundry	Grocery shopping	Doing Laundry	Doing laundry

<u>General housekeeping</u>:

Figure 6-6 shows the proportion of difficulty levels for the different age groups in the general housekeeping task. In the 18-30 year old age group, respondents perceived this task as easy to hard but most of them (20.4%) found it easy to perform. In the 31-50 year old age group, respondents perceived this task as easy to extremely hard but most of them (7.18%) also found this task was easy to perform. Similarly, in the 51-70 year old age group, respondents perceived this task as easy to extremely hard but the most of the respondents (13.3%) found this task was hard to perform. Furthermore, in the 71-90 year old age group, respondents perceived this task as easy to extremely hard but most of them (7.2%) found it extremely hard to perform. *Therefore, it is concluded that this task is easy for the first two age groups (up to 50 years) but hard or extremely hard for the third and fourth age group (over 50 years) respondents.*

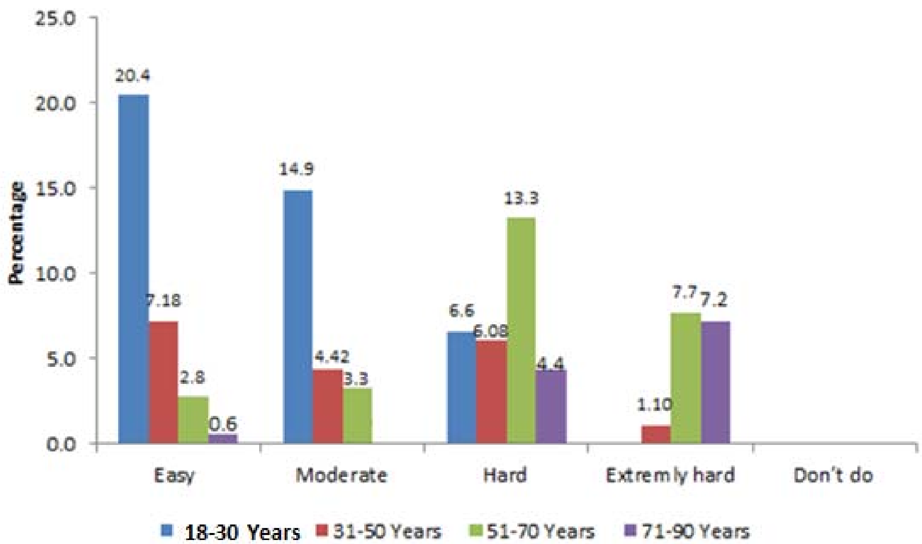


Figure 6-6 Proportion of difficulty levels for different age groups in general housekeeping task

<u>Preparing meals</u>:

Figure 6-7 shows the proportion of difficulty levels for the different age groups in preparing meals. In the 18-30 year old age group, respondents perceived this task as easy to extremely hard but the most of them (20.4%) found it easy to perform. In the 31-50 year old age group, respondents perceived this task as easy to extremely hard but the most of the respondents (6.63%) also found it easy to perform. Similarly, in the 51-70 year old age group, respondents perceived this task as easy to extremely hard but the most of them (9.9%) found it extremely hard to perform. Furthermore, in the 71-90 year old group, respondents perceived this task as easy to extremely hard but the most of them (7.7%) found it extremely hard to perform.

Therefore, it is concluded that this task is easy for the first two age groups (up to 50 years) but extremely hard for the third and fourth age group (over 50 years) respondents.

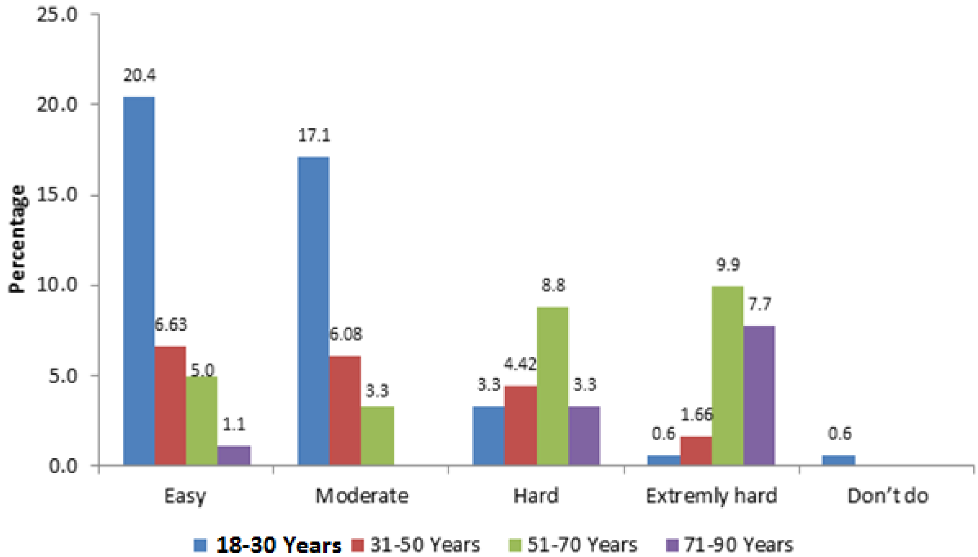


Figure 6-7 Proportion of difficulty levels for different age groups in preparing meals

<u>Grocery shopping</u>:

Figure 6-8 shows the proportion of difficulty levels for different age groups in a grocery shopping task. In the 18-30 year old age group, respondents perceived this task as easy to hard but most of them (25.4%) found it easy to perform. In the 31-50 year old age group, respondents perceived this task as easy to extremely hard but the most of them (8.8%) also found it easy to perform. Similarly, in the 51-70 year old age group, respondents perceived this task as easy to extremely hard but most of them (13.3%) found it hard to perform. Furthermore, in the 71-90 year old group, respondents perceived this task as easy and hard to extremely hard but most of them (7.2%) found it hard to perform. *Therefore, it is concluded that this task is easy for the first two age groups (up to 50 years) but hard for the third and fourth age group (over 50 years) respondents.*

It can also be noticed from Figure 6-8 (see red circle) that a small proportion (0.6%) of the 18-30 and 71-90 year age groups do not do or do not like to grocery shopping. For the 18-30 year old respondents they might be able to use other options for their grocery shopping, such as online shopping, but this might be an indication of a change of behaviour for the 71-90 year old respondents.

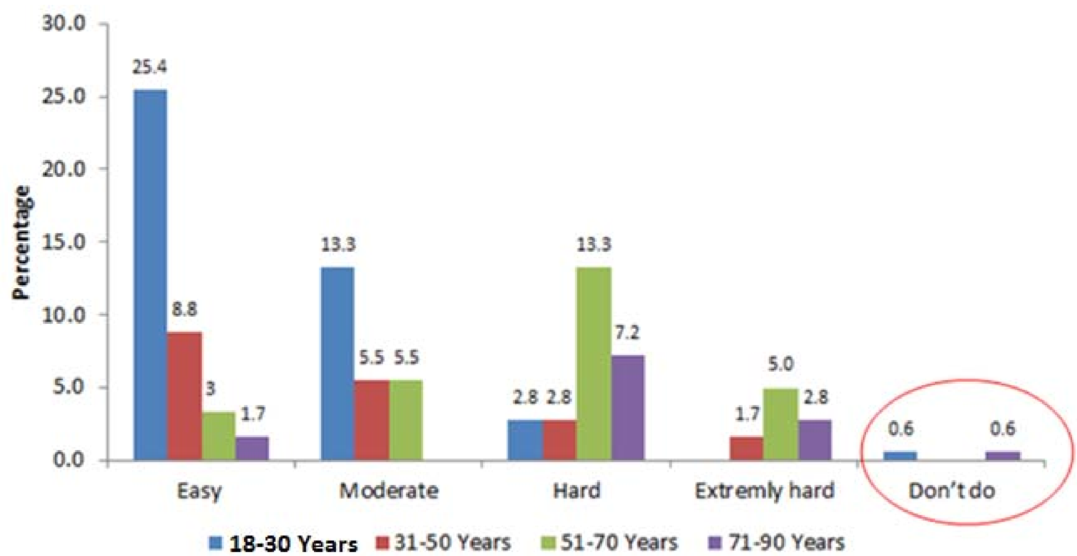


Figure 6-8 Proportion of difficulty levels for different age groups in grocery shopping task

<u>Doing Laundry</u>:

Figure 6-9 shows the proportion of difficulty levels with different age groups in doing a laundry task. In the 18-30 year old age group, respondents perceived this task as easy to hard but most of them (28.2%) found it easy to perform. In the 31-50 year old age group, respondents perceived this task as easy to extremely hard but most of them (8.3%) also found it easy to perform. Similarly, in the 51-70 year old age group, respondents perceived this task as easy to extremely hard but most of them (10.5%) found it hard to perform. Furthermore, in the 71-90 year old age group, respondents perceived this task as easy to extremely hard but most of them (6.1%) found it hard to perform. *Therefore, it is concluded that this task is easy for the first two age groups (up to 50 years) but hard for the third and fourth age group (over 50 years) respondents.*

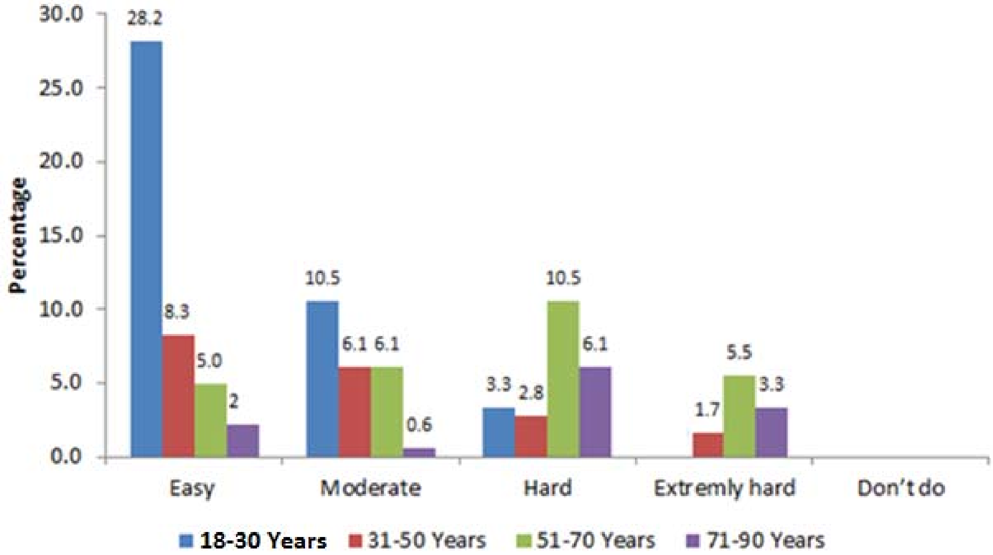


Figure 6-9 Proportion of difficulty levels for different age groups in doing laundry task

The above discussion makes it clear that the first two age groups (18-30 years and 31-50 years) perceived all four tasks as easy to perform. The other two age groups (51-70 years and 71-90 years) perceived general housekeeping and preparing meals as hard to extremely hard. Similarly, these two groups (51-70 years and 71-90 years) also perceived grocery shopping and laundry as hard to perform. Therefore, these tasks (general housekeeping, preparing meals and doing laundry) will be studied in further research.

6.1.5.2 Section 1: ii. How much time do people spend on performing basic daily living tasks?

To answer the research question "How much time do people spend on performing basic daily living tasks?", IADL survey question 6 ("Which of your everyday tasks do you spend most of your time doing and for how long?") was used. Table 6-4 shows the fraction of time spent by respondents in everyday tasks. It is clear from Table 6-4 (based on the sample size studied) people perform different everyday tasks in different fractions of time and most people spend time on food preparation tasks, computer use/access internet and housekeeping.

Table 6-4 Minimum and maximum time intervals used by respondents in basic daily living tasks with respect to the studied population (N=181)

Task(s) performed	Number of responses	Minimum time spent	Maximum time spent
Food preparation	47	15 minutes	More than 1 hour
Washing dishes	12	10 minutes	Up to 30 minutes
Computer use/access internet	30	1 hour	More than 2 hours
Housekeeping	20	30 minutes	More than 2 hours
Grocery shopping	12	1 hour	More than 2 hours, (or) sometime more than 2 hours
Laundry	13	15 minutes	1 hour
Cleaning and cooking food	16	30 minutes	More than 1 hour
Cleaning, cooking and washing dishes	15	30 minutes	More than 1.5 hour
Others (personal care, child care, activities etc.)	2	30 minutes	1 hour
No response	14	Nil	Nil

6.1.5.3 Section 2: iii. Which IADL tasks would people modify or change when performed?

In response to "Which IADL tasks would people modify or change when performed?", IADL survey question 3 ("For each of these tasks, have you modified or changed how you perform them over the years to make them easy to do?") was used. It was observed from the data that the tasks "making a telephone call", "use computer/accessing internet", "going round the supermarket independently", "going to the local corner shop independently", "using a car, using public transport", "managing any medication" and "managing household paperwork" were performed easily and without any modification by most of the people, so the focus was on the two tasks of "general housekeeping" and "able to perform personal laundry alone" for further investigation. Therefore, Figure 6-10 shows the proportion of respondents who modified or changed the IADL tasks ("general housekeeping" and "able to performed personal laundry alone") over a period of time. In both of these tasks, the respondents adopted different strategies to perform them over the years to make them easier, because they felt that these tasks were harder to perform, but the highest proportion (63%) in this respect was in general housekeeping. In that task, only 37% respondents were able to perform it with comfort without any modification, while the rest adopted the following strategies: 6% of respondents changed their postures (for instance, sitting down to do the task), 8% used assistive tools or aid, 9% took a longer time to perform or needed a break, 31% sought assistance, and 8% liked to avoid doing this task. Similarly, for the proportion of respondents able to perform a laundry task alone, 5% changed their postures (such as sitting down to do the task), 6% used assistive tools or aid, 6% took a longer time to perform or needed a break, 25% sought assistance, 7% took longer to perform and 1% liked to avoid doing this task.

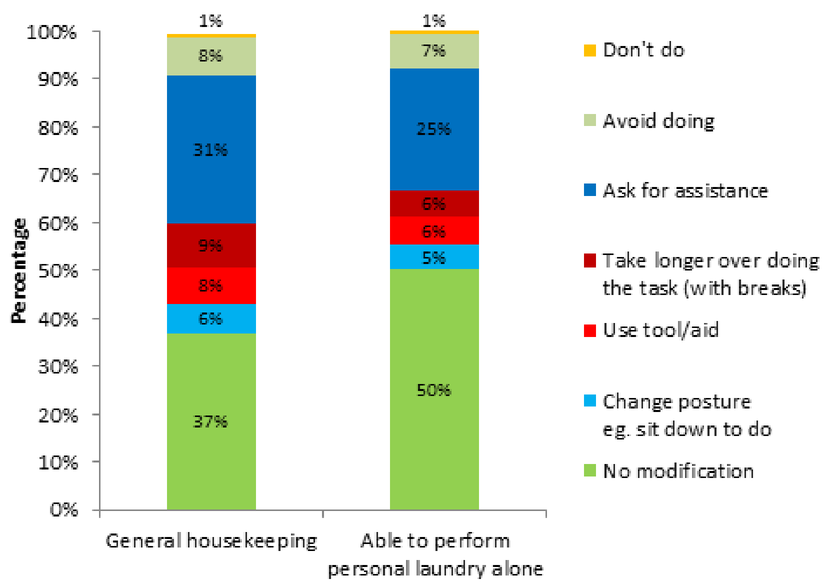


Figure 6-10 Proportion of respondents who modified or changed the IADL tasks over a period of time to make it easier

It is also interesting to know that a proportion of respondents (8% and 1%) were avoiding and not doing (don't do) their housekeeping. Although the proportions are low, the respondents in this category ('avoid' and 'don't do') might have some problems, which is why they were compromising with their general housekeeping.

The effects on the different age groups in performing general housekeeping and laundry tasks

Figures 6-11 and 6-12 show the proportion of strategies adopted by respondents in the different age groups in performing general housekeeping and laundry tasks alone. It has been observed that most of the respondents in the 18-30 and 31-50 age groups performed these tasks easily without modification but those in the 51-70 and 71-90 age groups sought assistance or asked for assistance in the performance of general housekeeping alone (see red circle in Figure 6-11) and performing laundry alone (see blue circle in Figure 6-12). Therefore, it is clear that the respondents over the age of 50 struggled in performing their daily tasks and wanted these to be modified to make them easy.

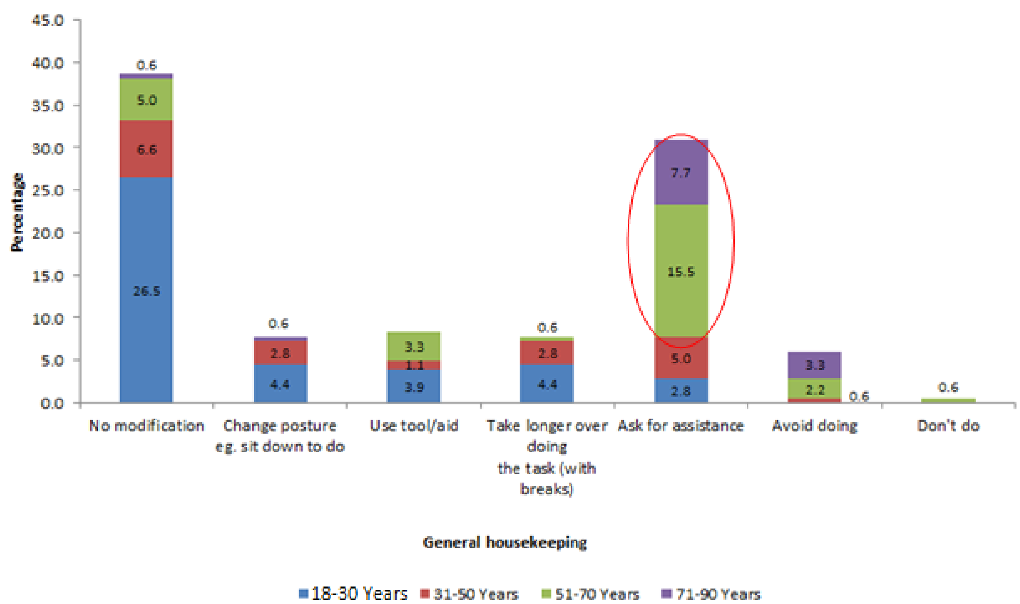


Figure 6-11 Proportion of strategies adopted by the different age groups in performing general housekeeping tasks.

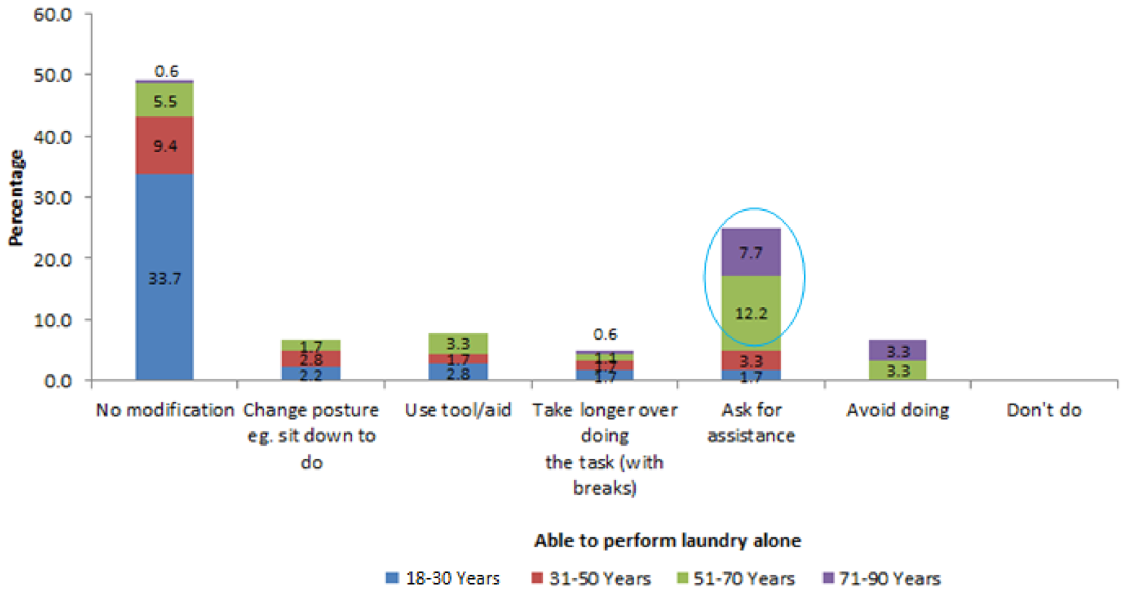


Figure 6-12 Proportion of strategies adopted by the different age groups to be able to perform laundry tasks alone

6.1.5.4 Section 2: iv. Which of the IADL tasks would different age groups people like to be modified to make them more comfortable to do?

To obtain a reply to "Which of the IADL tasks would different age groups of people like to be modified to make them more comfortable to do?", IADL survey question 7 ("Which of your everyday tasks would you most like to be modified to make it more comfortable?") was used. Table 6-5 shows the responses relating to the tasks most people wanted to be modified to make them comfortable to perform. It is clear that people wanted to modified three tasks (general housekeeping, grocery shopping and computer use) but most people wanted to consider general housekeeping (48%) and grocery shopping (6.6%) for modification so that they could perform them with ease. In order to understand the points of views of the different age groups, about the tasks which needed to be modified, the data is segregated into four age groups: 18-30 years, 31-40 years, 51-70 years and 71-90 years.

Table 6-5 Number of responses for each task which people want to be modified

Everyday tasks to be modified	Responses	Percentage
General housekeeping	87	48%
Grocery shopping	12	6.6%
Laundry	7	3.9%
Computer use	9	5%
Washing dishes	8	4.4%
Others (e.g. using microwave, using stairs)	13	7.2%
No modification	45	24.9%

Figure 6-13 shows the responses of the different age groups to the tasks which needed to be modified to make them comfortable to do. It is clear from the figure that all the age groups wanted to modify general housekeeping, grocery shopping and washing dishes. In general housekeeping the highest number of responses was 38 (20.9%), from the 18-30 year-old respondents; in grocery shopping the highest number was 4 (2.21%), from both the 18-30 and 71-90 year old respondents; and in washing dishes the highest number was 3 (1.66%), from the 31-50 year old respondents. Similarly, the 18-30, 31-50 and 71-90 year-old respondents wanted to modify laundry tasks while the 18-30, 51-70 and 71-90 year old respondents wanted to modify computer use tasks. Furthermore, in laundry the highest number of responses was 4 (2.21%), from the 18-30 year-old respondents, while in computer use tasks the highest number was 6 (3.31%), from the 51-70 year-old respondents. Therefore, it is concluded that most of the respondents wanted to modify general housekeeping, grocery shopping and laundry tasks.

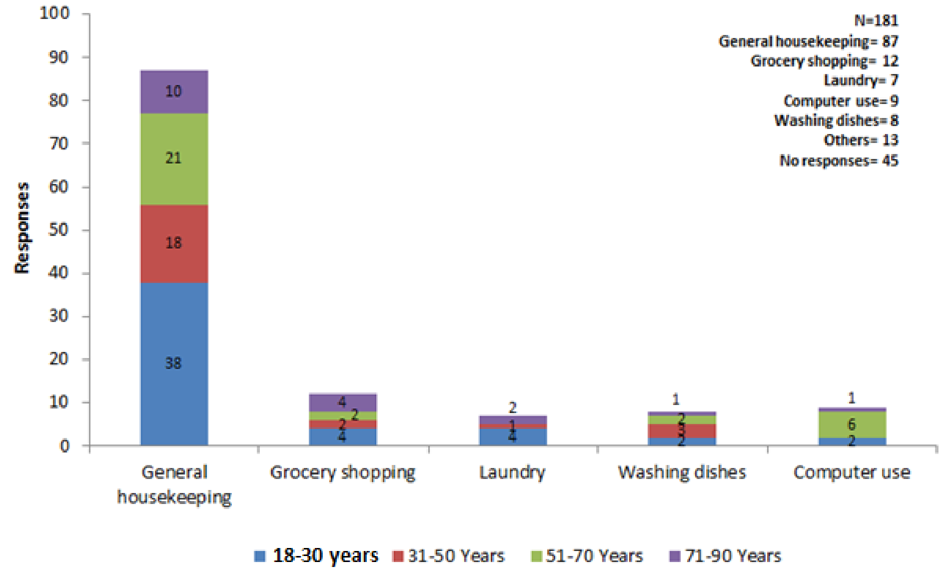


Figure 6-13 Responses of different age groups about the tasks which need to be modified to make them comfortable to perform.

6.1.5.5 Section 3: v. Which IADL tasks require higher physical effort?

In order to answer "Which IADL tasks require greater physical effort?", IADL survey question 2 ("Please rate the following tasks with respect to the amount of physical effort required") was employed. Here also it can be observed from the data that as well as "general housekeeping" and "able to perform personal laundry alone", respondents mentioned that the rest of the tasks only required a low level of effort to perform them, and hence the focus is on "general housekeeping" and "able to perform personal laundry alone". Figure 6-14 shows the proportion of respondents with respect to the physical effort required in performing the IADL tasks. As mentioned, the hardest among the IADL tasks studied with respect to the physical effort required is general housekeeping, because only 16% of respondents used merely a low level of effort, while 84% required a moderate to high level of effort to perform that task. Another interesting point about general housekeeping is that 1% respondents have stopped doing ('don't do') this task, which indicates that there is something wrong with the task. Although the proportion (1%) is very low, more consideration is still needed in relation to housekeeping, as it might indicate the first sign of a person's change in behaviour.

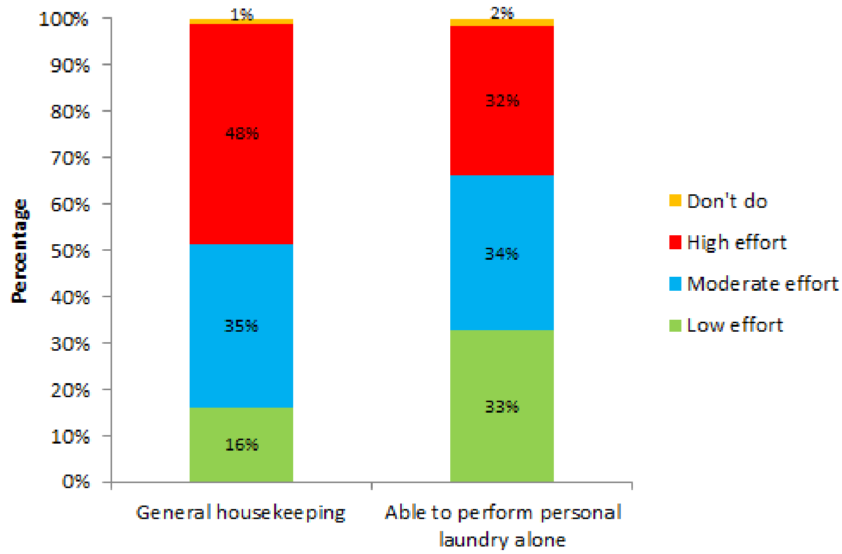


Figure 6-14 Respondent proportion for the amount of physical effort required in performing selected IADL tasks

6.1.5.6 Section 3: vi. Which of your IADL tasks cause you most physical discomfort?

In response to "Which of your IADL tasks cause you the most physical discomfort", IADL survey question 4 ("Which of your everyday tasks causes you the most physical discomfort?") was used. This was an open-ended question and anticipated lengthy answers. It has been noted that respondents mentioned many everyday tasks which caused them discomfort. Therefore, a schematic analysis was done which involved putting the responses into categories and then drawing a tree hierarchy of the categories and the results (as shown in Figure 6-15).

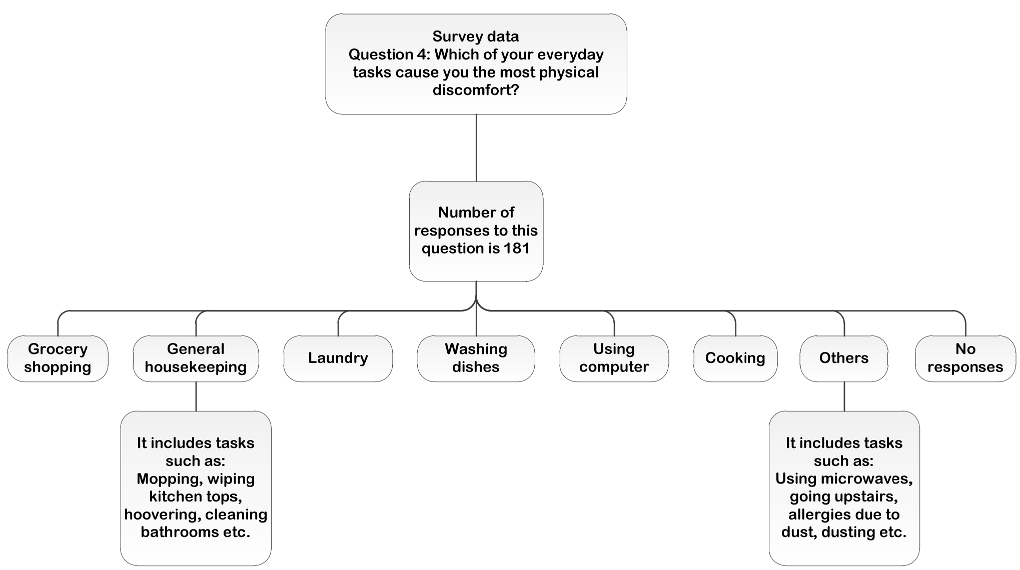


Figure 6-15 Tree hierarchy showing the categories used in analysis of Question 4

A Pareto chart (Figure 6-16) was used to highlight the most frequently documented tasks by using cumulative frequency [263]. It shows that the first four tasks (general housekeeping, grocery shopping, cooking and laundry) represented 85% of the studied population's responses for the task causing the most physical discomfort. Therefore, it is clear from Figure 6-16 that within the daily tasks there are four tasks which need more consideration, because they are harder and cause most physical discomfort when performed, and therefore focusing on these four tasks for further study might enable a person to perform their tasks effectively and the modification would help them to achieve their full potential in their daily tasks. The remaining tasks (computer use and washing dishes) caused less discomfort when compared to the first four tasks.

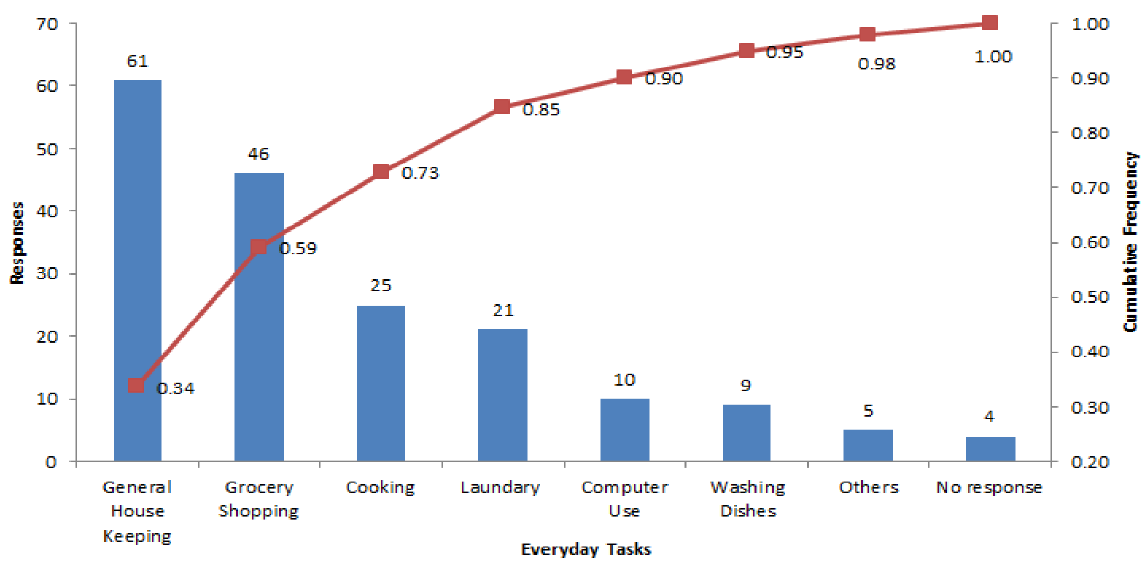


Figure 6-16 Responses and proportion of tasks that are harder and cause most physical discomfort when performed

6.1.5.7 Section 3: vii. Which parts of the body feel discomfort when IADL tasks are being performed?

In response to "Which parts of the body feel discomfort when performing IADL tasks?", IADL survey question 9: *Do you experience any pain or discomfort in your hand, wrist, arm, shoulders, neck or back when carrying out your everyday tasks?* was used. In performing their daily tasks, 21% (38 people) did not feel any discomfort while 63% (114) people felt discomfort in different parts of the body. Figure 6-17 shows the number of responses about the parts of the body which experienced discomfort in performing everyday tasks. During such performance, respondents felt discomfort in almost the whole of the body but the highest response was for back (29), neck & back (17), and then neck & shoulders (12). Therefore, it was necessary to look into the daily tasks which they found harder to perform. Figure 6-17 shows further details about the different age groups' responses to feeling discomfort during the performance of everyday tasks.

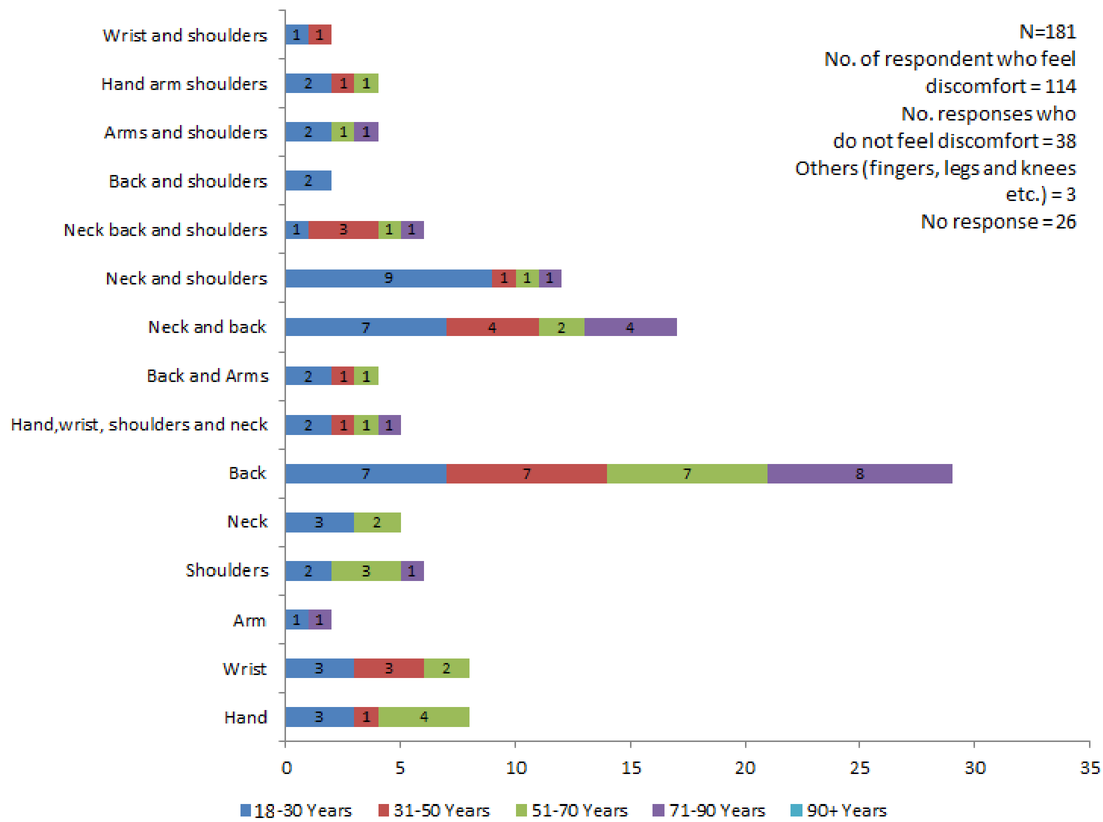


Figure 6-17 Responses relating to which parts of the body experience discomfort in performing everyday tasks.

6.1.5.8 Section 3: viii. Which IADL tasks cause the highest discomfort level?

To answer the research question "Which IADL tasks cause the highest discomfort level?", IADL survey question 10 ("How severe would you rate the discomfort?") was produced. Figure 6-18 shows the proportion of discomfort severity in everyday tasks. Overall, it shows that 30% of the respondents experienced mild discomfort in performing everyday tasks, whereas for 34% the discomfort was moderate and for 12% it was high.

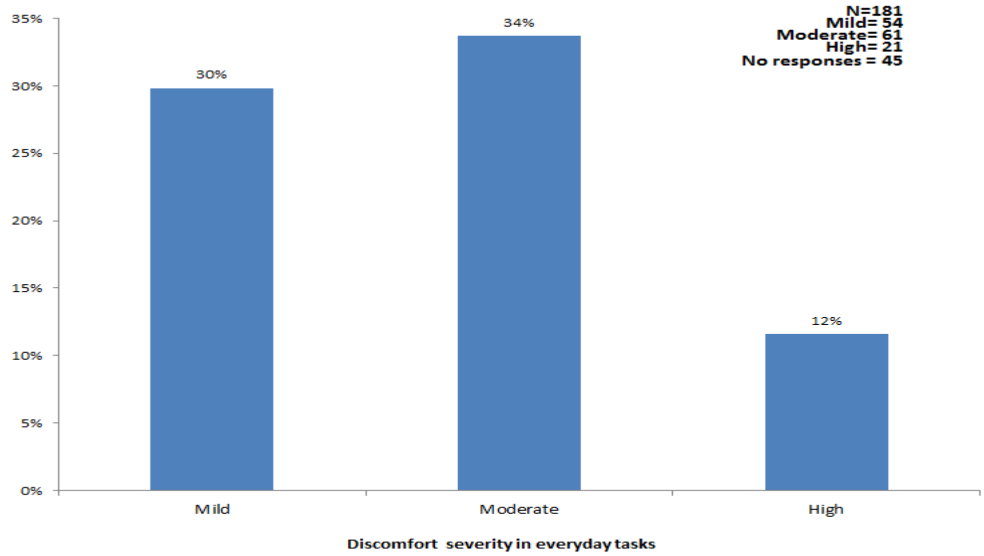


Figure 6-18 Responses to proportion of discomfort severity in everyday tasks

In order to see which tasks had the highest discomfort level, IADL question 4 (Which of your everyday tasks causes you the most physical discomfort?) was used in relation to IADL question 10 above. Figure 6-19 shows the tasks in which people feel different levels of discomfort when performing them. It shows that they felt discomfort in all tasks, but most felt moderate discomfort in two tasks – general housekeeping (34 responses) and grocery shopping (16 responses) – and mild discomfort in laundry tasks (8 responses). Similarly, people felt a high level of discomfort in performing general housekeeping (16 responses), grocery shopping (3 responses) and computer use (1 response), while the number of responses in relation to computer use and washing dishes is low compared to general housekeeping, grocery shopping and laundry but shows that caution is still needed when such tasks are performed. It is also clear that for the three tasks in which people have a high level response or rate them as causing moderate discomfort, they are struggling with the performance of these tasks, so it might be an indication of a person's behaviour in performing these tasks.

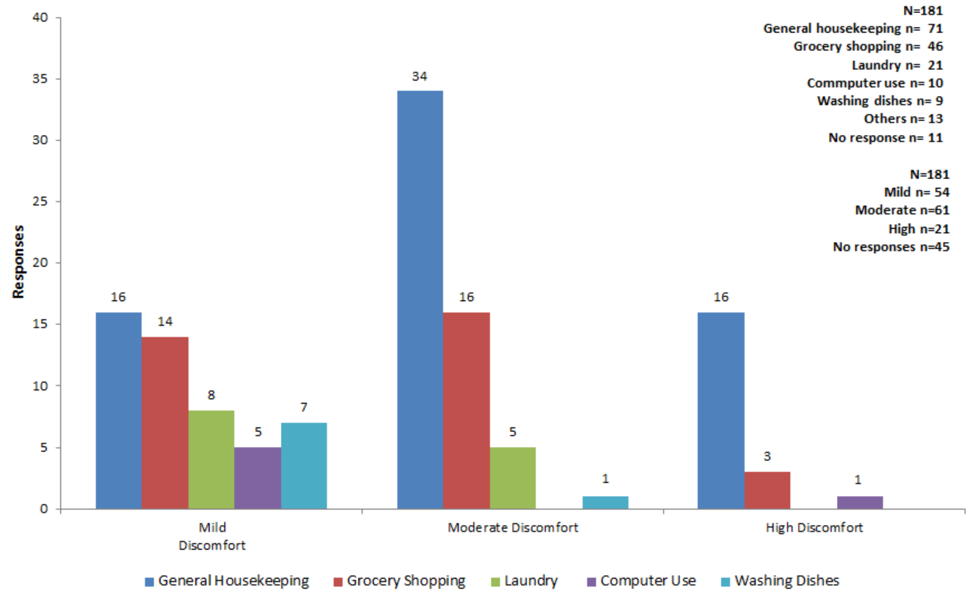


Figure 6-19 Everyday tasks in which people feel different levels of discomfort when performing them

The results of this survey make clear that people are struggling with their domestic tasks, especially with general housekeeping, preparing meals, grocery shopping and laundry. Thus the analysis of these domestic tasks might help us to discover some connection with their loss of independence and also help us to propose a tool for the assessment of domestic tasks because people are struggling to perform them and want them to be modified so that they can perform them easily.

6.1.6 Summary

Overall, the most difficult tasks to perform were housekeeping (69%), preparing meals (66%), grocery shopping (60%) and doing laundry (57%) respectively. Within the different age groups, the difficulties varied among the age groups: for the 18-30 and 31-50 year-old age groups the most difficult task was preparing meals, whereas for the 51-70 and 71-90 age groups the most difficult one was general housekeeping. By comparing the tasks (general housekeeping, preparing meals, grocery shopping and laundry) within each age group the following facts were revealed: *General housekeeping* was perceived as easy by the 18-30 & 31-50 age groups, but as hard or extremely hard by the 51-71 & 71-90 age groups. *Preparing meals* was perceived easy by 18-30 & 31-50 year-old respondents, but as extremely hard by the 51-71 & 71-90 years olds. *Grocery shopping* was perceived as easy by the 18-30 & 31-50 age groups, but as hard by the 51-71 & 71-90 age groups. *Laundry* was perceived as easy by the 18-30 & 31-50 year-old respondents, but as extremely hard by the 51-71 & 71-90 year olds. Therefore, it was decided to study general housekeeping, preparing meals and laundry tasks for further study. Table 6-6 summarises the survey results. It shows the highest response tasks and the tasks to be modified, according to the different opinions of the respondents. It also shows the discomfort level in IADL tasks and discomfort felt by people in the different age groups.

Table 6-6 Summary of survey results

Number of questionnaires found suitable for analysis	181
IADL tasks people find difficult to perform	General housekeeping (69%), preparing meals (66%), grocery shopping (60%) and doing laundry (57%)
IADL tasks that people in the different age groups would like to be modified to make the tasks more comfortable to perform	People want to modify three tasks: general housekeeping (48%), grocery shopping (6.6%) and laundry (3.9%), but the highest number of responses is for general housekeeping from all four age groups of respondents (18-30, 31-50, 51-70 and 71-90 years of age).
IADL tasks and highest physical effort	General housekeeping and Laundry (see figure 6-14)
The first four IADL tasks which cause physical discomfort to people when performed	General housekeeping, grocery shopping, cooking and laundry (see figure 6-16)
Discomfort in relation to parts of the body	Highest responses: back (29 responses from 18-30, 31-50, 51-70 and 71-90 year old age groups), neck & back (17 responses from all four age groups) and neck & shoulders (12 responses from all four age groups)
Tasks causing the highest discomfort level	Moderate discomfort and having a high number of responses: general housekeeping, grocery shopping.

The results of the survey agree with an internet-based survey conducted by Marut and Hedge in 1999 (N=382 respondents) which concluded that, among the tasks which are performed in a domestic environment the most tiring ones are mopping, doing laundry and preparing meals, and they also concluded that these tasks are harder to perform because they require effort, associated with fatigue, and required further attention of researchers [262]. Therefore, it has been decided to study general housekeeping, food preparation task and laundry for further study. (The online version of the survey can be found at the link: http://www.smart-survey.co.uk/s/82229KDFCH).

It is concluded that this survey-based study on instrumental activities of daily living revealed the reality and people's opinions about performing the tasks in a home environment and showed that people are struggling with the tasks of general housekeeping, preparing meals, grocery shopping and laundry. Almost all the respondents of all ages wanted them modified or made comfortable to perform. Therefore, it has been decided to investigate tasks: general housekeeping (cleaning task), food preparation task and laundry, and to provide a way for future research.

6.2 Questionnaire on food preparation task

Food preparation is an important everyday task. It involves the selection, measuring and combining of ingredients in specific quantities. Generally, when a person involved in food preparation, the following steps are needed:

1. Equipment gathering (pans and utensils, etc.)

2. Ingredient gathering (e.g. vegetable and spices)

3. Preparing raw ingredients (e.g. peeling/chopping, opening tins/packets, etc.)

Food preparation is essential for everyone to perform because it is defined within IADL tasks which are necessary for people to live independently. This study focuses on physical aspects of a food preparation task, and therefore this task is broken down into a series of sub-tasks, some of which requires more effort, or are harder to complete, than others. In order to gather opinions on this task it has been divided into five consecutive sections:

1. Gathering the pans and utensils
2. Gathering vegetables for rinsing
3. Peeling vegetables
4. Chopping/slicing
5. Stirring/frying

A questionnaire has been designed to gather the opinions, attitudes and factual information about the food preparation task. It consists of the five steps (survey designing, question development, testing and training, data collection and data analysis) [205] which have already been discussed in Chapter 3, Section 3.3.2.

6.2.1 Methods

It was decided that the focus of the survey should be on an individual's behaviour and the way they prepare food in their home. The preparation of food is one of the tasks included in the Lawton Instrumental Activities of Daily Living Scale [1], which is used to ascertain the person's functional level, and so would help to understand the way people prepare food in their home. The population for this survey was originally designed to be for people above the age of 40 years, but it was decided to cover all ages: (18-30), (31-50), (51-71), and (71-90) years old. The final target for this survey was 60 people.

In order to design the questions for the survey, a brainstorming session was conducted and three mind maps (see Section 15.2, Appendix A) were developed, based on three basic questions about IADLs as follows:

- What are the problems with IADL tasks?
- What parameters are needed in order to assess IADL tasks?
- How do you assess IADL tasks?

Figure 6-20 shows the main points of the mind map and simplified information regarding each point found through brainstorming. The result of the mind maps gives a general idea about designing the questions and provides the knowledge about the problems, what parameters are needed for assessment and how to assess the IADLs. From the mind maps, three parameters were selected: ease of performance, physical demand required to complete the task, and complexity of a task; and these were for use in designing the questions.

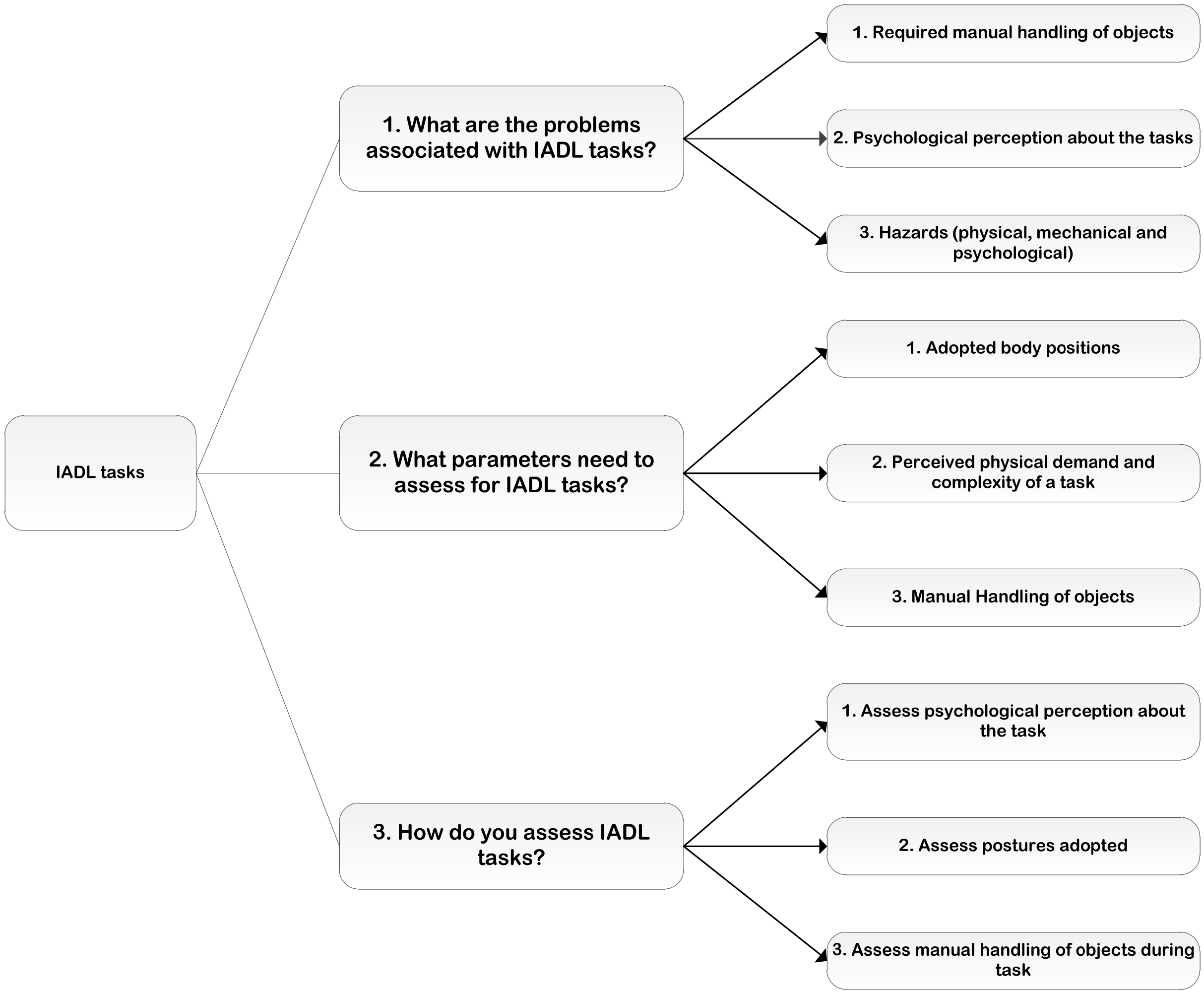


Figure 6-20 Main points of mind map and simplified information regarding each point

The questionnaire is divided into two sections (see Appendix A, Section 15.3). Section "A" is related to general information about the person's cooking habits and behaviour. It consists of four questions. Of these, questions one, three and four are closed-ended (this type of question has a limited number of options, pre-determined by the researcher, for each sub-task requiring responses by participants [264]). Question two is open-ended (this type requires meaningful answers of more than one word, and are normally used in exploratory research [265, 266]) which allows participants to convey their opinions freely about their perceived capabilities in a food preparation task. The following are the question in Section A:

- *Would you describe yourself as a primary or secondary cook in your house?*

- *How many people (including yourself) share your main meals of the day?*

- *Consider a typical week in your household and the seven main meals of the week. Of these seven, how many are:*

  i. *Prepared from raw or natural-state ingredients?*

  ii. *Made using pre-prepared elements (e.g. pre-chopped/diced vegetables and meat, frozen or tinned items)*

  iii. *Completely pre-prepared (e.g. ready-made meals, takeaways, meals out)*

- *How would you rate your skills in the kitchen?*

Section "B" is scenario-based, with four sets of questions as follows:

- *Overall, how easy would you find it to complete each sub-task?*

- *Please indicate the physical demand you feel would be required for each sub-task.*

- *Please indicate the complexity of the sub-task.*

- *From your own food preparation experiences, what would you say is the hardest part and why?*

Finally, demographic, lifestyle and existing condition information is gathered through the section called monitoring information (see Appendix A, Section 15.3).

Once a questionnaire has been designed, it is essential to test it before presenting it to participants or starting to collect data. The designed questionnaire under went three testing sessions; in the first session, feedback from different age groups was obtained (from someone who was the representative of the targeted population). In the second one, feedback was obtained from two researchers experienced in survey design, while in the final session it was obtained from two housewives who were experienced in food preparation tasks. The latest version was altered, by making some changes as a result of problems noticed in the pre-test results and feedback.

Table 6-7 Self-administration mode used and minimum sample needed for the study

Self-administration mode	No. of questionnaire distributed	No. of questionnaire found suitable for the study
University of Sheffield Library	26	23
University of third age group (U3A) Sheffield	42	37
Total	68	60

Population size = 68 (the number of questionnaire distributed)
Minimum sample size needed= 58 (see table 6-1 for sample size calculation)
Sample size used= 60

Subsequent to pre-testing, the questionnaire was ready for collecting the data. The targeted population was divided into four age groups: 18-30, 31-50, 51-70, and 71-90 years old. This study was investigating how an individual's behaviour affects the way they perform a food preparation task. Therefore, self-administrated modes is used to gather the data and table 6-8 shows the detail about the data is collected and minimum sample required for the study. The minimum sample size required is 58 participants but the study encompassed 60 participants in total (29 male, 31 female, with an actual age range of 20-82). Table 6-8 shows the mean age, height and weight of the sample size, while Table 6-9 shows the number of responses by each gender and the proportion within each age group.

Table 6-8 Characteristics of subjects (n=60)

Subject characteristics	Sample mean	Sample standard deviation	Minimum	Maximum
Age (years)	49.22	19.84	20	82
Height (cm)	167.08	8.27	150	185
Weight (kg)	68.72	11.07	40	105

Table 6-9 Number of responses and proportion within each age group (n=60)

Age Groups	Male	Female	Row Total	Percentage
18-30 years	5	5	10	16.7
31-50 years	7	6	13	21.7
51-70 years	11	8	19	31.6
71-90 years	6	12	18	30
Column Total	29	31	60	100

In this study, we use SPSS data analysis software to record and analyse the responses to each question by each participant. In order to analyse the questionnaire results, it is helpful to assign a numerical equivalent to the matrix results. Therefore, the following numeric values have been used in the statistical calculations, as shown in Table 6-10.

Table 6-10 Options used in questions and their numeric values

Options in question 1	Numeric options	Options in question 2	Numeric options	Options in question 3	Numeric options
With ease	0	None	0	Not all	0
Moderate effort	1	Minor	1	Slightly	1
Significant effort	2	Moderate	2	Some what	2
Delegate this task to someone else	3	Too much	3	Moderately	3
				Extremely	4

6.2.2 Results and Discussion

This section answers the statements mentioned at the beginning of this chapter with respect to the designed survey question numbers (see Appendix A, Section 15.3).

i. How is food preparation performed and perceived in the home?

In order to answer this statement, the food preparation questionnaire (section "A", questions 1, 2 and 3) was used. Figure 6-21 shows the proportion of participation in food preparation, which helps to understand the general habits and behaviour about food preparation. Most people within the population being studied (75%) considered themselves as the primary cook and 22% as the secondary cook. It means that within the studied population most people could cook food easily, have basic cooking skills and also knew how to cook a balanced meal. From Figure 6-22 it is clear that most people of all age groups regarded themselves as the primary cook while female respondents (see Figure 6-23) had a higher proportion within the 'primary cook' category.

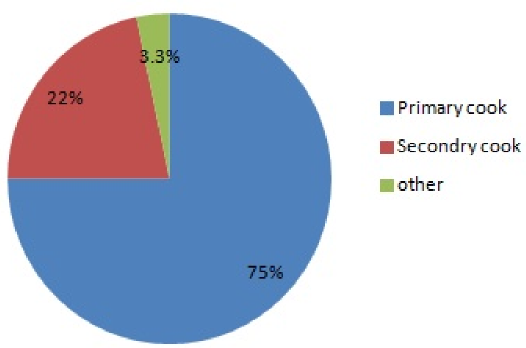


Figure 6-21 People's participation in food preparation task

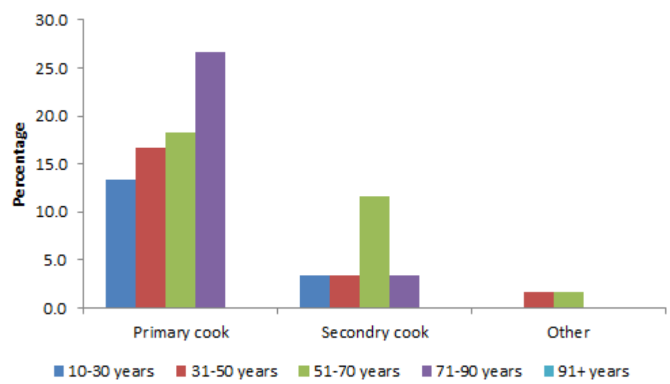


Figure 6-22 Effect of different age groups in participation in food preparation task

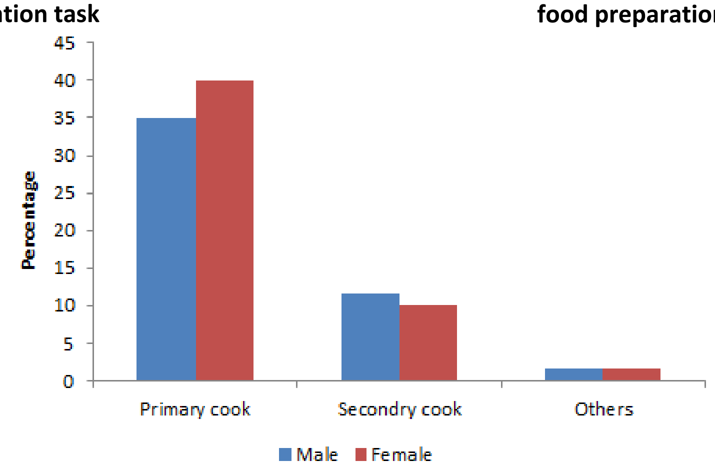


Figure 6-23 Effect of gender in participation in food preparation task

Figure 6-24 shows the proportion of people who share the main meal of the day. The duration of the food preparation chore can be estimated by the number of people one can cook for or share a main meal with. Generally, this Figure shows that people like to share food with two to seven people and most people (45%) share food with only two people. Figure 6-25 shows that most respondents in the 18-30 age group do not like to share their main meal with other people (my-self) while most respondents in the 31-50, 51-70 and 71-90 age groups shared their main meals with two people. Similarly, mostly male respondents (see Figure 6-26) liked to share their main meal with two people and the same applied to most female respondents.

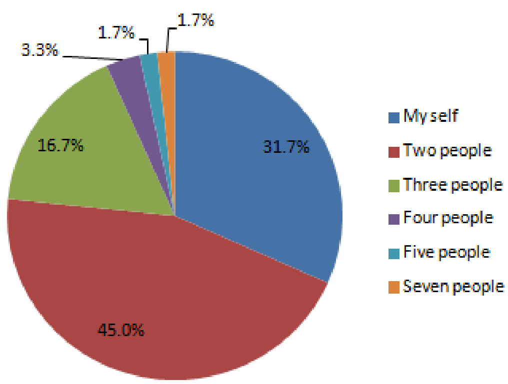


Figure 6-24 Proportion of peoples sharing the main meal of the day

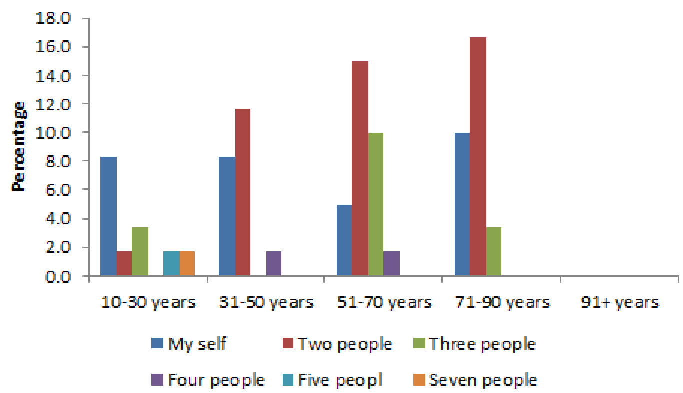


Figure 6-25 Proportion of different age group respondents sharing the main meal of the day

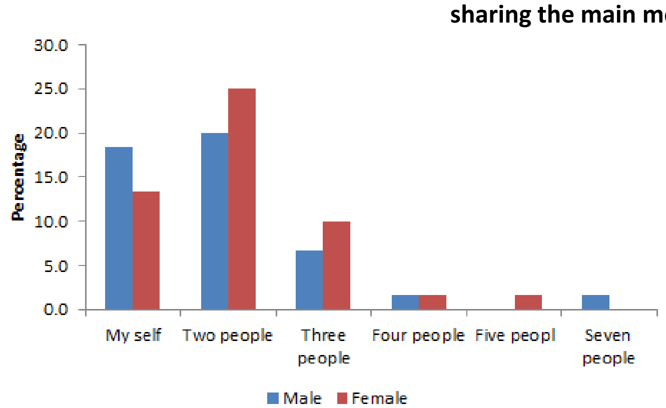


Figure 6-26 Proportion by gender of those who share the main meal of the day

Figure 6-27 shows the proportion of habits regarding the seven main meals in a typical week. From the pie chart below, it can be inferred that people have the habit of using all three options (raw or natural-state ingredients, pre-prepared and ready-made elements) for the preparation of the seven main meals of the week. However, most people (32.2%) liked using raw or natural ingredients while 28.3% use pre-prepared elements and 15% use ready-made ones for food preparation.

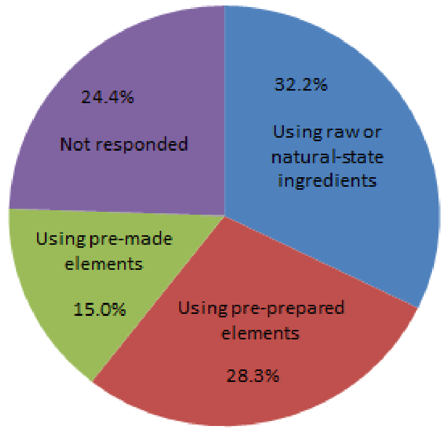


Figure 6-27 Proportion of habits in relation to the seven main meals in a typical week

ii. How do people rate their perceived capabilities in a food preparation task?

In order to answer this, question 4 of Section "A" of the food preparation questionnaire (How would you rate your skills in the kitchen?) was used. Figure 6-28 shows the perceived capabilities in the food preparation task in the population being studied (n=60). Food preparation is a daily chore and in theory everybody can cook, but the results of the survey show that a small population cannot cook (1.7%) or can make one meal (10%), whereas more than 50% of people can cook by following a given recipe and more than 30% are confident cooks. It is therefore inferred that a high proportion of people within the studied population can prepare food and easily follow the recipe.

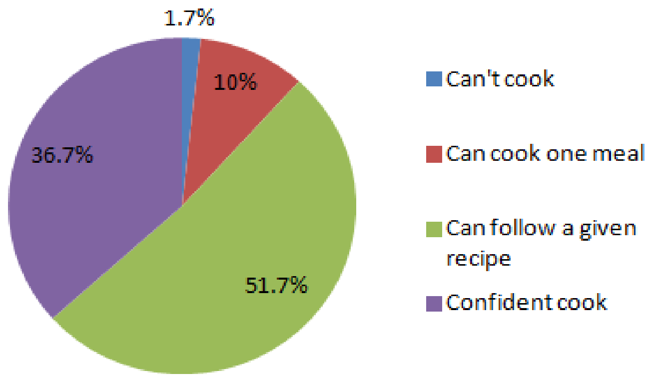


Figure 6-28 Respondents' perceived capabilities in food preparation task, within the studied population

iii. What is the hardest part of a food preparation task?

In order to answer this, questions 1, 2 and 3 of Section "B" of the food preparation questionnaire were used: 1. Overall how easy would you find it to complete each sub-task?; 2. Please indicate the physical demand you feel would be required for each sub task; and 3. Please indicate the complexity of the sub-task. As mentioned, food preparation is an essential daily domestic chore. It is interesting to learn from the results of the survey that more than 50% of the population studied considered food preparation to be easy and a task they could perform with ease. However, more than 60% found it physically demanding and 51% found it complex to perform different sub-tasks in food preparation. Figures 6-29, 6-30 and 6-31 show further details.

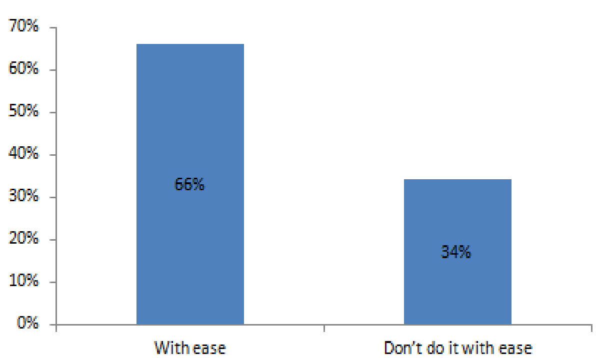


Figure 6-29 Respondent percentage who prepare food with ease / do not do so with ease

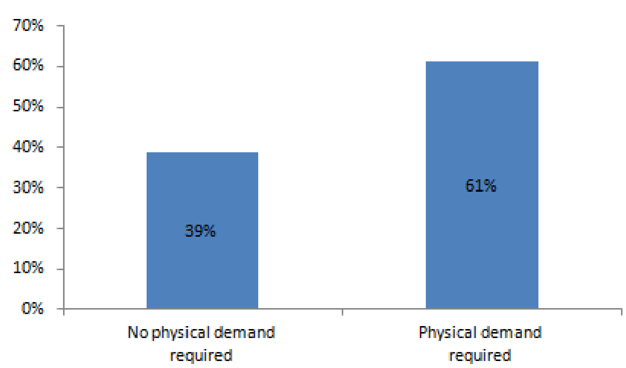


Figure 6-30 Respondent percentage who did / did not find food preparation physically demanding

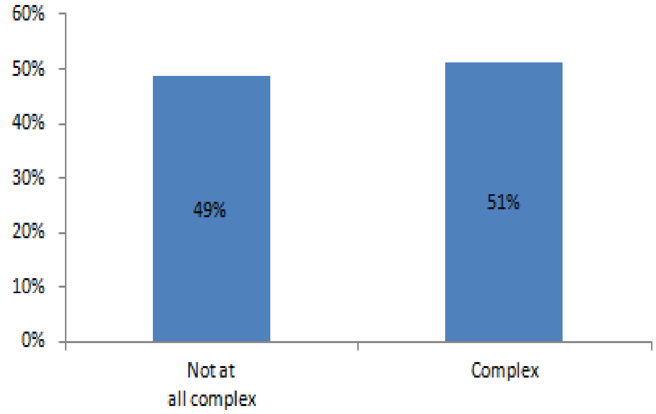


Figure 6-31 Respondent percentage who found food preparation task complex / not at all complex

The hardest part in food preparation means which sub-task requires the highest level of effort (easiness), is the most complex and requires a considerable amount of physical effort to perform.

(a) How easily would the respondents complete each sub-task?

It is clear from Figure 6-32 that the hardest sub-task in food preparation is peeling potatoes, because only 48.3% of the respondents were able to do this task with ease and 51.6% found it hard and put in a moderate to significant effort to do this task. The two easiest sub-tasks were “gathering pans and utensils” and “gathering potatoes for rinsing” because 88.3% people performed this task very easily. The other difficult sub-tasks were “chopping/slicing” and “stirring/frying”, as 46.7% and 48.3% of people respectively did not perform these tasks with ease. Figure 6-32 shows the further details.

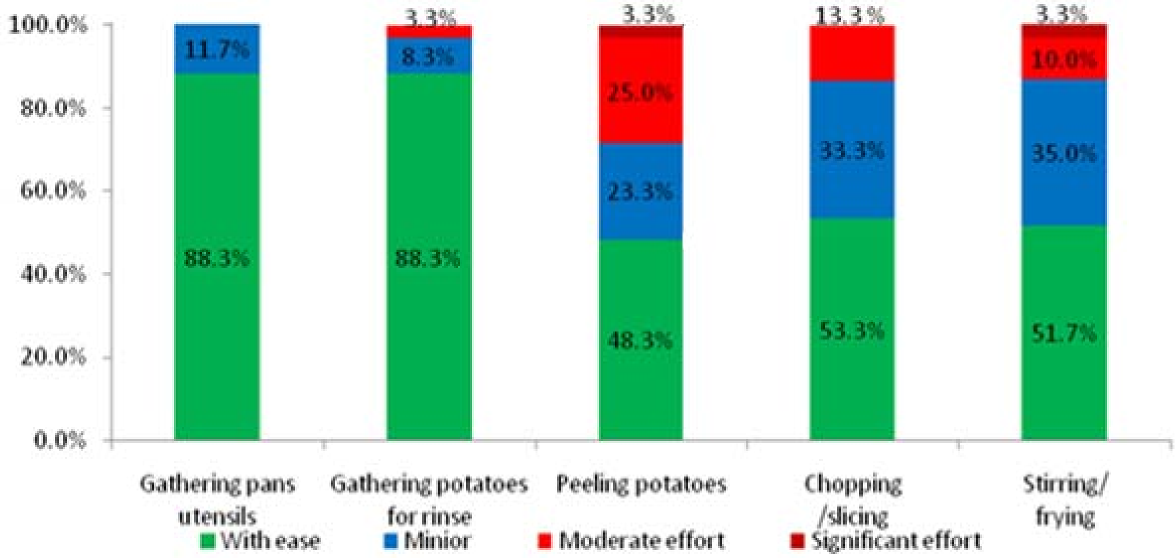


Figure 6-32 Hardest and easiest tasks in food preparation

(b) Physical demand required for each sub-task

In terms of the level of physical demand required to perform these sub-tasks, the trend shows that the hardest sub-task is chopping/slicing because only 22% people were able to do this task with less physical demand (none) and 78% of people (see Figure 6-33) found this task hard, with minor to moderate physical demand. Similarly, the stirring/frying and peeling potatoes were the second hardest sub-tasks because 73% people required moderate to too much physical demand in the preparation of food. The easiest sub-task in term of physical demand required was "gathering potatoes for rinsing", and the second was "gathering pans and utensils" because many of the respondents required no or much less physical demand in these aspects of food preparation. Thus on the whole it can be said that in preparing food people struggled with the sub-tasks of chopping/slicing, stirring/frying and peeling potatoes. Figure 6-33 also shows further details.

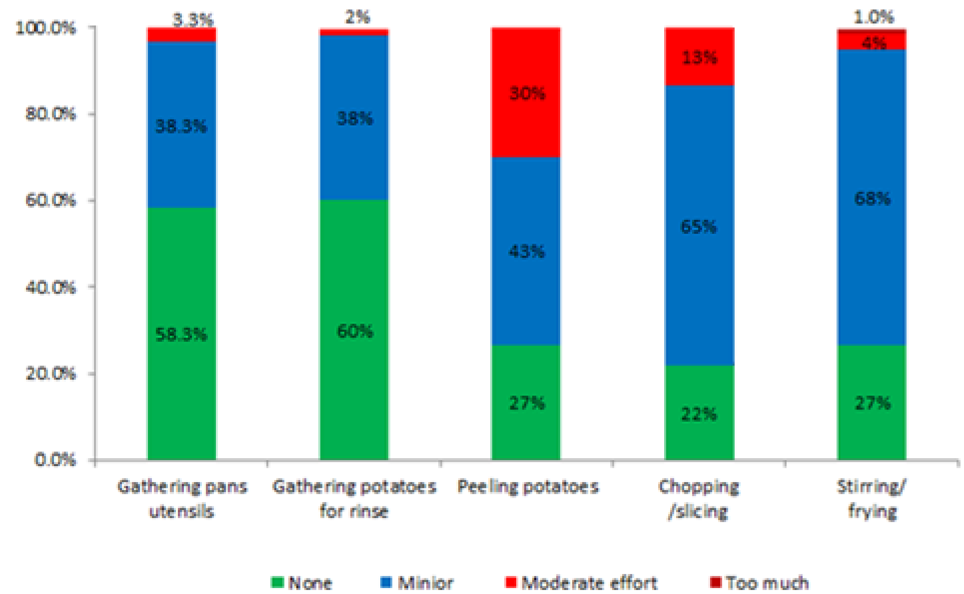


Figure 6-33 Hardest and easiest tasks in terms of physical demand required in food preparation

(c) Complexity of the sub-tasks

In terms of complexity (in other words, the most complex sub-task, how they perceived the performance of the sub-task and the number of steps in food preparation) the hardest sub-task was chopping/slicing because 82% people found this sub-task slightly to moderately complex. The second and third hardest sub-task was peeling potatoes and stirring/frying because 80% and 73% people respectively found this task slightly complex to moderately complex. In food preparation, the easiest sub-task in term of complexity was gathering pans and utensils and gathering potatoes for rinsing, because many respondents found these tasks not at all complex. Figure 6-34 shows further details.

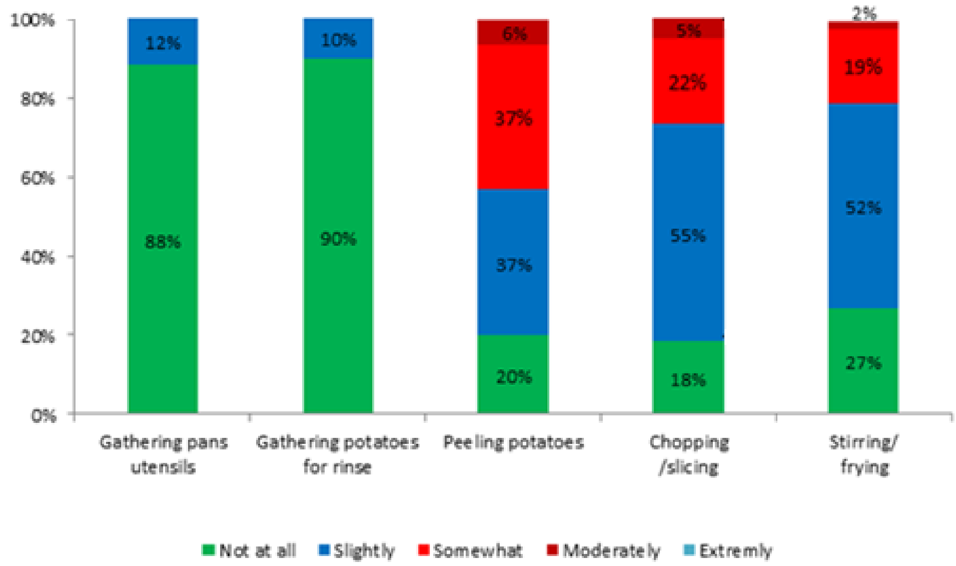


Figure 6-34 Hardest and easiest task in terms of complexity

Overall, in the general population studied, it can be said that in food preparation they struggled to perform three sub-tasks: peeling potatoes, chopping/slicing, and stirring/frying, because they were facing difficulty, needed physical demand and considered these sub-tasks as slightly to moderately complex; hence the conclusion is that among the five sub-tasks in food preparation, the hardest tasks are peeling potatoes and chopping/slicing.

From the above discussion it is clear that in the general population the hardest sub-tasks are peeling potatoes, chopping/slicing and stirring/frying. Basically three variables involved in this discussion are the physical demand required and the complexity or ease of performance. The correlation of these variables with respect to the sub-tasks is shown in Table 6-11 using a 95% confidence interval. The moderate ($0.36 \geq r \leq 0.67$) [267] and significant ($p<0.05$) correlation exists between these variables. Although moderate correlation is not so helpful [267], it shows that there is a significant relationship exist among these variables and evidence to reject the hypothesis and conclude that these variables are moderately related. It can also be concluded that in performing food preparation tasks these three variables are essential and might be responsible for changes in a person's habits and behaviour in later stages of life.

Table 6-11 Correlation among sub-tasks and three variables in food preparation task

Sub-task	Variables	Correlation (r)
Peeling potatoes	Physical demand required and complexity	0.447*
	Physical demand required and ease	0.468*
	Complexity and ease	0.38*
Chopping/slicing	Physical demand required and complexity	0.435*
	Physical demand required and ease	0.52*
	Complexity and ease	0.436*
Stirring/frying	Physical demand required and complexity	0.527*
	Physical demand required and ease	0.646*
	Complexity and ease	0.499*

*Shows significance level p<0.05

Hardest sub-task with respect to different age groups:

In order to see the hardest sub-task with respect to different age groups, the data was segregated, as mentioned earlier, into five age groups (18-30, 31-50, 51-70, and 71-90 years). Moreover, in order to see how people in the different age groups responded to the five sub-tasks of food preparation with three variables (how easy to complete, physical demand requirement and complexity of each task) and run cross tabulations between age groups and sub-tasks to obtain the chi square value and the significance difference. For chi-square analysis, the first step is to develop the hypothesis related to each variable, and Table 6-12 below shows the details of the variables and the hypotheses.

Using SPSS and running cross tabulation and a chi-square analysis between each sub-task, variable and age group, Table 6-13 shows the cross tabulation of one sub-task (stirring/frying), a variable (do it with ease and don't do it with ease) and respective age groups (18-30, 31-50, 51-70, and 71-90 years) as an example. Cross tabulation shows the descriptive and inferential statistics. In descriptive statistics it shows responses within "Do it with ease" and "Don't do it with ease" from the different age groups. In inferential statistics it shows three factors: Pearson's chi-square value, degree of freedom, and significance (P-value).

Table 6-12 Variables, levels and the hypothesis details

Variables	Level	Hypothesis
How easy it to complete?	Do it with ease / don't do it with ease	Different age group people can do each sub-task with ease
Physical demand required	No or less physical demand required / physical demand required	Different age group people required no or less physical demand for each sub-task
Complexity of the task	Not at all complex / complex	Different age group people consider each sub-task not at all complex

The standard form of reporting chi-square results is χ^2 (degree of freedom, sample size)= chi-square value, p=value [268].

Table 6-13 Cross tabulation (between different age groups and sub-task stirring and frying) and chi-square results

Age groups * Ease in_Stirring and_Frying – Cross tabulation

			Ease in_Stirring_and_Frying		
			with ease	don't do it with ease	Total
Age groups	18-30	Count	10	0	10
		Expected Count	5.2	4.8	10.0
	31-50	Count	3	10	13
		Expected Count	6.7	6.3	13.0
	51-70	Count	5	14	19
		Expected Count	9.8	9.2	19.0
	71-90	Count	13	5	18
		Expected Count	9.3	8.7	18.0
Total		Count	31	29	60
		Expected Count	31.0	29.0	60.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.545[a]	3	.000
Likelihood Ratio	25.895	3	.000
Linear-by-Linear Association	.296	1	.586
No. of Valid Cases	60		

a. 1 cell (12.5%) have expected count less than 5. The minimum expected count is 4.83.

(a) *How easy was it to complete each sub-task?*

In order the see which sub-task was the hardest among the different age groups of respondents with respect to how easy people found it to complete each sub-task during food preparation, the data was divided into two categories ("Do it with ease" and "Don't do it with ease"). Within the latter category, all the responses from "minor effort" to "significant effort" and "delegate task to someone else" are included. Figure 6-35 shows the responses within "Don't do it with ease" with respect to the different age groups.

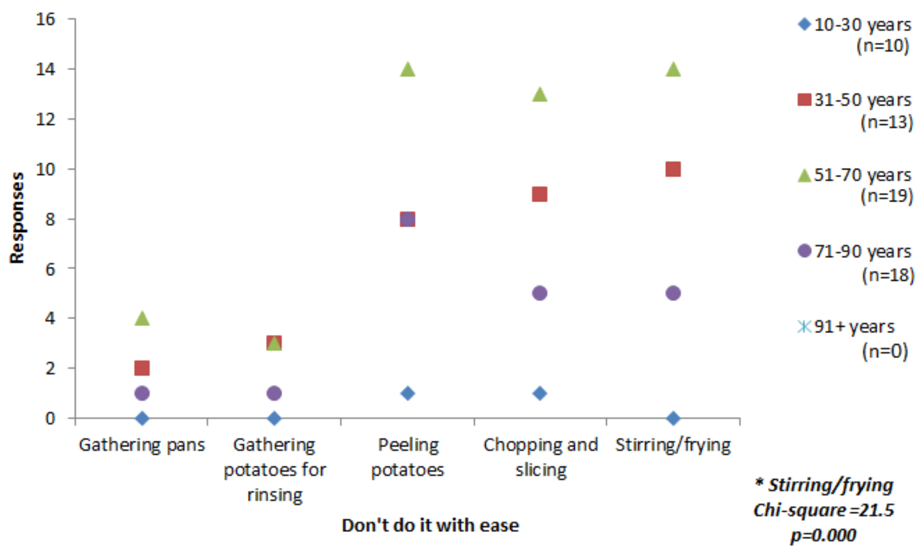


Figure 6-35 Sub-tasks, the chi-square value and significance within "don't do it with ease".

Table 6-14 shows the chi-square analysis among the different age group respondents with respect to how easy it was to complete each sub-task. It is clear from the table that all age groups respondents were struggling ("don't do it with ease") with three sub-tasks (peeling potatoes, chopping/slicing and stirring/frying) and the chi-square goodness-of-fit test revealed that there is a significant association between the age groups and the sub-tasks they "don't do with ease", therefore the null hypothesis is rejected and it can be concluded that there is strong evidence of a relationship between the different age groups and the sub-tasks (peeling potatoes, chopping/slicing and stirring/frying) which they "don't do with ease". The sub-tasks of peeling potatoes, chopping/slicing and stirring/frying having chi square values 11.524, 14.254 and 21.545 respectively. (The larger the chi-square value, the greater the likelihood that the difference is not due to chance [269] – see Table 6-14) which means that the stirring/frying sub-task has the strongest association with the different age groups who "don't do it with ease". It can be concluded, therefore, that the stirring/frying sub-task has the strongest association with the different age groups among all five sub-tasks and is considered the hardest part of the food preparation task in terms of how easy it to complete.

Table 6-14 Summary of chi-square analysis

Sub-tasks	No. of response within "don't do it with ease"				Chi-square values: χ^2 (degree of freedom, sample size)= chi-square value, p=value [268]	Significance
	18-30 years	31-50 years	51-70 years	71-90 years		
Gathering pans and utensils	0	2	4	1	χ^2 (3, 60)= 3.772, 0.287	NO
Gathering potatoes for rinsing	0	3	3	1	χ^2 (3, 60)= 3.929, 0.269	NO
Peeling potatoes	1	8	14	8	χ^2 (3, 60)= 11.524, 0.009	Yes
Chopping/slicing	1	9	13	5	χ^2 (3, 60)= 14.254, 0.003	Yes
Stirring/frying	0	10	14	5	χ^2 (3, 60)= 21.545, 0.000	Yes

Significance ($p<0.005$)

(b) <u>Physical demand required to complete each sub-task</u>

In order to see the hardest sub-task among the different age group respondents with respect to the physical demand required during the performance of each sub-task in food preparation, the data was divided into two categories: "Physical demand required" and "No physical demand required". Within the former category, all the responses from "minor" to "too much" are included.

Figure 6-36 shows the responses within "physical demand required" with respect to the sub-tasks, indicating that the responses varied according to each sub-task. The highest response was from the 51-70 age group, then the 31-50 and 71-90 age groups.

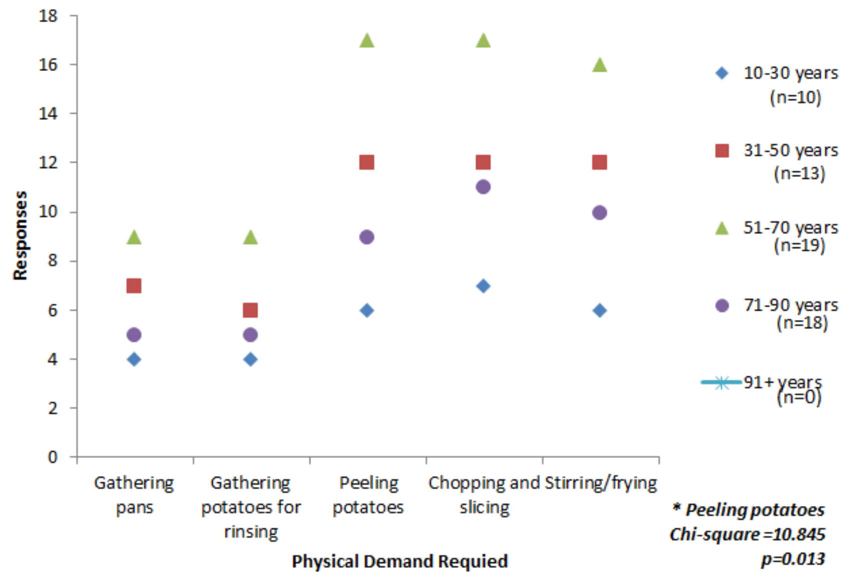


Figure 6-36 Sub-tasks and different age groups, the chi-square value and the level of physical demand required

Table 6-15 shows the chi-square analysis among the respondents in the different age groups with respect to the physical demands during the performance of each sub-task in food preparation. It is clear from Table 6-15 that all age group respondents struggled (physical demands) with three sub-tasks (peeling potatoes, chopping/slicing and stirring/frying), and the chi-square goodness-of-fit test revealed that the different age groups have a significant association with the sub-task of peeling potatoes because this was more physically demanding compared to other sub-tasks. Therefore, the null hypothesis is rejected and it is concluded that there is a strong relationship between the respondents of the different age groups and the sub-task of peeling potatoes with respect to the physical demands of doing that sub-task.

The sub-task of peeling potatoes has the chi-square value 10.845 (see Table 6-15), which means that this sub-task has a strong association with the different age group respondents with respect to physical. It can therefore also be concluded that the sub-task of peeling potatoes is the hardest part of the food preparation task in terms of the physical demand required.

Table 6-15 Summary of chi-square analysis

Sub-tasks	No. of responses within physical demand required				Chi-square values: χ^2 (degree of freedom, sample size)= chi-square value, p=value [268]	Significance
	18-30 years	31-50 years	51-70 years	71-90 years		
Gathering pans and utensils	4	7	9	5	χ^2 (3, 60)= 2.488, 0.478	No
Gathering potatoes for rinsing	4	6	9	5	χ^2 (3, 60)= 1.755, 0.625	No
Peeling potatoes	6	12	17	9	χ^2 (3, 60)= 10.845, 0.013	Yes
Chopping/slicing	7	12	17	11	χ^2 (3, 60)= 6.440, 0.092	No
Stirring/frying	6	12	16	10	χ^2 (3, 60)= 7.361, 0.061	No

Significance (p<0.005)

(c) Perceived complexity of each sub-task

In order to see the hardest sub-task among the different age groups with respect to the perceived complexity of each sub-task during food preparation, the data was divided into two categories: "Not at all complex" and "Complex". Within the latter, all the responses from "Slightly" to "Extremely" are included. Figure 6-27 shows the responses within "Complex" with respect to the different age groups. It shows that all the age groups considered the food preparation task complex, but the responses varied in each sub-task. The highest responses was for the 51-70 age group, then the 31-50 and 71-90 age groups.

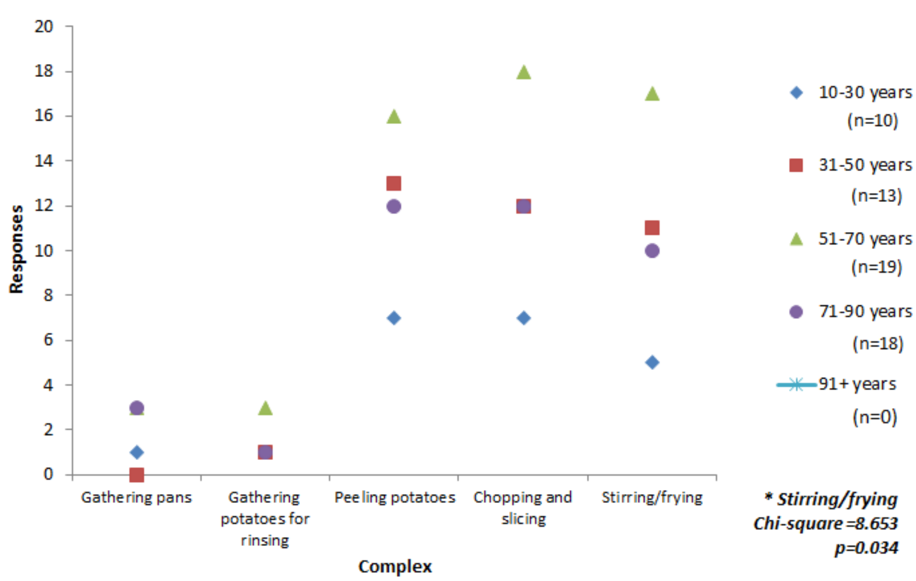


Figure 6-37 Sub-tasks and different age groups, the chi-square value and the complexity of a task

Table 6-16 shows the chi-square analysis among the respondents in the different age group with respect to the perceived complexity of the sub-tasks during the performance of each sub-task in food preparation. The chi-square goodness-of-fit test revealed that different age group respondents had a significant effect ($p<0.05$) on the sub-task of stirring/frying. Therefore the null hypothesis is rejected and it is concluded that people of different age groups perceived the sub-task of stirring/frying as complex. This sub-task has a chi square value 8.653 (see Table 6-16), which means that the sub-task of stirring/frying has a strong association with people of different age groups with respect to task complexity. It can therefore be concluded that the stirring/frying sub-task is the hardest part of the food preparation task in terms of complexity.

Table 6-16 Summary of chi-square analysis

Sub-tasks	No. of response within 'complex'				Chi-square values: χ^2 (degree of freedom, sample size)= chi-square value, p=value [268]	Significance
	18-30 years	31-50 years	51-70 years	71-90 years		
Gathering pans and utensils	1	0	3	3	χ^2 (3, 60)= 2.494, 0.476	No
Gathering potatoes for rinsing	1	1	3	1	χ^2 (3, 60)= 1.180, 0.758	No
Peeling potatoes	7	13	16	12	χ^2 (3, 60)= 6.086, 0.108	No
Chopping/slicing	7	12	18	12	χ^2 (3, 60)= 6.765, 0.080	No
Stirring/frying	5	11	17	10	χ^2 (3, 60)= 8.653, 0.034	Yes

Significance ($p<0.005$)

Effect on different age groups in performing three sub-tasks with respect to three parameters ("don't do it with ease", "required physical demand" and "perceived complexity")

Figure 6-38 shows the sum of responses in relation to the three subtasks (peeling potatoes, chopping/slicing and stirring/frying) within "don't do it with ease", "required physical demand" and "perceived complexity" which revealed that all three age groups struggled with these three parameters but the higher responses were from the 51-70 age group then the 31-50 and 71-90 ones. The following are the discussion with respect to each parameter:

Don’t do it with ease:

Within this parameter almost all the age group respondents “don’t do” sub-tasks (peeling potatoes, chopping/slicing and stirring/frying) “with ease”. However, the respondents in the 51-70 age group had a higher response compared to the other two groups (31-50 and 71-90). This means that respondents in the 51-70 age group perceived these three sub-tasks as having high difficulty level, which might indicate that respondents in this age group of respondents are more likely to be susceptible to changes in their behaviour in basic everyday tasks as compared to the other two age groups.

Required physical demand:

Within this parameter all age group respondents required physical demand in all three sub-tasks (peeling potatoes, chopping/slicing and stirring/frying). However, the respondents in the 51-70 age group had a higher response compared to the other two groups (31-50 and 71-90). This means that respondents in the 51-70 age group perceived these three sub-tasks as being harder to perform, as they needed to put in more effort than the other age group respondents and so it can be concluded that respondents in this age group need more consideration and assistance when performing basic everyday tasks.

Perceived complexity:

The same trend has been observed here, that all age group respondents perceived all three sub-tasks (peeling potatoes, chopping/slicing and stirring/frying) as complex. However, the respondents in the 51-70 age group had a higher response compared to the other two groups (31-50 and 71-90). This means that the numbers of steps which are essential to follow during the performance of these three sub-tasks produced a psychological effect on the respondents but this effect of each sub-task made those tasks harder for the 51-70 year old respondents as compared to those in the other two age groups.

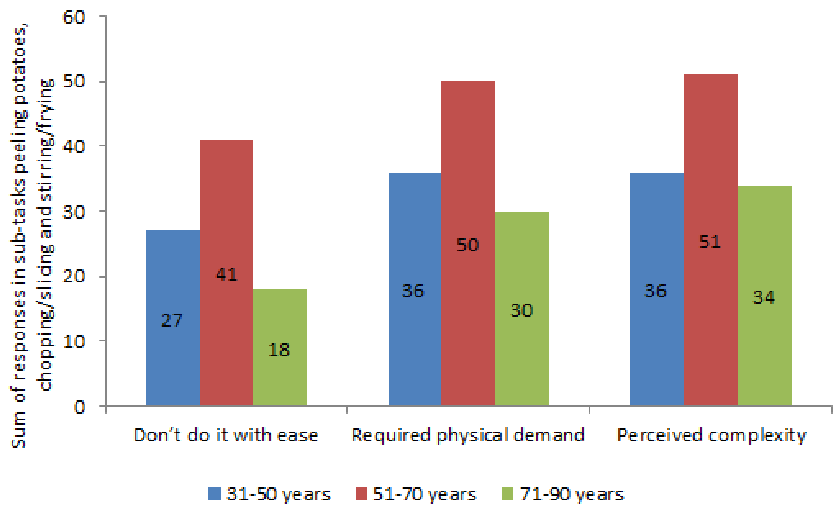


Figure 6-38 Sum of responses to the three subtasks (peeling potatoes, chopping/slicing and stirring/frying) within "don't do it with ease", "required physical demand" and "perceived complexity"

Comparison of middle age group (51-70) and older age group (71-90) in relation to changes in behaviour during performance of daily tasks

From the above discussion, an interesting fact has been revealed, which is that people in the middle age group (51-70) have more difficulty in daily tasks when compared to those in the older age group (71-90 or 71+), even though in general one would expect more problems from older people. To clarify this, a hypothesis was developed which stated that people between 51-70 years of age find daily tasks harder than those aged 71-90 years, and questioned whether this was because:

a. People aged 70+ do not do those tasks

b. They modify their behaviour to make those tasks easier

c. They modify their environment to make the tasks easier

d. A combination of the above

In order to verify the above-mentioned hypothesis statements the data from IADL survey question 3 can be used: “For each of these tasks, have you modified or changed how you perform them over the years to make them easy to do?” (see Section 15.1, Appendix A). Basically this question mentions the different strategies such as “change posture”, “use tool/aid” and “take longer over doing the task” etc. whereby people adapted themselves to modifying the task and making it easier for them to perform, which can be considered as “change in behaviour” and ”no change in behaviour”. As is clear from section 6.1.4, most of the respondents from the different age groups modified “general housekeeping” themselves over a period of time to make it easier (see Figure 6-10), so this task is used in order to study the above-mentioned hypothesis. Figure 6-39 shows the comparison between the middle age group and the older age group regarding change in behaviour or no change in behaviour in performing daily tasks. It can be seen from Figure 6-39 that 96% of respondents from the older age group modified their daily tasks themselves (because they noticed a change in their behaviour in performing the tasks) while 82% of respondents from the middle age group modified their daily tasks to make them easier to perform. This means that people in the middle age group found more tasks harder to perform but a 18% proportion of people said that they didn’t change their behaviour, and so they continued doing those tasks and did not adopt different strategies (such as “change posture”, “use tool/aid”, ask for assistance” or “take longer over doing the task”) which might have enabled them to perform those tasks more easily. This is illustrated in Figure 6-39, revealing that they have less proportion of respondents who notice change in their behaviour than people in the older age group. In contrast, the latter group adopted almost all the strategies to make their tasks easier to perform, which reflects the fact that they are more likely to be susceptible to change in their behaviour as compared to the middle age group.

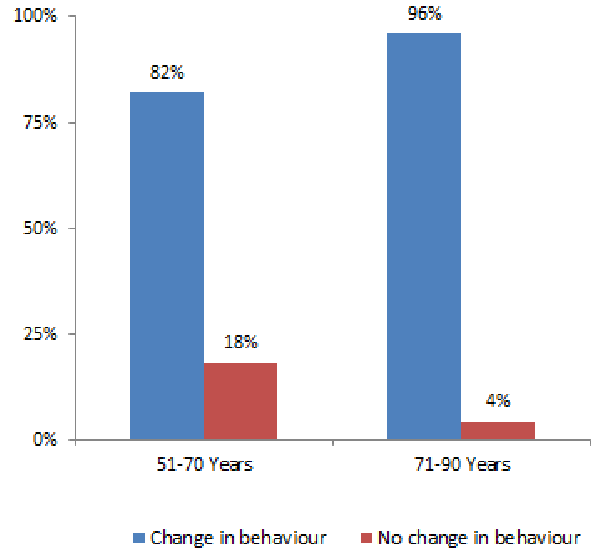


Figure 6-39 Comparison between middle age group and older age group regarding change and no change in behaviour in performing daily tasks

It is concluded that the respondents in the older age group noticed their change in behaviour during the performance of their daily tasks and tried to modify many of their daily tasks themselves, adopting strategies such as “change posture”, “use tool/aid”, “ask for assistance” and “take longer to over doing the task” etc. Therefore, statement “b”: *they modified their behaviour to make these tasks easier* is true for people in the older age group. In contrast, the respondents in the middle age group had more difficulties in performing their daily tasks as compared to older age group, and same trend was also observed in laundry tasks (see Figures 6-52, 6-54 and 6-56). As mentioned previously, an earlier study, based on phenomenography, illustrated four ways; Ignore, Struggle, Adjust and Resign in which people deal with daily life and the problems faced during the performance of daily tasks at home [4], and thus from the present study it might be concluded that the middle age group would fall within the category of the second way, which is “Struggle” and their attitude is to continue trying to carry out their daily tasks because, as mentioned, a 18% proportion of people in this age group said that they didn’t change their behaviour and continued doing their daily tasks over a period of time without making any modification. One would expect older age group to have more problems as compared to other age groups, yet this older age group modified their daily tasks, which is why they had fewer responses as compared to the people in the middle age group people. It is also concluded that the designed task assessment tool for ease and risk (AER) is more useful for people in the middle age group as compared to those in the other age groups, as the former are in the initial stages of their changes in behaviour. Furthermore, this age group of respondents habitually live an autonomous and high quality life, therefore if they are able to know earlier the risks involved in performing their daily tasks, it will enable them to be more cautious in their next stage of life and to live a life free from any disability that might otherwise arise.

6.2.3 Results summary

In many activities of daily living, food preparation is considered to be a simple task and most of us engage in this activity at least once in a day. The following is a summary of the results, drawn from the food preparation questionnaire:

- General food preparation task information gives an insight into the current behaviour/attitude or what a person perceives in relation to food preparation tasks. Food preparation is an essential daily chore and most people (within the studied population) consider themselves to be the primary cook. In the studied population, most respondents in each age group considered themselves to be the primary cook, and there were a higher proportion of female respondents within the primary cook category.

- Generally (within the studied population), it was found that people like to share food with two to seven people and most people share food with only two people. Most of the respondents in each age group (both male and female) liked to share their main meal between two people.

- In the seven main meals in a typical week, it was found people have a habit of using all three options (raw or natural-state ingredients, pre-prepared and ready-made elements). Most people (32.2%) like raw or neutral ingredients, while 28.3% liked pre-prepared and 15% preferred ready-made elements for food preparation.

- Within the studied population, more than 51.7% people were able to follow a given recipe and 36.7% peoples were confident cooks.

- Generally, food preparation was considered to be an easy domestic chore, with more than 50% of the people considering that food preparation was easy and they could perform it with ease. Nonetheless, more than 60% required physical demand and 51% found complexity in performing the different sub-tasks in food preparation (within the studied population)

- In the general population studied, the hardest sub-tasks in food preparation are peeling potatoes, chopping/slicing and stirring/frying. These sub-tasks were moderately and significantly correlated with three variables (how easily the sub-task was to complete, physical demand required and complexity), and so the hypothesis was rejected and it was concluded that these variables are moderately related.

- The different age group respondents had a strong association with the sub-tasks of peeling potatoes, chopping/slicing and stirring/frying with respect to “don’t do it with ease”. However, the chi-square value is larger for the stirring/frying sub-task (see Table 6-15), which means this sub-task had the strongest association with the different age groups, out of all five sub-tasks and was considered the hardest part of food preparation task in terms of how easy it was to complete.

- The respondents in the different age group had a strong association with the sub-task of peeling potatoes with respect to the level of physical demand required among all of the five sub-tasks. Therefore, this sub-task was the hardest sub-task of food preparation task in terms of physical demand required.

- The respondents in the different age group had a strong association with the sub-task of stirring/frying with respect to perceived complexity among all five sub-tasks. Therefore, this sub-task was the hardest sub-task of food preparation task in terms of perceived complexity.

- It is clear that all three age groups (31-50, 51-70 and 71-90) struggled with three sub-tasks (peeling potatoes, chopping/slicing and stirring/frying) within “don’t do it with ease”, “required physical demand” and “perceived complexity”. However, a higher level of responses came from the 51-70 year-old age group than from the other two (31-50 and 71-90), as a proportion (18%) of respondents (see figure 6-39) in the 51-70 year-old group said that they didn’t change their behaviour and continued doing their daily tasks over a period of time without making any modification. Therefore, it is recommended that the 51-70 year-old age group respondents should adopt the appropriate strategies (“change posture”, “use tool/aid”, “ask for assistance” and “take longer to over doing the task” etc.) themselves as early as possible, as adopted by the 71-90 old-age group which make their daily task easy to perform.

This study explains that within the food preparation task there are three variables which make the task harder. Among the five subtasks it has been found that the hardest ones are peeling potatoes, chopping/slicing and stirring/frying. A proportion of people struggled with these, which might indicate that people alter their behaviour in later stages of life in performing their day to day tasks. Therefore, identification of the hardest part of a task helps to identify early signs or warnings about changes in a person's ability as compared to earlier stages in their life.

6.2.4 Conclusion

The findings of this study show that food preparation is considered to be an easy domestic chore, although more than 50% of the people studied required physical demand and found complexity in performing different sub-tasks in food preparation. Generally in studied population, they considered themselves to be the primary cook and most of them liked to cook for themselves or share food between two people. The findings also showed that people are usually in the habit of using all three options (raw or natural-state ingredients, pre-prepared and ready-made elements) for the preparation of the seven main meals of the week. Another finding shows that in the general population studied, the hardest sub-tasks (peeling potatoes, chopping/slicing and stirring/frying) in the food preparation task were not highly correlated with how easy it was to complete, physical demand required and complexity, so the hypothesis is rejected and it is concluded that that they are moderately correlated. The trend in different age groups revealed that all three age groups struggled with the three sub-tasks of peeling potatoes, chopping/slicing and stirring/frying with respect to three parameters (how easy it is to complete, required physical demand and perceived complexity). However, a higher level of responses came from the 51-70 age group than from the other two (31-50 and 71-90), as a proportion of people in this age group said that they didn't change their behaviour and continued doing the daily tasks over a period of time without making any modification. It was also concluded that the hardest parts of food preparation are: i. stirring/frying (with respect to "how easy it is to complete"), ii. peeling potatoes (with respect to "physical demand required"), and iii. stirring/frying (with respect to "perceived complex"). Therefore, the identification of the hardest part of the tasks helps to identify early signs or warnings about changes in a person's ability as compared to their earlier stages of life. It is also concluded that food preparation is an essential task on the IADL scale and that identification of the hardest sub-task within the daily tasks might be useful for health care professionals to help people in the community to maintain their independence in later life. A further study with different tasks and a larger sample size would, however, be required in order to find the true relationship between the variables.

6.3 Laundry task

The questionnaire (section 6.1) results on the IADL tasks made it clear that people are struggling with laundry tasks. It was therefore decided that this task should be studied in more depth, and so the aim of this study was to gather information on the perceived hardness, physical demand and the complexity of different sub-tasks involved in laundry task, including what is the hardest part of this work. Doing laundry is an essential chore, ensuring personal hygiene which is important for our health. It contributes to our comfort and aesthetics, which refines one's personality. Doing laundry can be broken down into a series of sub-tasks, some of which require more effort, or are harder to complete. From this study it is proposed that the "hardest" task will also require the greatest effort, be the most complex and/or require a high level physical effort. Therefore, the hardest task in laundry work is highly correlated with respect to the physical demand required, complexity of the task and ease of completion. Hence the questionnaire has been designed to find the answers to the following questions:

- How is laundry performed and perceived in the home?
- What is the hardest part of doing laundry?
- What is the correlation and significance level of the hardest part in relation to the physical demand required, ease of use and complexity?
- What difficulties do people face during laundry tasks?

6.3.1 Method

We all do laundry in our homes as this is an essential part of any household and is defined within the IADL. In order to gather opinions on this activity it has been divided into five consecutive sub-tasks:

1. Gathering
2. Sorting and pre-treatment
3. Washing machine preparation
4. Drying clothes
5. Folding clothes

The first step is to gather the dirty laundry from the bin and also look for dirty clothes in other rooms and then to take all these clothes to the washing machine. The second step consists of sorting and pre-treatment. This could involve sorting the clothes into light, dark and white or sorting with respect to garment tags (hot, warm, cold and delicate wash). In addition, any pre-treatment such as stain removers can also be applied. The third step is to prepare the washing machine and select the desired cycle setting. This step can be broken down into loading the clothes into the drum, adding washing powder/liquid, closing the machine door and setting the cycle dial. The fourth step is drying the clothes; this can be done in a variety of ways, either by using a clothes drier or by hanging the washing on a line or an airer. This task includes unloading the washing machine, and putting the clothes out to dry. The fifth and final step is folding the dry clothes ready for distribution to the household or for further tasks such as ironing. Figure 6-40 shows these tasks and how they feed into one another.

A questionnaire was designed to gather the opinions, attitudes and factual information about the domestic laundry tasks among the general population. The development of the questionnaire consisted of five steps [205] which have already been discussed in Chapter 3, section 3.3.2.

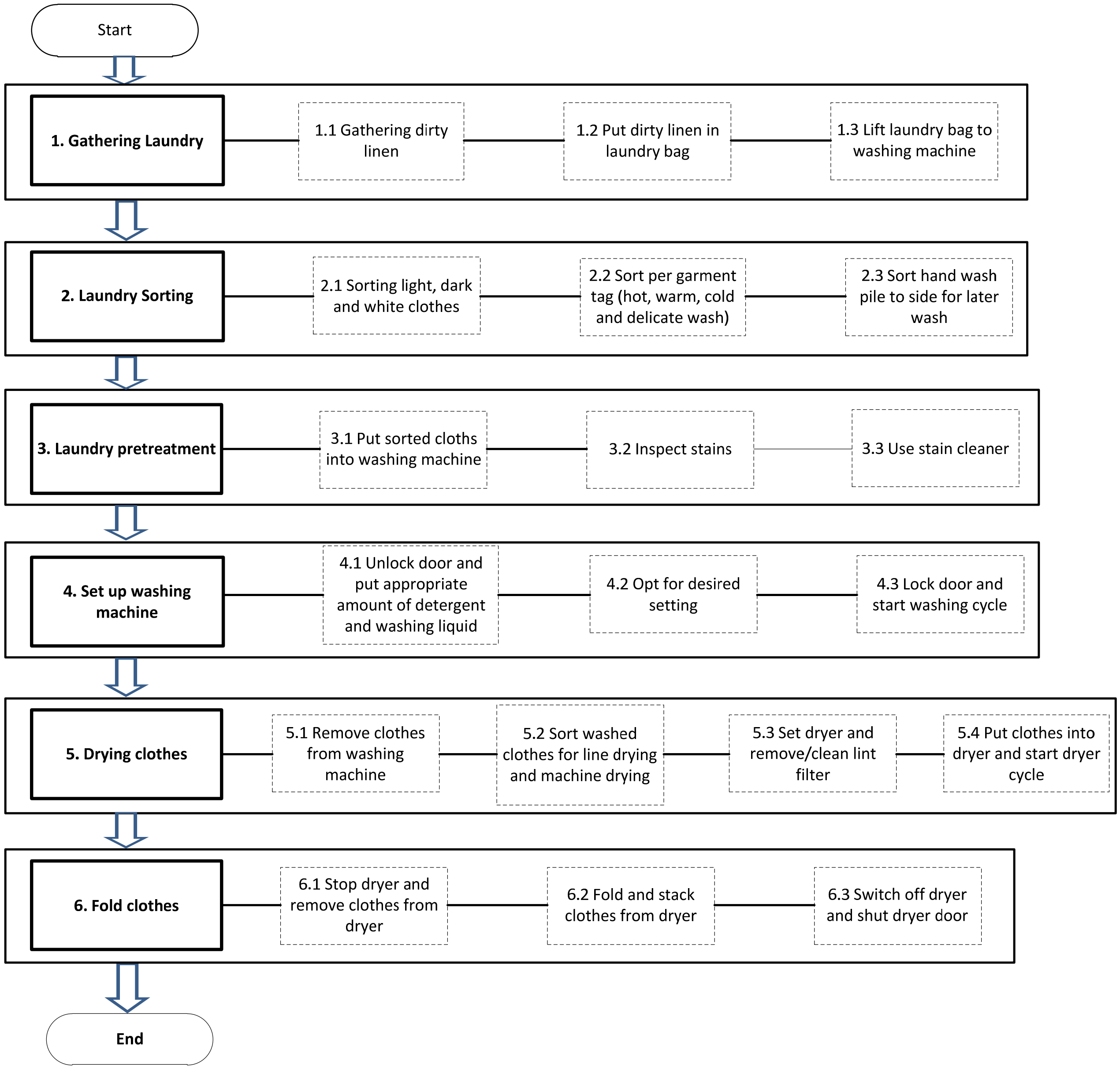


Figure 6-40 Typical tasks and subtasks involved in doing laundry

The purpose of this survey is to answer the above-mentioned question (section 6.3). It has been decided to design the survey based on an individual's behaviour and the way they performed the laundry in their home. Like the food preparation task, laundry is included in the Lawton Instrumental Activities of Daily Living scale [1] which is used to assess a person's functional level. Therefore, it helps to understand the way people perform and perceive laundry in their home. As in the food preparation task, the targeted population for this survey was people above 40 years of age, but it was decided to cover people of all ages: 18-30, 31-50, 51-70, and 71-90 years old. The final target for this survey was 60 people.

Question development for doing laundry tasks is also based on the mind map results (discussed in section 6.2.1). Three parameters – easiness (how easy was it to perform the task?), physical demand required to complete the task, and the complexity of a task – were used in designing the laundry questionnaire, which can be found in Appendix A, section 15.4. It is divided into two sections: section A is aimed at gathering some general information whereas the purpose of section B is to find information about each of the different tasks described above.

In section A, six questions were designed which were open-ended (types of questions that provide meaningful and more than one-word-answers and are usually used in exploratory research [265, 266]). Gathering this information is necessary because it provides qualitative information which helps to explore people's perception about pre-laundry matters. The following are the questions in section A:

- *When doing laundry in your house, how often do you do it?*
- *How many people do you do laundry for?*
- *Typically, how many loads do you do in a single time?*
- *How many loads would you do in a typical week?*
- *How many times do you typically have to go up and down stairs gathering the laundry?*
- *In which room is your washing machine located?*

In section B, the questionnaire focuses on gathering information about each task during the laundry activity. The first three questions are the close-ended ordinal type, while the remaining two questions are open ended and allow participants to respond freely using their own words to answer. The following are the questions in section B:

- *For each task how easy do you find it to complete?*
- *For each task please indicate the physical demand required*
- *For each task please indicate its complexity (perceived number of procedural steps)*
- *Please describe what you have to do in the following tasks:*

i. Gathering laundry

ii. Sorting and preparation laundry

iii. Washing machine preparation

iv. Drying clothes

v. Folding clothes

- *Please state any particular difficulties involved in the following tasks:*

i. Gathering laundry

ii. Sorting and preparation laundry

iii. Washing machine preparation

iv. Drying clothes

v. *Folding clothes*

At the end, demographic, lifestyle and existing condition information was gathered through the section called "Monitoring information" (see Appendix A, section 15.4).

After being designed, the questionnaire underwent two pre-test sessions (based on three basic goals of the pre-test: see section 3.3.2.3). In the first session, feedback was obtained from different researchers who possessed good experience in survey design, whereas in the second session, feedback was requested from respondents of different age groups. The final version was altered to incorporate some minor changes resulting from the pre-test results and feedback.

Table 6-17 Self-administration mode used and minimum sample needed for the study

Self-administration mode	No. of questionnaire distributed	No. of questionnaire found suitable for the study
University of Sheffield Library	27	25
University of third age group (U3A) Sheffield	44	35
Total	71	60

Population size = 71 (the number of questionnaire distributed)
Minimum sample size needed= 61 (see table 6-1 for sample size calculation)
Sample size used=60

A self-administered method was used for this study and the questionnaires were distributed (see section 15.4, Appendix A). The reason for using the self-administered method was to enable the researcher to be able to clarify any ambiguity on the spot and ensure the respondent answered the question correctly. When conducting a questionnaire-based study, it is important to define "What population would we like to study and what will be our sample size?". The larger the sample' the more likely the results are to be a good representation being studied. There are many studies which use different numbers of participants in their studies. Their studies are based on human testing and sample size ranges from 6 to 62 participants [270-275]. This study investigates how an individual's behaviour affects the way they perform a laundry task. Table 6-17 shows the detail about the data collected and minimum sample required for the study. The minimum sample size required is 61 participants but the study encompassed 60 participants in total (24 male, 36 female, with an actual age range of 22-90). Although a calculated sample size (n=61 participants) is approximately equal to actual sample size (n=60 participants) used in this study but it is assumed that it will not affect the results by whole. Table 6-18 shows the characteristics of the subjects participated in the study. Table 6-19 shows the number of responses by each gender and their proportion in each age group.

Table 6-18 Characteristics of subjects (n=60)

Subjects characteristics	Sample mean	Sample standard deviation	Minimum	Maximum
Age (years)	47.78	19.48	22	90
Height (cm)	167.9	8.69	152	186
Weight (kg)	69.7	9.97	45	104

Table 6-19 Number of responses and proportion within each age group

Age Groups	Male	Female	Row Total	Percentage
18-30 years	5	9	14	23.3
31-50 years	15	9	24	40
51-70 years	3	11	14	23.3
71-90 years	1	7	8	13.4
Column Total	24	36	60	100

As in the case of the food preparation study, this study uses SPSS statistical data analysis software to record and analyse the response for each question. It also uses the same techniques and assigns numeric equivalents which are referred to in table 6-10.

6.3.2 Results and Discussion

This section answers the statements mentioned at the beginning of section 6.3 with respect to the question numbers in the questionnaire that has been designed (see Appendix A, section 15.4).

i. How is laundry performed and perceived in the home?

In order to answer this question, section "A" of the questionnaire on laundry tasks (general information questions i, ii, iii, iv, v and vi) was used. Figure 6-41 shows the frequency with which people do an activity and it plots the proportion of responses to question 1: When doing laundry, how often do you do it? Most people like to do their laundry on a weekly basis and it is interesting to know that this is a regular but not a daily chore. Over 50% of people carry out their laundry task on a weekly basis and the size of the chore can be inferred from the number of people the laundry is done for, with 48.3% of the responses from single person loads. Figure 6-42 shows further detail. This data may be used to correlate whether a larger chore load is reflected in a greater perceived effort, in a later analysis.

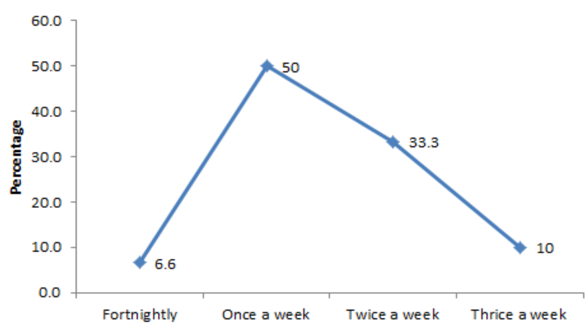


Figure 6-41 Respondent percentages for "How often people do the laundry?"

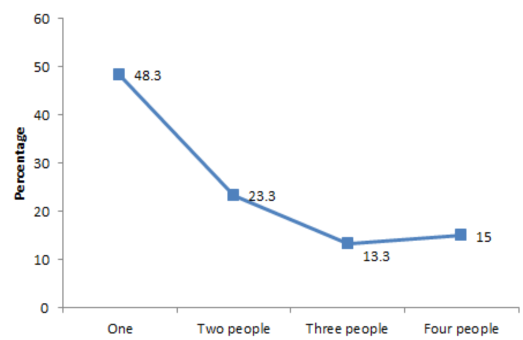


Figure 6-42 Respondent percentages for "How many people do you do laundry for?"

Laundry is a strenuous chore; it requires an effort to complete. This effort can be understood from the number of loads of washing in a typical week. The larger number of loads in a typical week have a higher perceived effort and most people like to do two and four loads respectively in a typical week. Figure 6-43 shows that 15% and 28.4% of people in the survey did one and four loads in a typical week. Normally gathering dirty clothes required numerous movements, such as gathering clothes from different rooms upstairs and downstairs and bringing them near to the washing machine. The survey responses indicate that 28 (46.7%) of people (see Figure 6-44) were not using stairs to complete the laundry chore and 76.7% had the washing machine located in the kitchen (see Figure 6-45).

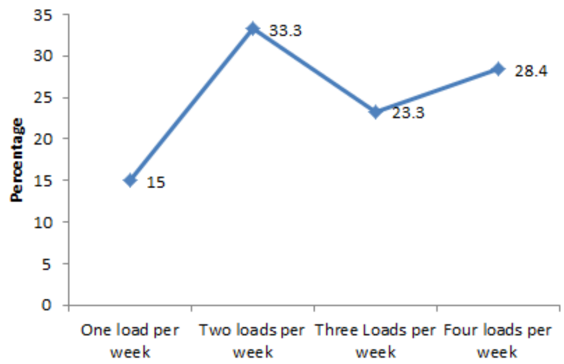


Figure 6-43 Respondent percentages for "How many loads would you do in typical week?"

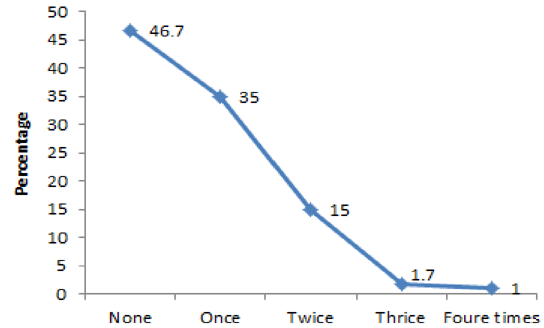


Figure 6-44 Respondent percentages for "How many times do you typically have to go up and down stairs gathering the laundry?"

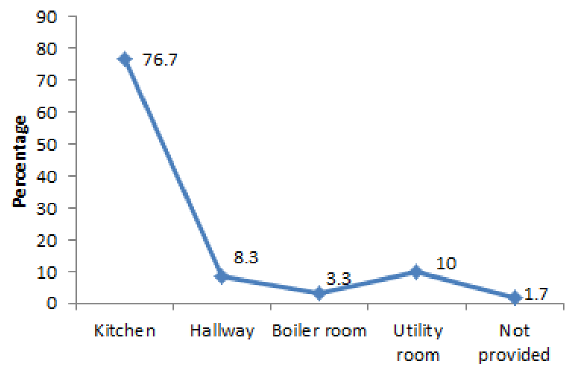


Figure 6-45 Respondent percentages for "in which room is your washing machine located?"

Figure 6-46 shows the participants' preferences in doing their laundry and the relationship between frequency and number of loads per week. The bubble size in Figure 6-46 shows the number of responses in the respective categories and the different colours of the bubbles shows the frequency of doing laundry in a typical week (for example, the red bubbles show "doing laundry once a week"). Most people do their laundry once or twice a week, with two or four loads respectively. It can be seen from Figure 6-46 that most of those who have one or two loads per week like to do laundry once a week, while most of those who have three loads per week prefer to do this twice a week, and similarly most people who do four loads per week like to do theirs twice a week. From these findings it can be inferred that changes in laundry load per week (more than 2 loads per week) forced people to do laundry more than once in a week, which in turn forced them to put more physical effort into their daily chores.

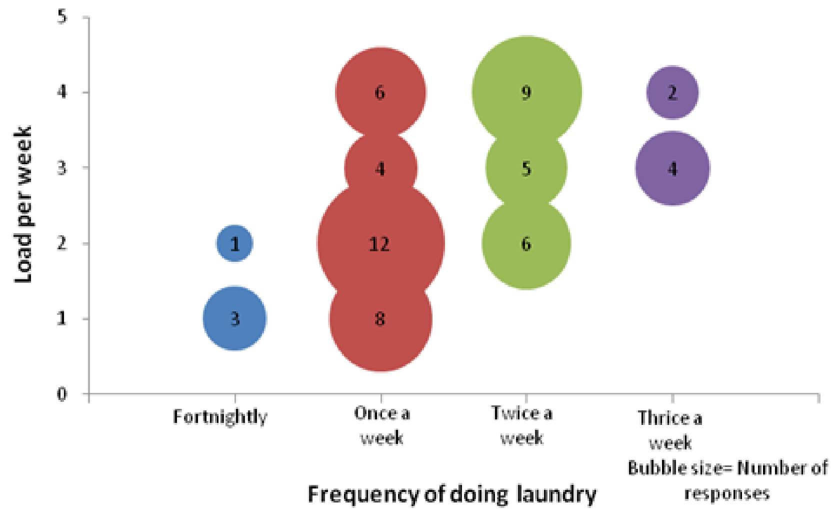


Figure 6-46 People's preferences in performing laundry tasks

Figure 6-47 shows the effect of the frequency of doing laundry in relation to the "number of people you do laundry for". The bubble size in Figure 6-47 represents the number of responses in the respective categories and the different colours show the "number of people you do laundry for" (for example, the blue bubbles represent doing laundry for one person),. Most people like to do their laundry once a week for one person (self) or two people (self+1) and twice a week for three (self+2) or four (self+3) people. It is seen from the figure 6-47 that as the frequency changes the number of responses to this question decreases.

This means that those people who do laundry for more than 2 people are normally doing this twice or three times a week. From this it can be inferred that as the "number of people you do laundry for" increases (more than 2 people) then the person does the laundry twice or more than twice a week, which forces the person to put in more physical effort into these daily chores.

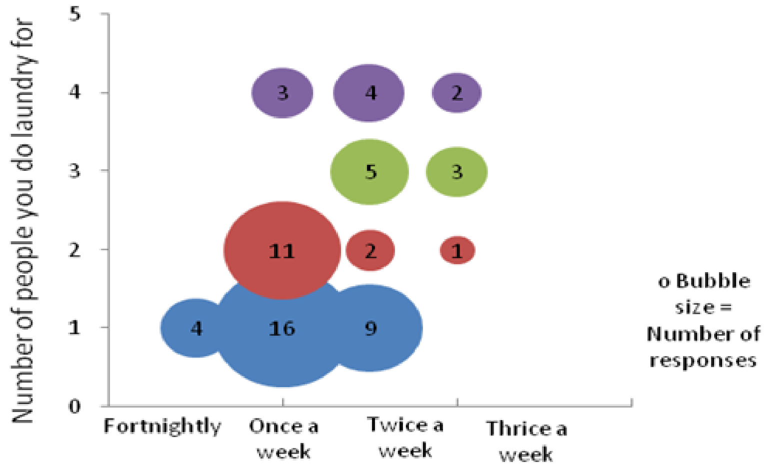


Figure 6-47 Effect of frequency of doing laundry on "number of people you do laundry for"

ii. What is the hardest part of doing laundry?

In order to answer this, question 1,2 and 3 of section "B" of questionnaire on laundry task were used: 1. For each task how easy do you find it to complete; 2. For each task please indicate physical demand require; and 3. For each task please indicate tasks complexity. The hardest sub-tasks within the laundry task help us to understand how people perceived the different sub-tasks because doing laundry generally involved in pulling, pushing, carrying material, folding and lifting which need physical strength which might results in short term or long term injuries [276] which will affect the person's comfortable level. Generally laundry is considered to be easy domestic chore but it is interesting to know from the result of studied survey which shows that more than 50% people consider laundry is easy and they can perform it with ease. Although, more than 60% people required physical demand and found complexity in performing different sub-task in doing laundry. Figures 6-48, 6-49 and 6-50 shows further details.

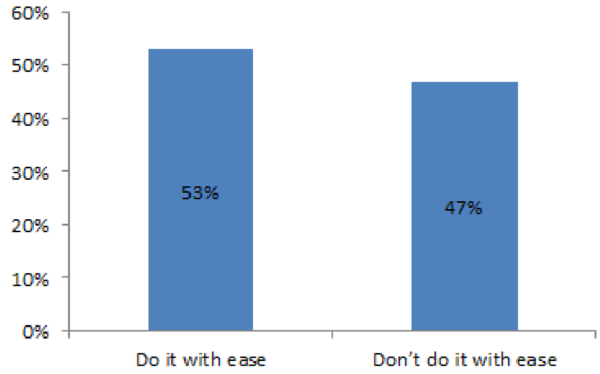


Figure 6-48 Respondent percentage of those who do it with ease and don't do it with ease.

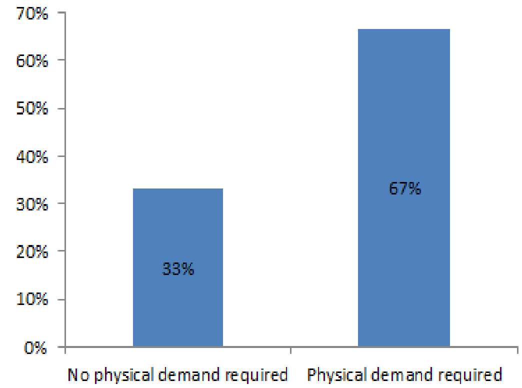


Figure 6-49 Respondent percentage who required or did not require physical demand

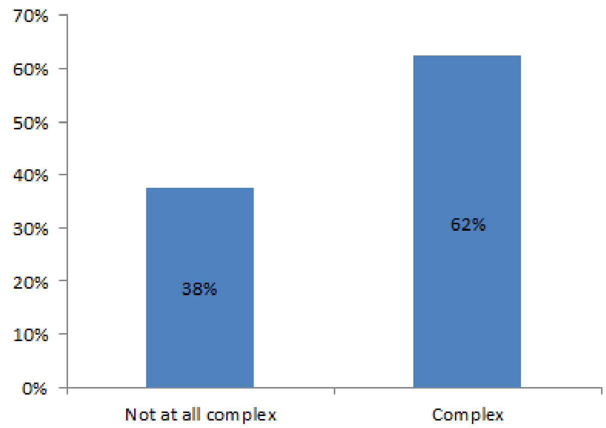


Figure 6-50 Respondents who found doing laundry complex and not at all complex

(a) How easy was it to complete each sub-task?

The next finding relates to the hardest part of the laundry task; in other words which task requires the greatest effort (in relation to ease of use), is the most complex and requires a high level of physical effort. Ease of use is measured by "how hard do you find laundry to complete"? There are four options in ease of use: "with ease", "moderate effort", "significant effort" and "delegate this task to someone else". Level of ease decreases progressively from "with ease" to "delegate this task to someone else". It is clear from Figure 6-51 that the hardest task in doing laundry is drying clothes, because only 32% of participants did this task with ease and 68% found it hard and they put in a moderate to significant effort to do it.

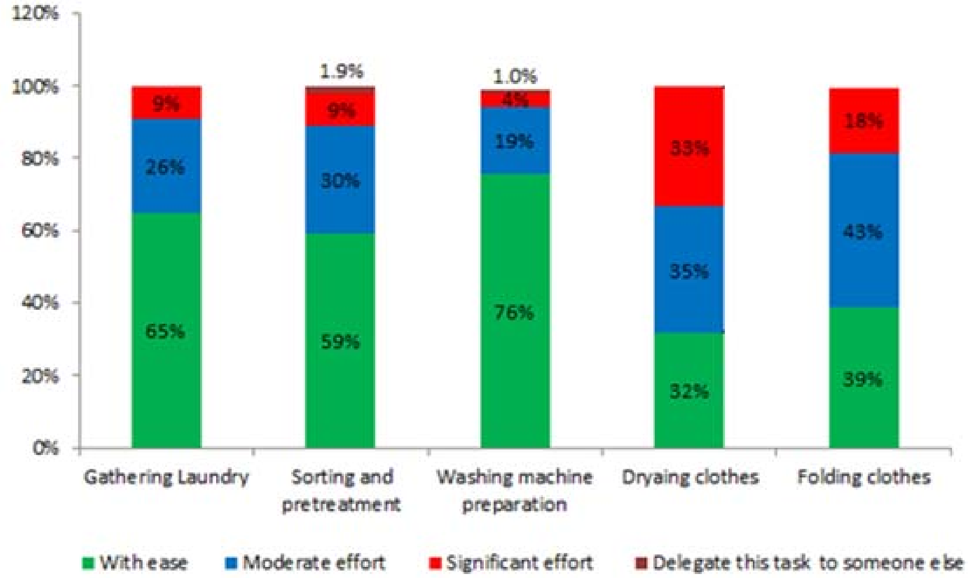


Figure 6-51 Hardest and easiest tasks in doing laundry

The second hardest task is folding clothes, because only 39% did this task with ease and 61% people put in a moderate to significant effort to perform it. The easiest task in doing laundry is washing machine preparation because 76% performed this task very easily. The second and third easiest tasks are gathering clothes and sorting and pre-treatment because 65% and 59% people performed these tasks with ease. Figure 6-51 shows an interesting fact which is that the sub-task of drying clothes makes the laundry task harder, as people have a problem handling the wet clothes (taking them out from the machine and putting them in the dryer, or taking the wet clothes to hang on a line outside or an airer inside). Therefore, within the laundry task, drying clothes is the hardest sub-task to perform.

Effect on different age groups with respect to how easy respondents complete hardest sub-task drying clothes

Figure 6-52 shows the proportion of how easily each group of respondents performed the hardest sub-task (drying clothes). It can be seen from figure 6-52 that all four age groups perceived this sub-task as harder to perform compared to the other sub-tasks, but the highest proportion (18.3%) came from 31-50 year old respondents as they required a moderate to significant effort in drying clothes. Similarly, the 51-70 and 71-90 year-olds also required a moderate to significant effort for this sub-task, but most respondents in these age groups (8.3% and 6.7% respectively) perceived drying clothes as moderately hard to perform. Furthermore, a small proportion (1.7%) of 31-50 year-old respondents did not like to perform this sub-task and delegated it to someone else.

It can therefore be concluded that most 31-50 year-old respondents perceived the drying clothes sub-task as harder to perform because they put in a significant effort while most respondents in the 51-70 and 71-90 age groups (8.3% and 6.7% respectively: see red circle) perceived this sub-task as moderately hard.

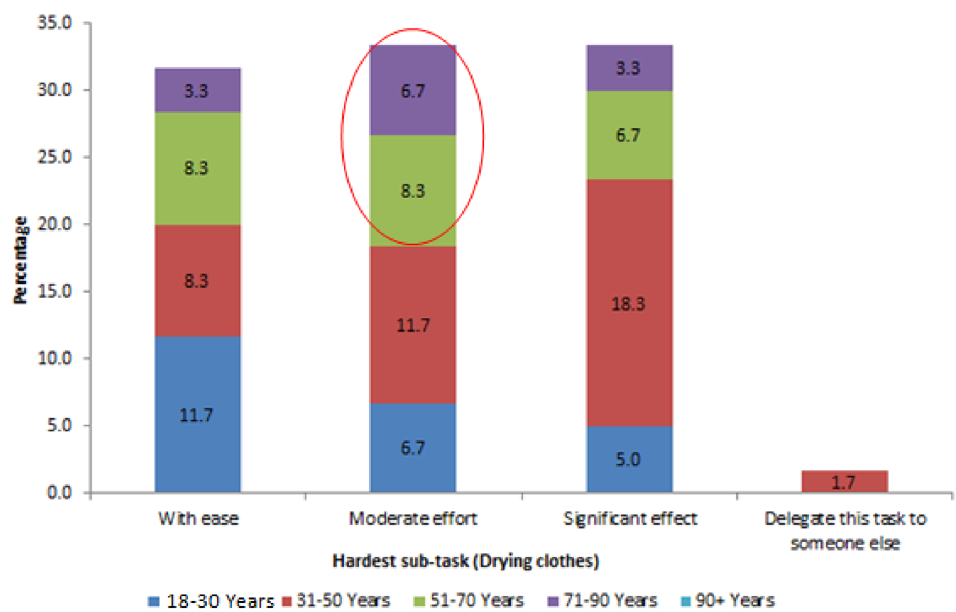


Figure 6-52 Proportion of how easily each group respondents performed the hardest sub-task (drying clothes)

(b) Physical demand required to complete for each sub-task

In terms of the physical demand required to perform these tasks, the same trend is observed (see Figure 6-53). The hardest task is drying clothes because only 19% of the participants did this task with ease, while 81% found this task hard and they rated it as minor to too much physical demand. Similarly, the second hardest task is folding clothes, because 80% of those surveyed considered there was moderate to too much physical demand in performing this task. The easiest task in term of physical demand required was washing machine preparation, followed by the second and third easiest tasks of sorting & pre-treatment and gathering clothes, respectively, because many people required no or minor physical demand in performing these tasks.

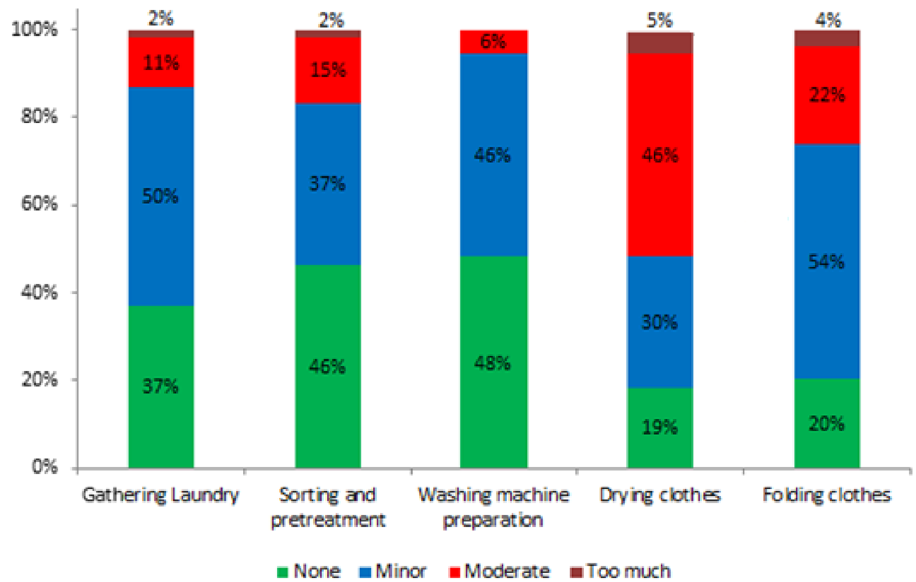


Figure 6-53 Hardest and easiest tasks in terms of physical demand required in doing laundry

On the whole it can be said that in doing laundry, people struggle with drying clothes and folding clothes. The participants rated drying clothes as the hardest of the five tasks and washing machine preparation as the easiest. In the drying clothes task, handling the wet clothes was difficult for them and they might feel some pain in parts of their body. Figure 6-53 shows further details.

Effect on different age groups with respect to physical demand required for hardest sub-task drying clothes:

Figure 6-54 shows the proportion of physical demand required to perform the hardest sub-task (drying clothes). It is seen from figure 6-54 that all four age groups of respondents perceived the sub-task of drying clothes as harder to perform compared to other sub-tasks, but the highest proportion (23.3%) came from the 31-50 year-old respondents as they required minor to too much physical demand to perform this sub-task of drying clothes. Similarly, the 51-70 and 71-90 year-old respondents also required minor to too much physical demand drying clothes, but most respondents in these age groups (10%, see red circle, and 6.7%, see blue circle, respectively) required moderate and minor physical demand to perform this sub-task. Furthermore, a small proportion (1.7%) of all age groups of respondents might not like or might struggle to perform this sub-task because it required too much physical demand.

It can be concluded, therefore, that most (23.3%) of the 31-50 year-old respondents perceived the sub-task of drying clothes as hardest to perform because they needed to put in a moderate effort while most (10%) of the 51-70 year-olds perceived this sub-task as moderately hard and most (6.7%) of the 71-90 year-olds perceived this sub-task as requiring a minor physical demand to perform this sub-task.

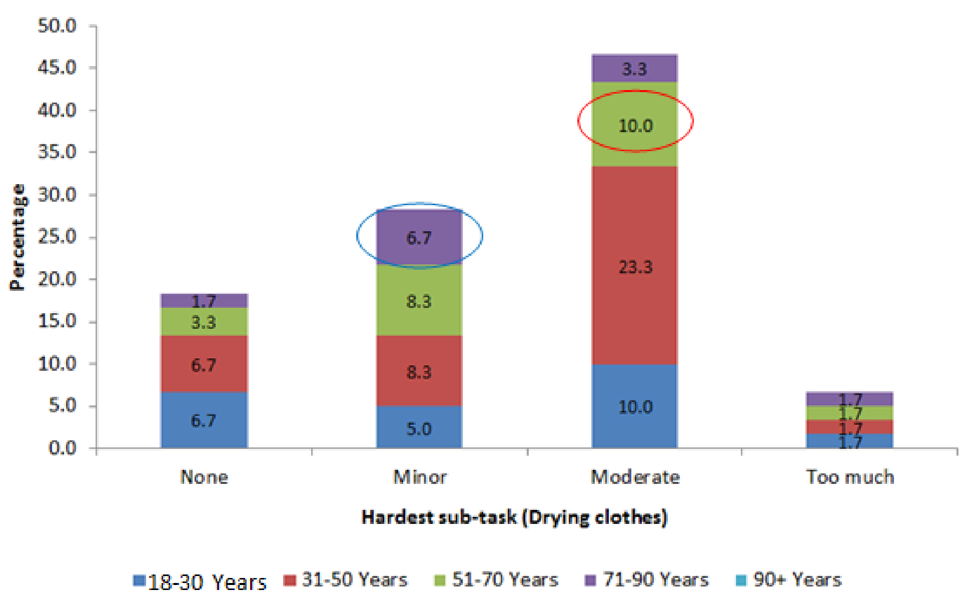


Figure 6-54 Proportion of physical demand required to perform the hardest sub-task (drying clothes)

(c) Perceived complexity of each sub-task

In terms of complexity (the most complex part in terms of the perceived number of steps), the hardest task is drying clothes because 74% of participants (see Figure 6-55) found this task slightly complex to extremely complex; and the second hardest was folding clothes because 67% found this task slightly complex to extremely complex. The easiest tasks in terms of complexity (perceived number of steps) were washing machine preparation, gathering laundry and sorting & pre-treatment because many people found these tasks not at all complex. Figure 6-55 shows further details.

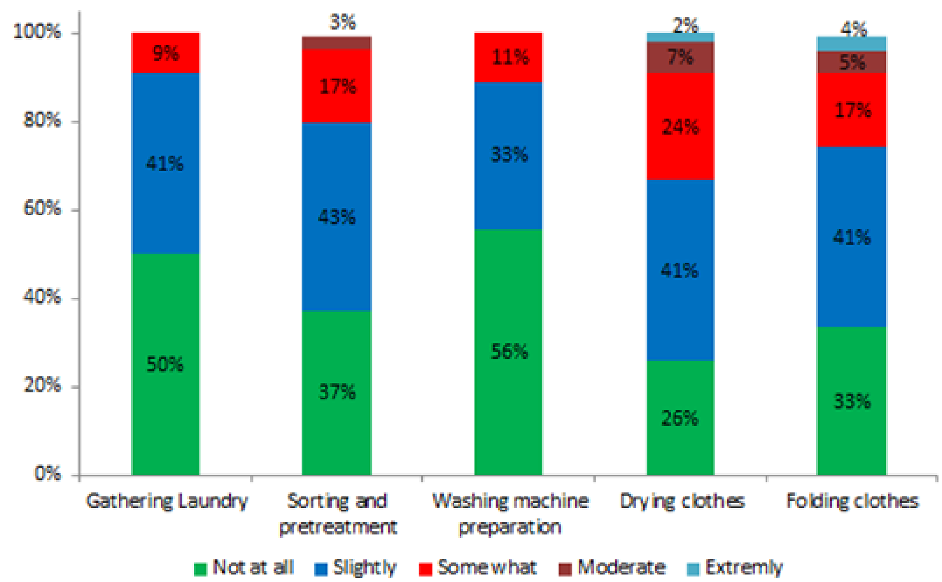


Figure 6-55 Hardest and easiest task in terms of complexity (perceived number of procedural steps)

Effect on different age groups with respect to perceived complexity of hardest sub-task drying clothes:

Figure 6-56 shows the proportion of perceived complexity to perform the hardest sub-task (drying clothes). It is seen from figure 6-56 that all four age groups of respondents perceived this sub-task as complex to perform as compared to other sub-tasks, but the highest proportion (13.3%) comes from the 31-50 years old respondents as they perceived each step in drying clothes as slightly to moderately complex, and proportion of the 51-70 and 71-90 year-old respondents perceived drying clothes as slightly to somewhat complex, whereas most of these two groups of respondents (13.3% and 5% respectively, see red circle) considered drying clothes as slightly complex. Furthermore, a small proportion (1.7%) of the 18-30 age group respondents felt that they might not like or might not be mentally prepared to do this task and considered this sub-task as extremely complex.

It can therefore be concluded that most of the 31-50 year-old respondents considered the sub-task of drying clothes as somewhat complex when performed, while most of the 18-30, 51-70 and 71-90 year-olds considered this sub-task as slightly complex.

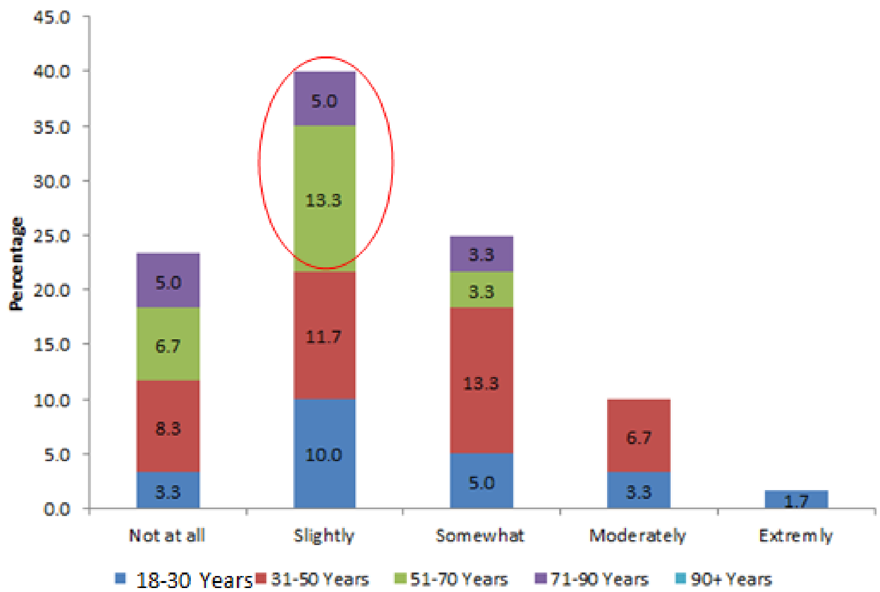


Figure 6-56 Proportion of perceived complexity to perform the hardest sub-task (drying clothes)

Overall, it can be said that drying clothes is a task which is not easy to perform, needs physical demand and has a complex number of procedural steps to perform, leading to the conclusion that among the five sub-tasks involved in doing laundry, the hardest is drying clothes and the easiest is washing machine preparation. It is also concluded that within all five age groups, the 31-50 years old respondents have the highest proportion in all three parameters (how easy to complete, required physical demand and perceived complexity), followed by the 51-70 and 71-90 year-olds in performing the hardest sub-task (drying clothes).

iii. What is the correlation and significance level of hardest part with physical demand required, ease of use and complexity?

In order to answer this question, three variables physical demand required, complexity of the task and ease of use (how easy do you find it to complete) was used in relation with the hardest part (drying clothes). Above discussion clear that the hardest part of the laundry is drying clothes. The correlation of these variables and other pre-laundry information with respect to hardest part (drying clothes) is shown in figure 6-57 using 95% confidence interval. The moderate correlation is exists between these three variables within the sub-task drying clothes. However, according to [267] a moderate correlation is not so helpful, but Significance relation found between physical demand required, complexity and easiness which means that the task become more harder to perform because person put in more strength to do the task which will alter or affect level person's easiness. During performing laundry the amount of physical demand required and complexity will affect the level of easiness and this make the task harder to perform, may be this effect responsible to change the behaviour for people in later stages of life.

The correlation between these three variables (physical demand required, complexity and ease of use) with other variables (pre-laundry information: number of people you do laundry for?, number of people you do laundry for?, how many load you do in a typical week?, how many times do you typically have to go up and down stairs gathering the laundry?, in which room is your washing machine located?) is shown in figure 6-57 and found that they are low or weakly correlated ($r \leq 0.35$) [267]. Although, some of the variable have a both positive and negative "r" values, low "r" value suggest that there is weak correlation between them even though the results would be significant since p-value < 0.05. From correlation table below it is clear that the hardest task in laundry having a weak correlation with some general information.

Correlation	Physical demand in drying	Complexity in drying	Ease of use in drying	How often you do laundry	How many people you do laundy for	How many loads you do in a week	Go up and down to gathering aundry	Location of your washing machine
Physical demand in drying	1	0.598*	0.543*	-0.017	0.285*	-0.005	0.194	**-0.2**
Complexity in drying		1	0.56*	0.235*	0.274*	-0.039	0.11	(-0.278*)
Ease of use in drying			1	-0.1	0.165	0.001	0.306*	**-0.141**
How often you do laundry				1	0.464*	0.434*	0.087	0.073
How many people you do laundy for					1	0.346*	0.262*	0.137
How many loads you do in a week						1	0.309	0.206
Go up and down to gathering aundry							1	-0.032
Location of your washing machine								1
*Shows significance level $p<0.05$								
Low or weak correlation ($r \le 0.35$)		Moderate correlation ($0.36 \ge r \le 0.67$)		Strong or high correlation ($0.68 \ge r \le 1$)				

Figure 6-57 Correlation between variables and their significance level for the hardest task in laundry

It is concluded, therefore, that the hardest part of doing the laundry (drying clothes) is moderately and significant correlated with the physical demand required, ease of use and the complexity, and so the hypotheses are rejected because there is a moderate correlation. It can also be concluded that these three variables (physical demand required, ease of use and complexity) are moderately and significantly correlated with “the number of people you do laundry for” and “how many times you typically have to go up and down stairs gathering the laundry”.

iv. What difficulties do people face during laundry tasks?

In order to answer this, question 5 of section “B” of the questionnaire on laundry task was used. The following sub-tasks are discussed below in which people were experiencing difficulties when performing laundry tasks.

Gathering laundry

Figure 6-58 shows the proportion of problems faced by people in the sub-task of gathering clothes. Most of the respondents (60%) said they did not have any problem and could perform this task with ease, although some experienced some problems such as excessive bending and reaching, feeling pain in some parts of the body and also the task involved lifting heavy loads.

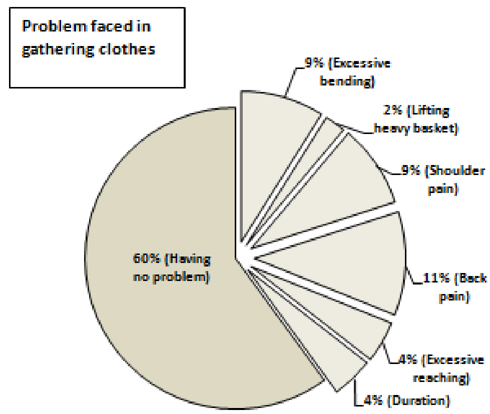


Figure 6-58 shows the people percentage having and don't have problems in gathering laundry.

It can be seen from Figure 6-58 that people experienced back pain and adopted excessive bending or reaching in the sub-task of gathering clothes. This might be an indication that this sub-task is not easy and requires physical effort when performed.

Sorting and pre-treatment

Figure 6-59 shows the detail and proportion of problems faced by people in the sub-task of sorting and pre-treatment of clothes. In this sub-task, most of the respondents (73%) did not have any problem and could perform this task with ease, although some experienced some problems such as excessive bending and feeling pain in some parts of the body. It can be seen from Figure 6-59 that people experienced hand and neck pain and adopted excessive bending postures during sorting and pre-treatment.

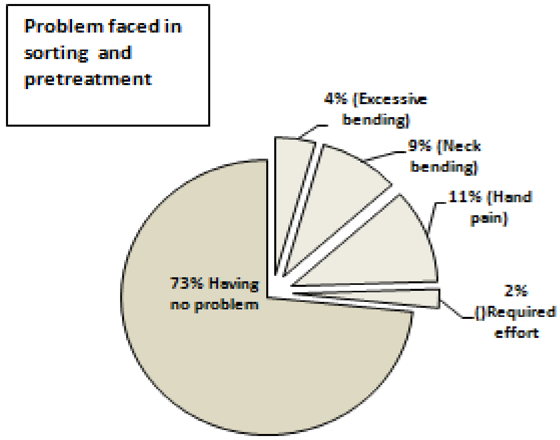


Figure 6-59 Percentage of people having and not having problems in sorting and pre-treatment of laundry.

Washing machine preparation:

In this sub-task mostly people did not have any problem and could perform it with ease (76%), although some experienced some problems such as excessive bending and feeling pain in some parts of the body. Figure 6-60 shows further details.

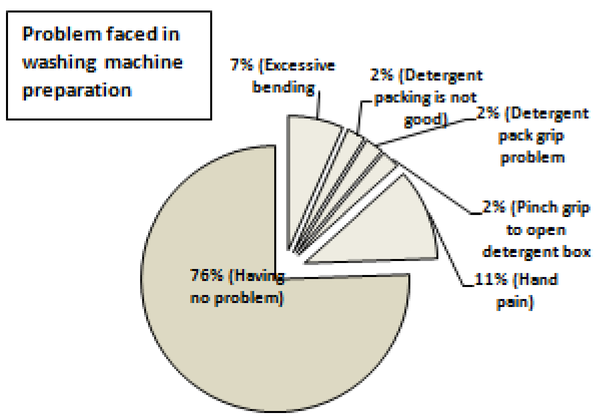


Figure 6-60 Percentage of people having and not having problems in washing machine preparation of laundry.

Drying clothes:

It has been mentioned earlier that this sub-task is considered to be the hardest part of the laundry and many of the respondents (56%) struggled with this task (see Figure 6-61). In this sub-task people complained about body pain (back, neck and shoulders) and they adopted excessive bending. A proportion of respondents (18%) also mentioned that drying clothes also required too much effort to perform. Therefore, in terms of the problem faced, it can be confirmed that drying is the hardest task. It involves forceful pulling and gripping wet clothes from the washing machine. Wet clothes are heavy to lift and tangled, so the person requires a forceful grip to pull them out, which might force him or her to adopt awkward and static postures and might be responsible for a change in habits in the later stages of life. Figure 6-61 shows further details about drying clothes.

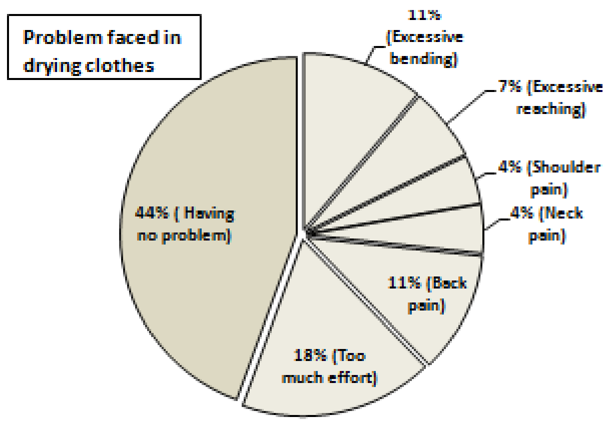


Figure 6-61 Percentage of people having and not having problems in drying clothes in laundry work.

Folding clothes:

In folding clothes most respondents (64%) did not have any problem (see Figure 6-62) and they could perform this task with ease, although some experienced problems such as feeling pain in some parts of the body (neck, shoulders, arms, hands and back), required physical effort and it also required too much time to fold all the dried clothes. Figure 6-62 shows further details.

It can be concluded that people struggled with all the five sub-tasks but the hardest one was drying clothes, in which almost all the respondents felt pain in their back, neck, shoulders and hands. As well as this, people adopted excessive bending and reaching in performing some sub-tasks. Therefore, it can be said that doing laundry is not an easy task, it requires physical effort and forces a person to adopt awkward postures.

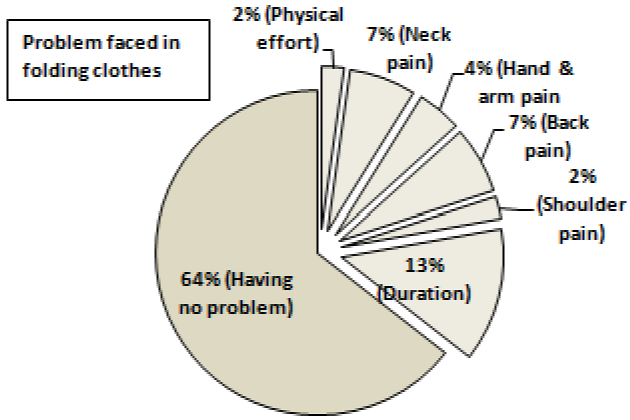


Figure 6-62 Percentage of people having and not having problems in folding clothes in laundry work.

6.3.3 Results Summary:

In many activities of daily living, doing the laundry is regarded as an essential task: everybody engages in this activity at least once a week and it is necessary in order to keep ourselves clean and hygienic. The following is the summary of results, drawn from the laundry questionnaire:

- General laundry information provides an insight into the current behaviour or what a person perceives about laundry tasks. It helps one to understand the frequency of doing laundry (most people like to do this once a week), and the fact that most people like to do their own laundry and to do two loads in a week.

- Generally, the respondents perceived laundry as an easy task but a proportion of them did not like to do laundry, in relation to ease of use, required physical demand and complexity of tasks. In the population being studied, the hardest sub-task was drying clothes with respect to ease of use (how easy was it to complete), physical demand required and complexity. It was found that within the hardest sub-task (drying clothes) all three age groups struggled. However, higher number of responses came from the 31-50 age group than from the other two groups (51-70 and 71-90).

- The hardest part (drying clothes) of the laundry is moderately and significant correlated with physical demand required, ease of use and complexity and the hypotheses are because these three variables are moderately correlated. It is also concluded that these variables are moderately and significantly correlated with "number of people you do laundry for" and "how many times you typically have to go up and down stairs gathering the laundry".
- The respondents faced different problems in performing laundry and experienced pain in different parts of the body; it was also found that in drying clothes they have a higher proportion of problems as compared to other sub-tasks, and this confirmed that drying clothes is the hardest task.

This study describes that within the laundry task there are three variables, discussed above, which make the task harder. Among the five subtasks studied, it has been found that the hardest part is drying clothes. A proportion of respondents struggled due to this hardest subtask, which might be a useful indicator that people will alter their behaviour in the later stages of their life. Therefore, the identification of the hardest part of the tasks helps to identify early signs or early warnings about changes in a person's habits as compared to the earlier stages of their life.

6.3.4 Conclusion:

The findings show that most people do their laundry once a week and two loads in a week and their washing machine located in the kitchen. Generally, the respondents perceived laundry as an easy task but a proportion of them did not like to do laundry, because of the hardness and complexity (perceived number of steps) involved, which affected the level of easiness and required a degree of physical demand. The findings show that the hardest part of the laundry is drying clothes and the easiest task is washing machine preparation. They also show that the hardest subtask (drying clothes) in laundry is not highly correlated with the physical demand required, complexity and ease of use, the hypothesis is rejected, and the conclusion is that they are moderately correlated. It is also concluded that people face different problems in performing laundry and experience pain in different parts of the body such as neck, back, shoulders and hand, and drying clothes is again found to be the hardest task in terms of problems to be faced. It is also concluded that in doing laundry, which is an important task in the activities of daily living, a proportion of people struggle due to the hardest subtask, and this might be an indicator that people will alter their behaviour in later stages of life. Further study with different tasks and a larger sample size would be required in order to confirm whether this relationship between the variables remains the same.

7 Experimental Work

It was mentioned previously that people struggle with the tasks: general housekeeping, preparing meals, Grocery shopping and laundry. Almost all the respondents of all ages wanted them modified or made comfortable to perform. Therefore, it has been decided to investigate tasks: general housekeeping (cleaning task), food preparation task and laundry for further investigation. Although, individual investigation of three tasks through questionnaire revealed the hardest part of the task which helps to identify the early signs or warning about the person's ability to perform their day to day tasks. In the experimental work, the physical aspect and subjective risk factors of the selected tasks were evaluated through the existing ergonomics assessment methods and subjective scales. Table 7-1 shows the brief description of experimental work conducted in this thesis.

Table 7-1 Brief outline of the proposed experimental work

Observational pilot Study	Mode of conducting, sample size & age group	Recruitment strategy	Participant(s) contacted through	Analysis framework	Data collection methods
1. Mopping task	Simulating in laboratory environment, n=20, age=24 to 65 years	• Easily perform the task in home environment • Having no medical conditions	• University of Sheffield Mechanical Engineering Department • University of third age group (U3A) Sheffield	• Rapid Entire Body Assessment (REBA) • Perceived discomfort (VAS scale) • Perceived exertion (Borg scale CR-10)	• Recorded videos • Photographs • Field notes • Observational data sheets • Data sheets
2. Food preparation task	Observational study in participant's home environment, n=1 & age= 33 years	• Easily perform the task in home environment • Having no medical conditions	• University of Sheffield Materials Engineering Department	• Rapid Entire Body Assessment (REBA) • Strain Index (SI) • Postural load on upper body (LUBA) • Subjective scales	• Recorded videos • Photographs • Field notes • Observational data sheets • Data sheets
3. Laundry task	Observational study in participant's home environment, n=2 & age= 33 years (male), 29 years (female)	• Easily perform the task in home environment • Having no medical conditions	• University of Sheffield Materials Engineering Department • University of Sheffield Mechanical Engineering	• Rapid Entire Body Assessment (REBA) • Rapid Upper Limb Assessment (RULA) • Postural load on upper body (LUBA) • Subjective scales	• Recorded videos • Photographs • Field notes • Observational data sheets • Data sheets

Ergonomics plays an important role in our daily life, affecting both the working environment as and the non-working (domestic) one. [251]. It has been defined as the relationship between person, equipment and environment which helps us to prevent or reduce the risk of injury or discomfort [277, 278] at work as well as in the home environment [278]. The main idea behind using ergonomics is to study risk factors (such as repetition, force, awkward postures, etc.) and prevent repetitive strain and injuries which are potentially developed by performing specific tasks [279]. Many people are immensely adaptable and accustom themselves to a wide variety of positions [280] during their performance of different tasks. However, many repetitive activities in a non-working environment can be a threat to health and cause and exacerbate pain and discomfort in the upper extremities (hand, wrist, elbow, shoulders and neck) [123]. People spend a great deal of time in their workplace or office and so workplace safety or ergonomics safety must be the top priority for employers. Another major portion of daily life is spent at home and many ailments develop in the home environment because of neglecting or overlooking ergonomics principles in day to day tasks. It is generally accepted that the home environment is associated with physical causes of accidents [281], with four high risk rooms being the kitchen, main activity room, bedroom and bathroom [282]). Ergonomics risk factors are present in all four rooms but the risks are significantly higher in the Kitchen than in the others [123, 282], and the accidents which occur in the kitchen are mostly due to poor ergonomics [123].

In the home environment, adults, particularly the elderly, are exposed to physical impairment and this has a strong impact on their day to day activities [250]. Many studies highlight the importance of ergonomics in the home environment, but most of them are based on anthropometry [250-252]. This shows that IADL tasks, within the home environment [82, 123, 251, 280, 283-285], have not been sufficiently examined and studied. There are many repetitive and stressful activities in the home environment, especially in the kitchen (such as peeling potatoes, chopping, cleaning, lifting heavy pots and kettles etc.), which can exacerbate pain in the wrist, hand, elbow, neck, shoulder and back [123]. Some traumatic and repetitive injuries are also related to home based tasks such as laceration, slip & fall, carpal tunnel syndrome (CTS), and tendonitis [123, 278].

Ergonomic techniques such as anthropometry are used to measure dimensions and other physical characteristics of the human body which are used in equipment and work space design in working and non-working environments [126]. More commonly used methods for assessing adopted postures are the Rapid Entire Body Assessment (REBA) [150] and the Rapid Upper Limb Assessment RULA [12]. Both are used as a screening tools and assess postural loads on the body [159]. REBA was designed in UK as a postural analysis tool for the whole body and for assessing musculoskeletal risks in different tasks in health-care and other service industries [159, 160]. However, it is evident that this tool is useful in any setting, whether the task is long or short in duration [169], or dynamic or static, or loads are being handled frequently or infrequently [159]. REBA is the only tool which assesses animate load handling and also considers coupling with the load handling [160]. REBA scores help to predict the risk level and action needed [150, 159]. Table 7-2 REBA scores and action levels.

Table 7-2 REBA scores and action levels

Score	Risk Level	Actions
1	Negligible	None necessary
2-3	Low	May be necessary
4-7	Medium	Necessary
8-10	High	Necessary soon
11-15	Very High	Necessary immediately

Source: [150]

In ergonomics intervention, perceived discomfort play an important role. Perceived discomfort generally reveals the short term effect of any physical activity and is used as subjective indicator [238]. In one study, it was concluded that perceived discomfort helps to predict future musculoskeletal pain at work [238]. Another study also shows the association between discomfort and risks of musculoskeletal disorders [239]. It is therefore necessary to study the effect of perceived discomfort not only in the work environment but also in the non-work one. According to the Cambridge Dictionary, "Discomfort is a feeling of being uncomfortable physically or mentally "[233]. It is also defined as "physical or mental distress"[234]. Discomfort is something that interferes or disturbs comfort and produces a mild pain effect [235]. Everybody tries to avoid discomfort by adopting different postures. It is related to physical activities and may be mild, moderate or high. It has also been suggested that "discomfort is a phenomenon of perception related to pain and fatigue"[236]. The discomfort assessment Visual Analogue Scale (VAS) is used in this study to measure the perceived discomfort [159] (See Figure 3-9 Discomfort assessment visual analogue scale (VAS).

As discussed in Chapter 3, feeling exertion in a task is essential, because force and effort are required to complete them. Exertion is an estimation of the force required for this task which reflects the muscular effort and biomechanical stress placed on the muscles [146]. According to one study [31], perceived exertion is the best indicator of physical strain. In the work environment, the perceived exertion and fatigue felt by a person is used as an indicator of musculoskeletal stress [240]. Physical strain is associated not only with heart rate, but also with other risk factors such as arrhythmias, blood pressure evaluations, depressions, body temperature changes, blood lactate level, and hormonal excretions, as well as being as an indicator of physical strain [240]. (See Table 3-17 for the Borg 10-points rating of Perceived

Exertion scale). As mentioned in the introduction to this chapter, the next section discusses the experimental work regarding domestic mopping, food preparation and laundry task.

7.1 Mopping task

As previously discussed (see table 6-7), people find many IADL tasks difficult to perform, and within these, general housekeeping (69%) was top of the list. Therefore, it was decided to investigate the domestic mopping task. The aim for this study was to apply an ergonomic assessment method to this task in order to identify task injury or risk of strain associated with it. To fulfil the aim of this study, the following objectives were identified:

1. To examine the effect of perceived discomfort and repetitive movements of arm and hands (repetitions) during the mopping activity
2. Whether the adopted postures render the person susceptible to any risk of injury by adopting the posture required in performing the mopping activity
3. Whether the physical strain has a significant effect during the mopping activity
4. To examine the adopted posture by using an ergonomic assessment method.

From the previous IADL questionnaire-based study (chapter 6),it is clear that people find many IADL tasks difficult to perform and want them to be modified to provide ease of use or comfort in activities of daily living. Therefore, it was decided to investigate the mopping task. Figure 7-1 Posture adopted during mopping activity.

Figure 7-1 Posture adopted during mopping activity

During the simulation of a mopping task it was revealed that many ergonomic risk factors are involved in this activity, such as repetitive movements of arm and hands, excessive bending, awkward postures and twisting. In this activity, the floor was mopped using a long-handle mop, in a zigzag pattern, while gradually moving backwards. Floor mopping in the home environment is a difficult task because it is necessary to clean under the table, round the back of sofas and other narrow places, this cleaning pattern is approximately similar to moving their hands in zigzag pattern, that’s why this study forced subjects to mop the floor in zigzag pattern which might force person to adopt awkward postures. Therefore, people feel exertion in their day to day tasks such as cleaning floor, especially with a wet mop, because this is a very physically demanding and time-consuming activity [272]. This task has been accepted as a strenuous and many studies has been done on this in the work environment [272]. However, the effects of this activity on a person’s heartbeat, adopted posture and perceived exertion, within the home environment, have not been sufficiently studied and reported in the previous literature. In this study, the focus is on ergonomic risk factors, and therefore the choice of task concentrates on the more physical IADLs performed by everyone within a home environment.

7.1.1 Method

For this study, the identification of the task was based on the IADL tasks as defined [1]: the ability to use a telephone, go shopping, prepare food, do housekeeping, do the laundry, use a mode of transportation, be responsible for one's own medicine, and handle finance. A survey was carried out to identify which specific IADL tasks are perceived to be the most difficult to perform. In this study we focus on general housekeeping and simulate a mopping task in a laboratory which helps to understand perceived discomfort, number of repetitions, postures adopted, perceived exertion and changes in heartbeat.

Sample population

It is assumed that the target population for this study included all healthy adults between ages 18-65, currently employees or students at The University of Sheffield. Twenty subjects (14 male and 6 female) has been selected for this study. Whilst the selected subject size (n=20) is small as compared to the population size; there is evidence that many researchers used fewer participants in their studies and still made a good contribution to the knowledge in this field [144, 270, 286, 287] therefore this sample size was deemed sufficient. All subjects were contacted through the email list of University of Sheffield. The subjects' dominant hand was right but almost all of them used both hands in this activity. Table 7-3 shows the characteristics of the subjects (n=20). Ethical approval was obtained from the University of Sheffield prior to this experimental work.

Procedure

Mopping was performed by the subjects in a laboratory environment but in the same way as it would be done at home. Figure 7-2 shows the steps followed by subjects during the mopping activity. All subjects were asked to mop a predefined area of 6.69 square metres, which is greater

Table 7-3 Characteristics of subjects (n=20)

Subjects' characteristics	Mean	Standard Deviation	Minimum	Maximum
Age (years)	36.5	11.39	24	65
Height (cm)	168.8	6.10	155	178
Weight (kg)	69	8.36	58	81
Average heartbeat before (bpm)	76	4.97	70	89
Average heartbeat after (bpm)	82	5.71	74	94

bpm= beats per minutes

than a standard minimum size living room [288], using a common household straight handled mop 110 cm (43 ins). The starting and end points were clearly marked and the mopping had to follow a zigzag pattern on the floor. Subjects needed to rinse the mop twice after reaching points 1 and 2 (see Figure 7-3). Two cameras were deployed (front and left side) to record the videos of different postures adopted by the subjects during this activity. Figure 7-3 Layout for mopping area. The number of repetitions and the discomfort level were recorded on the data recording sheet. The heartbeat rate, before and after mopping, was recorded by using a simple wrist electronic blood pressure monitor (Modal: AR-800A7) and simultaneously, verify the measured heartbeat of each subject by counting the beats for 60 seconds. Then, subjects were asked to rate their perceived exertion by using the Borg scale [241] at the end of the activity. Prior to the test, all the subjects were given written and verbal instructions on how to use Borg and VAS scales. The recorded video clips were used for posture analysis. Photographs were used to assess postural angles (maximum trunk bending). The lumbosacral (L5/S1) and cervical (C7) sections of the spine, which join the centre of gravity line were the reference points [272]. Figure 7-4 shows these reference points and the trunk angle (ϕ).

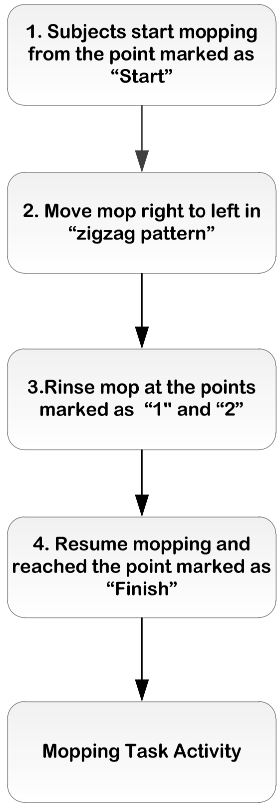


Figure 7-2 outline the steps followed by the subjects during mopping activity.

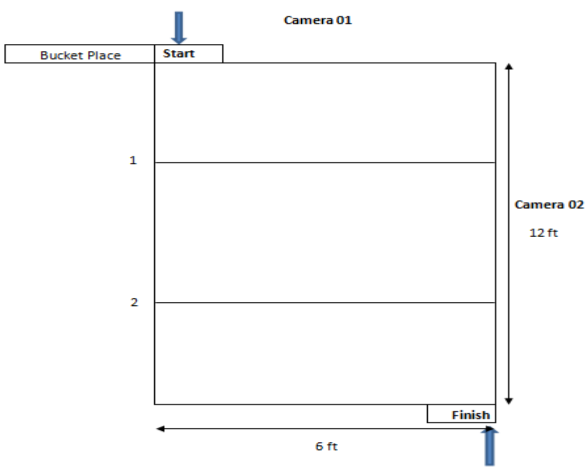


Figure 7-3 Layout for mopping area

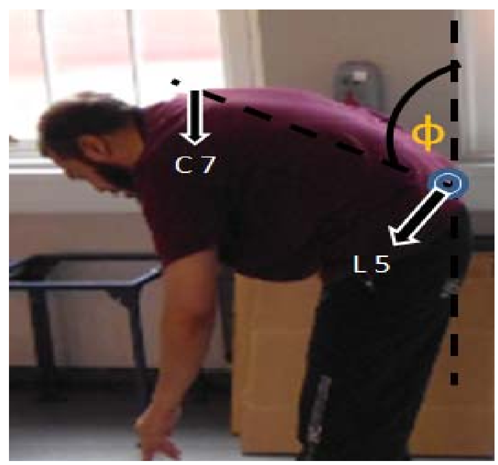


Figure 7-4 Reference points and trunk angle

7.1.1 Results and Discussion

The values of all measured variables are expresses as mean and standard deviation. The postures adopted during this activity were analysed using REBA. Paired t-tests were used to determine the significance between perceived discomfort and repetitions and between perceived exertion and changes in heartbeat during this activity. A scatter plot was used to determine the correlation between the variables using a 95% confidence interval. The findings from the experiment are shown in Table 7-4.

Mean perceived discomfort and repetition measured 4 (moderate discomfort) and 22.1 respectively. The scatter plot between perceived discomfort and repetitions (see Figure 7-5) shows a positive correlation and the t-tests show that this relation is significant. The mean perceived discomfort was found to be 4, which means that people felt moderate (VAS scale) discomfort in activities of daily living but it had a positive correlation (r=0.75) and significance relation (p<0.05) with the number of times people moved their arm and hands (repetition).

Table 7-4 Results of analysis of mopping task

Variables	Mean	SD	Correlation	P value
Perceived discomfort (VAS scale)	4	1.5	r=0.75**	0.0001**
Repetitions	22.1	3.24		
Average REBA score	8	0.31	*	*
Heart beat before (bpm)	76	4.97	*	*
Heart beat after (bpm)	82	5.71	*	*
Perceive exertion on (Borg scale CR-10)	4	1.27	r=0.78***	0.015***
Change in heart beat (bpm)	6	2.85		

*values not calculated, **correlation between perceived discomfort and repetitions, *** correlation between perceived exertion and change in heartbeat.

This meant that risk of injury was present, and so repetitive movements should be avoided within a task [289]. Ergonomics literature considers repetition 10 times per minute as an increased risk when the task lasts for one hour. In the mopping task, it was necessary to move a long-handled mop in a left to right pattern across the whole floor while gradually walking backwards, and it was mainly wrist and muscle force that controlled this movement. A previous study concluded that the repetitive movements and combination of force put a person at a risk of musculoskeletal problem, especially in the hand or wrist area [290]. To control the number of repetitions in everyday tasks is therefore important, because such repetitions may increase the chance of injury, such as pain in the hand or wrist, and arthritis.

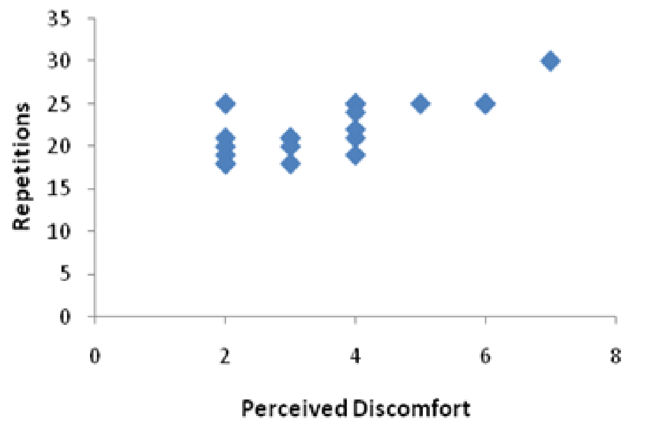


Figure 7-5 Positive relation between perceived discomfort and repetitions

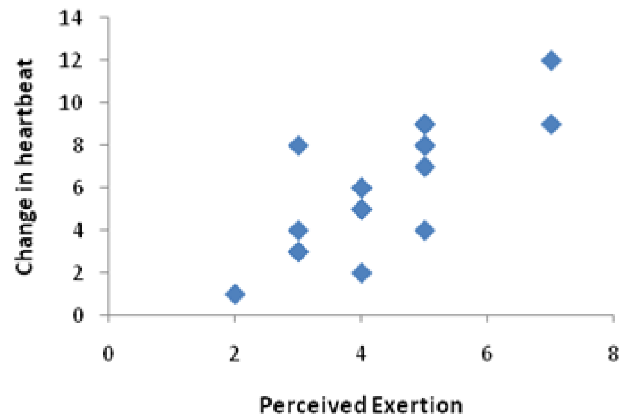


Figure 7-6 Positive relation between perceived exertion and change in heartbeat

The mean perceived exertion (Borg scale CR-10) was 4 (somewhat hard) and the mean heartbeat change was 6 bpm (beats per minute). The scatter plot between perceived exertion and change in heartbeat (see Figure 7-6) also shows the positive correlation. During the mopping task, the heartbeat rate before and after the task was measured, which helps to predict the physical strain experienced by a person. The mean perceived exertion was 4, which means that they found the activity somewhat hard. It was also found that the perceived exertion and change of heartbeat during this activity had a positive correlation ($r= 0.78$) and had a significant effect ($p<0.05$), which means that the subjects felt a physical strain during this activity. It shows that mopping is not easy to perform because it requires bending, a back and forth movement, lifting a water bucket and managing the weight of a mop, thus causing fatigue and increasing the likelihood of back pain [262], and so mopping can be considered as a strenuous task [291]. The results agreed with those of the survey conducted by Marut and Hedge, which concluded that mopping is the most tiring household task and requires more attention in future research [262].

The posture adopted during the mopping activity was successfully evaluated by the REBA ergonomic assessment method. The average REBA score was 8, which shows a high risk of injury and concludes that necessary action would be required soon. REBA is used to assess the musculoskeletal risks in a different range of tasks [13]. The REBA posture scores are related to a neutral position [292], and more deviation in the adopted postures resulted in higher scores. In the mopping task, most of the subjects adopted a bending posture, which resulted in a higher trunk angle and extreme bending of the back, which could increase the risk of lower back pain. The higher REBA score tells us that the postures that were adopted deviated from the neutral position; this means unbalanced forces, which would increase the chance of injury. It is recommended that redesigning the mop would help to reduce the trunk angle and provide a good coupling (by adding a handle) to help a person to maintain a neutral posture for their back and hand, which in turn would help to reduce the chances of injury and reduce the REBA score.

7.1.2 Limitations

The limitations of the study are as follows:

1. This study only uses one activity i.e. a mopping activity, so more activities may be required in order to generalize the results.
2. The sample size (n=20) in this study is small as compared to the whole population, but it is indicative of the behaviour of people regarding a mopping task, and thus it might be possible to detect variations in people's behaviour in doing mopping when compared with other housekeeping tasks, so a larger sample size might be needed in order to generalize the results.
3. The study uses subjective measurements and assumes that all subjects answered honestly.
4. A goniometer was not used for measuring the postural angles due to unavailability.

7.1.3 Conclusion

This study suggests a potential for the ergonomic assessment method (REBA) to be adopted in domestic settings, as it shows that mopping is not an easy task to perform, because the subjects were performing their tasks in a zone of moderate to high risk of injury. The average REBA score was high, indicating that there is a need for investigation and that changes are needed in the home environment. From the results, it is concluded that ergonomic risk factors such as repetition of movements and awkward postures do exist in the home environment. Usually people are unaware of these risk factors when performing day to day tasks. Although there are no specific tools or guidelines available to assess day to day tasks and quantify the risk associated with them, and it is the first time that an ergonomic assessment method (REBA) has been used for the evaluation of home based tasks, our findings confirm that people are struggling with day to day tasks, leading to the chances of injury. In the home environment they perform several tasks simultaneously and experience physical strain and biomechanical stress on the muscles, which is evident from change in heartbeat. Although at a young age it is less probable that these risks would affect a person's quality of life, they will lead to injury or physical disability such as arthritis, low back pain or stroke as they become older. It is also concluded that the REBA method, which assessed adopted postures, is not enough as it did not assess other risks such as the psychological perception of the tasks, and manual handling. In order to reduce these associated risk factors so as to ensure a better quality of life and to lower the probability of injury or ailment, it is recommended that the risk should be quantified through some assessment tool which helps redesign day to day tasks. Future studies with different tasks are also needed for the evaluation of more ergonomic risk factors which will reveal the situation within the home environment and the need for assessment tools to quantify the risk associated with day to day tasks.

7.2 Observational studies

7.2.1 Observational study on food preparation task

7.2.1.1 Aim of the pilot study

The aim of this pilot study was to apply ergonomic assessment methods to domestic food preparation tasks in order to identify task injury or risks of strain associated with food preparation tasks in the home environment. Furthermore, the study aims to look at whether those methods could be applied in order to minimize potential risks and optimize postural behaviour, such that the strain on the body is minimized.

7.2.1.2 Methods

In this observational study ergonomic industrial assessment methods are used (Rapid Entire Body Assessment (REBA); Strain Index (SI) and Postural Loading on Upper Body Assessment (LUBA) to evaluate the adopted postures and other subjective risk factors during a food preparation task. Occupational therapy methods are generally used as a rehabilitation tool after a specific incident occurs (post-event) and not for the identification of risk (pre-event). Therefore, the functional status of a person can be understood by the ability to perform self-maintenance, self-care and physical activities. The two common occupational therapy methods which assess a person's functional capabilities in relation to a physical disability are the Katz Index of Independence in Activities of Daily Living (ADLs) and the Lawton Instrumental Activities of Daily Living (IADLs). They are very simple and easy to use, but the problem is, they are based on a dichotomous response by the person ("do the task" or "don't do the task"). This type of response will not provide enough information about how the person maintains their mobility, maintains or changes body positions, or performs manual handling (carrying, moving and handling objects). Therefore, none of the occupational therapy methods is suitable for this study, which analyses the postures adopted by a person during food preparation tasks. It is therefore essential to define the postural analysis methods available in ergonomics. REBA, RULA, LUBA and SI are the methods used for analysing the postures adopted during everyday tasks and activities (see section 3.2.3 for details).

Apart from above-mentioned methods, subjective scales are also used in this study to record each subject's physical demand required, complexity of the task, perceived discomfort and fatigue level during a food preparation. Table 7-5 shows the subjective scales used in the studies. Ethical approval has been obtained from the University of Sheffield prior to experimental work.

Table 7-5 Subjective scales

Physical Demand Required Scale

1	2	3	4
None	Minor	Moderate	Too much

Complexity of the task

1	2	3	4	5
Not at all Complex	Slightly	Somewhat	Moderately	Extremely complex

Perceived Discomfort Scale

1	2	3	4	5
No discomfort	Mild	Moderate	High	Worst Possible Discomfort

Fatigue Severity Scale

1	2	3	4	5
No Fatigue	Mild	Moderate	Severe	Worst Possible

A paper-based survey was used to ascertain what the hardest part of the food preparation task was and to gather information on perceived hardness, physical demand and complexity of the different sub-tasks involved. The task was divided into five sub-tasks: gathering the pans and utensils; gathering vegetables for rinsing; peeling vegetables; chopping/slicing; stirring/frying. The survey, completed by 60 respondents (29 male, 31 female, age range: 20-82 years) identified the perceived the hardest part as being during the sub-task of chopping/slicing, with results showing that it required physical effort (78%) and was complex to perform (82%). The survey also concluded that people do not like to do sub-tasks such as peeling vegetables (51.6%).

Method

In this observational study, the participant was preparing food at home the way they would do normally. Five sub-tasks of food preparation were explained to them and they were instructed to do their food preparation task in a way that they performed normally on a daily basis. Two cameras were deployed to record the videos of the different postures adopted by the subjects while they were performing the food preparation. Table 7-6 shows the subjects' characteristics and anthropometrics.

Table 7-6 Subjects' characteristics and anthropometrics

Variables to measure	Subject
Age	33
Gender	Male
Height (cm)	173
Weight(kg)	74
Lifestyle	Active
Dominant hand	Right hand

Procedures

Typically the kitchen is the most commonly used room in the house [293]. In daily kitchen activities, everyone is fully involved and walking, bending or kneeling to reach what they need, as well as rummaging through the cupboards for the pans and utensils needed, while adopting awkward postures. Normally people adopted a standing posture while working in the kitchen because it requires physical mobility between the cooker/hob, refrigerator and sink (work triangle [294]). Working in a kitchen is not a problem for young people but could be one for some elderly people, especially when preparing their food, due to the reduction in their standing strength ability and endurance [250]. People usually use both hands while performing food preparation tasks, whereas the main tasks such as chopping, slicing and stirring are done by the dominant hand. For example, if someone's dominant hand is the right one, he holds the ladle with this hand while holding and stabilize the frying pan with the left one, and this forces him to apply force to stir the contents. Therefore he adopts some awkward postures such as bending the hands, neck and back. The postures that are adopted during food preparation are also associated with incorrect height of the cooker or hob and work-top. While performing a frying/stirring task a person needs to raise their hand because of the cooker height and the height of frying pan and using the ladle for stirring the food, which will add more height to the raising of the hand and force people to adopt awkward hand postures. Furthermore, raising the hand to reach up to different cupboards also contributes to adopting awkward hand and neck postures. Adopting neutral postures during everyday kitchen activities will help people to optimise their movements and minimise the stress on the body.

In Figure 7-7 shown below, the subject is preparing food for three people in his home in the way he normally does. He stands near kitchen worktop then bends from the waist and reaches up and down to different cupboards to gathers pans and utensils. He also gathers and rinses vegetables such as tomatoes and potatoes before preparing them. He uses the worktop as a work surface and places the onions and potatoes in the bowl. Using an ordinary steel peeler to peel the potatoes, he holds the potatoes in one hand and, using the peeler in the other hand, he rotates the potato in his hand and continues peeling it until all the skin has been removed. He then slices the potatoes into quarter of an inch size by using a sharp knife and using his finger nails as a guide for the slicing. He then chops the onion into small pieces, puts them into the frying pan and adds some oil to fry them. During these sub-tasks chopping/slicing and stirring/frying, the subject adopted different hand, neck and back postures and was involved in repetitious activities. Figure 7-7 thus shows snapshots of the subject preparing food in different postures. The sub-tasks are labelled.

7.2.1.3 Results and discussion

The subject prepares the food normally in a standing posture and uses both hands in sub-tasks involved in food preparation. Normally, he prepares food for three people (including himself) and uses raw or natural-state ingredients. The postures adopted were analysed using the ergonomic assessment methods REBA, SI and LUBA. Table 7-7 shows the five sub-tasks involved in food preparation as well as the REBA, SI and LUBA scores for each sub-task. Table 7-8 shows the duration, physical demand required, complexity of task, perceived discomfort and fatigue during the food preparation task.

(a) Gathering pans & utensils

(b) Gathering vegetables for rinsing

(c) Peeling vegetables

(d) Chopping/slicing

(e) Stirring/ frying

Figure 7-7 Snapshot of the subject preparing food

The findings show that the subject considered food preparation to be a short duration task and completed it in just 12 minutes (food cooking time is excluded). The average time required to complete each sub-task was 2 minute and 21 seconds. Among the five sub-tasks, gathering vegetables and stirring/frying were the shortest and longest respectively (see table 7-8).

The average overall REBA, SI and LUBA scores are shown in Table 7-7. The average REBA score suggests that the food preparation is a medium risk task, having a postural load of 7, which suggests that further investigation is required about the adopted postures because in an awkward position muscles become less efficient and more force is expended in order to complete

Table 7-7 shows the Ergonomics Analysis of food preparation task

	REBA Score					Strain Index				LUBA Postural load Score			
	1	2-3	4-7	8-10	11+	<3	3 to ≤ 5	5 to ≤ 7	≥ 9	1-5	5-10	10-15	15+
Gathering the pans and utensils		3				.38				5			
Gathering vegetables for rinsing		3				.38				5			
Peeling vegetables			4				4.5				6		
Chopping/slicing			5					13.5			8		
Stirring/frying			6						15.19		9		
Average			**4**					**6.78**			**7**		

the task [295]. Furthermore, SI classifies food preparation tasks as having some risk (see Table 5-16) associated with distal upper extremities (arm, shoulder, elbow, wrist and hand) [146]. According to Wan, Villeneuve and Fragala, neck pain is the most predominant reported symptom, but pain in the back and distal upper extremities are very common in industrial kitchens [296]. During the food preparation task it was observed that subject was performing the tasks in a standing position and was involved in repetitive tasks (chopping/slicing and stirring/frying). According to Halim and Omar, prolonged standing is associated with the onset of severe health problems such as increased risk of stroke and musculoskeletal disorders (MSD), and the duration of standing (when standing for more than 4 hours each day) [297]) also contributes to MSD and exposes a person to lower back pain [231]. However, in the task studied, all the sub-tasks lasted for short a duration and were repeated infrequently. Thus the average perceived discomfort and fatigue for the food preparation task was mild, physical demand required was minor and the complexity was considered only slightly complex.

Table 7-8 Subjective scale results for preparing food

Sub-Tasks	Actual duration (sec)	Physical demand required score	Complexity of task score	Perceived discomfort score	Fatigue severity score
Gathering the pans and utensils	63	None	None	None	None
Gathering vegetables for rinsing	58	None	None	None	None
Peeling vegetables	120	Minor	Somewhat	Moderate	Mild
Chopping/slicing	168	Moderate	Slightly	Moderate	Mild
Stirring/frying	300	Moderate	Somewhat	Moderate	Moderate
Average	142	Minor	Slightly	Mild	Mild

The sub-task stirring/frying was given the highest REBA score of 6 (indicating medium risk), an SI score of 15.19 (indicating the hazardous nature of task) and a LUBA postural load of 9 (indicating that action is required). The REBA score aimed to assess the whole body [13] while SI assessed the tasks to determine the risk of developing upper extremity disorders [47-49]. During the food preparation task, SI identified the sub-task (stirring/frying) which needed more caution when being performed because it involved neck and back postures which deviate from the neutral position and it also required the repetitive movement of different parts of the body (hand and wrist). According to Rucker and Moore, based on the SI score it is easy to discriminate between hazardous and safe tasks [47]. Therefore, the sub-task of stirring/frying required more consideration when being performed. Similarly, the LUBA scores for sub-tasks stirring/frying indicated the highest postural load of 9 (see LUBA score in Table 7-7), which reveals that stirring/frying is the sub-task in which people feel moderate perceived discomfort and fatigue, therefore they consider the task somewhat complex. The sub-task of stirring/frying required more forceful and repetitive activities as compared to the other sub-tasks, which means that the subject used his hand more extensively in stirring/frying, and this increases the likelihood of having repetitive strain injuries (RSI) if it last for a longer period of time. According to Mondal, continuously stretching and elongating the tendons during repetitive tasks may directly damage the tendons and increase the chances of fatigue, as well as reducing the chances for tissue to recover [123]. So, during food preparation the sub-tasks of stirrings/frying and chopping/slicing need more consideration and caution when being performed because prolonged repetitiveness has been cited by researchers as a risk factor for the development of upper extremity disorder [298] which triggers condition's such as arthritis [299], which eventually become the cause of decline in a person's physical capability and a loss of independence in later stages of life.

In this study, adopted postures and repetitive movements only lasted for a short period of time so did not pose high risk of injury. However, in daily activities many tasks are being performed simultaneously and people do not even think about the postures they adopt or other risk factors such as repetition. This might not be problem in the early stages but could be a cause for concern in later stages of life, and also plays a significant role in the development repetitive strain injuries (RSI).

7.2.1.4 Conclusion

The study showed that the food preparation task is not an easy daily chore. The subject adopted awkward neck and back postures and was involved in repetitive movements of different parts of the body (hand and wrist). As well as REBA and LUBA, this study suggests that another ergonomic assessment tool, the Strain Index (SI), has the potential to identify the hardest part of the food preparation task and easily discriminate among the sub-tasks. SI as used in the study revealed that the food preparation task has some risks and there is a sub-task, stirring/frying, which needs more consideration when performed. The food preparation did not pose a high risk of injury as the posture adopted and repetitive movements lasted for a short period of time. However, food preparation tasks combined with other IADL tasks that force a person to adopt similar postures and involve repetitive movement activities, would give more cause for concern as these will affect a person's quality of life later on. It could be further concluded that the results of this study were in agreement with previous survey results that the stirring/frying scored highest, 6, in REBA (indicating moderate risk) and 15.19 in SI (indicating the hazardous nature of the sub-task). It is also concluded that the average perceived discomfort, fatigue and physical demand required in the food preparation task was mild and minor and therefore the task was considered to be only slightly complex.

7.2.2 Observational study on Laundry task

7.2.2.1 Aim of pilot study

The aim of this pilot study was to apply ergonomic assessment methods and occupational therapy assessment methods to a domestic laundry task in order to investigate the validity and usefulness of using such methods to identify task injury or strain risks associated with laundry tasks in the home environment.

7.2.2.2 Assumption for the study

This study comparing the physical aspect (adopted postures) and subjective risk factors (physical demand required, complexity of the task, perceived discomfort and fatigue severity) associated with performing the laundry task. Although, subjects have different gender but this study evaluates the way they performed and perceived the laundry task. Therefore, it is assumed that both subjects have same strength capacity and not consider other parameters such as muscles power and muscles capability etc.

7.2.2.3 Methods

In this observational study ergonomic industrial assessment methods are used as follows: Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), and Postural Loading on Upper Body Assessment (LUBA), to evaluate the postures adopted (stooping and squatting or kneeling postures) during a domestic laundry task. These and occupational therapy methods have already been discussed in detail in sections 3.2.3 and 3.2.1; here they are being applied in relation to the different sub-tasks involved in performing a laundry task.

A paper-based survey was used to ascertain what the hardest parts of doing laundry are, and to gather information on the perceived hardness, physical demand and complexity of the different sub-tasks involved. After the task had been divided into five sub-tasks (gathering, sorting and pre-treatment, washing machine preparation, drying, and folding clothes) a paper survey of 60 respondents (24 male, 36 female, age range: 22-90 years) identified the perceived hardest part as being the drying clothes sub-task, as results showed that it requires physical effort (81%) and is complex to perform (74%). Subjective scales (see Table 7-5) were also used in this study to record the physical demand required, complexity of the task, perceived discomfort and fatigue level during the laundry task. Ethical approval was obtained from the University of Sheffield prior to the experimental work.

In the home of two subjects, the aim of performing a laundry task including five sub-tasks was explained to both subjects and they were instructed to do their laundry in the way that they would do it normally. Two cameras were deployed to record the videos of different postures adopted by the subjects while performing this task. Table 7-9 shows the subjects' characteristics and anthropometrics.

Table 7-9 shows the subjects' characteristics and anthropometrics

Variables to measures	Subject 1	Subject 2
Age	33	29
Gender	Male	Female
Height (cm)	173	158
Weight(kg)	74	70
Lifestyle	Active	Active

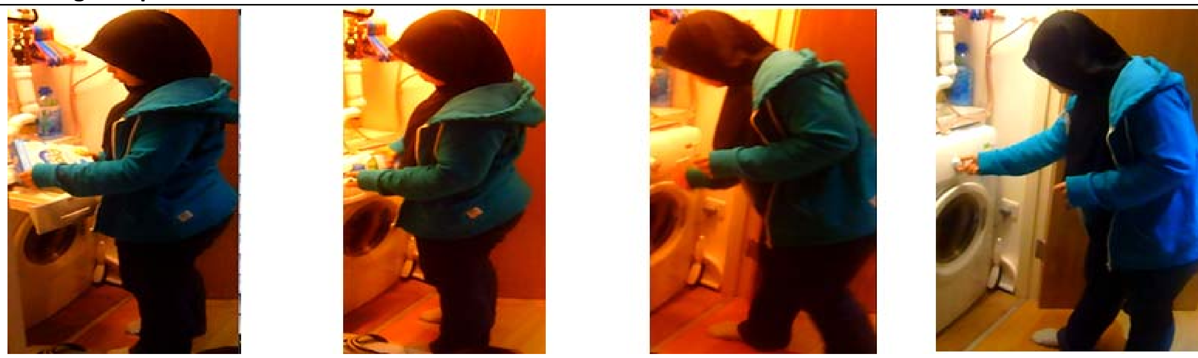
Procedure

Both people were doing the laundry. They pushed a dirty clothes laundry bin out of the laundry room and gathered or picked up dirty clothes from the bins located in different rooms of the house. They bent at the waist and reached into each bin to grab the dirty clothes, lift them out, transfer them to the laundry bin, then take them to the laundry room.

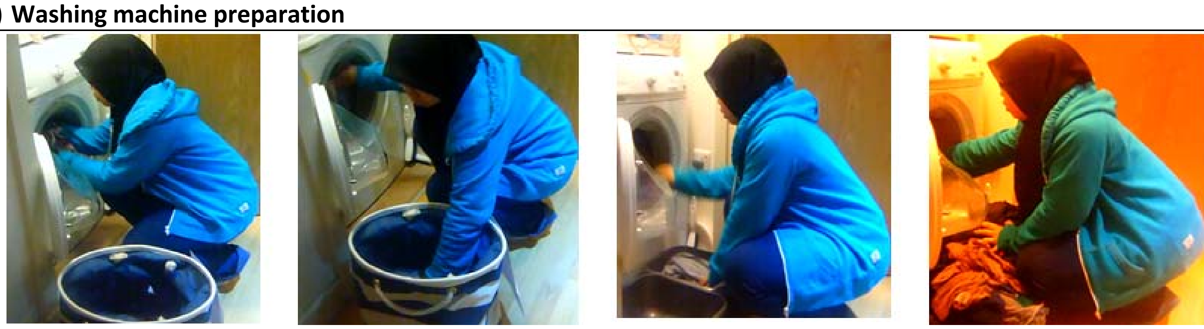
Figure 7-8 Snapshots of a subject performing laundry in a stooping posture. The photos are labelled with sub-tasks and brief explanation.

(a) Gathering Laundry

(b) Sorting and pre-treatment



(c) Washing machine preparation



(d) Drying clothes

(e) Folding clothes

Figure 7-9 Snapshots of a subject performing laundry task in squatting and kneeling postures. The photos are labelled with sub-tasks and brief explanation.

The contents of the dirty laundry bin were emptied onto the floor of the laundry room. They again bent at the waist and reached into the bin to grab pieces of loose laundry, untangled them and threw them into separate piles on the floor, sorting them with respect to colours (light, dark and white) and their tags (hot, warm, cold and delicate). This step was repeated until all the dirty clothes had been sorted and separated into their respective piles. The sorted clothes were loaded into the washing machine and the washing powder/liquid was added, the door was closed and cycle dial was set.

The loading and unloading involved extreme bending at the waist and reaching into the washer drum to pull out the clean laundry and transfer the clean laundry to the dryer. It involved lifting out and untangling the wet clothes and inserting them into the dryer. This machine was turned on when it is filled with subsequent loads.

The dried and clean laundry was unloaded from the dryer, put in the clean laundry bin and transferred to the folding area. The clean and dried laundry was again sorted and separate piles were made. Folding personal clothing is time-consuming because it involves sorting and storing each person's clothes into a specific pile or bin. The folding of heavy items such as jeans, jackets, towels and bed sheets requires repetitive and static shoulder flexion/abduction. The clothes are sorted and stored in piles, ready for distribution to the household. The five laundry subtasks (gathering, sorting and pre-treatment, washing machine preparation, drying and folding) are repeated by every person fortnightly, or once, twice or three times per week. Prior to the test, subjects were given written and verbal instructions on how to use subjective scales The performance of the laundry task was video-recorded and this was used later for posture analysis. Figure 7-8 and 7-9 shows the snapshot of subjects performing laundry in different postures and the photos were labelled with sub-tasks and a brief explanation.

7.2.2.4 Results and discussion

Two subjects participated in this study. Subject 1 normally adopted stooping postures throughout the laundry task, while subject 2 adopted squatting (drying clothes), kneeling (sorting and pre-treatment) and stooping (folding clothes) postures while performing the laundry task. An ergonomic analysis method such as REBA, RULA or LUBA was used to analyse the adopted postures. The physical demand required, complexity of task, perceived discomfort and fatigue were measured by using subjective scales. The time required to perform each sub-task was recorded by using a stop watch. Tables 7-10 and 7-11 show five sub-tasks involved in laundry as well as REBA, RULA and LUBA scores for each subject in performing each sub-task. Tables 7-12 and 7-13 show actual duration, physical demand required, complexity of a task, perceived discomfort and fatigue during the laundry task.

The findings show that doing the laundry is considered to be a short duration task (washing time is excluded). Subject 1 took an average of 125 seconds (2.08 minutes) while subject 2 took an average of 135 seconds (2.24 minutes) to complete each sub-task (see Tables 7-10 and 7-11). The longest and shortest duration sub-tasks were drying and gathering clothes respectively for both subjects. For subjects 1 & 2 the average REBA, RULA and postural load (LUBA score) for the overall laundry task is shown in Tables 7-10 and 7-11.

The average REBA and RULA scores for both subjects revealed that domestic laundry has medium level of risk and a postural load of 7 (subject 1) and 6 (subject 2) which suggests further investigation is needed about the adopted postures because the higher the postural load the greater the deviation of posture from a neutral position, resulting in a greater amount of stress on the body [300]. Both subjects adopted different postures while performing the laundry task and therefore the sub-task of drying clothes was given the highest REBA score of 8 (indicating high risk) and 7 (indicating medium risk), the RULA score of 6 and 5 (indicating moderate risk) and postural load 8 and 6 (LUBA score). The difference between the REBA and RULA scores is due to the parts of the body being targeted. RULA aims to assess stress on the neck and upper extremity [12] while REBA aim to assess the whole body [13]. As mentioned earlier, both subjects adopted different postures during the laundry task, and the average scores for both of them are shown in Figure 7-10. It explains that the average scores for REBA and RULA for both subjects are equal but the average postural load (LUBA score) of subject 2 is lower than that of subject 1, which means that subject 2 has less postural load than subject 1.

Further, analysing and comparing the sub-task of drying clothes revealed that all 3 of the scores for subject 2 were lower than those for subject 1 (see Figure 7-11). While, in the folding clothes sub-task the RULA scores was the same, the REBA and the postural load for subject 2 were lower than that for subject 1 (see Figure 7-12, which shows the comparison of scores in the sub-task of folding clothes). In conclusion we can say that subject 2 has adopted different postures (squatting, kneeling and stooping) during the performance of laundry, and that is why she has a lower postural load than subject 1. This means that to keep changing postures while performing daily tasks might help to reduce his postural load.

Table 7-10 Analysis of posture adopted by subject 1 in performing laundry task

	REBA Score					RULA Score				LUBA Postural load Score			
	1	2-3	4-7	8-10	11+	1-2	3-4	5-6	6+	1-5	5-10	10-15	15+
Gathering laundry			4				3				7		
Laundry sorting and pre-treatment		3					3			5			
Setting up washing machine			4				4				7		
Drying clothes				8				6			8		
Folding clothes			6					5			7		
Average			**5**				**4**				**7**		

Table 7-11 Analysis of the different postures adopted by subject 2 in performing laundry task

	REBA Score					RULA Score				LUBA Postural load Score			
	1	2-3	4-7	8-10	11+	1-2	3-4	5-6	6+	1-5	5-10	10-15	15+
Gathering laundry			4				3				5		
Laundry sorting and pre-treatment			4				4				6		
Setting up washing machine		2					3				6		
Drying clothes			7					5			6		
Folding clothes			5					5			6		
Average			**5**				**4**				**6**		

Table 7-12 Results of the stooping posture adopted by subject 1 in performing laundry task

Sub-Task	Duration (sec)	Physical demand required	Complexity of task	Perceived discomfort	Fatigue severity
Gathering laundry	90	Minor	Slightly	Mild	Mild
Laundry sorting and pre-treatment	125	Minor	Somewhat	Mild	Moderate
Setting up washing machine	135	Minor	Slightly	Moderate	Mild
Drying clothes	144	Moderate	Somewhat	High	Severe
Folding clothes	129	Moderate	Somewhat	Moderate	Severe
Average	125	Moderate	Somewhat	Moderate	Moderate

Table 7-13 Results of the squatting and kneeling postures adopted by subject 2 in performing laundry task

Sub-Task	Duration (sec)	Physical demand required	Complexity of task	Perceived discomfort	Fatigue severity
Gathering laundry	122	Minor	Not at all	No discomfort	No fatigue
Laundry sorting and pre-treatment	135	Moderate	Not at all	No discomfort	Mild
Setting up washing machine	125	None	Slightly	No discomfort	No fatigue
Drying clothes	154	Moderate	Slightly	Mild	Moderate
Folding clothes	139	Minor	Somewhat	No discomfort	Mild
Average	135	Moderate	Slightly	Mild	Mild

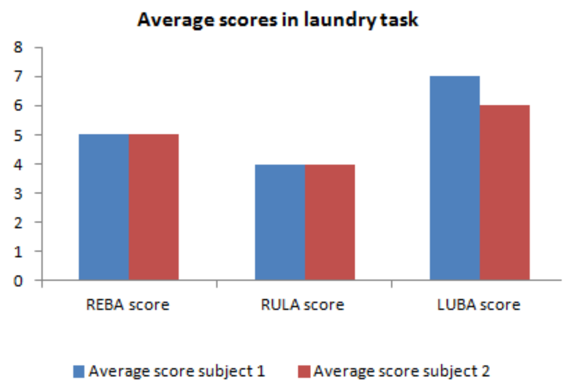


Figure 7-10 shows the average scores in laundry task

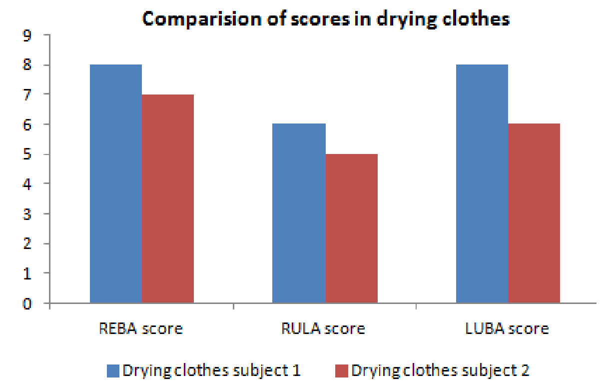


Figure 7-11 shows the comparison of scores in sub-task drying clothes

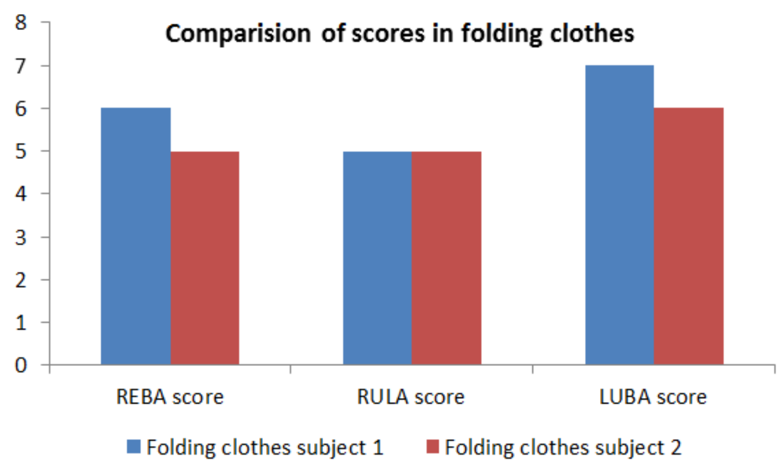


Figure 7-12 shows the comparison of scores in sub-task folding clothes

For subject 1, the average perceived discomfort, fatigue and physical demand required for the overall laundry task was moderate and therefore the laundry task is considered somewhat complex (see Table 7-12). Similarly, for subject 2, the average perceived discomfort and fatigue was mild, while the physical demand required was moderate, therefore the laundry task considered as slightly complex (see Table 7-13). The average subjective scores for subjects 1 & 2 in performing the laundry task revealed that subject 2 has lower subjective scores in complexity, perceived discomfort and fatigue severity than subject 1 but they required same level of physical demand (see Figure 7-13). Further, analysing and comparing the sub-task of drying clothes is shown in Figure 7-14, where the subject 2 has 3 lower subjective scores (complexity, perceived discomfort and fatigue severity) than subject 1 but they required the same level of physical demand (see Figure 7-14) in drying clothes. While, in the sub-task of folding clothes, all 3 of subject 2's subjective scores were lower (physical demand required, perceived discomfort and fatigue severity) than those for subject 1, but they had the same level of complexity in folding clothes (see Figure 7-15). In conclusion, it can be said that subject 2 adopted different postures during the laundry task and that is why her subjective scores are also low when compared to those of subject 1.

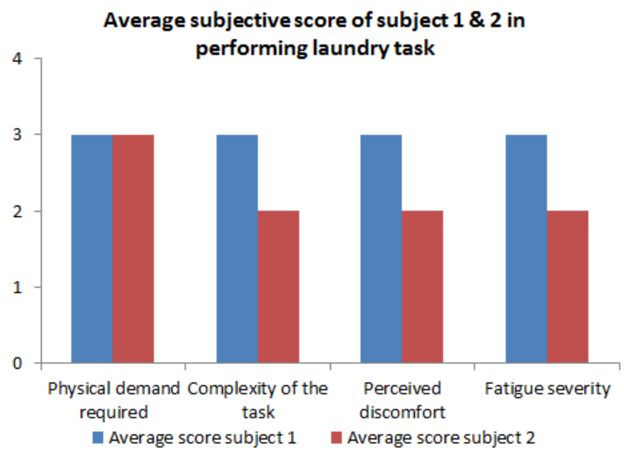


Figure 7-13 Average subjective scores of subject 1 & 2 in performing laundry task

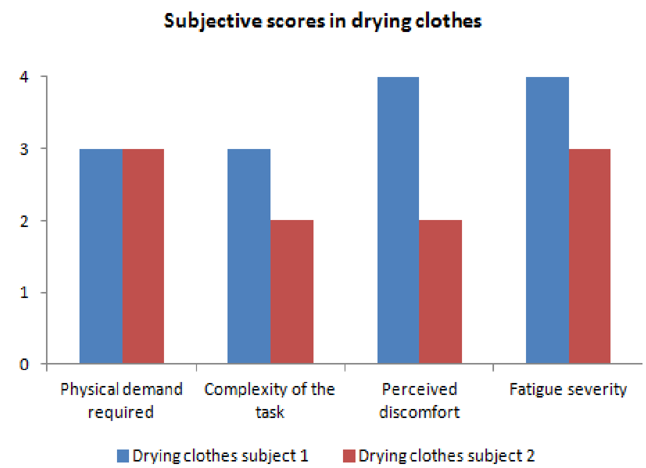


Figure 7-14 Subjective scores in sub-task of drying clothes

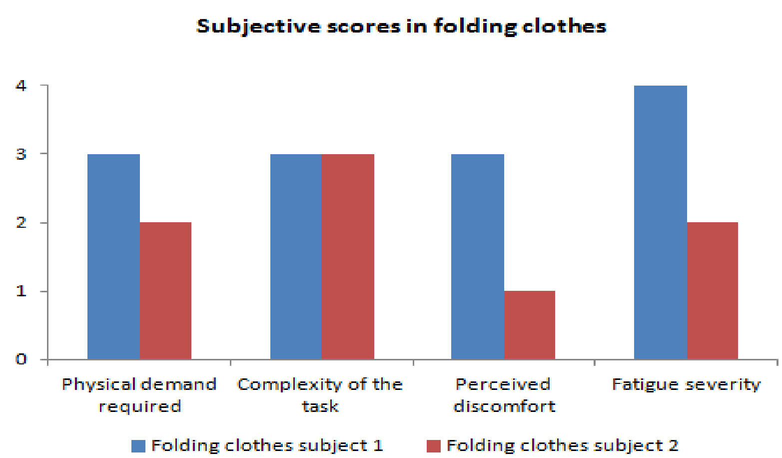


Figure 7-15 Subjective scores in sub-task of folding clothes

Overall we can say that if the person keeps changing his posture during the daily tasks, then their postural load and subjective scores (perceived discomfort, fatigue, physical demand required) are lower compared to those who keep to the same posture in performing daily tasks. Moreover, the REBA and RULA scores for sub-tasks drying and folding clothes indicate the urgency for further investigation and suggest that some changes are necessary. Similarly, LUBA scores for the sub-task of drying clothes indicates that it required the highest postural load (in both subjects), which reveals that drying clothes is the sub-task in which people felt the highest level of perceived discomfort, therefore the fatigue level was also moderate to severe. This means that the laundry task is not easy to perform, and the ergonomic tools highlighted that within the domestic laundry task, there is a sub-task which needs more consideration when being performed.

It is very important to maintain a neutral back and neck posture when performing daily tasks. During the laundry task, subjects adopted many non-neutral postures which entail a moderate risk level on the REBA and RULA scores. The LUBA scores indicate that further action is required (see Table 3-6) to perform the task with a low postural load. Moreover, other extreme non-neutral postures (stooping, squatting and kneeling) are adopted during the sub-tasks of drying and folding, but they were held for a short period of time and repeated infrequently. Nonetheless, subjects had to sustain bending the spine during these sub-tasks, which may be the reason why these showed a mild to severe level of fatigue and a mild to high level of perceived discomfort. According to the research done by Fathallah and Janowitz in 2004, extreme prolonged stooped postures have been strongly associated with lower back disorders (LBD) and the onset for musculoskeletal disorders (MSDs) [301]. Therefore, adopting neutral postures and sustaining the natural curves of the back and neck will enable people to perform daily activities effectively and help reduce the stress placed on the back.

This study has suggested that during the performance of laundry tasks we need to adopt different postures rather than maintain only one posture, as this helps to reduce the postural loads, perceived discomfort and fatigue. Furthermore, in this study the adopted postures only lasted for a short period of time and were repeated infrequently and so did not pose a high risk of injury. However, if a person were to engage in other IADL tasks (such as kitchen activities, ironing, vacuuming, polishing/dusting, bed making, dressing, shaving, cleaning teeth, bathing, showering, washing hair, cleaning the bath, shopping, driving, gardening) and maintained this posture for a long duration then it could trigger more cause for concern, as it would leads to high susceptibility of suffering back injury or lower back disorders (LBD).

7.2.2.5 Conclusion

This study suggests there is a potential for such ergonomic tools to be adopted in domestic settings, as it shows that doing laundry did not pose a high risk of injury as the postures adopted during laundry were of short duration and repeated infrequently, but that doing laundry combined with other IADL tasks that involved similar postures could trigger more cause for concern as they could affect a person's quality of life later on. Besides this, it can be concluded that during laundry tasks different the postures need to be adopted rather than maintaining only one posture, and this would help to reduce the postural loads, perceived discomfort and fatigue associated with laundry work. It could be further concluded that the result of this study is in agreement with the survey results, that the drying clothes sub-task scored highest, in the REBA, RULA and LUBA scores. Moreover, it shows that the average perceived discomfort and fatigue level are mild to moderate and that physical demand required is moderate and therefore the laundry task is considered slightly to somewhat complex. This study was successfully used for analysing IADL tasks and identifying the hardest task, which shows that ergonomic assessment methods have the potential to highlight tasks or sub-tasks which cause risk to people in performing laundry work. The identification of domestic tasks which are potentially hard to perform might reveal the first risk or sign of losing one's independence, and this could provide insights into the changes in behaviour that can happen with age. It was also found that ergonomic assessment tools on their own were not sufficient because although they successfully identified the hardest task through postural analysis, they did not consider other risk parameters such as the psychological perception of the tasks and manual handling.

7.3 Observational study on domestic tasks duration and frequency

The tasks performed in our daily life last for only a short duration and are repeated infrequently. This was observed both in the surveys conducted in this study and in the observational study of laundry and food preparation tasks. For observing the actual duration and frequency involved in performing different everyday tasks during a typical week, a list of daily tasks was designed (see section 16.1, Appendix B) and it was decided to conduct observational study for 7 people. A "7 days activity log booklet" was designed, to collect the data for the activities mentioned above (see section 16.2, Appendix B). Seven subjects were selected who were ready to participate in the study voluntarily and the log booklets were distributed among them to record the duration of their activities for a whole week. Table 7-14 shows the characteristic of the 7 subjects and their household details.

Table 7-14 Subjects' characteristics and their household details

Subject	Age (years)	Gender	Number of adults	Number of children	Number of infants	Style of home	General life style
S1	35	Male	02	1	1	Flat	Active
S2	28	Female	02	1	1	Flat	Active
S3	35	Male	02	0	0	Flat	Active
S4	35	Female	02	0	0	Fat	Active
S5	28	Male	02	0	0	Flat	Active
S6	29	Female	02	0	0	Flat	Active
S7	35	Female	02	2	0	House	Active

This study results show that each person performed many tasks which were of short duration and with differing frequencies (once a week, twice a week, three times a week and everyday) in a typical week. This means that everybody had different risk exposure levels; it was therefore necessary to quantify the risks in their daily activities on an individual basis. Figure 7-16 shows the average time spent and the frequency of activities performed in a typical week.

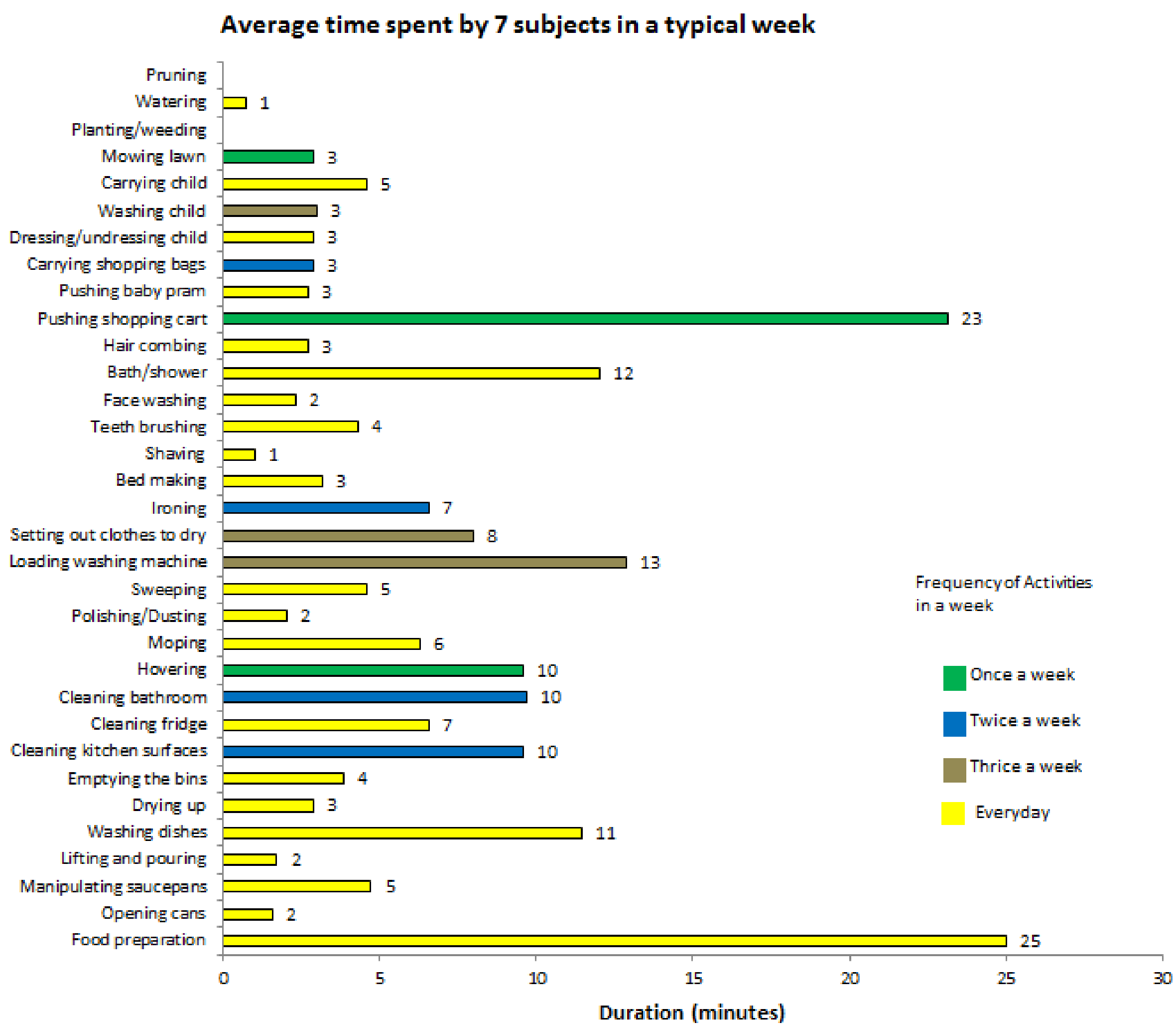


Figure 7-16 shows the average time spent and the frequency of activities performed in a typical week

In a typical week, the minimum numbers of average activities were performed on weekdays (Monday and Thursday) and also the minimum amount of time spent on performing activities was during weekdays (Tuesday). The maximum average activities were performed at weekends and the maximum amount of time spent on performing activities was also at weekends (see Figures 7-17 and 7-18).

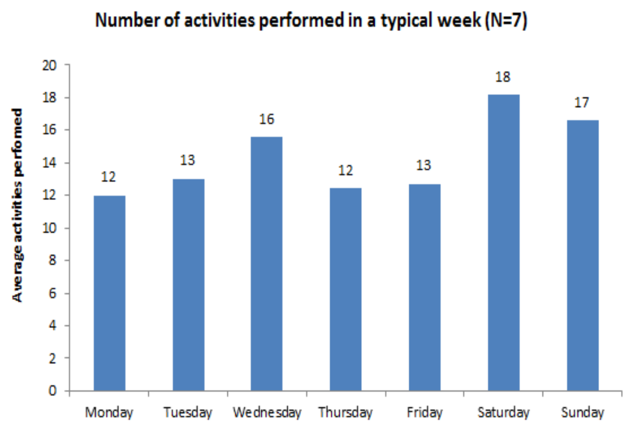


Figure 7-17 shows the average number of activities in a typical week

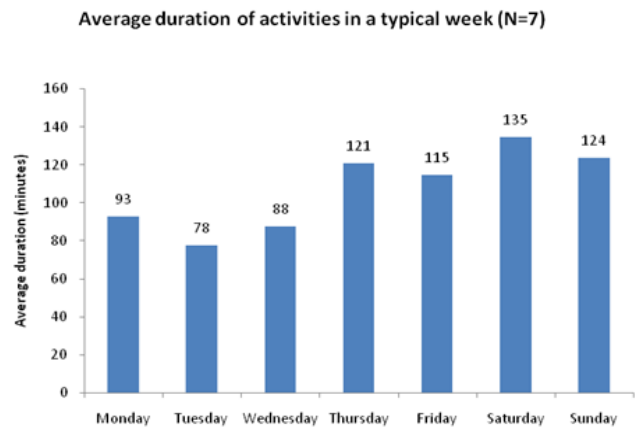


Figure 7-18 shows the average duration of activities in a typical week

The results also show that the average activities performed and average time spent in performing everyday tasks are significantly different ($p<0.05$) from weekdays, which means that people are performing more activities and spending more time at weekends on performing everyday tasks as compared to weekdays (see Figures 7-19 and 7-20). It was concluded that people are exposed to more risk during the weekends as compared to weekdays.

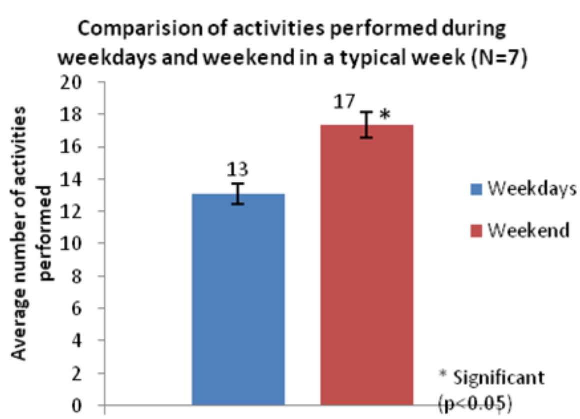


Figure 7-19 shows the comparison of activities performed during weekdays and weekend in a typical week

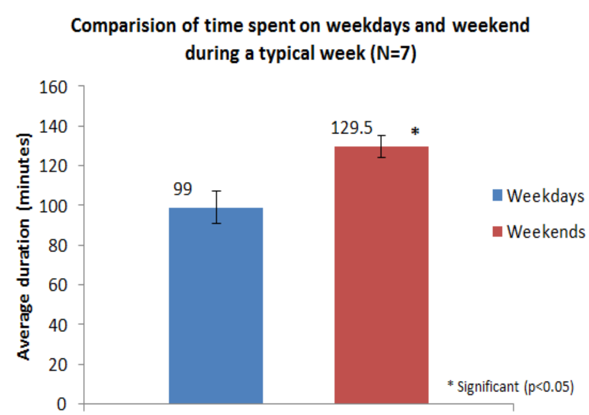


Figure 7-20 shows the comparison of time spent on weekdays and weekend in a typical week

7.4 Conclusion

It was concluded that average activities performed and average time spent in performing everyday tasks are significantly different from weekdays, which means that people are performing more activities and spending more time at weekends on performing everyday tasks as compared to weekdays. It was also concluded that people are exposed to more risk during the weekends as compared to weekdays.

7.5 Limitations

The limitations of the study are as follows:

1. This study only uses one task i.e. a laundry task, whereas more activities may be required in order to generalize the results.

2. The study used only two subjects, so more subjects might be required, again in order to generalize the results.

3. The study uses subjective measurements and assumes that all subjects answered honestly.

8 Development of task assessment tool for ease and risk (AER) within domestic environment

It is not easy to performing daily tasks and activities because mopping, food preparation and laundry survey and experimental work have revealed that these tasks required a considerable amount of effort and a number of postures to be adopted. As discussed in literature review that as people aged they are susceptible to lose their independence and their daily tasks harder for them to perform. The way (adopted postures) and the number of tasks performed simultaneously can accelerate this decline. Consequently person felt discomfort which leads a person to suffer musculoskeletal pain, which in turn leads to musculoskeletal disorders and then disability [238, 246]. The surveys in this study revealed people opinion that they were struggling in performing tasks within domestic environment. Similarly experimental work proved that ergonomics risk factors such as repetitions and awkward postures do exist in domestic environment. Normally, people are unaware of these risk factors when performing daily tasks, leading to the chance of injury in later life. Therefore, there is a need of assessment tool which should be able to identify and assess the risk level associated with single task and also assessed general behaviour or domestic load over a period of time. The tool should also be helpful in identifying those tasks which require more caution when being performed and which are responsible for a person's change in behaviour in later life. The prevention and controlling of the risk of injury, through knowledge in relation to activities of daily life is the key way for a person to improve their level of independence and an appropriately designed tool can help individuals to prioritize their tasks according to their ability to perform.

Therefore, in this project an attempt has been made to investigate and understand the daily tasks, and evaluate the psychological and physical risk factors through designing a new assessment tool which quantifies the load and risk related to the performance of domestic tasks.

8.1 Previously developed and proposed tool's analytical parameters and their context of use

As mentioned previously, this study assesses the domestic tasks by using three analytical parameters: psychological perception of the task, adopted postures and manual handling of objects. These parameters are investigated through brainstorming and through developing a mind map (see section 15.2, Appendix A). The parameters cover both the occupational therapy and ergonomics perspective to the problem. In addition to the mind map, it is noticeable that whenever a person performs any domestic task, he or she is involved in three aspects: 1) How the tasks should be done (psychological perception of the task)?, 2) Using parts of the body to perform that task (adopted posture), and 3) Lifting/lowering, pushing/pulling and carrying the objects (manual handling) during the performance of the tasks. Therefore, these three analytical parameters are more appropriate for the evaluation of domestic tasks. Before discussing the development process of task assessment tool for ease and risk (AER) it is necessary to check the existing assessment tool and their context of use within the studied literature. As discussed previously that this project aims to investigate and understand the daily tasks and evaluate the psychological and physical risk factors which might affect the person's performance of daily tasks. Therefore although the experimental work revealed that existing ergonomics tools successfully identified physical risk (only postures adopted) associated with the performance of daily task through postural analysis none of the existing tools is fit for simultaneously analysing psychological and physical risk factors related to domestic tasks., Table 8-1 has been developed to show the previously developed assessment tools and proposed tool's analytical parameters and their context of use.

Within last 15 to 20 years researchers developed many assessment tools for different environments and used ergonomics risk factors [153] as their tool's analytical parameters. The AER is aimed at self-assessment; therefore it is simple, robust, quick and universal for use with home environment tasks. Therefore, the selection of parameters of proposed assessment tool is based on surveys and experimental work of this thesis and carefully reviewed the literature available on previously developed tools (see table 3-18).

Table 8-1 Previously developed and proposed tool parameters and their context of use

Assessment tools		Analytical parameters	Context of use	
			Working environment	Non-working (domestic) environment
Previously developed	WERA [54]	• Postural analysis • Force • Vibration • Contact stress • Task duration	WERA can be used in any workplace	Not suitable for domestic environment
	ART [55]	• Frequency/repetition • Postural analysis • Additional factors	ART used by people who involved in design, assessment and inspection of repetitive work	Not suitable for domestic environment
	NEPRA [56]	• Postural analysis • Force/load • Muscles score	This tool good for postural assessment of workstation to reduce musculoskeletal injuries risk associated with manual assembly operation	Not suitable for domestic environment
	ROSA [57]	• Postural analysis	The tool is designed for quantifying the risk associated with office computer work	Not suitable for domestic environment
	ManTRA [58]	• Postural analysis • Repetition movement • Vibration • Task frequency	It is a measurement tool used by health and safety inspector for auditing workplaces	Not suitable for domestic environment
	Ergonomics screening tool [59]	• Motion rating • Force rating • Posture rating	Used for workplace screening	Not suitable for domestic environment
Proposed tool	Task assessment tool for ease and risk (AER)	• Psychological perception • Posture adopted • Manual handling	Not suitable for working environment in a present form	AER evaluates and quantifies load and the risk level associated with the performance of domestic tasks which could be responsible for a person's change in behaviour in the later stages of life.

8.2 Rationale of selecting analytical parameters for AER

"Risk is inherent in every situation and for every activity"[63]. According to Hedge et al., the risk of musculoskeletal disorders (MSDs) occurs both within and outside the work place [5], and is also defined as:

MSD risk = *f* (work MSD risks + non-occupational MSD risks) [5]

It is therefore probable that a person may exacerbate their level of MSD risks by performing daily tasks or activities (non-occupational). To date, very little attention has been paid to the possible roles of non-occupational exposure within the home environment in the development of non-occupational MSD risks. Therefore, this study was undertaken in relation to such daily tasks and activities to quantify the risk level which might be helpful in order for people to maintain their independence and lifestyle, and to lead full, active and safe lives in their own homes.

The selection of analytical parameter for AER was crucial because tasks and activities performed in home environment are much harder to perform when compared to an industrial environment. Therefore, that person is exposed to psychological (anxiety, fatigue, perceived physical demand and perceived complexity) and physical (adopted postures and manual handling) risks during the performance of daily tasks. Previous sections in this study have mentioned that there is a lack of suitable assessment tools for quantifying the risk associated with the performance of tasks in relation to the activities of daily life. There are many existing tools available within the occupational therapy and ergonomics contexts but they are not adequate for evaluating the risks in performing tasks in a home environment. It has become visible from the previous studies (surveys and experimental work) that there is a need for a tool to quantify risk in the home environment with respect to the analytical parameters: psychological perception of the task (its perceived physical demand and complexity), physical demand (posture adopted during performance of the task) and manual handling (lifting/lowering, pushing/pulling and carrying) tasks. Therefore, the decision has been made for the selection of all three analytical parameters (psychological perception of the task, physical demand and manual handling) for AER, however some assistance has taken from previously developed tool's analytical parameter (postural analysis) to develop the AER analytical parameter (adopted postures). Table 8-2 shows the suitability of analytical parameter which fulfils the AER designing criteria. Next section describes the selection of risk analytical parameters and criteria for AER.

Table 8-2 Suitability of previously developed tool's analytical parameters in AER designing.

Assessment tools		Analytical parameters	AER designing criteria		
			Psychological perception of the task	**Physical demand (adopted postures)**	**Manual handling of the task**
Previously developed	WERA [54]	• Postural analysis • Force • Vibration • Contact stress • Task duration	None of the analytical parameter is suitable	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable
	ART [55]	• Frequency/repetition • Postural analysis • Additional factors	None of the analytical parameter is suitable	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable
	NEPRA [56]	• Postural analysis • Force/load • Muscles score	None of the analytical parameter is suitable	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable
	ROSA [57]	• Postural analysis	None	Postural analysis can be used for assessing adopted postures	None
	ManTRA [58]	• Postural analysis • Repetition movement • Vibration • Task frequency	None of the analytical parameter is suitable	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable
	Ergonomics screening tool [59]	• Motion rating • Force rating • Posture rating	None of the analytical parameter is suitable	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable
	RULA [12]	• Postural analysis • Muscles use score • Force/load score	None of the analytical parameter is suitable	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable
	REBA [13]	• Postural analysis	None of the	Postural analysis	None of the

	• Coupling score • Activity score	analytical parameter is suitable	can be used for assessing adopted postures	analytical parameter is suitable
LUBA [148]	• Postural analysis	None	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable
SI [146]	• Intensity of exertion • Duration of exertion • Effort/minute • Hand/wrist posture • Speed of work • Duration per day	None of the analytical parameter is suitable	Postural analysis can be used for assessing adopted postures	None of the analytical parameter is suitable

8.1 Selection of risk analytical parameters and criteria

This segment describes the selection of the three risk analytical parameters and their assessment criteria for the risk categories. The section also explains each parameter which is assessed with the three risk categories in their assigned respective colours (green= low, yellow= moderate and red= high).

8.1.1 Psychological perception of the task

The psychological perception of the task is important to consider because a person's mental state might means that they under or overestimate the risk and this would influence their ability to perform the task. According to the US Department of Health and Human Services, mental health and some psychological factors such as anxiety and depression also contribute to pain especially in the lower back region [302]. The psychological perception of the performance of the task is a subjective experience and the discomfort involved in the task might interfere with a person's ability to cope with daily activities. It is well known that people have different psychological perceptions of the task they are performing and its severity depends not only upon the situation but also on how they perceive it. So, quantifying the psychological perception risk of a task helps a person to function more effectively in their daily activities. It is assumed that, for making the assessment simple and to provide ease of use, this study only focused on two psychological perception factors (i.e. perceived physical demand required and complexity of a task). Other factors such as unwillingness to do the job could be incorporated in future work as this perception factor would give insight into recorded behaviours.

8.1.1.1 Perceived physical demand required

Analysis of the survey results in both laundry and food preparation showed that people considered the tasks easy or hard based on the perceived physical demand required for that task. For example, in performing the laundry task 81% people found that drying clothes was harder to perform than other laundry tasks, and classified the physical demand as minor to too much. To quantify the risk associated with the perceived physical demand required for a task proposed subjective scale based on three categories and respective risk levels. Table 8-3 is used to quantify the risk associated with the perceived physical demand required.

Table 8-3 Risk levels and subjective categories of perceived physical demand required

1	2	3
None (OR) Minor	Moderate	Too much

8.1.1.2 Perceived complexity of a task

The perceived complexity of a task is also an important variable to consider when analysing everyday tasks. From the previously studied surveys, the laundry survey, for example, mentioned that 67% of people considered the laundry task to be slightly to extremely complex. To quantify the risk associated with perceived complexity for a task proposed subjective scale also based on three categories and respective risk levels. Table 8-4 is used to quantify the risk associated with the perceived complexity of a task.

Table 8-4 Risks levels and subjective categories of perceived complexity of a task

1	2	3
Not at all (OR) Slightly	Moderately	Extremely

8.1.2 Adopted postures

The aim is to develop the criteria for adopted postures in activities of daily life, using similar criteria to those used in ergonomic tools such as Rapid entire body assessment (REBA)[13], Rapid upper limb assessment (RULA)[12] and Postural load on the upper limb (LUBA) [148], which involved a check of non-neutral or awkward postures.

In activities of daily life, body movements almost always involve all three planes [303] and are often complex movements that are not straight up and down, but involve significant rotation and/or side bending. The main idea of this study is to assess the adopted postures by observing the body part movements (for instance, head/neck, arm, wrist and back). Performing a task in a non-neutral posture increases the physical demand required for that task [304] and the person is susceptible to neck and back pain because the physical demand required for the task is a significant risk factor for musculoskeletal disorder [305, 306]. Table 8-5 shows the three risk levels and non-neutral posture criteria.

The research done by Li and Buckle in 1999 suggests that researchers and practitioners like to use descriptive words rather than assessment of a particular posture angle [150], but it might be impractical to measure the posture angles when a person is performing daily tasks. Thus, observation of approximate postural angles of the neck, arm, wrist and back is used to assess particular risk levels, and also to provide example pictures to demonstrate the ease of movement otherwise, when assessing the adopted postures. In the present study, green is referred to where an almost neutral posture is present, with the number “1”. Similarly, red colour refers to the high level of risk associated with non-neutral postures and is assigned the number “3”. The moderate risk level is represented by yellow, with the number “2”. The observer records his or her postural risk score in the respective box.

Table 8-5 Risk levels and non-neutral posture criteria for adopted posture assessment

Body part or joint	Non neutral posture criteria[55]	1	2	3
Head/ neck	Observed obvious angle between head and back when performing the task	Head/neck postures is almost neutral	Head/neck flexed between 10° to 20°	Head/neck flexed greater than 20° or extension
Shoulder /arm	Elbow is abducted to chest height and unsupported	Elbow is supported and close to body or flexed 0° to 20° or extended 0° to -20°	Elbow is abducted and flexed/extended between 20° to 45°	Elbow is fully abducted and flexed/extended more than 45°
Back	Back is flexed more than 20°	Almost neutral posture is observed or back is flexed between 0° to 20°	Back is flexed between 20° to 60°	Back is flexed more than 60°
Wrist	Observed obvious wrist angle	Almost neutral or straight position	Flexed/extended between 0° to 15°	Flexed/extended greater than 15°
Leg	Both legs are well supported and balanced in both a standing and sitting position	Well supported and balanced (OR) sitting with feet flat on the floor	One or both legs are not supported (minor flexion) or balanced	Legs are not supported and are bent from the knees (flexion more than 30°)

Source: [55]

8.1.2.1 Significance of adopted postures in activities of daily life:

Human body postures play a vital role in performing daily activities. In lifting activities, the elbow often has to be positioned in space and stabilized by the upper arm in order to then perform many activities (for example, combing or washing hair, or reaching a back zipper). The range of movements for the flexion of the elbow is between 30° to 130° [307]. Generally, performing an activity in an extension position is harder than in a flexion position because extension movements against gravity, whereas flexion involves movements in line with gravity [308]. According to Kamitani et al., “Spinal posture in the sagittal plane is associated with future dependence in activities of daily living” [309]. Therefore, if daily activities are not performed appropriately, they aggravate the conditions of the back, hands, arms and shoulders, resulting in conditions such as lower back pain and arthritis which in turn lead to a reduction in a person's mobility and an increase in susceptibility to disability [310, 311].

8.1.3 Manual handling

As well as adopted postures, other factors such as manual handling are also involved in activities of daily living. Manual handling tasks involve lifting/lowering, pushing, pulling and carrying [60, 61]. In everyday activities at home person is involved in tasks such as lifting a laundry bag, emptying bins, or carrying shopping bags (see section 16.4 Appendix B, page 4 of booklet for more activities). These tasks require more consideration and caution when performed because improper lifting/lowering, pushing/pulling and carrying increase the likelihood of injuries such as lower back pain [302, 312]. According to the US Department of Health and Human Services, "men and women are equally affected by low back pain and the first attack of low back pain typically occurs between the ages of 30 and 50 years"[302]. Thus, it is necessary to quantify the risk associated with manual handling tasks, so that injury can be prevented before it actually happens and so help people to maintain their independence in their daily activities. Table 8-6 shows the risk levels and manual handling criteria for the assessment of everyday tasks.

Table 8-6 Risk levels and manual handling criteria for the assessment of everyday tasks

Manual handling tasks	Manual handling criteria	1	2	3
Lifting/lowering	Based on load handling	Person handling light load (e.g. < 1 kg)	Person handling moderate load (1 to 5 kg)	Person handling heavy load (e.g. > 5 kg)
Pushing/pulling	Based on the load which needs to be pushed/pulled	Person pushing/pulling light load (e.g. < 1 kg)	Person pushing/pulling moderate load (e.g. 1 to 5 kg)	Person pushing/pulling heavy load (e.g. >5 kg)
Carrying	Based on the load which needs to be carried	Person carrying light load (e.g. < 1 kg)	Person carrying moderate load (e.g. 1 to 5 kg)	Person carrying heavy load (e.g. >5 kg)

Source: [60, 61]

8.2 Duration and frequency of a task

The duration and frequency of a task are also important parameters to be considered because the tasks performed in the home environment are entirely different from those in an industrial environment. Therefore it is necessary to calculate the duration and frequency multiplier, so that the risk associated with the performance of daily tasks is adjusted respectively with actual duration frequency.

Frequency and duration multipliers

It can be inferred from the observational study (see section 7.3) that the activities performed in a typical week vary from person to person. The more time spent by a person on performing the specific tasks the more he or she is exposed to risk. As their exposure risk level is based on the duration of the tasks and its performing frequency, it is necessary to develop the multiplier factor to adjust or vary the risk level from person to person. The frequency of a task is the number of times a person performs the task over a period of a week. For the development of the frequency multiplier, the frequencies considered were once, twice, 3 times and 4-7 times in a week. If any task was performed more than three times a week it was considered as performed every day. In daily activities, most tasks, such as cooking and personal care tasks are done on a daily basis but some are done one once, twice or three times a week. Table 8-7 shows the frequency of a task and the multiplication factors. The aim of the duration factor is to consider the time spent in performing daily tasks. The duration of task is the time spent by a person in performing that task. In daily activities each task has a different duration and researchers mention that performing tasks in non-neutral (awkward) postures is associated with pain, even if the task lasts as little as 15 minutes [313]. Therefore, it is necessary to observe the effect of duration in performing the task. Table 8-8 shows the duration of a task and the multiplication factors.

Table 8-7 Frequency of a task and multiplication factors

Frequency	Frequency Multiplier
Once a week (1/7)	0.14=1/7
Twice a week (2/7)	0.3=2/7
3 times a week (3/7)	0.43=3/7
4 to 7 times a week (7/7)	1=7/7

Table 8-8 Duration of a task and multiplication factors

Duration of task	Duration Multiplier
Less than 5 min	0.04=((0+5)/2)/60
5 to 15 min	0.17= ((5+15)/2)/60
16 to 25 min	0.34=((16+25)/2)/60
26 to 35 min	0.51=((26+35)/2)/60
36 to 45 min	0.68=((36+45)/2)/60
46 to 60 min	0.88=((46+60)/2)/60
More than 1 hour	1.25=((60+90)/2)/60

Duration and frequency matrix

In order to make the selection of the multiplier easier, the frequency and duration tables were combined in the form of a matrix. The example table below shows the frequency and duration of a task in order to select a multiplier.

	Multiplier table	Frequency per week Once	Twice	3 times	4-7 times
Duration of task	Less than 5 mins	0.006	0.01	0.02	0.04
	5 – 15 mins	0.02	0.05	0.07	0.17
	16 – 25 mins	0.05	0.10	0.15	0.34
	26 – 35 mins	0.07	0.15	0.22	0.51
	36 – 45 mins	0.10	0.20	0.29	0.68
	46 – 60 mins	0.12	0.26	0.38	0.88
	More than 1 hr.	0.18	0.38	0.54	1.25

As mentioned earlier that duration and frequency of a task are important parameters to be considered because the tasks performed in the home environment are unique and last for short interval of time. The more time spent by a person on performing the specific tasks the more he or she is exposed to risk. As their exposure risk level is based on the duration of the tasks and its performing frequency, it is necessary to add the multiplier factor to adjust or vary the risk level from person to person. In a typical week, as the frequency of the particular tasks is increases the duration of tasks also increases. In linear relationships, any given change in an independent variable (frequency per week) produces a corresponding change in the dependent variable (duration of a task). In order to check the relation between frequency and task duration a scatter diagram has been prepared by using the data from table 8-7 & 8-8, the relationship between variables (frequency per week and duration of a task) can sometimes be seen more clearly if we draw a simple line graph by connecting the points on the scatter diagram. Due to this reason, rather than connect the points, it is often more useful to determine the straight line or smooth curve that can best be drawn as close as possible to the points on the scatter diagram. This is referred to as the best fit line or trend-line. If the trend-line is straight, rather than curved, then the relationship between the two variables is described as linear. As we can observe from the figure 8-1 that the scatter plot between frequency per week and duration of a task is best fitted by a straight line it means that it follows the linear relationship.

Similarly, apart from linear model different models such as exponential and Logarithmic are also used to fit the plotted data points and got different R2 (coefficient of determination) values (see the example table below). It is clear from example table below that linear model having R^2=0.9734 fit the data extremely well as compared to other models. Therefore it is predicted that relation between frequency per week and duration of a task follow a linear relationship up to certain duration, it might possible that it will follow other relationship (exponential or Logarithmic model) after certain duration. The figure 8-1 shows the linear relation between frequency per week and duration of a task.

Models	R^2 Values
Linear Model	0.9734
Exponential Model	0.8844
Logarithmic Model	0.8415

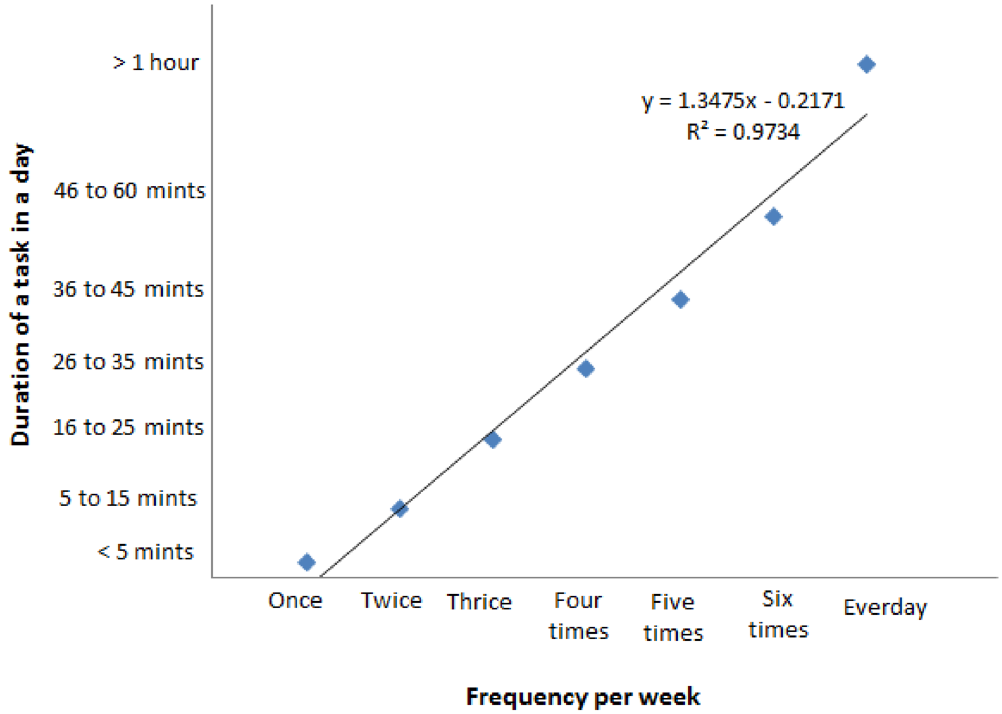


Figure 8-1 Liner relation between duration of a task and frequency per week

8.3 Development of scoring scheme and risk rating table

The main focus of this assessment process is to apply a straightforward tool that a person could easily use to screen the risks related to daily tasks. The tool uses three basic colours (green, yellow and red) to assign the risk level and also assign numeric numbers (1, 2 and 3) to each risk level for quantifying the risk level. Therefore, a fundamental assumption with this tool is that the risk related to performing daily tasks can be quantified by adding the risk level associated with each parameter. The two other parameters – duration and frequency of the task – introduce the multiplier, which shows an individual's exposure to the task performed. According to Pinder, [314] there will be some other unattributed risks and errors, apart from the quantified risk, as it is not possible to cover all the risks in the tool [55, 314].

The scoring scheme mathematically written is:

(1)	*Task risk =*	*Total exposure score + unattributed risk + error*	*[314]*
(2)	*Total risk score =*	*Risk score of perceived physical demand + risk score of perceived complexity of a task + risk score of adopted*	

		postures of neck, arm, wrist, back and leg + risk score of manual handling tasks (lifting/lowering, pushing/pulling and carrying)
(3)	*Total exposure score=*	*Total risk score X frequency multiplier X duration multiplier*

Based on total exposure score, three risk ratings (low, moderate and high) were proposed for the present study, to be used for future evaluation and discussion about the task. Three actions were also proposed to be taken in relation to the performed task.

The calculation of the critical IADL exposure scores for selecting the appropriate risk level is as follows:

First it is necessary to categorise the frequency and duration of the tasks into three levels, as mentioned (low, moderate and high). Observing the frequency of tasks (Table 8-7), it can be seen that the frequencies “once a week” and “4 to 7 times a week” are categorised as low and high and those of “twice a week” and “3 times a week” are categorised as moderate (see the example tables below)

Frequency	Frequency Multiplier
Once a week (1/7)	0.14 (Low)
Twice a week (2/7)	0.3 (Moderate)
3 times a week (3/7)	0.43 (Moderate)
4 to 7 times a week (7/7)	1 (High)

Duration of task	Duration Multiplier
Less than 5 min	0.04 (Low)
5 to 15 min	0.17 (Low)
16 to 25 min	0.34 (Moderate)
26 to 35 min	0.51 (Moderate)
36 to 45 min	0.68 (Moderate)
46 to 60 min	0.88 (High)
More than 1 hours	1.25 (High)

Similarly, observing the duration of a task (Table 8-8), it can be seen that the duration of a task taking up to 15 minutes is categorised as low while the duration of a task taking more than 45 minutes is categorised as high and the duration of a task lasting between 16 and 45 minutes is moderate (see the Table below). Using an AER record sheet designed for the purpose, if we rate moderate in all three parameters then the IADL exposure score for the moderate risk level is 1.6 to 5 (16 x 0.3 x 0.34=1.6 and 16 x 0.43 x 0.68= 4.67 ≈ 5). Any number below 1.6 is considered as low and above 5 is considered as high. The table below shows the details:

IADL Exposure Score	Risk Rating	AER implications about the task
<1.6	Low	Task is easy to perform, but requires caution
1.6 to 5	Moderate	Task is not easy to perform; requires more consideration
>5	High	Task is hard to perform; further investigation is required urgently

8.4 Final format of task assessment tool for ease and risk (AER)

Incorporate all three analytical parameters (psychological perception, adopted posture and manual handling), risk criteria and also add duration and frequency multiplier to obtain the final format of AER. As this pro-forma will be used by ordinary people to record their task risk level it is named as "Task Assessment tool for ease and risk (AER) record sheet". To provide the ease of use to the user, an accompanying booklet for the AER has been design in order to provide information about AER and a step by step guide. Therefore, AER consists of record sheet(s) and the booklet. Figure 8-2 shows the task assessment tool for ease and risk (AER) record sheet and the booklet is shown in appendix B, section 16.4.

<u>Significance of AER</u>

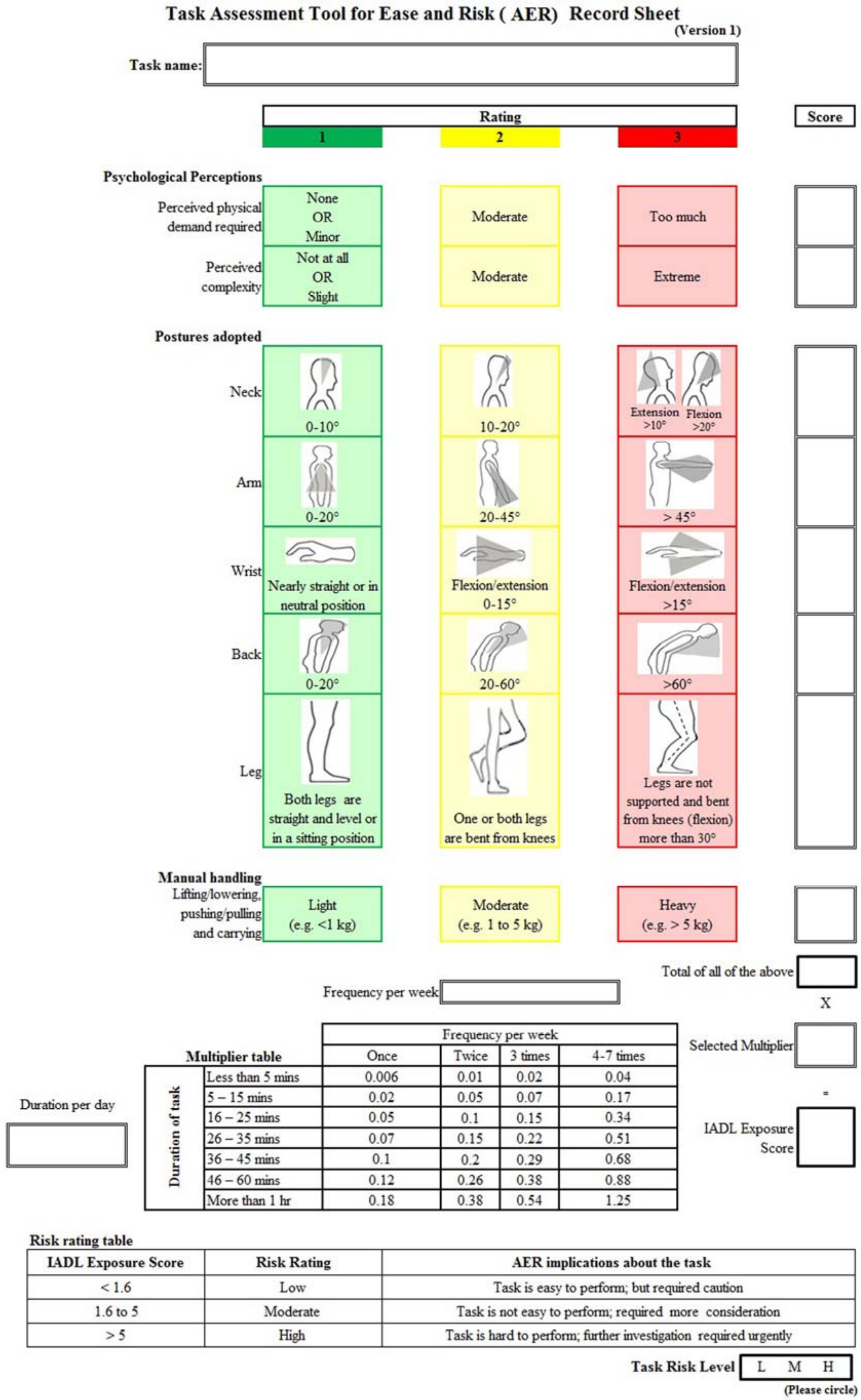
- AER is a simple and easy to administer self-assessment, it covers almost all the tasks performed in a domestic environment and can help to maintain a person's well-being and quality of life (this claim was tested through a feedback questionnaire see table 8-11).
- AER provides knowledge of the risk level in tasks being performed, based on psychological perception, posture adopted, manual handling, the duration of the task and its frequency,

which will help a person to think about the tasks being performed and to control and lower the risk level through performing such tasks in the proper way (adopting neutral postures and lowering the duration and frequency)

- Knowledge of the risk level through AER can make the person become cautious about the particular tasks and provide a comprehensive and proactive surveillance instrument to help people through early detection and management of problems such as neck and back pain which are associated with the performance of daily tasks.

- AER might be helpful for occupational therapists to assist their clients and help them to perform the tasks in a neutral way. Early identification of risk levels might help occupational therapists to assist or enable clients to perform their tasks effectively and independently.

- Knowing the risk level through AER is beneficial for ageing individuals, as through AER a physiotherapist or other health care professional can observe their client's performance of some basic tasks and evaluate the alignment of the body, flexibility and muscle length and strength.



Task Assessment Tool for Ease and Risk (AER) Record Sheet
(Version 1)

Task name:

	Rating 1	Rating 2	Rating 3	Score
Psychological Perceptions				
Perceived physical demand required	None OR Minor	Moderate	Too much	
Perceived complexity	Not at all OR Slight	Moderate	Extreme	
Postures adopted				
Neck	0-10°	10-20°	Extension >10° / Flexion >20°	
Arm	0-20°	20-45°	> 45°	
Wrist	Nearly straight or in neutral position	Flexion/extension 0-15°	Flexion/extension >15°	
Back	0-20°	20-60°	>60°	
Leg	Both legs are straight and level or in a sitting position	One or both legs are bent from knees	Legs are not supported and bent from knees (flexion) more than 30°	
Manual handling Lifting/lowering, pushing/pulling and carrying	Light (e.g. <1 kg)	Moderate (e.g. 1 to 5 kg)	Heavy (e.g. > 5 kg)	

Total of all of the above

X

Frequency per week

Multiplier table

Duration of task	Once	Twice	3 times	4-7 times
	Frequency per week			
Less than 5 mins	0.006	0.01	0.02	0.04
5 – 15 mins	0.02	0.05	0.07	0.17
16 – 25 mins	0.05	0.1	0.15	0.34
26 – 35 mins	0.07	0.15	0.22	0.51
36 – 45 mins	0.1	0.2	0.29	0.68
46 – 60 mins	0.12	0.26	0.38	0.88
More than 1 hr	0.18	0.38	0.54	1.25

Duration per day

Selected Multiplier

=

IADL Exposure Score

Risk rating table

IADL Exposure Score	Risk Rating	AER implications about the task
< 1.6	Low	Task is easy to perform; but required caution
1.6 to 5	Moderate	Task is not easy to perform; required more consideration
> 5	High	Task is hard to perform; further investigation required urgently

Task Risk Level L M H
(Please circle)

Figure 8-2 Task assessment tool for ease and risk (AER) record sheet

- According to Dr. Iva Lloyd (editor-in-chief of NDHealthFacts), “discomfort and pain are often the first signs of poor posture. Discomfort is a result of additional stress on muscle, ligaments, joints and cartilage. Pain is often the result of poor posture that eventually causes anatomical changes, potentially causing constriction of blood vessels and nerves [315]”. Therefore, knowing one’s own risk level through AER can help to maintain the neutral postures which might enable the individual to reduce the discomfort in performing daily tasks.

8.4.1 Particular users

The designed assessment tool is very simple to use and requires no particular user for the assessment. Any person can use this tool to quantify his risk level of a task performed in the home environment. There is no specific age or gender for the user of this tool, but it is that whilst people between 18-65 years of age can use it by themselves, people over 65 and having some medical conditions use this tool under the supervision of an observing adult or healthcare personnel [334]. The tool will be used by those users who can easily read and understand the English language and mark or record their risk rating and scores clearly with a pen or pencil.

Health care personal can also use this tool to assess the patient who is under consideration in relation to the performance of daily tasks and to identify which is the hardest task for the patient to perform. It is also expected that this tool will assist occupational therapists, ergonomist, physiotherapists and general physicians in creating an inventory of their client’s performance of daily tasks, and that it will prove to be a comprehensive and proactive surveillance instrument to enable people to perform their daily tasks effectively and independently.

8.4.2 How ordinary person use the AER?

The person who is performing the task records his or her psychological perceptions, adopted postures and manual handling scores in the respective boxes (see figure 8-2). All the scores are added together and recorded in the total score box. The frequency multiplier and duration multiplier are selected and the IADL exposure score is calculated, which is the product of three parameters as follows:

1. Total score: the sum of the psychological perception score, adopted postures score and manual handling score.
2. Frequency multiplier: the frequency at which the person repeats the task in a week
3. Duration multiplier the actual time spent by the person in performing the task

The IADL Exposure score is then used to evaluate the risk level and AER implications of the task.

8.4.3 Who will use the AER

The initial idea was for AER to be used by ordinary people who want to know information about risk level of their performed tasks. The AER will classify the tasks into three level of risk (low, moderate and high) which can also be considered as how hard the task is for a person, the higher the risk level the harder the task is for that person to perform. Therefore AER will help person to prioritize their daily tasks according to their ability to perform without the help of any health care personnel which also reduce the economic burden of health care system within the society. The designed tool has potential to be customised for other people such as designers who design things for older people in domestic environment. The modification such as introducing some other multipliers (e.g. age and strength etc.) can be employed in AER but this customisation is out the scope of this thesis.

8.4.4 Specific tasks for assessment

The designed tool is applicable to those tasks in which people adopt different postures and are also involved in manual handling while performing daily tasks. The tool is to be used to quantifying the risk associated with each task separately and so would not be good for quantifying the risk of tasks collectively.

8.4.5 Specific device and environment for use

The designed tool has a paper booklet and requires the use of a pencil or pen to record the scores and observations about the performed tasks. A stopwatch is required to record the actual time elapsed in performing the tasks. As the tool is based on observational techniques for postures adopted, using an angle measuring gauge (goniometer) is optional and may require advanced skills or knowledge. There is a specific environment (domestic) for the use of this tool and, as mentioned, anyone can use this tool. Health care personnel can also use this tool for rehabilitation or for evaluating the tasks which are harder for the person who is under observation.

8.4.6 Specific training for use

Although the designed tool is simple to use and requires no training, a little training is recommended in relation to the adopted postures and some manual handling tasks. The training program consists of the following topics:

- Explanation of the phrases about the designed tools
- Assessors must have a knowledge of the neutral and non-neutral (awkward) postures

- Explanation about the manual handling techniques (lifting/lowering, pushing/pulling and carrying)
- Complete explanation about the criteria used for quantifying the risk levels for each parameter
- Brief demonstration session about how to use the tool.

8.4.7 Strengths

- The tool is very simple to use
- It stimulates the discussion about the tasks which are harder to perform
- It distinguishes between easily performed tasks and those which are hard to perform
- It has the ability to detect early signs and symptoms (pre-event) and to caution people to keep themselves safe from any injury that could otherwise happen in the future.
- It has an ability to compare the current risk levels with previous or future risk levels and see how people are coping with the ability to perform activities of daily life.
- It helps to prioritize the tasks according to the person's ability to perform them
- Identification of the hardest task will help researchers and manufacturers to design or redesign the home appliance involved, which in turn will help to reduce the stress on the body
- The tool reveals the nature of the tasks and suggests strategies about maintaining independence in daily activities

- By evaluating their own risk level a person can adjust his or her environment according to the ease of performance of those tasks: for example, using a top-loading washing machine instead of a front-loading one, to avoid excessive bending.

8.4.8 Limitations

- The tool is semi-quantitative and based on observation
- It analyses each daily task separately
- Although it helps to identify which tasks require more consideration to perform it does not explain what action is needed as a result
- It does not consider the force and repetition required for performing the tasks
- It only considers two psychological perception parameters, and so other factors – such as anxiety and depression are not considered.

8.5 User trials

8.5.1 Overview

Figure 8-3 shows an overview of the user trials procedure. As mentioned, the assessment tool (AER) has been developed for assessing domestic tasks within the home environment. The AER is based on self-assessment and is simple to employ, so any person can benefit from using it to analyse their performed tasks. It consists of a booklet and a record sheet. The booklet provides an introduction about the AER and a step by step guide about how to do the assessment. The concept of the record sheet is to provide the information which is essential to evaluate the risk associated with the performance of task. So the record sheet should be simple and easy for anyone to understand. Before analysing the daily tasks by using the AER, it is necessary to check the quality of record sheet (so that anyone can understand its contents and use it easily). It is also important to investigate the validity of the designed tool. Therefore, this study is divided into two parts, as shown below:

Part-I: Evaluation of the ease of use of the record sheet

Part-II: Pilot observed trial of the AER

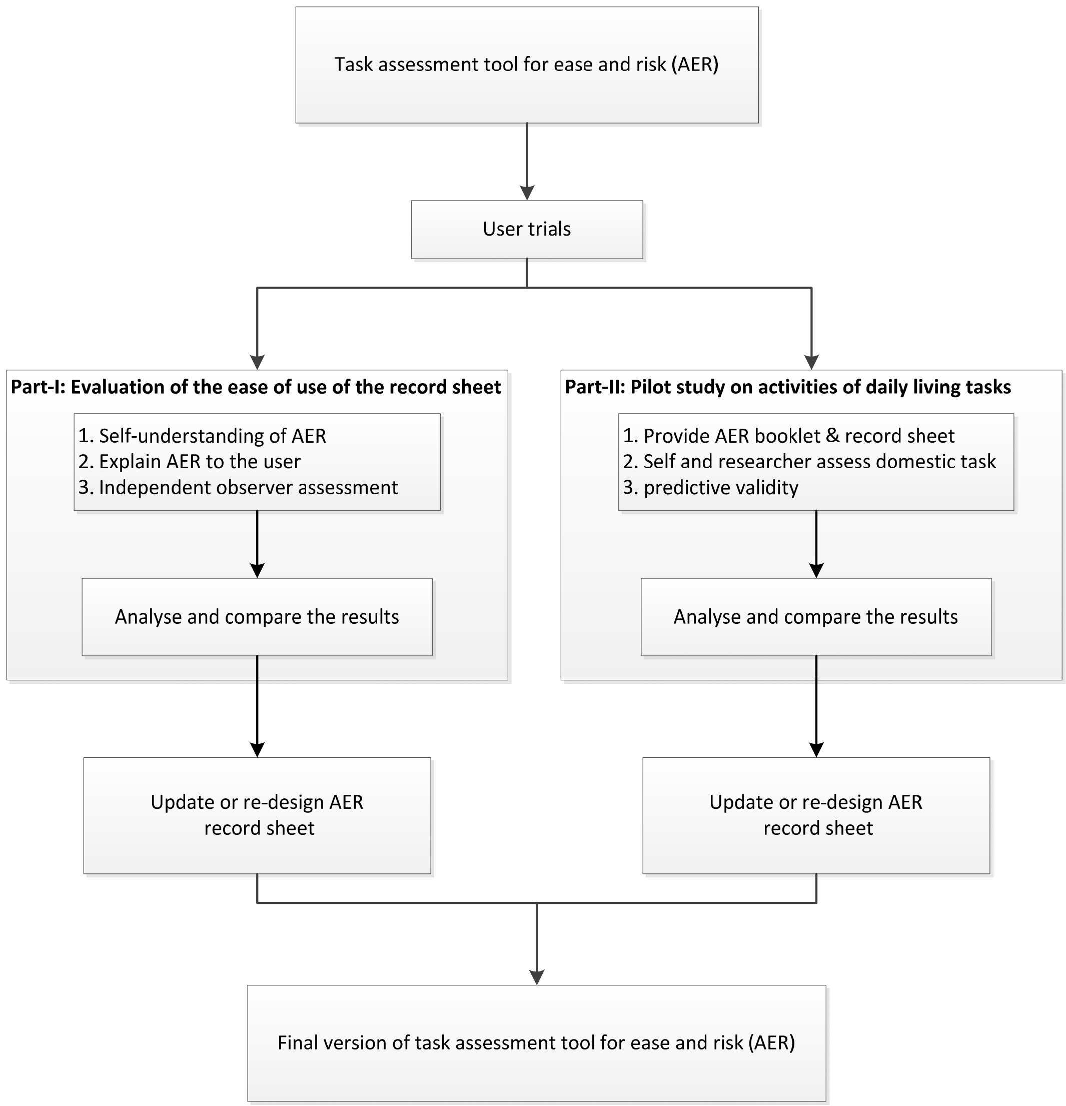


Figure 8-3 Overview of user trial procedure

8.5.2 Part-I: Evaluation of the ease of use of the record sheet

A precise and well-designed form is like a conversation. It must be easy for ordinary people to use and understand, especially for people with a low literacy level. In order to use any tool for assessing tasks, it must have two elements, as defined by Karhu et al. [144] and Escobar [315]:

(1) simplicity: (the assessment tool should be simple enough to be used by an ordinary person) (2) exactitude: (the tool needs to be concise enough to avoid ambiguous answers). Therefore, it is necessary for the users to understand the contents of the record sheet and be able to fill the AER record sheet without difficulty.

8.5.2.1 Aim of the study

The aim of this study is to analyse the ease of use of the designed task assessment tool (AER) record sheet by using healthy able-bodied participants.

8.5.2.2 Method

AER is based on self-assessment. It consists of a booklet and record sheet, and the participant receives step by step instructions from the booklet about how to use the record sheet. The participant needs to use a three-point rating scale to rate his physiological perception, posture adopted and manual handling of objects during the performance of a task, and record these on the AER recording sheet. The participant therefore needs to understand the contents of the record sheet clearly and easily fill in the AER record sheet. Therefore, the study consists of the following three steps:

1. Provide the AER booklet and record sheet for the participant to do the self-assessment
2. Explain the AER record sheet and ask the participant to redo the self-assessment, then
3. The researcher will do the assessment for the participants independently.

The target population for this study included all healthy adults between ages 18-65, currently employees/students of University of Sheffield. Ten participants were selected (5 male and 5 female) based on inclusion/exclusion criteria of age, gender and physical fitness. Table 8-9 shows the number of participants (n=10) who participated in the examination of the quality of the AER recording sheet. All the participants were contacted through the email list of University of Sheffield however because of the nature of the study, as was hard to gather data from the daily tasks performed by each person within a domestic environment. However, there is evidence that many researchers used fewer participants in their studies and still made a good contribution to the knowledge in this field [144, 270, 286, 287]. Table 8-9 shows further details about the participants.

Table 8-9 Number of subjects who participated in the study

Age group	Number of subjects who participated	Male	Female	Location	Duration of study
40-60 Years	10	5	5	Participant’s home	30 minutes

Procedures

Before commencing the user trials, all participants filled an informed consent form, and were provided with an AER booklet and record sheet for the assessment of daily tasks. As the AER tool is based on self-assessment, it was important that each participant read through the instructions and step by step guide. They were informed that during the trials each person would be asked to perform any daily task or could select any IADL task from the list provided with the booklet (see section 16.4, Appendix B, booklet page 4) and perform this normally, and then analyse themselves by using an AER record sheet. To test the ease of use of AER, it was necessary for the subjects to know clearly the rating scheme shown the record sheet. Similarly, the three variables being measured (psychological perception, posture adopted and manual handling) are also explained in the booklet, so each participant was instructed to go through the booklet before analysing the tasks they had performed. As the subjects were self-assessing their own performed tasks the other factor to be considered was the evaluation of the total of the rating scores for each variable, selection of the multiplier, IADL exposure score and task risk level. The selection of the multiplier was based on task duration and frequency, whereas the IADL exposure score was the product of sum of the rating scores and selected multiplier.

8.5.2.3 Result and discussion

Table 8-10 shows the self-assessed, self-reassessed and researcher-assessed exposure scores and respective risk levels. In this part of the study each participant performed a single task. Before starting the trial each participant read the booklet with the step by step guide for self-assessment and how to use the recording sheet. It has been noted from the different exposure scores that almost all the participants were comfortably able to self-assess their performed task; only one participant found some problem there because her understanding of the English language was not good, and therefore the researcher managed to help her understand in her own language and found that she did well in the self-reassessed performed task.

Table 8-10 Results of analysis of ease of use of activities of daily life using AER record sheet

Participants	Age (years)	Gender	Task Performed	Time spent	IADL Exposure Score			Risk Level
					Self-assessed	Self-re-assessed	Researcher-assessed	
P1	49	Male	Washing dishes	30 min	7.65	7.14	7.14	Moderate
P2	40	Male	Bed making	6 min	0.98	1.05	1.05	Low
P3	46	Male	Washing dishes	10 min	2.38	2.55	2.55	Moderate
P4	51	Male	Pushing shopping trolley	15 min	0.8	0.7	0.8	Low
P5	40	Female	Cleaning bathroom	20 min	2.25	2.1	2.25	Moderate
P6	56	Female	Room cleaning	30 min	Not able to self-	1.19	1.26	Low

					assess			
P7	42	Male	Food preparation	25 min	5.78	5.1	4.76	High
P8	50	Female	Vacuuming	16 min	2.40	2.25	2.25	Moderate
P9	40	Female	Food preparation	30 min	9.18	8.16	7.65	High
P10	48	Male	Sweeping	15 min	3.23	3.23	2.89	Moderate

It can be observed from Table 8-10 that there is some dissimilarity between the participants' self-assessment and the researcher's assessment in the exposure scores, but that they have the same selected risk level. When the researcher explained the procedures then the self-reassessment of some participants exactly matched those of the researcher-assessed exposure scores, which can easily be understood from Figure 8-4. Therefore, it is concluded that without any explanation one might obtain conservative results and with some explanation one could obtain more realistic and precise results. It is also possible that regular use of AER record sheet by participants would obtain precise and consistent results. It is also concluded that some sections of the AER record sheet might need explanation in order for some participants to obtain better results. Figure 8-4 shows the self-assessed, self-reassessed and researcher-assessed exposure scores.

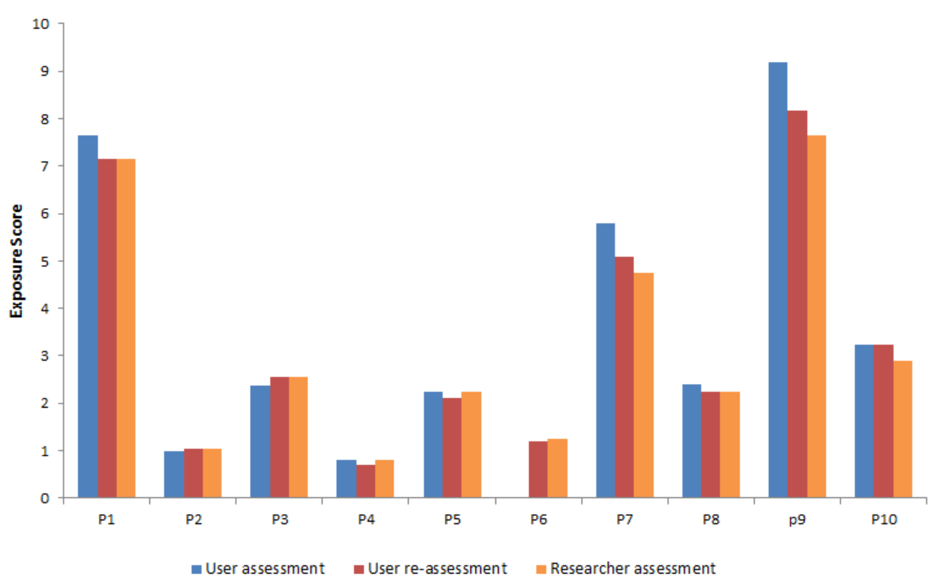


Figure 8-4 Self-assessed, self-reassessed and researcher-assessed IADL exposure scores

A feedback questionnaire (see section 15.5, Appendix A) was used to determine the ease of use of AER record sheet for all participants (n=20), using a rating scale where 1 is "strongly disagree" and 5 is "strongly agree". It shows that AER is simple and easy to use (mean 4 ± 0.8 & mode 5), free from ambiguity and easily understandable (mean 4 ± 0.6 & mode 5), applicable to almost all the tasks performed in home environment (mean 4 ± 0.7 & mode 4) and does not require training for assessment (mean 4 ± 0.8, & mode 5). The participants confirmed that the AER scoring system is easy and understandable (mean 4 ± 0.9, mode 5), frequency and duration are easy to select from the multiplier table (mean 5 ± 0.7, mode 5) and IADL exposure is easy to calculate (mean 5 ± 0.7, mode 5). Therefore, the selection of the final risk is also simple and easy (mean 5 ± 0.6, mode 5). Overall, participants rated the AER recording sheet as GOOD.

It is inferred from the table 8-11, almost all participants are strongly agreed (based on the mode values, mean values might be confusing to make decision) with the all contents of the record sheet and concluded that the AER record sheet provided ease of use and was a reliable instrument to assess a domestic environment. Table 8-11 shows the self-assessment ratings of the feedback questionnaire on ease of use of the AER record sheet.

Table 8-11 Feedback questionnaire results on using AER record sheet

S.No.	Statements	Rating Scale					Mean (SD)	Mode
		1	**2**	**3**	**4**	**5**		
1	AER recording sheet is simple and easy to use	-	1	1	7	11	4 (0.8)	5
2	AER recording sheet is free from ambiguity and easily understandable	-	-	1	9	10	4 (0.6)	5
3	AER is applicable to almost all the tasks performed in home environment	-	-	2	10	8	4 (0.7)	4
4	AER does not require training to do assessment	-	1	1	7	11	4 (0.8)	5
5	AER scoring system (risk rating: low, moderate, high) is easy and understandable	-	2	1	8	9	4 (0.9)	5
6	Frequency and duration multipliers are easy to select from the multiplier table	-	-	2	4	14	5 (0.7)	5
7	IADL exposure score is easy to calculate	-	-	1	3	16	5	5

							(0.7)	
8	Selection of final risk level (low, moderate, high) from risk rating table is easy	-	-	1	4	15	5 (0.6)	5

Note: Rating scale ranges from 1= strongly disagree, 2= mildly disagree, 3= neutral, 4= mildly agree, 5= strongly agree.

8.5.3 Part-II: Pilot study on tasks in activities of daily life

8.5.3.1 Aim of the pilot study

The aim of this pilot study is to quantify the risk and examine the predictive validity of the AER against the perceived discomfort in performing the activities of daily life.

8.5.3.2 Method

In this study the designed task assessment tool (AER) (see figure 8-2) is used for evaluating the risk level and domestic load in performing daily tasks. The study also validates the AER against the perceived discomfort in performing these daily activities (see table 3-19 for assessment tools which used discomfort in their tool validation). According to Golafshani, “Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are” [316]. There are many forms of validity [17], but the present study uses a technique called predictive validity, which measures how well the AER can predict those daily tasks that entail a risk in relation to perceived discomfort. Predictive validity is measured by sensitivity and specificity [17]. Numerous studies have been found which used sensitivity and specificity analysis to validate the design assessment methods [17, 243, 245, 317], and it has therefore been decided to use this form of analysis to validate the AER.

In this study sensitivity can measured as the proportion of those people having risk and feeling discomfort in performing daily tasks. It also reflects the ability of an exposure assessment tool to correctly identify positive tasks (those tasks predicted by the assessment tool to be hazardous) as problem tasks (resulting in illness or injury) [318]. It can be expressed mathematically as:

Sensitivity= true positive (TP)/(true positive (TP)+ false negative (FP)) [319]

= Probability of having risk when feeling discomfort in performing daily tasks

The sensitivity index indicates that the assessment tool can identify those tasks that involve risk and where the person feels discomfort in performing them. A trial which has a high numeric value of sensitivity helps to capture all possible subjects who are at risk and also feel discomfort in performing their daily activities [320]. Thus the sensitivity values easily screen out the tasks which need to be monitored. Specificity is the proportion of those people who are not at risk and do not feel any discomfort in performing their daily tasks. It refers to the ability of the exposure assessment tool to correctly identify negative tasks (those tasks predicted by the assessment tool to be safe) as safe tasks (not resulting in illness or injury). It can be mathematically expressed as:

Specificity= true negative (TN)/(true negative (TN)+ false positive(FP)) [319]

= probability of having no risk and feeling no discomfort in performing daily tasks

Another term which is determined by sensitivity and specificity is accuracy, which measures the proportion of the correctly classified subjects (TP+TN) within all subjects (TP+ FP+ TN+ FN) [320]. Accuracy through sensitivity and specificity measures the degree of veracity of the assessment tool on a specific condition [320].

Table 8-12 Terms used to explain sensitivity, specificity and accuracy

		Perceived Discomfort		
		Having discomfort	No discomfort	Row Total
AER trial results	RISK (IADL exposure score ≥ 1)	TRUE POSITIVE (TP) (Having risk and discomfort)	FALSE POSITIVE (FP) (Having risk but no discomfort)	TRUE POSITIVE + FALSE POSITIVE (Total number of tasks having risk)
	No RISK (IADL exposure score <1)	FALSE NEGATIVE (FN) (No risk but having discomfort)	TRUE NEGATIVE (TN) (No risk and no discomfort)	FALSE NEGATIVE +TRUE NEGATIVE (Total number of tasks having NO or LOW risk)
	Column Total	TRUE POSITIVE+ FALSE NEGATIVE (Total number of tasks having discomfort)	FALSE POSITIVE + TRUE NEGATIVE (Total number of tasks having no discomfort)	Total number of tasks performed by participants in a study = TP +FP +FN + FP

Source: [320]

Researchers have defined the two characteristics of the assessment test: sensitivity and specificity [321]. The above-mentioned matrix explained the idea which was used in calculation of sensitivity and specificity. In table 6-11, true positive (TP) shows the number of subjects having risk and discomfort in performing activities of daily living. True negative (TN) shows the number of subjects having no risk and feel no discomfort in performing the activities of daily living. False positive (FP) identifies the subjects having risk but feeling no discomfort, while the false negative (FN) shows the number of subjects having no risk but feeling discomfort, in performing such activities.

It is essential for a person to adopt certain postures to perform their domestic tasks. A person's posture can be defined as, "the position of one or many body segments in relation to one another and their orientation in space" [322]. Moes defines discomfort as the lack of comfort, and comfort as an absence of pain or suffering [323]. Adopting good postures in performing our activities is important because it actively encourages a person's efficiency in their movements and increases their quality of life and well-being [324]. Adopting non-neutral or bad postures distorts the proper vertical alignment of a person's body [324] and results in severe fatigue and discomfort [325], strain on different muscles, and possible pain in later stages of life [324]. The tool that has been designed considers five body postures (neck, arm, wrist, back and leg) and their extreme flexion/extension with abduction/adduction that causes the person to feel a higher level of discomfort in performing tasks [54]. It is therefore necessary to pay attention to tasks that are performed in extreme or non-neutral postures because these are associated with discomfort [326] and are a good indicator of a person's perceived work load [327]. According to the Kansas Chiropractic Foundation, a lifetime adoption of poor posture could start symptoms such as fatigue, tight or achy muscles in the neck, back, arms and legs, and joint stiffness and pain

[328]. Therefore, in this study the AER record sheet is used to evaluate the risk, and participants' responses about their perceived discomfort in performing various daily activities is recorded by means of a dichotomous scale (having discomfort and having no discomfort). A single page for the AER record sheet has been designed for recording the score of each task performed by each participant and a stopwatch was used for recording the time spent in performing the tasks.

The target population for this study included all healthy adults between ages 18-65, currently employees/students of University of Sheffield. Ten participants were selected (5 male and 5 female) based on inclusion/exclusion criteria of age, gender and physical fitness. In this pilot study, the subjects are performing many daily activities in their homes, such as cooking, cleaning, laundry work and personal care (see 16.1 in Appendix B for the list of activities in daily life). The designed tool was explained to the subjects and they were instructed to do their daily tasks in the same way as they would do normally. Table 8-13 shows the subjects' age group details and location, as well as the duration of the study.

Table 8-13 Subjects' age groups, pilot study location and duration of study

Age group	Number of subjects who participated	Male	Female	Location	Duration of study (based on number of tasks performed)
20-39 Years	6	3	3	Participant's home	1-2 hours
40-60 Years	4	2	2	Participant's home	1-2 hours

<u>Procedures</u>

The task assessment tool (AER) booklet and record sheet was provided to each participant and they were instructed to read through these prior to performing the tasks. The study took place in each person's home environment. Participants were asked to carry out a range of domestic tasks in the same way as they would do them normally. The AER booklet provides them with step by step guidance for the self-assessments. During the performance of each task, the subject has to think about their perception of the task and rate the physical demand and complexity, the postures adopted and the most uncomfortable and dominating positions for the relevant parts of the body, and also consider the manual handling of objects. Participants were also instructed to record the frequency and duration of each task on the record sheet. At the end, participants provided the AER record sheets to the researcher, having self-assessed the risk levels for every task performed during the trial session. The researcher also informed the participants that a video would be recorded of the performance of the tasks and that video recordings would be used by the researcher to observe the adopted postures rate them by using AER record sheet. Some participants requested that the video recordings of them should be removed after the final assessment. Tables 8-15 to 8-18 shows the snaps of the participant in the adopted postures, as well as of manual handling details during the trial of the tasks being performed.

8.5.3.3 Results and discussion

During the trial sessions, 10 participants performed a range of activities such as cooking, cleaning, laundry and personal care tasks. Each activity contained sub tasks and all tasks were individually analysed by using the designed task assessment tool (AER) which provides a total score based on three variables (psychological perception, adopted postures and manual handling). The frequency and duration of a task was used to obtain an exposure score by multiplying their related multipliers. Then the exposure score was used to select the appropriate risk and action to be taken. Table 8-14 shows the detailed results analysis of activities of daily living by using the AER record sheet.

Table 8-14 Results of analysis of activities of daily living using AER record sheet

Participants	Age (years)	Gender	No. of tasks performed	Time spent	No. of tasks having			Domestic load (average exposure score)	Overall risk
					High risk	Moderate risk	Low risk		
P1	33	Male	16	1hr 46 min	1	2	13	1.12	Low
P2	29	Male	9	1hr 38 min	1	1	7	1.33	Low
P3	26	Male	11	1hr 39 min	0	3	8	1.1	Low
P4	36	Female	6	1hr 11 min	0	1	5	1.4	Low
P5	42	Male	11	1hr 25 min	0	3	8	1.13	Low
P6	40	Female	10	1hr 58 min	1	6	3	2.3	Moderate
P7	51	Female	5	2hr 0 min	0	2	3	2.67	Moderate
P8	34	Female	11	2hr 28 min	0	5	6	1.95	Moderate
P9	36	Female	7	1hr	0	3	4	1.5	Low
P10	43	Male	2	1hr	1	0	1	3.34	Moderate

Table 8-15 Photos of cooking activities; detailed posture analysis; and manual handling details of a subject

<u>Cooking Activities</u>

Food preparation

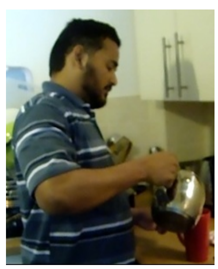
Postural analysis:
- Back flexion
- Neck flexion
- Elbow extension
- Shoulder abduction

Manual handling:
- Lifting
- Lowering
- Carrying
- Pushing

Using Saucepans

Postural analysis:
- Back flexion
- Neck flexion
- Elbow extension

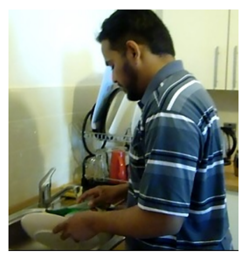
Manual handling:
- Lifting saucepans (2 kg)
- Lowering



Lifting and pouring

Postural analysis:
- Neck side bending
- Shoulder adduction
- Wrist deviation

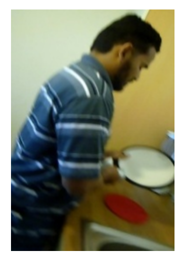
Manual handling:
- Carrying kettles (2kg)



Washing dishes

Postural analysis:
- Neck flexion
- Back flexion
- Shoulder abduction
- Wrist deviation
- Supination

Manual handling:
- Carrying dishes and plates (2kg)



Drying dishes

Postural analysis:
- Neck flexion
- Back flexion
- Elbow flexion
- Shoulder abduction
- Pronation

Manual handling:
- Carrying dishes and plates (2kg)

Table 8-16 Photos of cleaning activities; detailed posture analysis; and manual handling details of a subject

Cleaning Activities

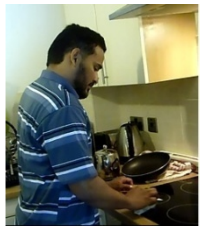
Emptying the bins	Cleaning kitchen surface	Vacuuming	Polishing/dusting	Cleaning fridge
				
Postural analysis: • Neck extension • Back flexion • Wrist deviation • Elbow extension **Manual handling:** • Lifting/carrying rubbish or refuse bags (4kg)	**Postural analysis:** • Neck flexion • Elbow extension • Wrist deviation • Shoulder abduction	**Postural analysis:** • Neck flexion • Shoulder abduction • Shoulder extension • Elbow extension **Manual handling:** • Lifting/Pushing (4kg)	**Postural analysis:** • Neck extension • Back flexion • Elbow flexion • Shoulder abduction • Wrist deviation **Manual handling:** • Pushing/pulling furniture (5kg)	**Postural analysis:** • Neck extension • Back flexion • Elbow extension • Shoulder abduction • Repetitive wrist movement • Wrist deviation

Table 8-17 Photos of laundry tasks; detailed posture analysis; and manual handling details of a subject

Laundry Tasks

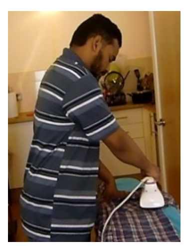
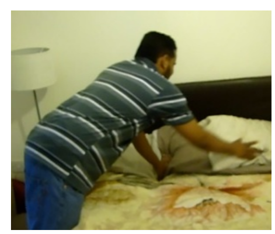
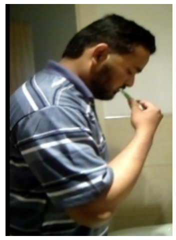
Loading washing machine	Ironing	Bed making
	 	
Postural analysis: • Neck extension • Back flexion • Supination • Wrist deviation • Shoulder flexion • Knees bending **Manual handling:** • Pulling/pushing (2kg)	**Postural analysis:** • Neck flexion • Back flexion • Shoulder abduction • Elbow extension Wrist deviation **Manual handling:** • Lifting/pushing (2kg iron + 4 kg iron stand) • Repetition of elbow	**Postural analysis:** • Neck extension • Back flexion • Shoulder extension • Elbow extension • Wrist deviation **Manual handling:** • Pulling

Table 8-18 Photos of personal care tasks; detailed posture analysis; and manual handling details of a subject

Personal care tasks

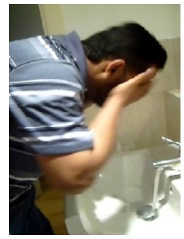
Shaving

Postural analysis:
- Neck flexion
- Neck side bending
- Elbow flexion
- Wrist flexion



Teeth brushing

Postural analysis:
- Neck flexion
- Neck side bending
- Elbow flexion
- Wrist flexion



Face washing

Postural analysis:
- Neck extension
- Back flexion
- Elbow flexion
- Wrist extension
- Shoulder flexion

Hair combing

Postural analysis:
- Neck flexion
- Neck side bending
- Elbow flexion
- Shoulder abduction

Table 8-19 shows the descriptive statistics for the exposure scores assessed by the participants and researcher. It shows that the self-assessed exposure scores ranged from 0.08 to 6.12, with a mean of 1.56. It shows a good spread and provides information that the AER will be able to discriminate between low and high risk tasks, which will help people to prioritize the tasks with the known risk level. However, the self-assessment mean exposure scores were higher than the researcher's ones, which means that during assessment the participants overestimated the , and this in turn revealed that participants need to be more cautious when rating the variables.

Table 8-19 Descriptive statistics for participants and researcher assessment of exposure scores

AER exposure score assessment by	Mean	Median	Mode	Minimum	Maximum
Self-assessment by participants	1.56	0.97	0.44	0.08	6.12
Researcher	1.52	0.82	0.52	0.09	7.65

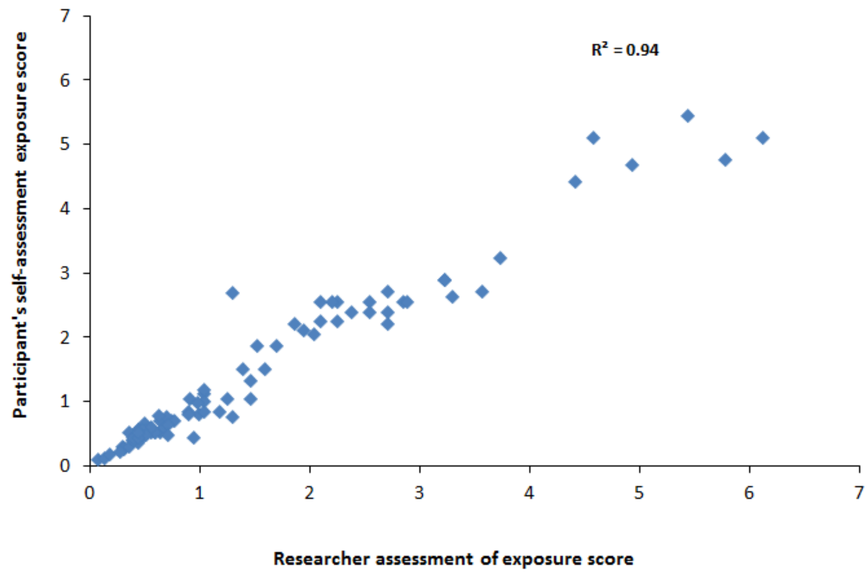


Figure 8-5 Comparison of participant's self-assessed and researcher assessed exposure scores during user trial

Figure 8-5 compares the exposure scores between the participants' self-assessment and researcher assessment (R^2=0.94) during the user trial. It shows that the scores of the former were reasonably similar when compared to those of the researcher. It also revealed that regular use of AER assessment in daily tasks will help to obtain more accurate and reliable results.

In this study domestic load can be defined as the sum of all exposure scores divided by the number of tasks performed by each participant. From Figure 8-6 it is clear that the domestic load for almost all participants' self-assessment is more than the researcher assessed domestic load which revealed that participants overrated all the tasks they performed during the trial sessions. However, as the end result was the same risk level, it may be possible to assume that regular use of AER assessment will help them to obtain precise results.

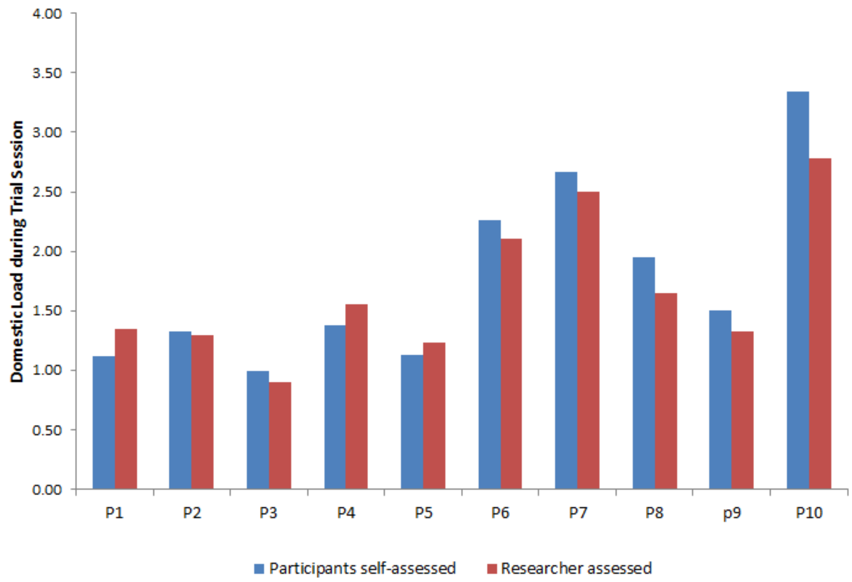


Figure 8-6 shows the user assessed and researcher assessed domestic load of each participant during trial sessions

Figures 8-7 to 8-16 show the self-assessed and researcher assessed exposure scores and also show the perceived discomfort felt by participants in performing the tasks during the trial session. It has been noted that the exposure scores from almost all the participants is slightly less than those of the researcher but with the same risk level (low, moderate and high). It would seem, therefore, that regular use of the AER record sheet would help to obtain accurate results.

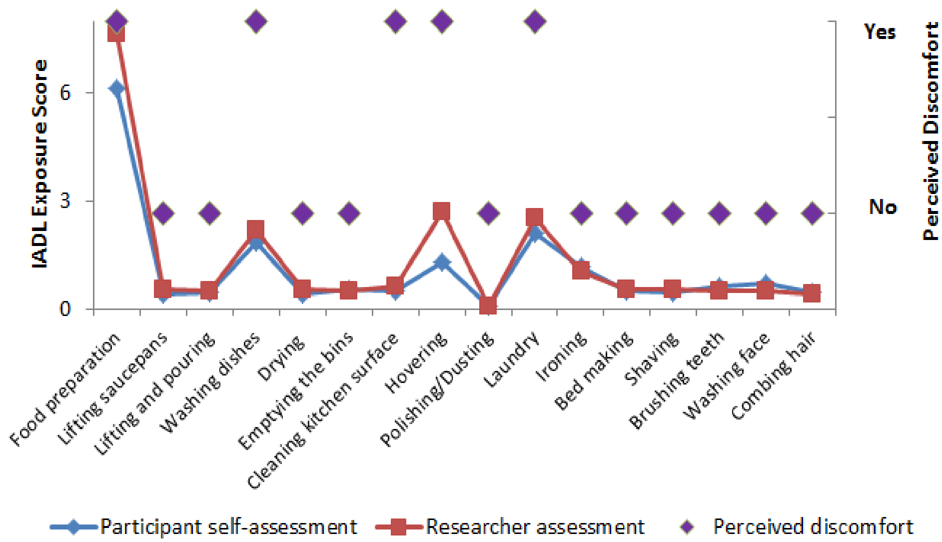


Figure 8-7 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 1

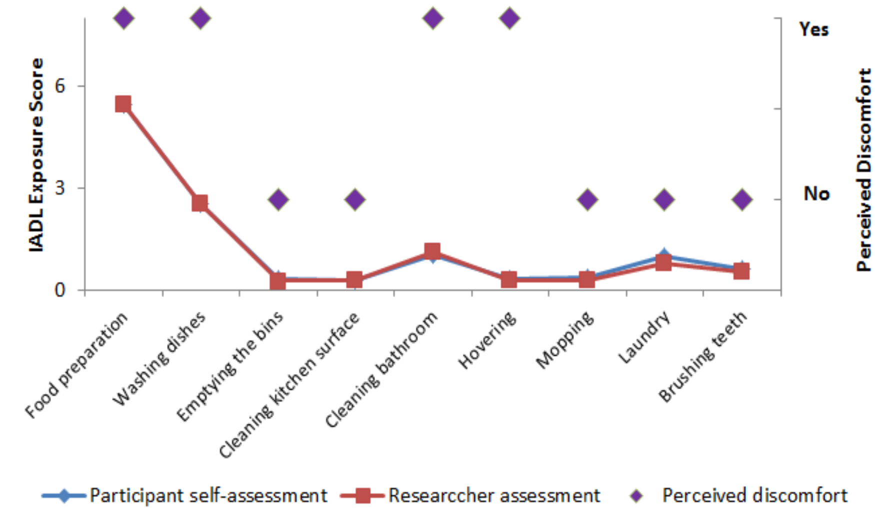


Figure 8-8 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 2

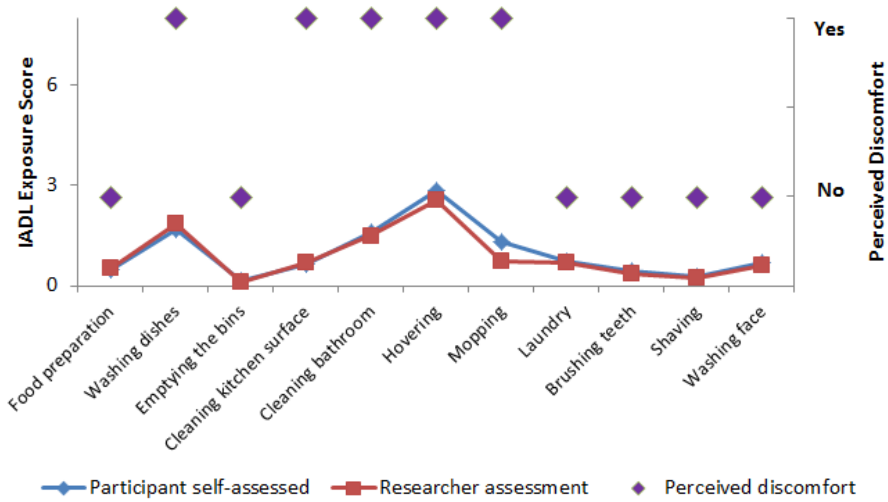


Figure 8-9 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 3

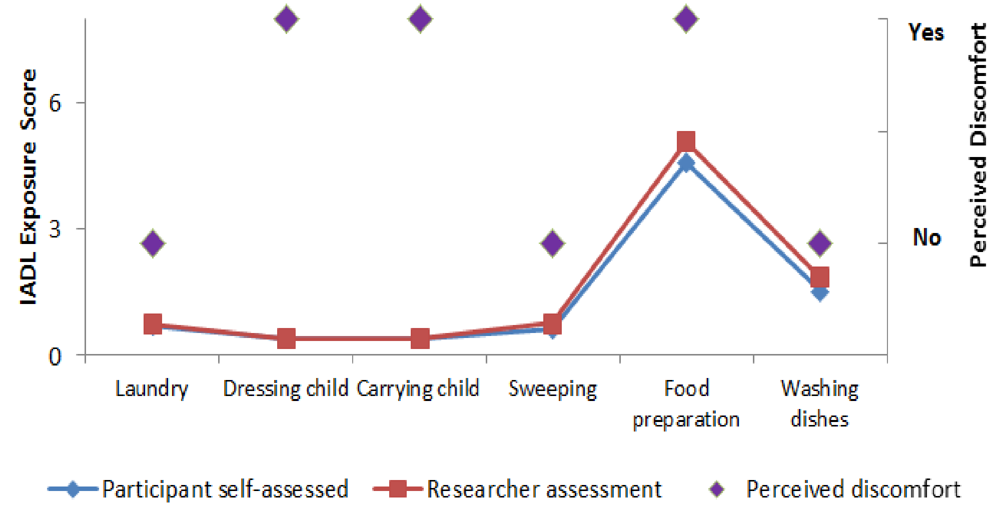


Figure 8-10 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 4

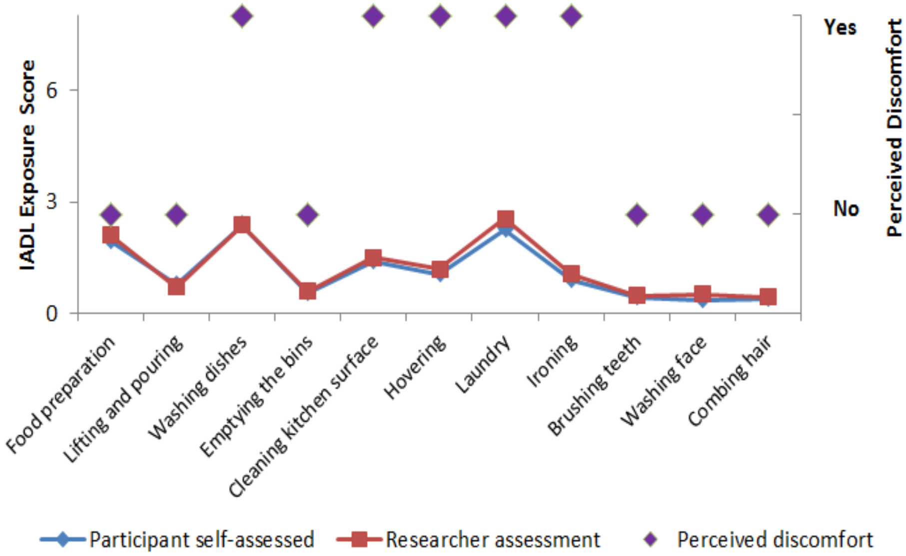


Figure 8-11 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 5

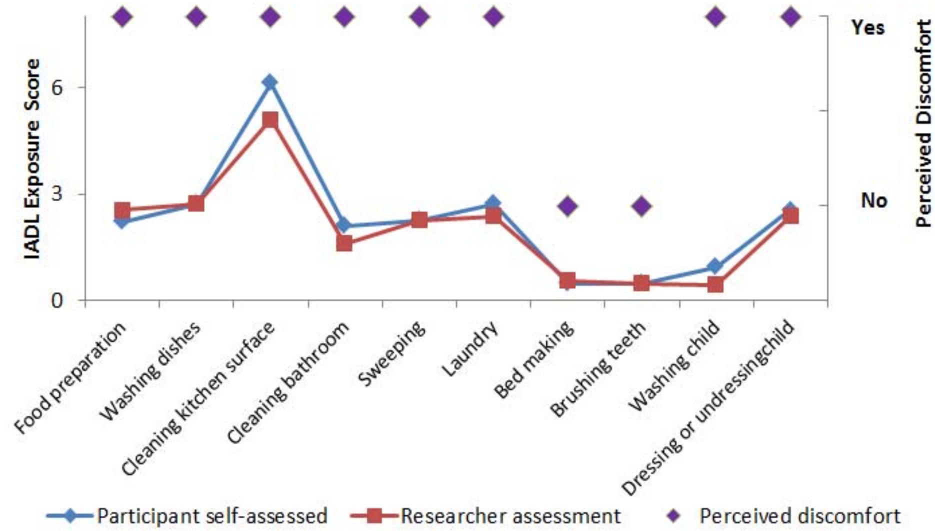


Figure 8-12 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 6

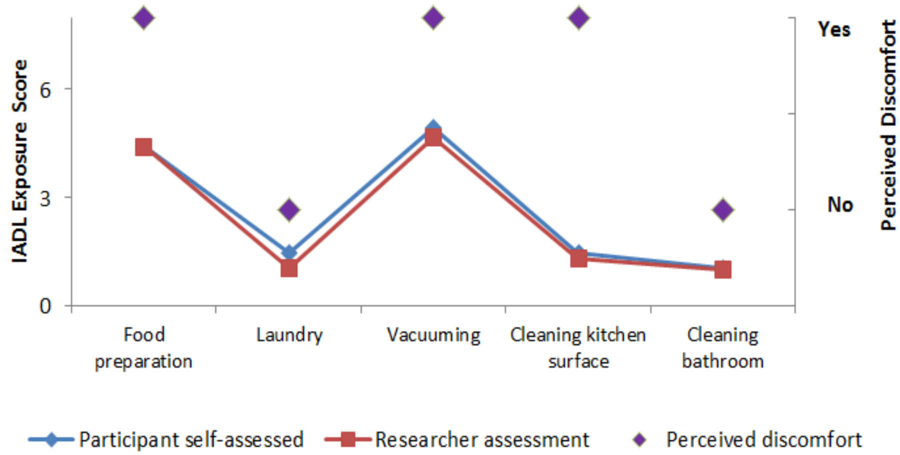


Figure 8-13 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 7

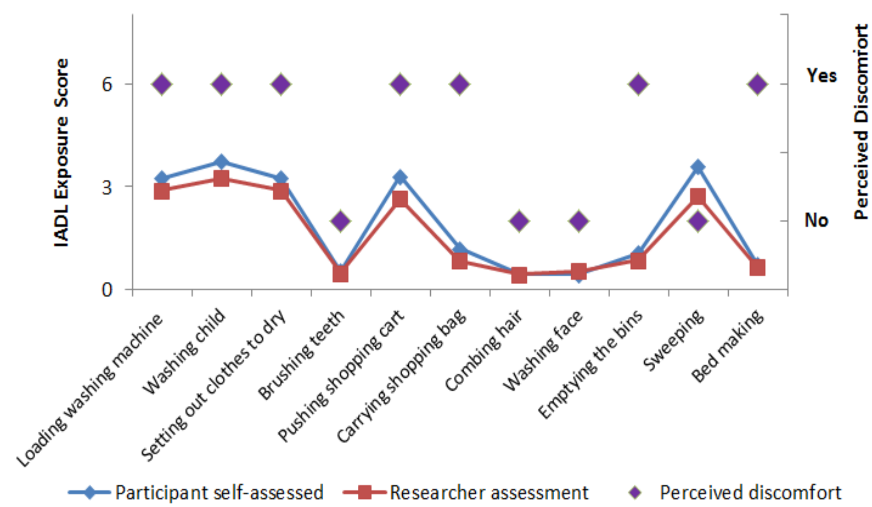


Figure 8-14 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 8

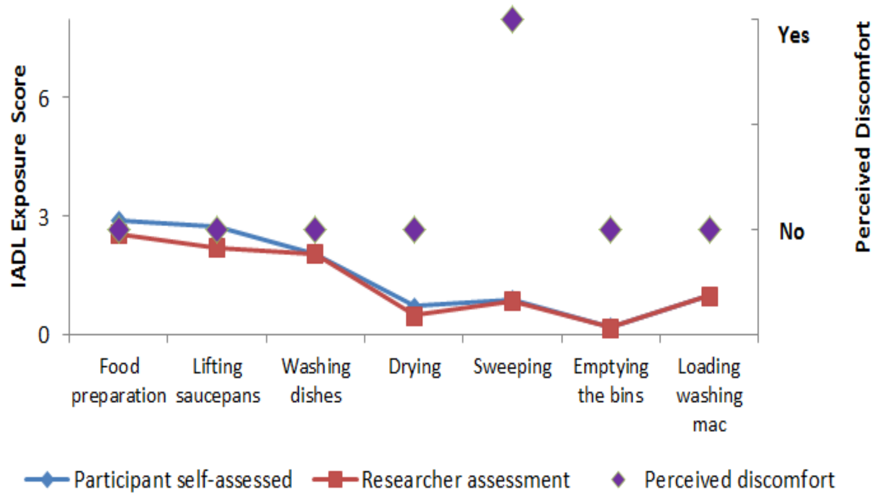


Figure 8-15 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 9

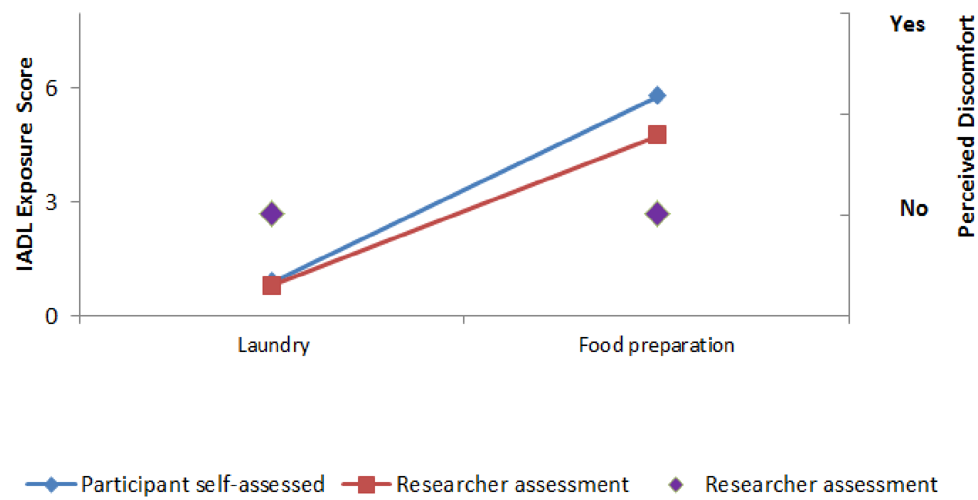


Figure 8-16 Self-assessed, researcher assessed exposure scores and perceived discomfort by participant 10

Explanation of participant number 1 activities

Participant 1 has been selected to explain how one can proceed with AER record sheet during the trial session. Table 8-20 shows the summary of tasks performed by participant 1 and figure 8-17 shows the AER record sheet of participant's food preparation task and selected risk level. Analysing the basic activities revealed that there are different risk levels in each activity which are performed by the participant 1. In cooking activities participant is exposed to low to high risk, exposed to low to moderate risk in laundry task, Therefore, need to be more careful when performed cooking and laundry tasks.

In the cooking activities, the participant performed five tasks, shown in Table 8-20, and each task has a different risk level. During the trial session the participant spent 26 minutes on these activities. Normally he prepares food every day and he found a high risk with the IADL exposure score of 6.12. This means that the food preparation task was harder for participant 1 to perform and required further consideration in relation to the psychological perception, postures adopted and manual handling tasks. The participant's psychological perception of the food preparation task is moderate, as it required moderate physical demand and he considered the task to be moderately complex. Analysing the self-assigned ratings revealed that the subject adopted moderately non-neutral postures of arm (rated risk is 2 see figure 8-17), while his neck, wrist and back were neutral and his legs were well supported and balanced during the food preparation task. As well as the postures he adopted, he was also involved in manual handling activities (lifting, pushing and carrying), such as lifting pots and saucepans (see Table 8-20) and rated the manual handling risk as moderate. The other task in which participant 1 had moderate risk was in washing dishes, as he adopted many awkward postures and was also involved in manual handling activities such as carrying dishes.

Table 8-20 Activities performed by participant 1, his domestic load and associated risk levels during trial session

IADL Tasks List

Please select and evaluate risk for the activities which you perform in your daily life:

Please state: Age:_____33 years

Gender: _______Male

Basic everyday activities		Total Score	Frequency	Duration in minutes	Selected multiplier	*IADL Exposure score*	*Exposure Risk*
Cooking activities	Food preparation	12	every day	26	0.51	***6.12***	***High***
	Opening cans	-	-	-	-	-	-
	Using saucepans	11	every day	2	0.04	***0.44***	***Low***
	Lifting and pouring	12	every day	2	0.04	***0.48***	***Low***
	Washing dishes	11	every day	6	0.17	***1.87***	***Moderate***
	Drying	11	every day	2	0.04	***0.44***	***Low***
Cleaning activities	Emptying the bins	14	every day	1	0.04	***0.56***	***Low***
	Cleaning kitchen surface	10	Twice	9	0.05	***0.5***	***Low***
	Cleaning bathroom	-	-	-	-	-	-
	Vacuuming	13	Twice	17	0.1	***1.3***	***Low***
	Mopping	-	-	-	-	-	-
	Polishing/Dusting	13	Once	4	0.06	***0.08***	***Low***
	Sweeping	-	-	-	-	-	-
Laundry tasks	Loading washing machine	14	3 times	16	0.15	***2.1***	***Moderate***
	Setting out clothes to dry	-	-	-	-	-	-
	Ironing	18	3 times	11	0.07	***1.19***	***Low***
	Bed making	13	every day	1	0.04	***0.52***	***Low***
Personal care tasks	Shaving	12	every day	2	0.04	***0.48***	***Low***
	Brushing teeth	16	every day	2	0.04	***0.64***	***Low***
	Washing face	15	every day	3	0.04	***0.6***	***Low***
	Bath/shower	-	-	-	-	-	-
	Combing hair	11	every day	2	0.04	***0.48***	***Low***
Grocery shopping	Pushing shopping cart						
	Pushing baby pram						
	Carrying shopping bags						
Children activities	Dressing/undressing child						
	Washing child						
	Carrying child						
Gardening Activities	Mowing lawn						
	Planting/weeding						
	Watering						
	Pruning						
Total Score						***17.87***	

Total activities performed in a typical week	16	
Sum of all IADL exposure scores	17.87	
Domestic load and risk level for typical session or typical week	**1.12**	Risk Level L **M H**

(Please circle)

Task Assessment tool for ease and risk (AER) Record Sheet

(Version 1)

Task name: Food preparation

	Rating 1	Rating 2	Rating 3	Score
Psychological Perceptions				
Perceived physical demand required	None OR Minior	Moderate	Too much	2
Perceived complexity	Not at all OR Slight	Moderate	Extreme	2
Postures adopted				
Neck	 0-10°	 10-20°	 Extension >10° Flexion >20°	1
Arm	 0-20°	 20-45°		2
Wrist	 Nearly straight or in neutral position	 Flexion/extension 0-15°	 Flexion/extension >15°	1
Back	 0-20°	 20-60°		1
Leg	 Both legs are straight and level (or) in a sitting position	 One or both legs are bent from knees	 legs are not supported and bent from knees (flexion) more than 30°	1
Manual handling				
Lifting/lowering, pushing/pulling and carrying	Light (e.g. <1 kg)	Moderate (e.g. 1 to 5 kg)	Heavy (e.g. > 5 kg)	2

Total of all of the above: 12

x

Frequency per week: 7 times (everyday)

Selected Multiplier: 0.51

=

IADL Exposure Score: **6.12**

Duration per day: 26

Multiplier table

Duration of task	Frequency per week: Once	Twice	3 times	4-7 times
Less than 5 mins	0.006	0.01	0.02	0.04
5 – 15 mins	0.02	0.05	0.07	0.17
16 – 25 mins	0.05	0.1	0.15	0.34
26 – 35 mins	0.07	0.15	0.22	0.51
36 – 45 mins	0.1	0.2	0.29	0.68
46 – 60 mins	0.12	0.26	0.38	0.88
More than 1 hr	0.18	0.38	0.54	1.25

Risk rating table

IADL Exposure Score	Risk Rating	AER implications about the task
< 1.6	Low	Task is easy to perform, but required caution
1.6 to 5	Moderate	Task is not easy to perform required more consideration
> 5	High	Task is hard to perform, further investigation required urgently

Task Risk Level: L M H

(Please circle)

Figure 8-17 shows the analysis of food preparation task using AER record sheet

Similarly, in the laundry task, loading the washing machine and hanging out the clothes to dry had a moderate risk level.

During the trial session, participant 1 performed 16 tasks, with a total exposure score of 17.87. The participant's domestic load was 1.12 and his associated risk level is low (see Table 8-20). Although the participant's risk level for the session is low, he performed some activities which had a high to moderate risk level (see Table 6-19), so he needs more caution and consideration when performing these daily tasks, and this will help him to maintain or reduce the domestic load for a typical session or week.

Comparing the IADL exposure score of participant 1 with the that of the researcher, it was revealed that most of the activities underrated (three out of four activities i.e. cooking, cleaning and laundry) by participant , but participants need more caution when performing cooking and laundry tasks because knowing their own risk level in performing tasks helps people to lower the risk of those tasks being high and moderate by altering the task duration or frequency, as this will lower the respective multiplier and the result will be a lower exposure score and risk. The other way to reduce the risk level is to pay attention to one's adopted postures and try to perform the tasks in neutral postures (see Appendix C, section 17.1 for further counter measures to reduce the risk level) because this minimizes the amount of strain and stress on the body [329] (for instance, in performing tasks one should avoid bending and twisting simultaneously and make sure to keep the back straight and bend the knees when working with a fridge/freezer or oven [7]).

Figure 8-18 shows participant 1's average IADL exposure score in four basic activities. These scores are also helpful for health care professionals, so that they can suggest to the person which tasks he must be careful about when performing them.

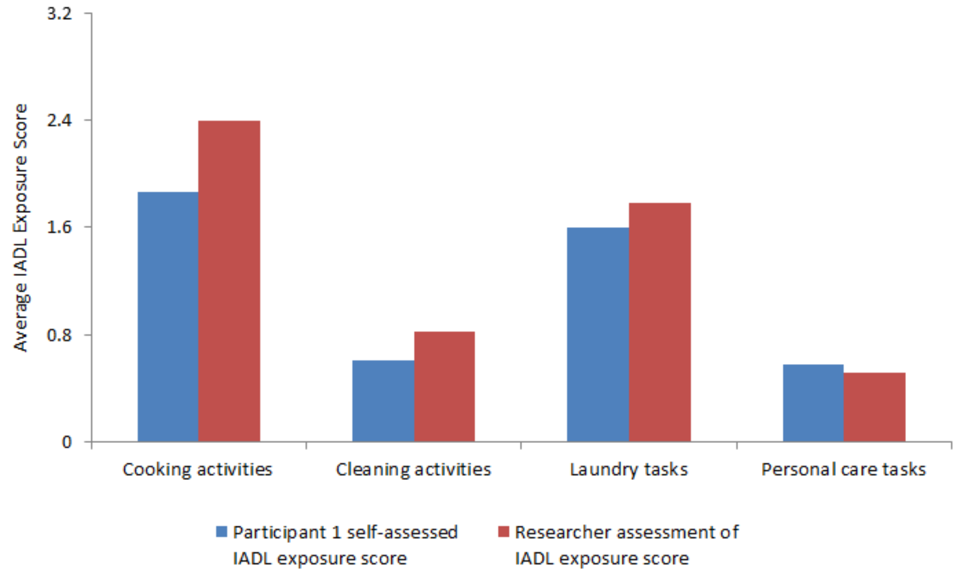


Figure 8-18 Participant 1's average IADL exposure score in basic activities

Similarly, Figure 8-19 shows the participant's and researcher's domestic load during the trial session. Participant 1's domestic load was lower than the researcher's one, and this reveals that consistent using of AER will help to obtain more precise results. It is also helpful to compare the current domestic load with the previous done, as this will help to show how the person is coping with their daily tasks and also indicate the person's ability and behaviour in the performance of basic essential tasks.

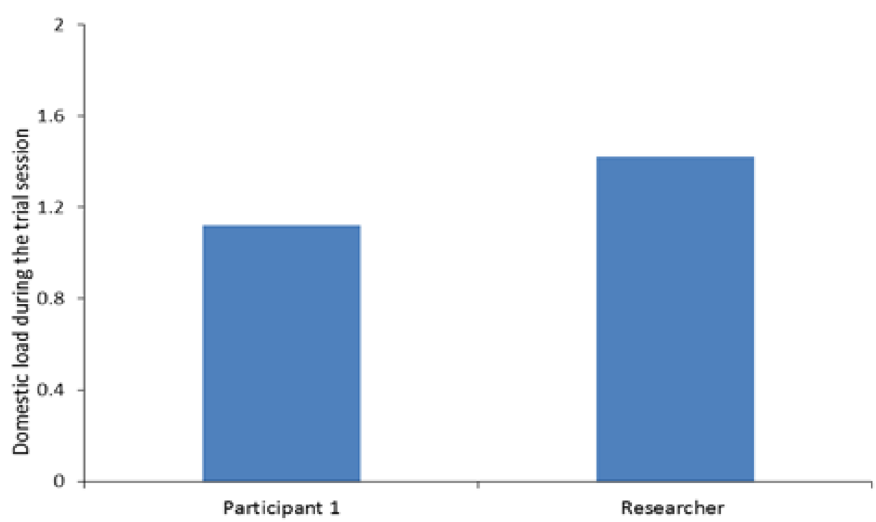


Figure 8-19 Participant's and researcher's domestic load during trial session.

AER validation

In order to ascertain the predictive validity of an assessment tool, it is essential to examine the risk level predicted by the assessment tool and compare this with the measure of some incidence such as any pain or discomfort in performing the tasks because the adoption of extreme or non-neutral postures is associated with discomfort [326]. Within the literature review various studies (see table 3-19, section 3.3.8) have been found, which validate their tools against body part discomfort. Therefore the same technique is used in this study for validating the designed tool.

A good assessment tool has the potential to discriminate between two conditions, and for this study the conditions are: (i) risk and no risk (ii) having discomfort and no discomfort. AER has the potential to segregate the task into high, moderate and low risk in relation to having perceived discomfort or no perceived discomfort. In order to calculate the predictive validity of AER, this study uses IADL exposure score cut-off values. Those tasks having an IADL exposure score equal to or greater than one (IADL exposure score ≥ 1) are considered to be risky tasks and those having an IADL exposure score of less than one (IADL exposure score < 1) are regarded as tasks having no or low risk. The reason for using cut-off values in the IADL exposure scores is that there are many tasks in the domestic environment which take very little time (less than 5 minutes) to perform (for example, brushing teeth, washing face or combing hair) and have a low risk level, with IADL exposure scores of less than 1, and it is therefore assumed that those tasks have no risk, which makes the predictive calculations easy.

Sensitivity, specificity, predictive indexes and accuracy analysis is performed between the AER results with respect to perceived discomfort in performing the daily tasks. Ten participants performed 88 tasks during the trial session and segregated their daily tasks into four categories: risk and having discomfort, called true positive (TP); risk and having no discomfort, called false positive (FP); no risk and having discomfort, called false negative (FN); and no risk and having no discomfort, called true negative (TN). Table 8-21 shows the number of tasks within each category. To ascertain the ability of AER to accurately categorize a person's risk level in performing these daily tasks, the sensitivity, specificity and predictive indexes were determined by the formulas used by Marley and Kumar [243].

Table 8-21 Number of task within respective categories

AER Trial Results	Perceived Discomfort (Yes)	Perceived Discomfort (No)	Row Total
Risk (IADL exposure score ≥1)	32 (TP)	12 (FP)	44
No Risk (IADL exposure score <1)	9 (FN)	35 (TN)	44
Column Total	41	47	88

In Table 8-21, the two columns indicate the real conditions of tasks performed by participants, having discomfort or no discomfort. The rows indicate the results of the self-assessment of tasks by participants using AER, having risk or no risk. The first cell (blue) in the matrix contains the number of tasks (true positive) performed by participants having risk and discomfort. The fourth cell (grey) shows the number of tasks (true negative) having no risk and no discomfort. A good assessment tool will have a minimal number of tasks in the second (green) and third (light blue) cells [330, 331]. The second cell indicates the number of tasks having risk and not feeling any discomfort, called false positive. Similarly, the third cell indicates the number of tasks having no risk and feeling discomfort, called false negative. The assessment tool is said to be efficient and to perform well when it has a higher number of participants in the first (blue) and fourth (grey) cell [330, 331], meaning it can predict both risk and no risk tasks with respect to perceived discomfort in a domestic environment.

Table 8-22 Calculation of sensitivity, specificity, predictive values and accuracy

Sensitivity:	**Specificity:**	**Positive Predictive value:**
={TP/(TP+FN)}*100%	={TN/(TN+FP)}*100%	={TP/(TP+FP)}*100%
={32/(32+6)}*100%	={35/(35+12)}*100%	={32/(32+12)}*100%
=78%	=74%	=73%
Negative Predictive value:	**Accuracy:**	
={TN/(TN+FN)}*100%	={(TP+TN)/(TP+FP+FN+TN)}*100%	
={35/(35+9)}*100%	={(32+35)/(32+12+9+35)}*100%	
=80%	=76%	

Source for formulas: [320]

Table 8-22 shows the numeric values of sensitivity, specificity, predictive indexes and accuracy. Sensitivity, specificity, positive and negative predictive values determine the usefulness of diagnostic assessment [332]. The sensitivity value shows that self-assessed tasks by AER can identify those tasks that are very likely to have risk and discomfort with 78% accuracy. It means that the assessment tool has the ability to detect 78% of people who feel discomfort and who rate their tasks as having risk, and it misses only 22% of people who have both conditions. The specificity value shows that AER can also have the ability to predict and discriminate between those tasks having no risk and not feeling discomfort, with an accuracy of 74%. This means that the assessment tool has the ability to detect 74% people who do not feel discomfort and who rate their tasks as having no risk. The predictive value measures the usefulness of an assessment test [330]. The positive predictive value measures the proportion of true positive within all tasks rated as having risk, while the negative predictive value measures the proportion of true negative within all tasks rated as not having risk, by AER. The positive predictive value indicates the proportion of those tasks performed by participants having risk and discomfort within all the tasks having risk predicted by AER, which means that 73% of participants who have identified their tasks as having risk also feel discomfort in performing the tasks. The negative predictive value indicates the proportion of those participants having no risk and feeling no discomfort, which means that 80% of participants who have identified their tasks as having no risk also do not discomfort in performing the tasks. The positive and negative predictive values depend upon the occurrence of a specific condition in the participants examined (for instance, the number of people feeling discomfort or not feeling it, in performing the tasks). The positive and negative predictive values therefore vary from one study to another, depending upon the occurrence of the condition. The assessment tool measures the proportion of correctly identified tasks as either positive or true negative. The calculated value of accuracy is 76%, which means the designed tools have a good proportion of true results being identified (both true positive and true negative) in the population studied.

The sensitivity, specificity, predictive values and accuracy of the newly developed assessment tool are essential because they gives an idea of accuracy of assessment uncertainty when employed [262]. High sensitivity and specificity values which would ensure the false negative (no risk but having discomfort) and false positive (risk but no discomfort) were minimized, which represents the significance and level of accuracy of AER. Although the AER also has high specificity (74%) but the tool has the ability to discriminate well between the conditions and is revealed to be a reliable indicator for capturing perceived discomfort in performing activities of daily living. AER has both high sensitivity and specificity, thus showing that AER has been validated and provides a good knowledge of the risk and conditions such as perceived discomfort which are associated with performing the tasks and is also useful for identifying those tasks that might pose a risk of injury. Moreover, it is believed that AER may play a vital role in the development of comprehensive and proactive strategies for the detection of problems related to the home environment and manage them effectively before they can affect people’s quality of life.

8.6 Conclusion

The task assessment tool for ease and risk (AER) for the domestic environment was developed based on self-assessment and provides knowledge about the risks associated with the performance of daily tasks. AER is useful in the detection of risk and providing early warnings for healthy individuals as well as for those undergoing rehabilitation processes, as it can easily identify the tasks that are hardest to perform. The AER assessment covers the psychological perception (perceived physical demand and perceived complexity) of the task, and physical risk factors (posture adopted and manual handling of objects), as well as duration and frequency of tasks. The AER physical risk factor concerning adopted postures considered five main parts of the body (neck, arm, wrist, back and leg) that have been identified as essential for performing tasks, while adopting non-neutral postures increases the physical demand required for the tasks and the person becomes susceptible to neck and back pain because the physical demand required for the task is a significant risk factor for musculoskeletal disorder [305, 306]. In the ease of use trials, it was confirmed that almost all participants were able to self-assess the tasks they performed, although there was some dissimilarity between the participants' self-assessment of IADL exposure scores and those of the researcher, but they had the same selected risk levels, and it is therefore assumed that regular use of the AER record sheet will obtain precise and consistent results. The feedback questionnaire confirmed that this record sheet is simple and easy to use, free from ambiguity, easily understandable and does not require training before conducting the assessment. It is therefore concluded that the AER record sheet provides ease of use and is a reliable instrument for assessing the domestic environment. In the validity trials, the AER predicted risk level is measured in relation to perceived discomfort and it was found that AER has high sensitivity (78%) and specificity (74%) values which reveals that AER is a sensitive and useful tool for identifying risk and perceived discomfort in performing daily tasks. It also indicates a high positive predictive value (73%), which again demonstrates the usefulness of such an assessment tool [330]. It is therefore confirmed that AER efficiently identified those tasks in which participants felt discomfort, within all the tasks predicted by AER as having risk. It also confirmed the accuracy of

AER (76%), from which it can be inferred that AER has the ability to identify true results in the studied population. Overall it is concluded that AER has both high sensitivity and specificity, showing that AER has been validated and provides good knowledge about people's essential daily tasks and is also helpful for identifying the tasks that might pose risk for injury in the later stages of life.

9 General Discussion

The aim of project was to develop a self-assessment tool for evaluating domestic tasks and quantifying the load and risk level associated with performing such tasks. Four objectives were identified to fulfil the aim of the study, as shown (figure 9-1) below in the form of a simple flow chart:

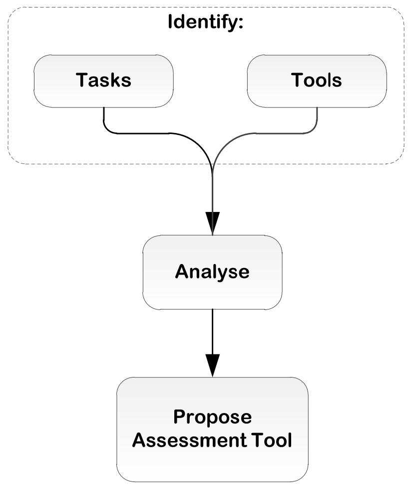


Figure 9-1 objectives of the study in the form of simple flow chart

This study initially reviewed the relevant literature on the problems faced by people in performing their activities of daily living among them most common are potential risk of losing one's independence and being forced to move into care homes. The reviewed literature critically and extensively discussed two disciplines: i. Occupational therapy and ii. Ergonomics. It was found that occupational therapy indicates two well-known methods: the KATZ ADL and the Lawton IADL, which assist health care professionals in the evaluation of the functional status of a person after a specific injury occurs i.e. post-event. The KATZ and Lawton methods are both based on a number of tasks (KATZ is based on 6 tasks whereas Lawton is based on 8) performed by a person, in order to evaluate their functional status. The KATZ and Lawton IADL scale based on numeric values either 0 (dependent) or 1 (independent) to assess the functioning status of a person.

Although most of the occupational therapy methods provide information about a variety of post-event disabilities, none of them indicate any risk before the specific injury occurs (pre-event). These scales are often used to evaluate a person's functional skills in different daily tasks which enable health care professionals to make the decision about whether that person going to stay in their own home or not. In addition, health care professionals use these scales for rehabilitation purposes, which enable people to maintain or restore their independence and return to their home again. In this study the identification of the case study tasks was based on the IADL tasks as defined by Lawton and Brody, which consist of the ability to use a telephone, carry out shopping, prepare food, do housekeeping, do laundry, use a mode of transportation, be responsible for one's own medicine, and handle finance [1].

Similarly in ergonomics, it was found that, it provides a safe and comfortable environment to work in, either at home or in the workplace. Furthermore ergonomic techniques are helpful to detect early signs and symptoms and provide caution before any incidence happens. This study used the principles and techniques of ergonomics, where the concern is to develop the best fit between people and their tasks [9] and where the assessment tools are used effectively in order to study the effects of force, repetition and awkward postures on the distal and upper parts of the body [11, 12]. Ergonomic assessment tools have until now mostly been used in an industrial environment [14, 16], whereas in this study the ergonomic assessment methods have been used for the evaluation of home-based tasks. This study has focused on ergonomic risk factors: repetitive motion and awkward body postures, therefore the choice of tasks for this study has mainly focused on physical tasks performed by people within their home environment.

A survey-based study on instrumental activities of daily living was used to identify which specific IADL tasks are perceived to be most difficult to perform. It revealed that a significant number of people are struggling with the tasks around the home. The results found that people are struggling in general housekeeping (69%), preparing meals (66%), grocery shopping (60%) and laundry (57%) and want them to be modified (48%, 6.6% and 3.9% people want general housekeeping, grocery shopping and laundry to be modified) or made comfortable. It was therefore decided to investigate the tasks involved in general housekeeping, preparing meals and doing laundry. Three case study tasks were identified for research: mopping, food preparation and laundering, covering the variety of tasks within the IADL remit in order to understand how people perceived and performed these tasks in their home environment. After deciding on the case study tasks, the experimental work was initiated, the aim of which was to identify the potential ergonomic risk factors during IADL tasks performed at home using ergonomic assessment methods. The following procedures were undertaken during the experimental work, which helped the researcher to understand the tasks performed within the home environment:

- Simulating these tasks within a known environment
- Applying ergonomic assessment methods to the case study tasks
- Identifying risk factors within each case study task
- Evaluating the suitability and methods used in the ergonomic assessments against the occupational therapy assessments

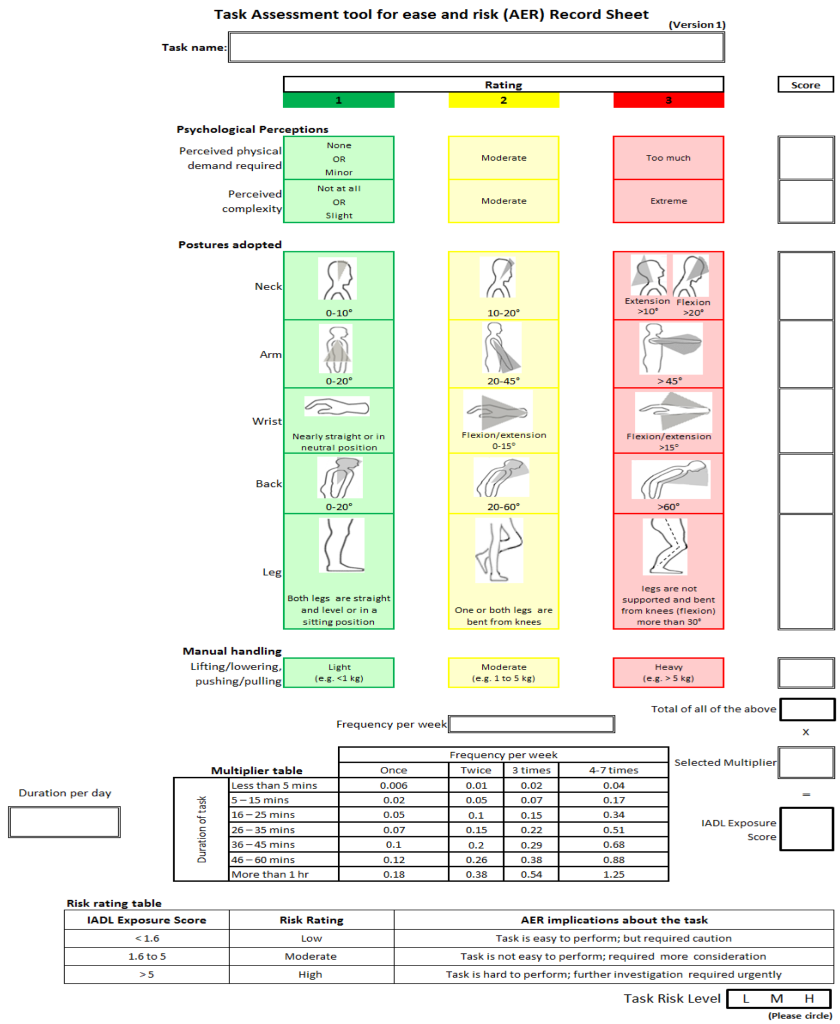
The mopping task was simulated in a lab environment and studied the effects of ergonomic risk factors: adopted body postures, repetition and perceived discomfort and related chance of injury associated with this task. It was found that people were performing mopping task in a zone of moderate to high risk of injury and experience physical strain and biomechanical strain on the muscles. For the food preparation and laundry tasks, techniques used were a questionnaire and an observational study. The questionnaire obtained people's opinions, while the observational study was useful for understanding the hardest part of each task in a real home environment. Using the observational data each task performed was analysed using ergonomic observational methods: RULA, REBA, SI and LUBA. They were chosen because these ergonomic assessments covered almost all parts of the body (wrist, arms, shoulders, neck, back and legs) most relevant to the tasks.

In the food preparation questionnaire-based study, it was found that the hardest sub-task for the general population were peeling potatoes and chopping/slicing. The results also showed that the 31-50, 51-70 and 71-90 year-old age groups struggled with three sub-tasks with respect to three parameters: "don't do it with ease", "physical demand required" and "complexity of task" but that a higher number of responses came from the 51-70 age group than from the other two age groups. This means that people in the middle age group found more tasks harder to perform but a 18% proportion of people said that they didn't change their behaviour (see figure 6-39), and so they continued doing those tasks and did not adopt different strategies (such as "change posture", "use tool/aid", ask for assistance" or "take longer over doing the task") which might have enabled them to perform those tasks more easily, while the respondents in the older age group (71-90 year-olds) seemed to acknowledge their age and noticed their change in behaviour and adopted many strategies to make their tasks easier to perform.

Similarly, in the laundry questionnaire-based study it was found that the hardest sub-task for the general population was drying clothes, but that a higher number of responses came from the 31-50 age groups than from the other two groups (51-70 and 71-90). It was also found that all three age groups were struggling to perform the laundry task but the 51-70 year-old group had more responses as compared to the older age group (71-90) and followed the same trends as in the food preparation task, as they (51-70 year-olds) failed to adopt any strategies and were not making their tasks easy for themselves to perform as the older people did.

It was identified during the ethnography study of food preparation and the laundry task that performing these two tasks is not easy. Although they lasted for a short duration and were repeated infrequently, if combined with other IADL tasks they could trigger more cause for concern and might be responsible for changes in behaviour in later stages of life. Furthermore, it is concluded that ergonomic assessment methods are not enough on their own because people are exposed to some other risks apart from the ergonomic risk factors. So critical thinking was employed and a mind map was developed (see section 15.2, Appendix A) on "How to assess the IADL task" which revealed the three parameters: 1. psychological perception of the tasks, 2. adopted posture, and 3. manual handling of objects. Although the ergonomic assessment methods successfully evaluated the postural load, but the use of ergonomic assessment method directly to assess domestic tasks is not appropriate because other parameters such as psychological perception and manual handling of objects was also important to take into consideration when analysing the domestic tasks.

In addition to the mind map results, it is clear that whenever a person performs any domestic task, they are involved in three aspects: i. how the tasks should be done (psychological perception of the task), ii. using parts of the body to perform that task (adopted posture) and iii. lifting/lowering, pushing/pulling and carrying the objects (manual handling) during the performance of the tasks. Therefore, these three parameters are essential and more suitable for the evaluation of domestic tasks because they cover both occupational therapy and ergonomics perspective and are helpful for understanding domestic tasks. After selecting the parameters, it was decided that a subjective scale should be used in order to measure the psychological perception of the task whereas ergonomic techniques were used for measuring the adopted postures and manual handling of objects.



Multiplier table

Duration of task	Frequency per week: Once	Twice	3 times	4-7 times
Less than 5 mins	0.006	0.01	0.02	0.04
5 – 15 mins	0.02	0.05	0.07	0.17
16 – 25 mins	0.05	0.1	0.15	0.34
26 – 35 mins	0.07	0.15	0.22	0.51
36 – 45 mins	0.1	0.2	0.29	0.68
46 – 60 mins	0.12	0.26	0.38	0.88
More than 1 hr	0.18	0.38	0.54	1.25

Risk rating table

IADL Exposure Score	Risk Rating	AER implications about the task
< 1.6	Low	Task is easy to perform; but required caution
1.6 to 5	Moderate	Task is not easy to perform; required more consideration
> 5	High	Task is hard to perform; further investigation required urgently

Figure 9-2 Task assessment tool for ease and risk (AER)

Then the task assessment tool (see figure 9-2) was proposed which would be helpful in investigating and understanding the daily tasks by evaluating the psychological and physical risk factors and quantifying the load and risk related to the performance of domestic tasks. The designed tool is described as "a task assessment tool for ease and risk within the domestic environment" because it motivates the user to perform the tasks in the proper way (for example, using the appropriate body postures and analysing the load before handling during the performance). Calculating the risk level is also helpful for selecting alternative tasks depending on whether the risk level is high or moderate. Through this tool, a person can prioritize their tasks within the known risk level, according to their ability, and this reduces the stress on their body and can help them to improve their level of independence. However, it is expected that the designed tool will be helpful for occupational therapists, ergonomists, physiotherapists and general physicians, who will be able to recommend their patients to use this tool as developing the inventory for their daily tasks, so that they can easily identify or point out the tasks which are harder for them to perform and be better able to perform those particular tasks(s). In the end it is expected that the "Task Assessment Tool for Ease and Risk (AER)" will prove to be an efficient self-assessment tool and will help to enhance the health care professional services by providing this tool to the whole community in order to enable people to maintain their independence and stay in their own home as long as possible. Consequently, this will also help to reduce the financial burden on government officials and enable them to build up a society within the country with fewer issues of dependency. In addition to this the tool could be used remotely as an efficient self-assessment tool on sites such as www.agewelluk.org.uk or NHS direct. Enabling people to understand their tasks through this tool, perform their tasks in an efficient way and enjoy an independent life style at home as long as possible would help people future proof their ageing journey.

10 Conclusion

The following are the explicit conclusions which can be drawn from this thesis:

- A comprehensive and critical literature review discussed the problems faced by people in performing their activities of daily living and the implications of these for their quality of life. The literature review also critically and extensively discussed the methods used in ergonomics and occupational therapy and concluded that both disciplines have developed various methods with different aims, in order to benefit humanity, but it is mainly occupational therapy methods that are used to develop strategies of care of individuals, whereas ergonomics methods are used for fitting the tasks according to the person's ability. Researchers and practitioners should therefore help the community through advanced technological techniques (ergonomics) by developing the best fit between people and their daily tasks [9] which might prevent or reduce the likelihood of their functioning independently.

- A survey-based study on instrumental activities of daily living revealed that people are struggling with the tasks of general housekeeping, preparing meals, grocery shopping and laundry and want them to be modified or made comfortable.

  A food preparation survey in the present study found that generally people consider this to be an easy domestic chore, while a proportion of people found this chore hard because they found it physically demanding and complex to perform different sub-tasks in preparing food (such as chopping, slicing or stirring). Within the population studied, people considered themselves to be the primary cook. It was found that for the general population the hardest sub-tasks were peeling potatoes and chopping/slicing. The hardest sub-tasks in the food preparation task were moderately and significantly correlated with three variables, as shown in Table 5-7. The different age groups of people had a strong and significant association with sub-tasks with respect to "don't do it with ease", "physical demand required" and "complexity of task". It was also found that 31-50, 51-70 and 71-90 year-old respondents were struggling with three sub-tasks with respect to "don't do it with ease", "physical demand required" and "complexity of task" but a higher number of responses came from the 51-70 age group than from the other two age groups, as a proportion of respondents in the 51-70 year-old said that they didn't change their behaviour, and so they continued doing their daily tasks and did not adopt different strategies. However, the respondents in the older age group acknowledged their age and noticed their change in behaviour and adopted many strategies to make their tasks easier to perform. Therefore, it can be concluded that if people start adopting different strategies at an earlier age to perform their daily tasks, then they might be able to maintain their independence for a longer period of time.

A laundry survey study found that in general, people perceived laundry as an easy task but a proportion of people do not like to do laundry because they found it hard and complex to perform, so it affected the level of ease and required a degree of physical demand. It was found that the hardest part of doing laundry is drying clothes, which is moderately and significant correlated with the physical demand required, level of ease and complexity. It was also found that within the hardest sub-task (drying clothes) all three age groups were struggling, but that a higher number of responses came from the 31-50 age groups than from the other two groups (51-70 and 71-90). Thus a proportion of people are facing problems in performing laundry and have a pain in different parts of their body, and it was found that in drying clothes they had a higher proportion of problems compared to their performance of other sub-tasks, which confirms that drying clothes was the hardest task.

- In domestic mopping it is observed that ergonomic risk factors such as awkward postures and repetition exist in the home environment but usually people are unaware of them. The study adopted an ergonomic assessment method (REBA) to assess domestic mopping tasks and the results revealed that postures adopted during such tasks lie in the zone of moderate to high risk of injury. It disclosed that subjects were feeling moderate discomfort, which has a positive and significant correlation with the number of times people move their arms and hands (repetition). It also found that the perceived exertion and change of heartbeat has a positive correlation and significant effect, which means that the subjects also feel physical strain during the mopping task.

  A food preparation observational study used three ergonomics methods: REBA, LUBA and SI. Each subject considered the food preparation tasks as a short duration task and the average time to complete each sub-task was two minutes and twenty-one seconds. The average REBA score revealed that food preparation is a medium risk task and the average LUBA score was 7 which showed that food preparation needs further investigation about the postures adopted. The average strain index (see Table 5-19) suggested that in the food preparation task there is some risk involved, which is associated with distal upper extremities (arm, shoulder, elbow, wrist and hand). The average perceived discomfort and fatigue for the food preparation task was mild, the physical demand required was minor and the task was considered to be slightly complex. Based on the REBA and LUBA scores, the hardest sub-task in food preparation was stirring/frying, which was medium risk and required more caution when being performed. Similarly, the SI method indicated the hazardous nature of stirring/frying because it involves neck and back postures which deviate from the neutral position and also require a repetitive movement of different parts of the body (hand and wrist). The food preparation did not pose a high risk of injury, as the postures adopted and repetitive movements lasted for only short period of time. However, the food preparation task combined with other IADL tasks which forced a person to adopt similar postures and involved repetitive movement activities triggered more cause for concern, as these will affect our quality of life later on.

The laundry observational study mentioned the potential for ergonomic tools to be adopted in domestic settings, as doing laundry did not pose a high risk of injury as the postures adopted during laundry were of short duration and repeated infrequently but as in the case of the food preparation task, if combined with other IADL tasks they could trigger more cause of concern and might be responsible for changes in behaviour later stages of life. It was concluded that while doing laundry, people need to adopt different postures rather than remain in one posture, and this helps to reduce the postural loads, perceived discomfort and fatigue associated with laundry. The ethnography results were in agreement with the survey that the drying clothes sub-task scored highest in the REBA, RULA and LUBA scores. Furthermore, it showed that the average perceived discomfort and fatigue level was mild to moderate and the physical demand required was moderate and therefore the laundry task could be considered slightly to somewhat complex.

- Finally, this thesis has developed and presented a new self-assessment tool for the domestic environment, called a Task assessment tool for ease or risk (AER), which is based on three parameters: (i) psychological perception of the tasks, (ii) adopted postures and (iii) manual handling. AER makes the individual aware, through the knowledge of their own risk level, to be cautious in performing the tasks. AER can easily distinguish between those tasks which help the individual to take heed of the way in which he or she is performing the tasks. Performing them in non-neutral postures leads the individual to vulnerable conditions in the later stages of life, whereas having knowledge, through AER, of the risk level when performing a task will help to understand the right way to perform such tasks. Furthermore, the knowledge of the risk level revealed by the AER tool will provide the necessary information for a person to lead or adopt an efficient and independent lifestyle for as long as possible.

11 Contribution to knowledge

The knowledge of science progresses in small steps. Every small contribution adds to this knowledge and helps us to progress in understanding that area bit by bit. It is hoped that this project and the resulting thesis and publications have made a small contribution to our understanding of the tasks performed during activities of daily living, and how to perform them in ways that are essential for everyone's healthy lifestyle.

Although there are many published works intended for the domestic environment, most of these use ergonomic techniques to study people's home environment and address many issues and consequently resolve those issues by designing or redesigning tasks. In this research I have used three domestic tasks to understand the way in which people perceived and performed the tasks and analysed their adopted postures. The combination of the survey and observational study is helpful in order to understand the problems regarding the performance of daily tasks. Thus this thesis has made a contribution to evaluate and understand the person's own risk level in performing daily tasks through the self-assessment tool that has been developed.

In a mopping study it was found that the participants adopted different postures which deviated from a neutral posture (with a high average REBA score), and so they experienced physical strain and biomechanical stress on the muscles and required caution in performing this task. The mopping required repetitive movements, lifting, bending and twisting, which cause fatigue and increase the likelihood of back pain [262] and so mopping can be regarded as a strenuous task [291]. This thesis contributed by explaining to people that mopping is not an easy task and they must take heed of their adopted postures and keep monitoring their daily task risk through AER.

In another study which is based on a survey and observational study of food preparation and a laundry task, it was found that in each task there were sub-tasks which were harder to perform, based on three variables which make the task harder to perform: how easy the subjects found the task to complete, physical demand required and complexity. Through the food preparation and laundry surveys it was discovered which were the hardest sub-tasks in which people are struggling because they were not easy to perform, required physical demand and were considered complex. Similarly, through the observational study of food preparation and laundry, the hardest sub-tasks have been identified by using the different ergonomic assessment tools. In food preparation and laundry the hardest sub-tasks needed more consideration when performed.

Thus the thesis has contributed to the knowledge in this field by demonstrating that daily chores which are essential for healthy lifestyles are not easy to perform and it has also suggested that ergonomic tools can be adopted in the home environment. However, a person may perform many tasks simultaneously that involve non-neutral postures, which could trigger cause for concern in relation to affecting our quality of life. Early identification and having the knowledge of risk in performing daily tasks help people to maintain their independence in the later stages of life. This work has also contributed to the knowledge in this area by developing the self-assessment tool for ease and risk (AER) for the domestic environment which will assist people in performing their daily tasks in an efficient way so that their risk level which is predicted through AER should be minimized. Furthermore, it is hoped that the early detection of risks in our daily tasks might help to identify those risk factors which are responsible for musculoskeletal disorders, and this identification will in turn decrease the likelihood of dependency.

11.1 Published work

Zaheer, A., Carre, M., Yoxall, A., and Rowson, J. Evaluation of Adopted Postures and the Hardest Part of the Domestic Laundry Task. in Design4health. 2015. Sheffield, UK: Proceedings of the Third European Conference on Design4Health 2015.

11.2 Planned publication

Working on following publication which will also contribute to knowledge:

1. Evaluation of adopted postures in domestic mopping task
2. Evaluation of adopted postures in domestic food preparation
3. Comparison of middle age group and older age group people in relation to change in behaviour during performance of domestic food preparation and laundry tasks
4. Keep changing adopted postures provide the ease in performing daily tasks.
5. Task Assessment Tool for ease & risk (AER): Self-assessment tools develop to evaluate the ease & risk associated with the performance of tasks in domestic environment.

12 Limitations of the study

The following are the limitations of this thesis:

1. Firstly, it only uses three domestic tasks (mopping, food preparation and laundry), to analyse potential ergonomic methods, and so more domestic tasks may be required in order to generalize the results

2. In the ethnography study only two subjects were used, and it is possible that the results would vary with different subjects

3. In the survey and ethnography study, subjective measurements were used and it was assumed that all subjects answered correctly and honestly.

4. The sample size was small in relation to representing the whole population; results might vary and a larger sample size would be required in order to generalize the results.

13 Further research

A huge range of research could be conducted within the domestic environment. There is an opportunity for the ergonomist or health and safety professional to review the domestic tasks performed by people in depth. For future research it is recommended to have a more comprehensive study by using large number of people because the designed tool is in its infant phase, it required to carrying out more assessment to gather more data and confidence in the tool and bringing in professionals such as occupational therapists and physiotherapists.

It is also recommended for the future work that this designed tool have a potential to customize for other professionals such as designer who design things for older people in domestic environment but it required possible addition of other measurements factors such as baseline strength or age, physical health etc.

Similarly, it is recommended that this work should be extended by using other ergonomic risk factors (for example, repetitions, forceful, vibration and contact stress) and psychological ones (such as anxiety, fatigue and dexterity). Currently, flexion and extension of the wrist, shoulder, neck and back have been considered, and it is recommended to consider abduction, adduction and side or lateral bending in future work in order to refine the assessment criteria, as it might affect a person's rating sections. In this assessment tool, the height and weight of a person is not considered, but this might be useful in future studies, as well as considering the person's BMI index which might affect the posture adopted in performing activities of daily living. In order to increase the accuracy further, it is recommended that there should be further development of the postural angles identification by using the picture recognition software as used by Mohamad et al. in 2009 [333].

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15 Appendix A

15.1 Questionnaire on Instrumental activities of daily living (IADL)

Instrumental Activities of Daily Living (IADL) Task Questionnaire

Incorporating ease of use into everyday design means more people can benefit from such products and services. This is becoming increasingly important as many people are struggling with daily life, the Activities of Daily Living (ADL) and Instrumental Activities of Living (IADL). ADL refers to those activities which are essential to people being able to live independently, they are especially related to the movement and care of their body

Note: Please read the following information carefully.
This survey is for research purpose only, any information you give will not be used for any other purpose. Your participation in this survey is entirely voluntary. You may withdraw from participation at any time with no adverse consequences. The information you give will be kept strictly confidential. Any information you give will be anonymised before use, and will not be personally identifiable. This research has been approved by the ethics committee of the Department of Mechanical Engineering of The University of Sheffield. If you agree please proceed further, otherwise close the survey.

Data protection and confidentiality: This survey is being done as part of a PhD dissertation at University of Sheffield, all responses to this questionnaire will remain anonymous. The data collected will be used to design assessment tool for the ease of use. If you have any questions or concerns about completing the survey you may contact researcher at, mep12az@sheffield.ac.uk

Daily Living Tasks

1. Please rate the following tasks in terms of difficulty to perform

	Easy	Moderate	Hard	Extremely Hard	Don't do
Using the telephone	○	○	○	○	○
Use computer / access internet	○	○	○	○	○
Grocery Shopping	○	○	○	○	○
Preparing meals	○	○	○	○	○
General housekeeping	○	○	○	○	○
Doing laundry	○	○	○	○	○
Managing any medication	○	○	○	○	○

2. Please rate the following tasks with respect to the amount of physical effort required:

	Low effort	Moderate effort	High effort	Don't do
Making a telephone call				
Use computer / access internet				
Going round the supermarket independently				
Going to the local corner shop independently				
General housekeeping				
Able to perform personal laundry alone				
Use car				
Use public transport				
Managing any medication				
Managing house hold paper work				

3. For each of these tasks, have you modified or changed how you perform them over the years to make them easi to do? (tick all that apply)

	No modification	Change posture eg. sit down to do	Use tool/aid	Take longer over doing the task (with breaks)	Ask for assistance	Avoid doing	Don't d
Making a telephone call							
Use computer / access internet							
Going round the supermarket							
Going to the local corner shop							
General housekeeping							
Able to perform personal laundry							
Use car							
Use public transport							
Managing any medication							
Managing house hold paper work							

4. Which of your everyday tasks causes you the most physical discomfort and why?

5. Which of your everyday tasks do you feel is the most awkward to perform and why?

6. Which of your everyday tasks do you spend most of your time doing and how long?

7. Which of your everyday tasks would you most like to be modified to make it more comfortable?

8. Indicate any tools or assistive device you use regularly (tick all that apply)


Jar opener


Easy grip cutlery


Grab rails


Walking trolley


Plug adapter grip


Walking stick


Grabber

- [ ] Jar opener
- [ ] Easy grip cutlery
- [ ] Grab rails
- [ ] Walking trolley
- [ ] Plug adapter grip
- [ ] Walking stick
- [ ] Grabber
- [ ] Other (please specify):

9. Do you experience any pain or discomfort in your hand, wrist, arm, shoulders, neck or back when carrying out your every day tasks?

- No
- Yes

Please specify task and area :

10. How severe would you rate the discomfort?

- Mild
- Moderate
- High
- Extreme

Monitoring Information

Please give your personal details. All data remain confidential and anonymous.

11. Please select:

- Male
- Female

12. Please select:

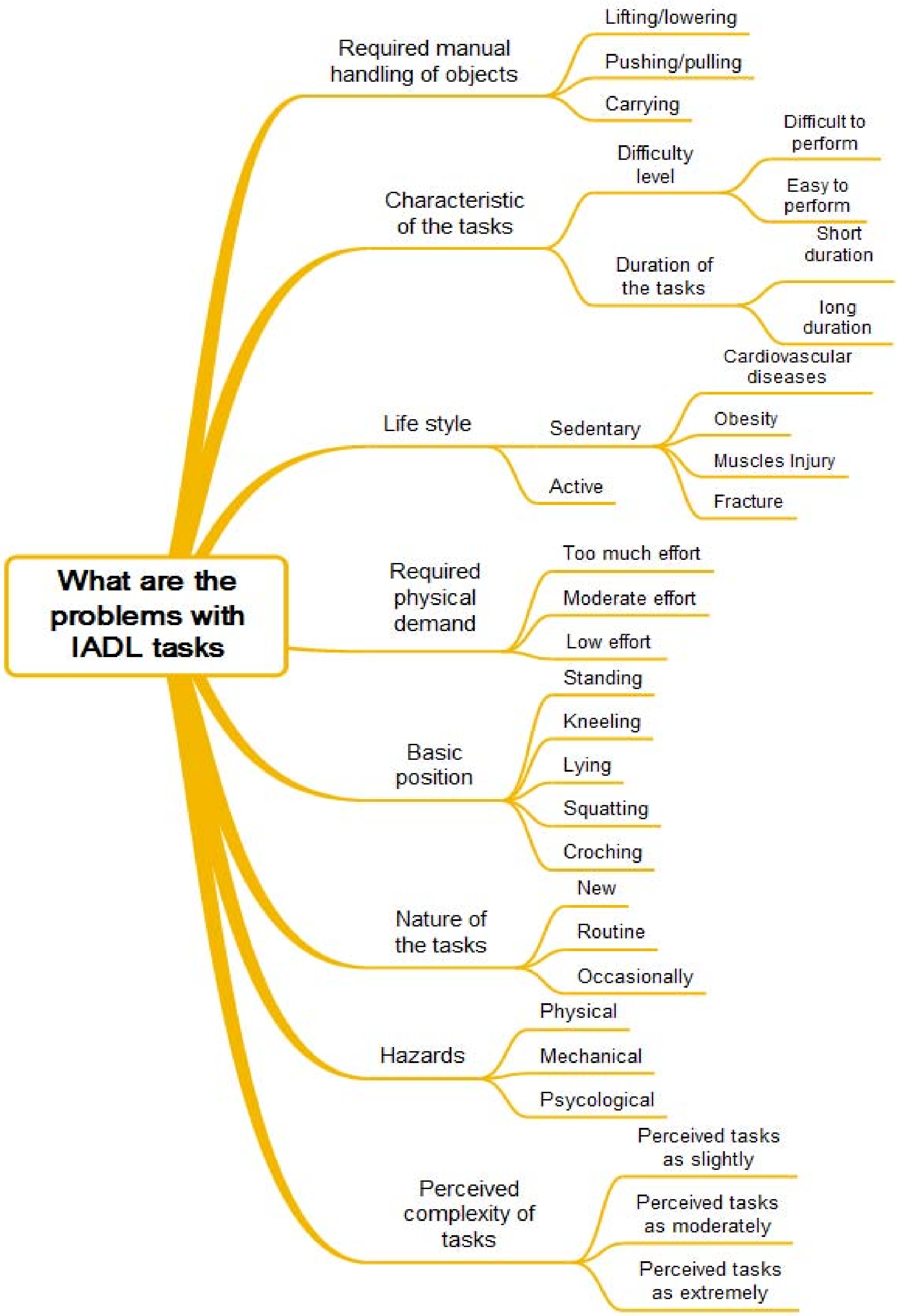
- 10-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 90+

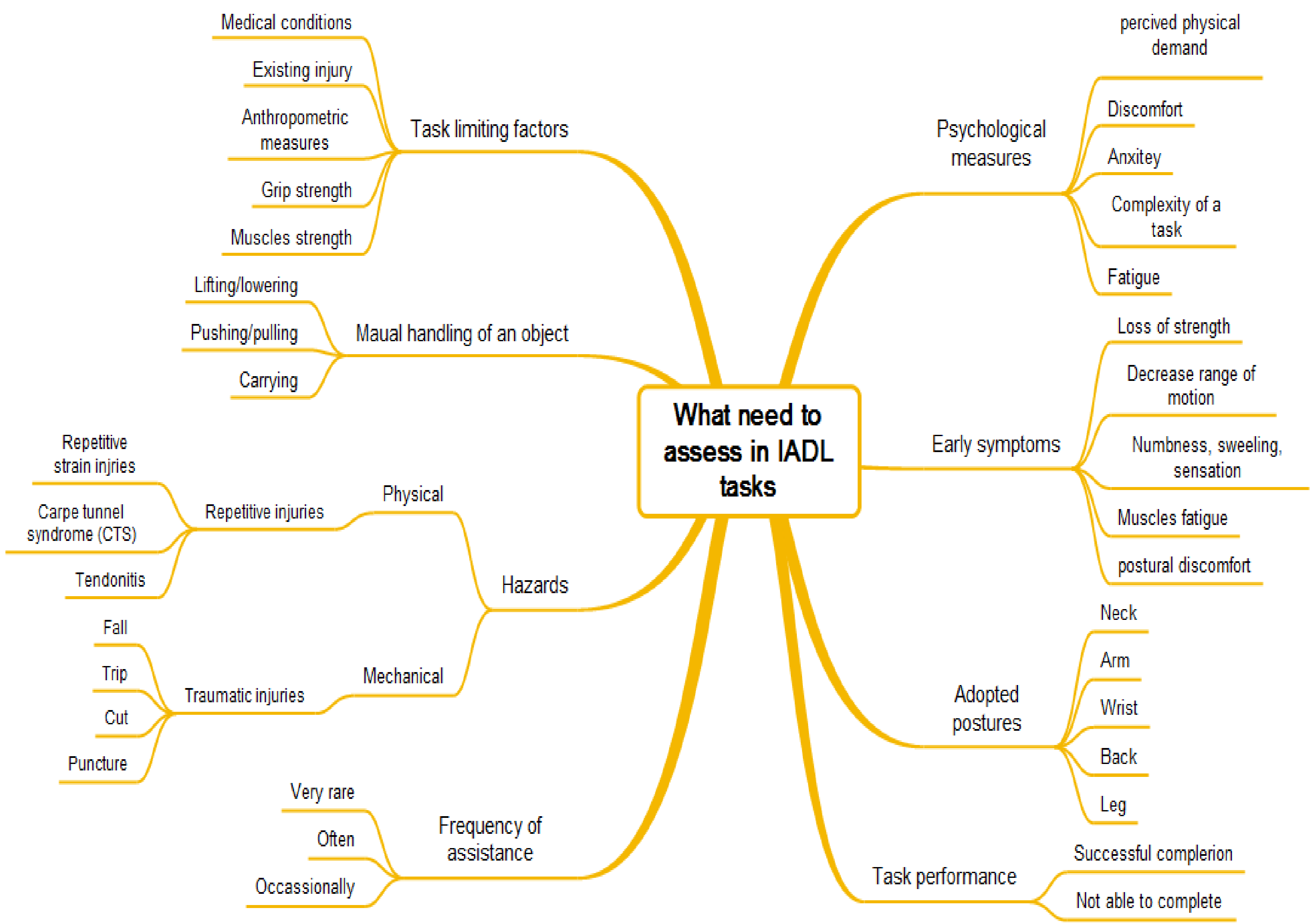
13. Do you consider yourself to have a disability or long term health condition that affects your daily activities? Please choose which conditions apply

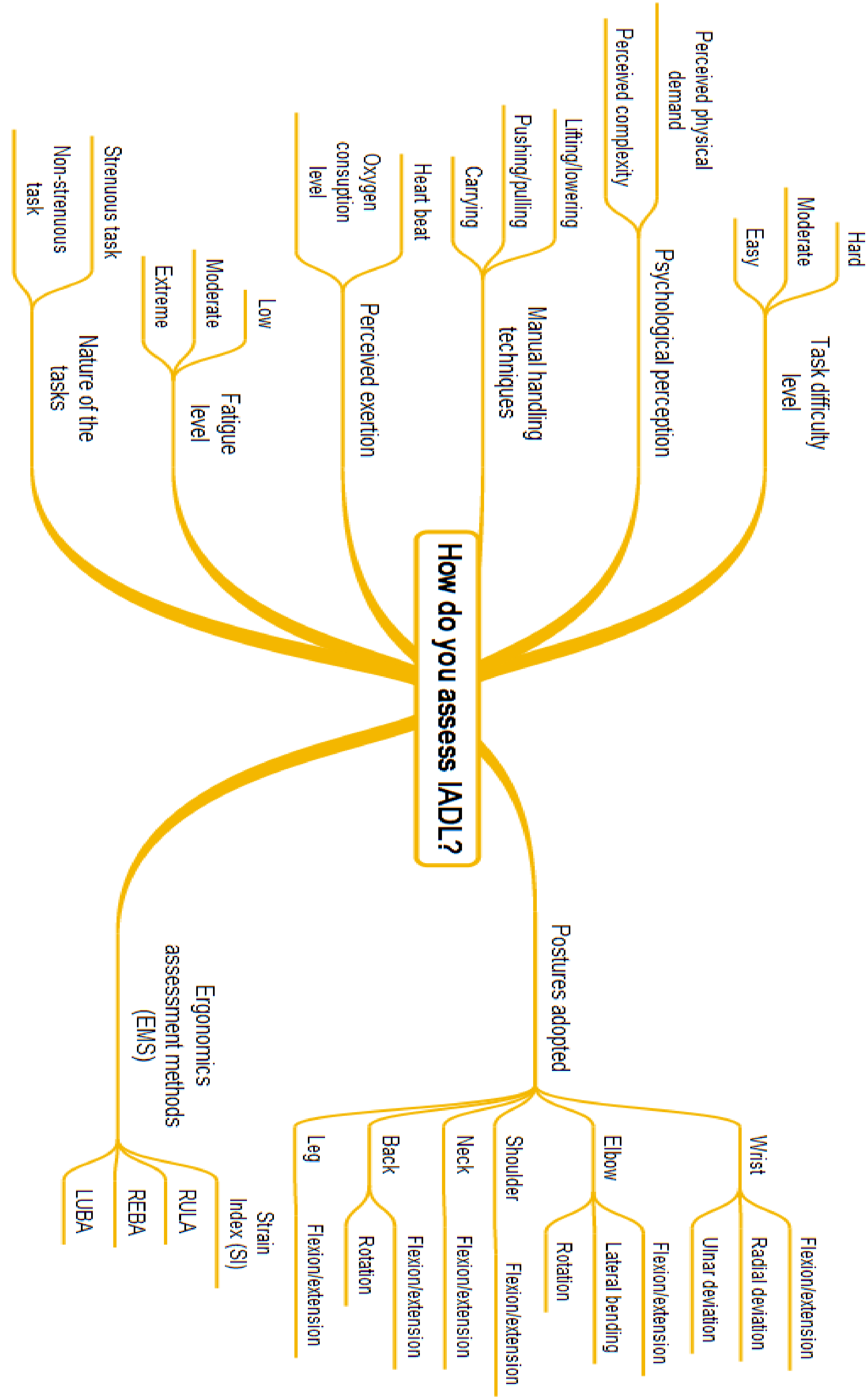
- None
- Visual Impairment
- Physical disability affecting your arms and upper body
- Physical disablity affecting your mobility to move around
- Other (please specify):

*** The End***

15.2 Mind maps




What need to assess in IADL tasks
Task limiting factors
Medical conditions
Existing injury
Anthropometric measures
Grip strength
Muscles strength
Maual handling of an object
Lifting/lowering
Pushing/pulling
Carrying
Hazards
Physical
Repetitive injuries
Repetitive strain injries
Carpe tunnel syndrome (CTS)
Tendonitis
Mechanical
Traumatic injuries
Fall
Trip
Cut
Puncture
Frequency of assistance
Very rare
Often
Occassionally
Psychological measures
percived physical demand
Discomfort
Anxitey
Complexity of a task
Fatigue
Early symptoms
Loss of strength
Decrease range of motion
Numbness, sweeling, sensation
Muscles fatigue
postural discomfort
Adopted postures
Neck
Arm
Wrist
Back
Leg
Task performance
Successful complerion
Not able to complete


How do you assess IADL?
Task difficulty level
Hard
Moderate
Easy
Psychological perception
Perceived physical demand
Perceived complexity
Manual handling techniques
Lifting/lowering
Pushing/pulling
Carrying
Perceived exertion
Heart beat
Oxygen consuption level
Fatigue level
Low
Moderate
Extreme
Nature of the tasks
Strenuous task
Non-strenuous task
Postures adopted
Wrist
Flexion/extension
Radial deviation
Ulnar deviation
Elbow
Flexion/extension
Lateral bending
Rotation
Shoulder
Flexion/extension
Neck
Flexion/extension
Back
Flexion/extension
Rotation
Leg
Flexion/extension
Ergonomics assessment methods (EMS)
Strain Index (SI)
RULA
REBA
LUBA

15.3 Questionnaire on Food preparation tasks

<u>Questionnaire on Food preparation tasks</u>

The aim of this questionnaire is to collect your views on what is the hardest part of food preparation and also ask you to rate the difficulty experienced in terms of physical demand and complexity in some different subtasks involved in food preparation.

Food preparation involves the selection, measuring and combining of ingredients in specific quantities. It also involves gathering pans and utensils, preparing vegetables and basic cooking.

The questionnaire is divided into two sections. Section A is related to general information about your cooking habits and behaviour. Section B is scenario based and gathers information about each of the different subtasks.

<u>Section A: General habits & behaviour</u>

1.Would you describe yourself as a primary or secondary cook in your house? (A primary cook is the one who cooks meals most often and carries out extra activities such as baking etc. A secondary cook is the one who assists in preparation, and performs clean-up activities etc.)

i. Primary cook ☐

ii. Secondary cook ☐

iii. Other ☐ (Please explain:_____________________________)

2. How many people (including yourself) share your main meal of the day? ☐

3. Consider a typical week in your household and the seven main meals of the week. Of these seven, how many are:

i. Prepared from raw or natural-state ingredients? ☐	Of these how many do you:
	i. Cook yourself? ☐
	ii. Assist in the cooking? ☐
	iii. Not assist in any way? ☐

ii. Made using pre-prepared elements (e.g. pre-chopped/diced vegetables and meat, frozen or tinned items)?	☐	Of these how many do you: i. Cook yourself? ☐ ii. Assist in the cooking? ☐ iii. Not assist in any way? ☐
iii. Completely pre-prepared (e.g. ready-made meals, takeaways, meals out)	☐	Of these how many do you: i. Cook yourself? ☐ ii. Assist in the cooking? ☐ iii. Not assist in any way? ☐

(Please ensure the total 7)

4. How would you rate your skills in the kitchen? (Please circle which is appropriate)

1	2	3	4	5
Can't cook	Can make toast	Can cook one meal	Can follow a given recipe	Confident cook

Section B: Scenario

Joe is preparing sausage and mash with onion gravy. He gathers pans and utensils and also gathers vegetables (eight potatoes and four onions). He peels the potatoes and puts them on to boil, then slices the onions and fries them in some oil. The sausages are also fried in oil. Based on this scenario please answer the following questions.

1. Overall, how easy would you find it to complete each sub task?

Sub tasks	With ease	Minor effort	Moderate effort	Significant effort	Delegate this task to someone else and why
Gathering the pans and utensils					
Gathering potatoes for rinse					
Peeling potatoes					
Chopping/slicing					
Stirring/frying					

2. Please indicate the **physical demand** you feel would be required for each sub task?

Sub tasks	None	Minor	Moderate	Too much
Gathering the pans and utensils				
Gathering potatoes for rinse				
Peeling potatoes				
Chopping/slicing				
Stirring/frying				

3. Please indicate the **complexity** of the subtask

Sub tasks	Not at all	Slightly	Somewhat	Moderately	Extremely
Gathering the pans and utensils					
Gathering potatoes for rinse					
Peeling potatoes					
Chopping/slicing					
Stirring/frying					

4. From your own food preparation experiences what would you say is the hardest part and why?

Monitoring Information:

Please state:

Age: _____________; Gender: _______________________

Height: ____________; Weight: ______________________

Please state your lifestyle: highly active☐, active☐ and inactive ☐

Do you have any existing condition/injuries that may have affected your effort levels responses or

behaviour? (Yes/No):__________if yes, please provide brief details if you are willing to: ______________________

____

(Optional)

***** Thank You *****

Note:

This research has been approved by the ethics committee of the Department of Mechanical Engineering of the University of Sheffield. This survey is being done as part of a PhD dissertation at University of Sheffield, all responses to this questionnaire will remain anonymous. The data collected will be used to design assessment tool for the ease of use. If you have any questions or concerns about completing the questionnaire you may contact the researcher (Asim Zaheer) at, mep12az@sheffield.ac.uk

15.4 Questionnaire on Laundry task

Questionnaire on Laundry tasks

The aim of this questionnaire is to collect your views on what is the hardest part of doing laundry and also ask you to rate the hardness, physical demand and complexity of different tasks involved in doing laundry.

We have divided the whole laundry process into five tasks: gathering, sorting and pretreatment, washing machine preparation, drying clothes and folding clothes.

The first step is to gather dirty laundry from the bin and also look for dirty clothes in other rooms and then to take the clothes to the washing machine.

The second step consists of sorting and pretreatment. It can involve sorting into light, dark and white clothes or sorting with respect to garment tag (hot, warm, cold and delicate). In addition this can be when any pretreatment such as stain removers are applied.

The third step is to prepare the washing machine and select the desired cycle setting; this step can be broken down into loading the clothes into the drum, adding washing powder/liquid, closing the machine door and setting the cycle dial.

The fourth step is drying the clothes; this can be done in a variety of ways, either by use of clothes drier or by hanging the washing on a line or airer. This task includes unloading the washing machine, and putting the clothes out to dry.

The fifth and final step is folding the dry clothes ready for distribution to the household.

The questionnaire divided into two sections "A" and "B". Section A is gathering some general information. Section B is gathering information about each of the different tasks described above.

Section A: General information

I. When doing laundry in your house, how often do you do it?

II. How many people do you do laundry for?

III. Typically how many loads do you do in a single time?

IV. How many loads would you do in a typical week?

V. How many times do you typically have to go up and down stairs gathering the laundry?

VI. In which room is your washing machine located?

Section B: Each task

1. For each task how easy do you find it to complete

Step no.	Laundry tasks	With ease	Moderate effort	Significant effort	Delegate this task to someone else	If delegated please state why:
1st	Gathering the clothes					
2nd	Sorting and pretreatment					
3rd	Washing machine preparation					
4th	Drying clothes					
5th	Folding clothes					

2. For each task please indicate physical demand required

Step no	Laundry tasks	None	Minor	Moderate	Too much
1st	Gathering the clothes				
2nd	Sorting and pretreatment				
3rd	Washing machine preparation				
4th	Drying clothes				
5th	Folding clothes				

3. For each task please indicate tasks complexity (Perceived number of procedural steps)

Step no	Laundry tasks	Not at all	Slightly	Somewhat	Moderately	Extremely
1st	Gathering the clothes					
2nd	Sorting and pretreatment					
3rd	Washing machine preparation					
4th	Drying clothes					
5th	Folding clothes					

4. Please describe what you have to do in the following tasks

I. Gathering laundry: ____

____

III. Washing machine preparation:____

____

IV. Drying clothes: ____

____

V. Folding clothes: ____

____

5. Please state any particular difficulties involved in the following tasks

I. Gathering laundry: ____

____

II. Sorting and preparation laundry: ____

____

III. Washing machine preparation:____

____

IV. Drying clothes: ____

____

V. Folding clothes: ____

____

Monitoring Information

Please state your age and gender: _______________________

Please state approximate height and weight: ____________________________________

Please state your lifestyle (highly active, active and inactive):_______________

Do you have any existing condition/injuries that may have affected your effort level responses or behavior? (Yes/No):__________if yes, please provide brief detail: _______________________(Optional)

Note:

This research has been approved by the ethics committee of the Department of Mechanical Engineering of the University of Sheffield. This survey is being done as part of a PhD dissertation at University of Sheffield, all responses to this questionnaire will remain anonymous. The data collected will be used to design assessment tool for the ease of use. If you have any questions or concerns about completing the questionnaire you may contact researcher at, mep12az@sheffield.ac.uk

15.5 AER record sheet feedback:

AER record sheet feedback:

1. Please rate the AER record sheet on the following statements by using 5 point scale (1= strongly disagree to 5= strongly agree)

Statements	Rating scale				
	1	**2**	**3**	**4**	**5**
• AER recording sheet is simple and easy to use	1	2	3	4	5
• AER recording sheet is free from ambiguity and easily understandable	1	2	3	4	5
• AER is applicable to almost all the tasks performed in home environment	1	2	3	4	5
• AER do not need training to do assessment	1	2	3	4	5
• AER scoring system (risk rating- low, moderate, high) is easy and understandable	1	2	3	4	5
• Frequency and duration multiplier are easy to select from the multiplier table	1	2	3	4	5
• IADL exposure score is easy to calculate	1	2	3	4	5
• Selection of final risk level (low, moderate, high) from risk rating table is easy	1	2	3	4	5

2. What did you like most about the AER booklet and recording sheet?

3. What do you find difficult about the AER recording sheet and why?

4. What aspect of the recording sheet could be improved?

5. Any other comments

6. Overall, I would rate AER record sheet as: (please circle)

Good Average Poor

Thank you for your feedback

16 Appendix B

16.1 List of activities of daily living tasks performed by individual's in typical day or a week

Cooking activities	
1.1	Food preparation
1.2	Opening cans
1.3	Manipulating saucepans
1.4	Lifting and pouring
1.5	Washing dishes
1.6	Drying up
Cleaning activities	
2.1	Emptying the bins
2.2	Cleaning kitchen surfaces
2.3	Cleaning fridge
2.4	Cleaning bathroom
2.5	Hovering
2.6	Moping
2.7	Polishing/Dusting
2.8	Sweeping
Laundry tasks	
3.1	Loading washing machine
3.2	Setting out clothes to dry
3.3	Ironing
3.4	Bed making
Personal care tasks	
4.1	Shaving
4.2	Teeth brushing
4.3	Face washing
4.4	Bath/shower
4.5	Hair combing
Grocery shopping	
5.1	Pushing shopping cart
5.2	Pushing baby pram
5.3	Carrying shopping bags
Childcare activities	
6.1	Dressing/undressing child
6.2	Washing child
6.3	Carrying child
Gardening activities	
7.1	Mowing lawn
7.2	Planting/weeding
7.3	Watering
7.4	Pruning

16.2 7 Day Activity Log

7 day Activity Log

Name: ____________________

Age: ____________________

Gender: ____________________

Starting date: ______________

Finishing date: ______________

Instructions:

At the start of everyday please write the day and date as an entry across the log book. Every day for the duration of the study please note every time you complete one of the tasks in the activity code key overleaf, when you started the task and how long it went on for (round up to the nearest minute). If the task involved lifting, please add a comment about what was lifted and if possible an estimate of its weight. Feel free to add comments on an activity if the pace of the task was particularly rushed or relaxed.

Activity code key

Cooking activities	
1.1	Food preparation
1.2	Opening cans
1.3	Manipulating saucepans
1.4	Lifting and pouring
1.5	Washing dishes
1.6	Drying up
Cleaning activities	
2.1	Emptying the bins
2.2	Cleaning kitchen surfaces
2.3	Cleaning fridge
2.4	Cleaning bathroom
2.5	Hovering
2.6	Moping
2.7	Polishing/Dusting
2.8	Sweeping
Laundry tasks	
3.1	Loading washing machine
3.2	Setting out clothes to dry
3.3	Ironing
3.4	Bed making

Personal care tasks	
4.1	Shaving
4.2	Teeth brushing
4.3	Face washing
4.4	Bath/shower
4.5	Hair combing
Grocery shopping	
5.1	Pushing shopping cart
5.2	Pushing baby pram
5.3	Carrying shopping bags
Childcare activities	
6.1	Dressing/undressing child
6.2	Washing child
6.3	Carrying child
Gardening activities	
7.1	Mowing lawn
7.2	Planting/weeding
7.3	Watering
7.4	Pruning

Example table

Please see the table below for recording the rest of the activities

Start of each day

Activity code	Time started	Duration (mins)	Comments (optional)
— DAY 0 Monday —			
4.2	7.15	2	rushing
1.1	7.18	6	packed lunches
2.1	7.40	3	full black sack (heavy)

Code from key

Comments to add any details

Activity code	Time started	Duration (mins)	Comments

Activity code	Time started	Duration (mins)	Comments

Data about your household

Number of adults: ________________

Number of children (2-18yrs): ________________

Number of infants (<2yrs): ________________

Style of home: House/Bungalow/Flat/Other__________

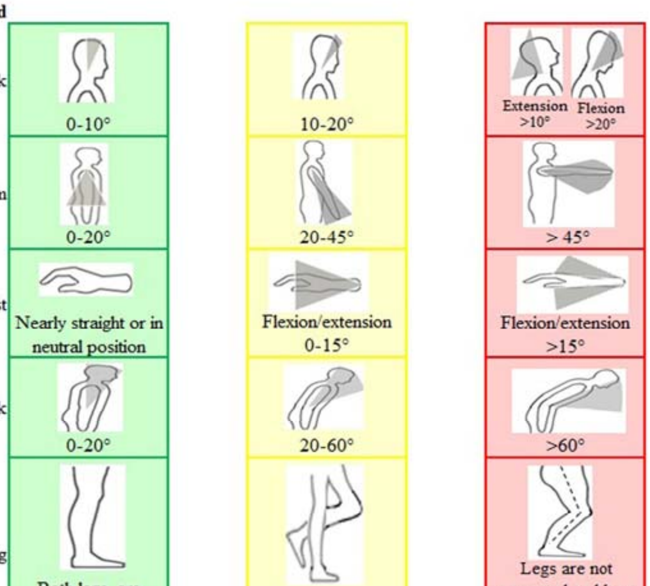
General lifestyle status: Active/Inactive

16.3 Task assessment tool for ease and risk (AER)

Task Assessment Tool for Ease and Risk (AER) Record Sheet
(Version 1)

Task name:

	Rating 1	Rating 2	Rating 3	Score
Psychological Perceptions				
Perceived physical demand required	None OR Minor	Moderate	Too much	
Perceived complexity	Not at all OR Slight	Moderate	Extreme	
Postures adopted				
Neck	0-10°	10-20°	Extension >10° Flexion >20°	
Arm	0-20°	20-45°	> 45°	
Wrist	Nearly straight or in neutral position	Flexion/extension 0-15°	Flexion/extension >15°	
Back	0-20°	20-60°	>60°	
Leg	Both legs are straight and level or in a sitting position	One or both legs are bent from knees	Legs are not supported and bent from knees (flexion) more than 30°	
Manual handling Lifting/lowering, pushing/pulling and carrying	Light (e.g. <1 kg)	Moderate (e.g. 1 to 5 kg)	Heavy (e.g. > 5 kg)	



Total of all of the above

X

Frequency per week

Selected Multiplier

=

IADL Exposure Score

Duration per day

Multiplier table

Duration of task	Once	Twice	3 times	4-7 times
	Frequency per week			
Less than 5 mins	0.006	0.01	0.02	0.04
5 – 15 mins	0.02	0.05	0.07	0.17
16 – 25 mins	0.05	0.1	0.15	0.34
26 – 35 mins	0.07	0.15	0.22	0.51
36 – 45 mins	0.1	0.2	0.29	0.68
46 – 60 mins	0.12	0.26	0.38	0.88
More than 1 hr	0.18	0.38	0.54	1.25

Risk rating table

IADL Exposure Score	Risk Rating	AER implications about the task
< 1.6	Low	Task is easy to perform; but required caution
1.6 to 5	Moderate	Task is not easy to perform; required more consideration
> 5	High	Task is hard to perform; further investigation required urgently

Task Risk Level L M H

(Please circle)

16.4 Task assessment tool for ease and risk (AER) Booklet

Task Assessment Tool for Ease and Risk (AER) within the Domestic Environment

The task assessment tool for ease and risk (AER) evaluates the risk associated with the performance of daily domestic tasks. The tool uses the self-assessment of daily tasks to detect early warnings about habits and behaviour before an injury actually occurs. The tool is based on three risk parameters: the psychological perception of the task, the postures adopted and the manual handling load.

Who can use the AER?

AER is simple to employ and any person can benefit from using it to analyse their performed tasks. People of any age and gender can easily use AER. However, people aged over 65 years may need assistance from another adult or healthcare professional to complete the assessment. It can also be used with a patient who is under observation by healthcare professionals as a means of assessing their performance of instrumental activities of daily living tasks.

What tasks can be assessed?

The design tool specifically covers instrumental activities of daily living (IADL) tasks (see page 4) but can also be extended to cover all tasks performed in the home environment. In order to carry out an assessment you will need: this booklet, a record sheet, pen or pencil and clock. It requires little or no training about postures adopted and manual handling of objects during the performance of tasks. The designed record sheet, use through the assessment with simple categories for the postures.

The AER is capable of assessing the risk level associated with individual tasks; however, it can also be used to assess the domestic load of an individual over time. Assessing weekly tasks using the IADL task list (see page 4) to record every single task can identify the overall domestic load of a person. The tool is helpful to identify those tasks which require caution and might be responsible for the decline in a person's ability. AER has the ability to compare the current risk levels with previous or future risk levels and quantify changes in ability when activities of daily living are performed repeatedly over time. Through the quantification of risk, the designed tool provides information, which helps a person to prioritize the tasks according to their ability to perform them. The development of AER plays a vital role in maintaining the person's independence level through preventing and controlling risk because by knowing their own risk level, they can adjust their own environment or habits to reduce the physical effort in performing that task.

Turn over for step by step guide

Step by Step Guide

1. Select and record the IADL task to be assessed (see IADL tasks list on page 4)

2. Record the task duration (time spent to complete the tasks)

3. Record the number of times the task is performed in a typical week

4. Think about your perception of the task and rate the physical demand and complexity using the three-point rating scale

5. For this assessment, think about the postures adopt when carrying out the task. Use the rating scale to record the most extreme posture adopted. By "most extreme" this means most uncomfortable in terms of bending, twisting or reaching, and working with your neck or back bent

6. Consider manual handling (lifting/lowering, pushing/pulling, and carrying) during the task and rate it as light, moderate or heavy

7. Add the scores of each parameter (**4, 5** & **6**) and record in "total of all of the above box".

8. Select the appropriate frequency and duration multiplier from the multiplier table, e.g. if a task duration is 26 minutes and frequency is 3 times in a week then multiplier is 0.22 (see figure below) and record the multiplier in a respective box.

Frequency: 3 time

Duration: 26

Multiplier table

Duration of task	Once	Twice	3 times	4-7 times
Less than 5 mins	0.006	0.01	0.02	0.04
5 – 15 mins	0.02	0.05	0.07	0.17
16 – 25 mins	0.05	0.1	0.15	0.34
26 – 35 mins	0.07	0.15	$\boxed{0.22}$	0.51
36 – 45 mins	0.1	0.2	0.29	0.68
46 – 60 mins	0.12	0.26	0.38	0.88
More than 1 hr	0.18	0.38	0.54	1.25

(Columns: Frequency per week)

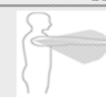
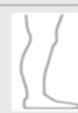
9. Multiply **7** X **8** and record in IADL exposure score box.

10. Look up the risk rating for the IADL exposure score and record the final result.

Assessment tool for ease and risk (AER) Record Sheet

(Version 1)

1 Task name:

	Rating 1	Rating 2	Rating 3	Score
4 Psychological Perceptions				4
Perceived physical demand required	None OR Minior	Moderate	Too much	
Perceived complexity	Not at all OR Slight	Moderate	Extreme	
5 Postures adopted				5
Neck	 0-10°	 10-20°	 Extension >10° Flexion >20°	
Arm	 0-20°	 20-45°		
Wrist	 Nearly straight or in neutral position	 Flexion/extension 0-15°	 Flexion/extension >15°	
Back	 0-20°	 20-60°		
Leg	 Both legs are straight and level (or) in a sitting position	 One or both legs are bent from knees	 legs are not supported and bent from knees (flexion) more than 30°	
6 Manual handling				6
Lifting/lowering, pushing/pulling and carrying	Light (e.g. <1 kg)	Moderate (e.g. 1 to 5 kg)	Heavy (e.g. > 5 kg)	

Total of all of the above 7

3 Frequency per week

x

8 Selected Multiplier

=

9 IADL Exposure Score

2 Duration per day

Multiplier table 8

Duration of task	Frequency per week: Once	Twice	3 times	4-7 times
Less than 5 mins	0.006	0.01	0.02	0.04
5 – 15 mins	0.02	0.05	0.07	0.17
16 – 25 mins	0.05	0.1	0.15	0.34
26 – 35 mins	0.07	0.15	0.22	0.51
36 – 45 mins	0.1	0.2	0.29	0.68
46 – 60 mins	0.12	0.26	0.38	0.88
More than 1 hr	0.18	0.38	0.54	1.25

10 **Risk rating table**

IADL Exposure Score	Risk Rating	AER implications about the task
< 1.6	Low	Task is easy to perform, but required caution
1.6 to 5	Moderate	Task is not easy to perform required more consideration
> 5	High	Task is hard to perform, further investigation required urgently

Task Risk Level L M H 10

(Please circle)

<u>**IADL Tasks List**</u>

Please select and evaluate risk for the activities which you performed in your daily life:

Please state:
Age:______________
Gender: ___________

Basic everyday activities		Total Score	Frequency	Duration in minutes	Selected multiplier	*Exposure score*	*Exposure Risk*
Cooking activities	Food preparation						
	Opening cans						
	Using saucepans						
	Lifting and pouring						
	Washing dishes						
	Drying						
Cleaning activities	Emptying the bins						
	Cleaning kitchen surface						
	Cleaning bathroom						
	Vacuuming						
	Mopping						
	Polishing/Dusting						
	Sweeping						
Laundry tasks	Loading washing machine						
	Setting out clothes to dry						
	Ironing						
	Bed making						
Personal care tasks	Shaving						
	Brushing teeth						
	Washing face						
	Bath/shower						
	Combing hair						
Grocery shopping	Pushing shopping cart						
	Pushing baby pram						
	Carrying shopping bags						
Children activities	Dressing/undressing child						
	Washing child						
	Carrying child						
Gardening Activities	Mowing lawn						
	Planting/weeding						
	Watering						
	Pruning						
Total Score							

Total Activities performed in a typical week		
Sum of all exposure scores		
Domestic load and risk level for typical week		Risk Level **L M H**

(Please circle)

17 Appendix C

17.1 Recommendation for controlling your risk level in daily tasks [329]

Basic everyday activities	Risk level		Control Measures	Residual Risk level
Cooking activities	Moderate Risk	High Risk	➢ Avoid prolonged standing; use a stool or high chair to sit when cooking, chopping/slicing vegetables, and washing dishes ➢ Stand close to the sink and avoid bending or stooping. ➢ Avoid using a sink which is too deep ➢ Try to keep your back as straight as possible ➢ Avoid lifting heavy pots, dishes, trays, kettles etc. ➢ Avoid prolonged postures which lead to postural strain ➢ Avoid tasks which require bending or reaching too low or too high ➢ Store the items which are often used, such as trays, pots and pans, within easy reach to avoid excessive reaching or bending. ➢ Work surface or kitchen counter top should be proper height, to evade excessive bending ➢ Adjust your cooker height. If it is low, bend your knees not your back ➢ Avoid bending and twisting simultaneously. Keep the back straight and bend knees when working with fridge/freezer and oven.	If all recommendation are placed properly, then they will help the individual to reduce the residual risk level
Cleaning activities		High Risk	➢ Hoovering pace should be one room per day ➢ Use cylinder hoovers instead of upright hoovers, as cylinder hoovers are lighter than upright. ➢ While hoovering, use your leg power to walk along and move your whole body to and fro with a sweeping action. ➢ Use extra extension poles and avoid twisting, reaching and bending movements. ➢ Polishing/dusting pace should be one room per day ➢ Using a dusting device such as a feather duster to minimize excessive reaching ➢ Polishing/dusting should be done below the shoulder height (do not over-extend) and use each hand alternatively. ➢ For high dusting, use telescopic handles or a ladder. Use both hands to hold handle, keep the elbows close to your body and diminish excessive reaching ➢ Bend your knees not back when emptying the bins	

Laundry tasks	Moderate Risk	High Risk	➢ Bend knees, not back, during laundry ➢ Kneel on a cushion to put the dirty clothes in to the washing machine and to take out the wet clothes out Use a stool or low chair beside the washing machine to transfer the clothes ➢ Try to avoid repetitive movements while drying and folding clothes ➢ Don't lift and carry the laundry basket full of clothes ➢ Use an anti-fatigue mat to reduce standing fatigue ➢ Ironing pace should be 10 minutes or less per day ➢ Adjust ironing surface height, so it is high enough to avoid bending or stooping. Make sure the height is not too high, otherwise it will continuously raise the arm and put a strain on upper back, shoulder and neck ➢ Stand close as possible to the iron stand ➢ Avoid prolonged standing and use a stand up chair. it helps to maintain good posture and also reduces some weight from the legs. ➢ if possible, use a light weight iron such as a steam iron, as this need less effort for ironing ➢ Avoid repetitive bending and twisting during ironing ➢ Avoid bending or stretching over bed; sit on your knees to make your bed ➢ Use fitted bed sheets, that are easy to use and involve lesser lifting and bending ➢ Try to use an assistive device (such as Bed-MadeEZ) in making your bed.	If all recommendation are placed properly, then they will help the individual to reduce the residual risk level
Personal care tasks	Moderate Risk	High Risk	➢ Avoid prolonged standing ➢ Use a stool or high chair while shaving, cleaning your teeth and washing your face, and avoid bending or stooping ➢ While having a shower, if you have a problem in standing use a stool or high chair to sit on ➢ Avoid bending over sink while washing your hair, as it aggravates strain on your back ➢ Do not raise your hands above the shoulder while having a bath, to scrub your back or comb your hair. Use an ergonomically designed assistive device to do these. ➢ Be careful when sitting or standing and getting out of the bath tub.	

Grocery Shopping	Moderate Risk	High Risk	➢ Plan several small trips in a week ➢ Must know the correct techniques for lifting, bending and carrying ➢ Carry shopping bags in both hands and balance the weight between both hands. Use shopping bags with handles. It makes it less stressful and easier to carry the bags ➢ Use a rucksack for carrying and lifting stuff ➢ Do not carry a shopping basket for longer period of time, use supermarket trolley instead ➢ At check out when loading bags into the trolley, avoid extended reaching	If all recommendation are placed properly, then they will help the individual to reduce the residual risk level
Childcare Activities	Moderate Risk	High Risk	➢ Use tripod lift and pivot technique to lift infant. ➢ Use your legs, don't use your back to lift infant. ➢ When you hold your baby, don't place him/her on one hip ➢ Bend your knees to lift your child from the ground level ➢ When dressing or undressing the child, used a raised surface and avoid bending over the child ➢ When holding your baby try to keep your wrist in a neutral position (avoid extreme flexion) ➢ Use specially designed pillows (such as Boppy pillow and My Breast Friend pillow) when bottle feeding or breast feeding your baby, which will diminish strain on your neck, back, shoulders and wrist ➢ Try to use a hands-free baby carrier: it will help to keep good biomechanics and provide symmetrical support to your baby ➢ Don't be a supermum or superdad: try to delegate your daily tasks to other members of your family (pushing your baby pram, carrying baby for you, carrying nappy bags) ➢ Reduce the amount of time spent sitting on the floor with unsupported back ➢ When lifting/lowering the child from the cot, lower its sides, as this will help to reduce strain on your back	

Gardening activities	Moderate Risk	High Risk	➢ Avoid bending, keep your back straight and use adjustable-handled tools and handle extenders (rakes, brooms and hose) for your garden work ➢ When lifting boxes and bags from the ground, bend knees not your back, and learn lifting techniques. ➢ When you work near the ground such as weeding, do not kneel with both knees; kneel with one knee because that helps us to keep the back straight. ➢ Use built-up cushioned gripstools for cutting and trimming branches. These tools lessen the strain on your wrist and hand. ➢ Use long handled tools and avoid excessive reaching while you are working in a standing or sitting position ➢ Avoid a prolonged tight grasp of tools and objects ➢ Avoid working above shoulder height as it puts a strain on your neck, shoulders and back ➢ Examine the load before lifting: if it is too heavy, ask for help ➢ Use ergonomically designed tools, which will help to maintain good posture	

Source: [329]

17.2 Transcript of OT interview

Question asked by Occupational Therapy expert

OT expert asked student: First, Please tell me, your understanding how occupational therapy works or what is the aim of OT (occupational therapist)?

Student: What is the philosophy or treatment medium in occupational therapy? Or how OT assists people?

Student: What types of tasks or activities OT focused during their treatment?

Student: What stage OT called in to the intervention process in medical project?

Supervisor: So what you do, you talk about baking, so does Occupational therapy in general reference...in the home more than hospital environments?

Student: Being an OT professional what would be your ideal assessments?

Supervisor: In term of assessment, what you can use for reference point of norm?

Student: How about some sort of tool which give you same thing but not asking by patient by observing the person?

Student: Do you have concern about the tasks they are doing?

Supervisor: What's the typical analysis you involved in...as you are talking about referrals, i mean two secessions twenty sessions can you make as short as one session?

Supervisor: In terms of problems under very broad......obviously we got natural things occurred....you're talking about some result like stroke or work accident, through aging or musculoskeletal what's the most common general..is it aging..?

Student: Let me tell you...my mother used to slice the potatoes ten years ago now she don't like this activity..so why she don't like such activities now?

Student: Is there any physical measures which tell me don't continue this activity or you will end up with some sort of injury..?

Student: I found two things in literature, arthritis is the biggest thing and then lower back pain..but in ergonomics literature, risk factors like repetition, posture thing and discomfort feel if you control or reduce the number of injuries..will it be helpful?

Supervisor: Ergonomics risk factors seems more dangerous than war probably more people died in work than haven't in war..
Student: It is found in literature that musculoskeletal disorders have both work related or non-work related risk factors..whats your opinion about that?

Supervisor: Please come back to set of questions which student gathers, how real the OT support for the person or patient, its seems to me there is a step, not gradual slippage into OT, not a very subtle identification,...i can't do this task..what's your point of view?

Student: We know from the research....people exposed to risk factors which lead to further injuries on their workplace..

Student: is it quite interesting that.. i would suggest, they have normal patterns..in dealing with coping strategies.

Supervisor: Let me give a personal example like arthritis in little finger and what you find using four fingers, use three fingers or two, quite obviously that changes the load muscles and....the function of your fingers or hand.

Supervisor: let's talk about some example such as using rolling pin, in terms of you don't actually do measurements on rolling pin exercise is actually....tasks so formal mechanical, as an ergonomics you understand it suggest rolling pin exactly same tasks as repetitive tasks.

17.3 Transcript of ergonomics interview

<u>Questions asked by researcher</u>

Question #1: How ergonomics works and what is its aim toward different working environments?)

Question #2: What is the philosophy or treatment medium in ergonomics? Or how ergonomist assists people?

Question #3: How ergonomics works with other disciplines such as occupational therapy and physiotherapy, etc.?

Question #4: The research mentions that "Risk is inherent in every situation and for every activity" [63] so, how the risk influence person's performance in work and home environment?

Question #5: How do you define the risk within this context?

Question #6: Is this possible to assess the risk associated with performance of daily tasks?

Question #7: Do you think there is an effect of psychological and physiological risks around the person when performing the daily tasks?

Question #8: Do you think evaluation of psychological and physiological risks within domestic environment helps health care personnel to monitor person's capability to cope with their daily tasks?

Question #9: Is there any existing ergonomics assessment tool, which is considered fit for analysing the tasks or activities performed within home environment? If yes, which assessment tool or method would you recommend for assessing domestic tasks or activities?

17.4 Ethics application for Survey

University Research Ethics Application Form for Staff and PGRs

The University Of Sheffield.

This form has been approved by the University Research Ethics Committee (UREC)

Date:	20/06/13
Name of applicant:	Asim Zaheer
Research project title:	Designing Hand-Held Equipment for Ease of Use

Complete this form if you are a **member of staff or a postgraduate research student** who plans to undertake a research project which requires ethics approval via the University Ethics Review Procedure. [X]

or

Complete this form if you plan to submit a **'generic' research ethics application (i.e. an application** that will cover several sufficiently similar research projects). Information on the 'generic' route is at: www.sheffield.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/review-procedure/generic-research-projects [ ]

If you are an undergraduate or a postgraduate-taught student, this is the wrong form.

PLEASE NOTE THAT YOUR DEPARTMENT MAY USE A VARIATION OF THIS FORM: PLEASE CHECK WITH THE ETHICS ADMINISTRATOR IN YOUR DEPARTMENT

This form should be accompanied, where appropriate, by all Information Sheets/Covering Letters/Written Scripts which you propose to use to inform the prospective participants about the proposed research, and/or by a Consent Form where you need to use one.

Further guidance on how to apply is at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/review-procedure

Guidance on the possible routes for obtaining ethics approval (i.e. on the University Ethics Review Procedure, the NHS procedure and the Social Care Research Ethics Committee, and the Alternative procedure) is at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/ethics-approval

Once you have completed this research ethics application form in full, and other documents where appropriate, check that your name, the title of your research project and the date is contained in the footer of each page and email it to the Ethics Administrator of your academic department. Please note that the original signed and dated version of 'Part B' of the application form should also be provided to the Ethics Administrator in hard copy. Ethics Administrators are listed at: www.shef.ac.uk/polopoly_fs/1.99105!/file/Ethics-Administrators.pdf

I confirm that I have read the current version of the University of Sheffield 'Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue', as shown on the University's research ethics website at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy [X]

Part A

A1. Title of Research Project:
Designing Hand-Held Equipment for Ease of Use

A2. Contact person (normally the Principal Investigator, in the case of staff-led research projects, or the student in the case of supervised-postgraduate researcher projects):

Title: Mr.
Name: Asim Zaheer
Post: PhD Student
Department: Mechanical Engineering
Email: mep12az@sheffield.ac.uk
Telephone: 07425845787

A2.1. Is this a postgraduate researcher project? If yes, please provide the Supervisor's contact details:

Title: Dr.
Name: Jennifer Rowson
Post: Lecturer in Design and Simulation
Department: Mechanical Engineering
Email: j.rowson@sheffield.ac.uk
Telephone: +44 (0) 114 222 7878

A2.2. Other key investigators/co-applicants (within/outside University), where applicable. Please list all (add more if necessary):

Title: Dr.
Name: Matt Carré
Post: Senior Lecturer
Department: Mechanical Engineering
Email: m.j.carre@sheffield.ac.uk
Telephone:

Title:
Name:
Post:
Department:
Email:
Telephone:

A3. Proposed Project Duration:

Start date: July 2013
End date: December 2015

A4. Mark 'X' in one or more of the following boxes if your research:

	involves adults with mental incapacity or mental illness
	involves prisoners or others in custodial care (e.g. young offenders)
	involves children or young people aged under 18 years
	involves using samples of human biological material collected before for another purpose
	involves taking new samples of human biological material (e.g. blood, tissue) *
	involves testing a medicinal product *
	involves taking new samples of human biological material (e.g. blood, tissue) *
	involves additional radiation above that required for clinical care *
	involves investigating a medical device *
	is social care research
	is ESRC funded

* If you have marked boxes marked * then you also need to obtain confirmation that appropriate University insurance is in place. The procedure for doing so is entirely by email. Please send an email

addressed to insurance@shef.ac.uk and request a copy of the 'Clinical Trial Insurance Application Form'.

It is recommended that you familiarise yourself with the University's Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue before completing the following questions. Please note that if you provide sufficient information about the research (what you intend to do, how it will be carried out and how you intend to minimise any risks), this will help the ethics reviewers to make an informed judgement quickly without having to ask for further details.

A5. Briefly summarise:

i. The project's aims and objectives:
(this must be in language comprehensible to a lay person)

The primary aim of this study is to understand the activities of daily living (ADL) and instrumental activities of daily living (IADL) which is suffered when people get older. As the society is ageing, it brings a general reduction in abilities and increases disability which results in dependency on other people. This work will focus on maintaining a healthy society because it is important for peoples to retain their independence in their daily activities

ii. The project's methodology:
(this must be in language comprehensible to a lay person)

A simple survey will be used to collect the data regarding to daily living tasks. This survey includes some informal discussion as well as written questions on perceived performance. Using ergonomics tools and techniques to analyze the collected data.
This part of the study is expected to take a maximum of one hour for each participant. The tests may include holding and placing objects, opening food and common containers, electromyography (recording of electrical activity produced by muscles) and strength measurement.

A6. What is the potential for physical and/or psychological harm/distress to participants?

There is no increased risk of physical harm to the participants. None of the tests are strenuous or dangerous.
All participants are free to withdraw from participation at any time without giving reason, and this is clearly explained to the participants. Questions will be related to the test procedure and will not cover any sensitive information.

A7. Does your research raise any issues of personal safety for you or other researchers involved in the project? (especially if taking place outside working hours or off University premises)

No

If yes, explain how these issues will be managed.

A8. How will the potential participants in the project be:

i. Identified?

ii. Approached?

iii. Recruited?

Participants will mainly be recruited through third party organisations for seniors, such as lunch groups, activity groups and social organisations. The mailing lists of these organisations, regular publications and other membership contacts will be used for publicising the research. Participants will also be recruited through the university announcements for younger users. It will then be decided by the individual to respond or not to the advertisements for participation in the testing.

A9. Will informed consent be obtained from the participants?

Yes [X] No [ ]

If informed consent or consent is <u>NOT</u> to be obtained please explain why. Further guidance is at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/policy-notes/consent

A9.1. This question is only applicable if you are planning to obtain informed consent:

How do you plan to obtain informed consent? (i.e. the proposed process?):

Informed consent will be obtained through a consent form, which will be presented to the participants on arrival. The consent form will then be explained to the participant, and they will have opportunity to read the form and ask questions before signing and dating the documents to indicate consent.

Remember to attach your consent form and information sheet (where appropriate)

A10. What measures will be put in place to ensure confidentiality of personal data, where appropriate?

The questionnaire and interview data collected will include the participant's Age, Gender and general information about their everyday life, which will contain no personally identifiable information within it. The raw data will only be handled by the project student, or the investigators named in the table above. Any data that is published will be anonymised so that there are no personally identifiable details contained. Participants may ask that any information given be destroyed/deleted at any time.

A11. Will financial/in kind payments (other than reasonable expenses and compensation for time) be offered to participants? (Indicate how much and on what basis this has been decided)

No

A12. Will the research involve the production of recorded media such as audio and/or video recordings?

YES [X] NO [ ]

A12.1. This question is only applicable if you are planning to produce recorded media:
How will you ensure that there is a clear agreement with participants as to how these recorded media may be stored, used and (if appropriate) destroyed?

As a sub section to the consent form, consent to the video analysis will be given. The video data will only be focused on the hands whilst performing the task. The recorded media will be stored in a compressed and passworded archive file, on the lead researchers office computer, as well as a backup copy on a secure internet server and encrypted portable media. Access to the video files will be exclusively retained by the lead researcher. Any still frames extracted from the video files will be edited to assure anonymity for the participant before allowing access for others involved with the project (named above), or before publication. Participants may ask that any recordings be destroyed/deleted at any time.

Guidance on a range of ethical issues, including safety and well-being, consent and anonymity, confidentiality and data protection are available at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/policy-notes

University Research Ethics Application Form - Part B - The Signed Declaration

Title of Research Project:

Designing Hand-Held Equipment for Ease of Use

I confirm my responsibility to deliver the research project in accordance with the University of Sheffield's policies and procedures, which include the University's '*Financial Regulations*', '*Good Research Practice Standards*' and the '*Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue*' (Ethics Policy) and, where externally funded, with the terms and conditions of the research funder.

In signing this research ethics application form I am also confirming that:

- The form is accurate to the best of my knowledge and belief.
- The project will abide by the University's Ethics Policy.
- There is no potential material interest that may, or may appear to, impair the independence and objectivity of researchers conducting this project.
- Subject to the research being approved, I undertake to adhere to the project protocol without unagreed deviation and to comply with any conditions set out in the letter from the University ethics reviewers notifying me of this.
- I undertake to inform the ethics reviewers of significant changes to the protocol (by contacting my academic department's Ethics Administrator in the first instance).
- I am aware of my responsibility to be up to date and comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data, including the need to register when necessary with the appropriate Data Protection Officer (within the University the Data Protection Officer is based in CiCS).
- I understand that the project, including research records and data, may be subject to inspection for audit purposes, if required in future.
- I understand that personal data about me as a researcher in this form will be held by those involved in the ethics review procedure (e.g. the Ethics Administrator and/or ethics reviewers) and that this will be managed according to Data Protection Act principles.
- If this is an application for a 'generic' project, all the individual projects that fit under the generic project are compatible with this application.
- **I understand that this project cannot be submitted for ethics approval in more than one department, and that if I wish to appeal against the decision made, this must be done through the original department.**

Name of the Principal Investigator (or the name of the Supervisor if this is a postgraduate researcher project):

Jen Rowson

If this is a postgraduate researcher project, insert the student's name here:

Asim Zaheer

Signature of Principal Investigator (or the Supervisor):

Jen Rowson	**Date: 20/06/2013**

Email the completed application form and provide a signed, hard copy of 'Part B' to the Ethics Administrator (also enclose, if relevant, other documents).

University Research Ethics Application Form for Staff and PGRs

The University Of Sheffield.

This form has been approved by the University Research Ethics Committee (UREC)

Date:	23/07/13
Name of applicant:	Asim Zaheer
Research project title:	Designing Hand-Held Equipment for Ease of Use

(Initially title was different)

Complete this form if you are a **member of staff or a postgraduate research student** who plans to undertake a research project which requires ethics approval via the University Ethics Review Procedure. [X]

or

Complete this form if you plan to submit a **'generic' research ethics application (i.e. an application** that will cover several sufficiently similar research projects). Information on the 'generic' route is at: www.sheffield.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/review-procedure/generic-research-projects [ ]

If you are an undergraduate or a postgraduate-taught student, this is the wrong form.

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Guidance on the possible routes for obtaining ethics approval (i.e. on the University Ethics Review Procedure, the NHS procedure and the Social Care Research Ethics Committee, and the Alternative procedure) is at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/ethics-approval

Once you have completed this research ethics application form in full, and other documents where appropriate, check that your name, the title of your research project and the date is contained in the footer of each page and email it to the Ethics Administrator of your academic department. Please note that the original signed and dated version of 'Part B' of the application form should also be provided to the Ethics Administrator in hard copy. Ethics Administrators are listed at:
www.shef.ac.uk/polopoly_fs/1.99105!/file/Ethics-Administrators.pdf

I confirm that I have read the current version of the University of Sheffield 'Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue', as shown on the University's research ethics website at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy [X]

Part A

A1. Title of Research Project:
Designing Hand-Held Equipment for Ease of Use

A2. Contact person (normally the Principal Investigator, in the case of staff-led research projects, or the student in the case of supervised-postgraduate researcher projects):

Title: Mr	Name: Asim Zaheer
Post: PhD Student	Department: Mechanical Engineering
Email: mep12az@sheffield.ac.uk	Telephone: 07438129072

A2.1. Is this a postgraduate researcher project? If yes, please provide the Supervisor's contact details:

Title: Dr	Name: Jennifer Rowson
Post: Lecturer	Department: Mechanical Engineering
Email: j.rowson@sheffield.ac.uk	Telephone: +44 (0) 114 222 7878

A2.2. Other key investigators/co-applicants (within/outside University), where applicable. Please list all (add more if necessary):

Title: Dr	Name: Matt Carré
Post: Senior Lecturer	Department: Mechanical Engineering
Email: m.j.carre@sheffield.ac.uk	Telephone:

Title:	Name:
Post:	Department:
Email:	Telephone:

A3. Proposed Project Duration:

Start date: July 2013 End date: December 2015

A4. Mark 'X' in one or more of the following boxes if your research:

☐	involves adults with mental incapacity or mental illness
☐	involves prisoners or others in custodial care (e.g. young offenders)
☐	involves children or young people aged under 18 years
☐	involves using samples of human biological material collected before for another purpose
☐	involves taking new samples of human biological material (e.g. blood, tissue) *
☐	involves testing a medicinal product *
☐	involves taking new samples of human biological material (e.g. blood, tissue) *
☐	involves additional radiation above that required for clinical care *
☐	involves investigating a medical device *
☐	is social care research
☐	is ESRC funded

* If you have marked boxes marked * then you also need to obtain confirmation that appropriate University insurance is in place. The procedure for doing so is entirely by email. Please send an email

addressed to insurance@shef.ac.uk and request a copy of the 'Clinical Trial Insurance Application Form'.

It is recommended that you familiarise yourself with the University's Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue before completing the following questions. Please note that if you provide sufficient information about the research (what you intend to do, how it will be carried out and how you intend to minimise any risks), this will help the ethics reviewers to make an informed judgement quickly without having to ask for further details.

A5. Briefly summarise:

i. The project's aims and objectives:
(this must be in language comprehensible to a lay person)

The primary aim of this study is to assess activities of daily living (ADL) and instrumental activities of daily living (IADL) from an ergonomic assessment perspective in relation to how habits alter with age. As the society is ageing, it brings a general reduction in abilities and increased instances of disability which result in a dependency on other people. This work will focus on maintaining a healthy society because it is important for peoples to retain their independence in their daily activities

ii. The project's methodology:
(this must be in language comprehensible to a lay person)

Study consists of a collecting data by a simple experimental setup of mopping task in lab environment, observational study on food preparation task and laundry task in home environment, regarding to Instrumental Activities of Daily Living (IADL) tasks and sub tasks. Video will be recorded for further analysis; using ergonomics and occupational tools and techniques to analyze the collected data.

A6. What is the potential for physical and/or psychological harm/distress to participants?

There is no increased risk of physical harm to the participants. None of the tests are strenuous or dangerous.
All participants are free to withdraw from participation at any time without giving reason, and this is clearly explained to the participants. Questions will be related to the test procedure and will not cover any sensitive information.

A7. Does your research raise any issues of personal safety for you or other researchers involved in the project? (especially if taking place outside working hours or off University premises)

No

If yes, explain how these issues will be managed.

A8. How will the potential participants in the project be:

i. Identified?

Participants will mainly be identified through third party organisations for seniors, such as lunch groups, activity groups and social organisations

ii. Approached?

Participants will mainly be approached through third party organisations for seniors, such as lunch groups, activity groups and social organisations. The mailing lists of these organisations, regular publications and other membership contacts will be used for publicising the research.

iii. Recruited?

Participants will mainly be recruited through third party organisations for seniors, such as lunch groups, activity groups and social organisations. The mailing lists of these organisations, regular publications and other membership contacts will be used for publicising the research. Participants will also be recruited through the university announcements for younger users. It will then be decided by the individual to respond or not to the advertisements for participation in the testing.

A9. Will informed consent be obtained from the participants?

Yes [X] No [ ]

If informed consent or consent is <u>NOT</u> to be obtained please explain why. Further guidance is at: www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/policy-notes/consent

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How do you plan to obtain informed consent? (i.e. the proposed process?):

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Remember to attach your consent form and information sheet (where appropriate)

A10. What measures will be put in place to ensure confidentiality of personal data, where appropriate?

The survey and interview data collected will include the participant's Age, Gender and general information about their daily living tasks, which will contain no personally identifiable information within it. The raw data will only be handled by the project student, or the investigators named in the table above. Any data that is published will be anonymised (Any photos and videos will be blurred, no one can identified the face of participants) so that there are no personally identifiable details contained. Participants may ask that any information given be destroyed /deleted at any time.

A11. Will financial/in kind payments (other than reasonable expenses and compensation for time) be offered to participants? (Indicate how much and on what basis this has been decided)

No

A12. Will the research involve the production of recorded media such as audio and/or video recordings?

YES [X] NO [ ]

A12.1. This question is only applicable if you are planning to produce recorded media:
How will you ensure that there is a clear agreement with participants as to how these recorded media may be stored, used and (if appropriate) destroyed?

As a sub section to the consent form, consent to the video analysis will be given. The video data will only be focused on the hands whilst performing the task. The recorded media will be stored in a compressed and passworded archive file, on the lead researchers office computer, as well as a backup copy on a secure internet server and encrypted portable media. Access to the video files will be exclusively retained by the lead researcher. Any still frames extracted from the video files will be edited to assure anonymity for the participant before allowing access for others involved with the project (named above), or before publication. Participants may ask that any recordings be destroyed/deleted at any time.

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Title of Research Project:

Designing Hand-Held Equipment for Ease of Use

I confirm my responsibility to deliver the research project in accordance with the University of Sheffield's policies and procedures, which include the University's '*Financial Regulations*', '*Good Research Practice Standards*' and the '*Ethics Policy Governing Research Involving Human Participants, Personal Data and Human Tissue*' (Ethics Policy) and, where externally funded, with the terms and conditions of the research funder.

In signing this research ethics application form I am also confirming that:

- The form is accurate to the best of my knowledge and belief.
- The project will abide by the University's Ethics Policy.
- There is no potential material interest that may, or may appear to, impair the independence and objectivity of researchers conducting this project.
- Subject to the research being approved, I undertake to adhere to the project protocol without unagreed deviation and to comply with any conditions set out in the letter from the University ethics reviewers notifying me of this.
- I undertake to inform the ethics reviewers of significant changes to the protocol (by contacting my academic department's Ethics Administrator in the first instance).
- I am aware of my responsibility to be up to date and comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data, including the need to register when necessary with the appropriate Data Protection Officer (within the University the Data Protection Officer is based in CiCS).
- I understand that the project, including research records and data, may be subject to inspection for audit purposes, if required in future.
- I understand that personal data about me as a researcher in this form will be held by those involved in the ethics review procedure (e.g. the Ethics Administrator and/or ethics reviewers) and that this will be managed according to Data Protection Act principles.
- If this is an application for a 'generic' project, all the individual projects that fit under the generic project are compatible with this application.
- **I understand that this project cannot be submitted for ethics approval in more than one department, and that if I wish to appeal against the decision made, this must be done through the original department.**

Name of the Principal Investigator (or the name of the Supervisor if this is a postgraduate researcher project):

Dr. Jennifer Rowson

If this is a postgraduate researcher project, insert the student's name here:

Asim Zaheer

Signature of Principal Investigator (or the Supervisor):

Jennifer Rowson	**Date: 20/06/2013**

Email the completed application form and provide a signed, hard copy of 'Part B' to the Ethics Administrator (also enclose, if relevant, other documents).

17.5 Ethics application for development of task assessment tool for eases and risk within domestic environment

The University Of Sheffield.

Application 007151

Section A: Applicant details

Created:
Thu 10 December 2015 at 11:25

First name:
Asim

Last name:
Zaheer

Email:
mep12az@sheffield.ac.uk

Programme name:
N.A.

Module name:
N.A.
Last updated:
04/01/2016

Department:
Mechanical Engineering

Date application started:
Thu 10 December 2015 at 11:25

Applying as:
Postgraduate research

Research project title:
Designing an Ability Assessment Tool (AAT) for the Domestic Environment

Section B: Basic information

1. Supervisor(s)

Name	Email
Jennifer Rowson	j.rowson@sheffield.ac.uk

2: Proposed project duration

Proposed start date:
Thu 10 December 2015

Proposed end date:
Mon 1 February 2016

3: URMS number (where applicable)

URMS number
- not entered -

4: Suitability

Takes place outside UK?
No

Involves NHS?
No

Healthcare research?
No

ESRC funded?
No

Involves adults who lack the capacity to consent?
No

Led by another UK institution?
No

Involves human tissue?
No

Clinical trial?
No

Social care research?
No

5: Vulnerabilities

Involves potentially vulnerable participants?
No
Involves potentially highly sensitive topics?
No

Section C: Summary of research

1. Aims & Objectives

The aim of the research is to evaluate and trial a new method for the assessment of domestic tasks within the home environment. The study will be focused on evaluating the Ability Assessment Tool (AAT) using healthy able-bodied subjects.
The study is divided into two parts:
Part-I: evaluation of the ease of use of the record sheet,
Part-II: pilot observed trial of the AAT

2. Methodology

Part-I of the study will be evaluating the assessment for ease of use, participants will be presented with the AAT booklet and asked to carry out the assessment for a single task as it is stated in the booklet. The researcher will be present at all times and participants will ask to perform and self-assess the task by using the record sheet provided and do some calculation and mark the risk level in the record sheet. After that researcher will explain the whole procedure to the participants and ask the participants to redo the assessment, in the same time researcher also does the assessment for the participants

Part-II of the pilot trial participants will be asked to carry out and assess a range of domestic tasks, the study will take place in the participantâ€™s home environment with the researcher present to record the video of his adopted postures during the performance of tasks. Initially, AAT booklet is provided with the record sheet and instructs participants to follow the step by step guide during the self-assessment. As these activities are performed on a daily basis (e.g. cooking, cleaning, ironing etc.) all the participants know the procedure of performing these tasks. Participants will ask to perform the series of tasks and rate each task individually by using the provided record sheet. During the performance of each task participants has to think about taskâ€™s perception and rate the physical demand and complexity, postures adopted rate the most uncomfortable body parts positions and consider manual handling of objects. Participants also instructed to record the frequency and duration of each task on record sheet. At the end, participants will provide the AAT record sheets having self-assessed risk level for all the tasks performed during the trial secession.

3. Personal Safety

Raises personal safety issues? No

Pesonal safety management

- not entered -

Section D: About the participants

1. Potential Participants

The potential participants for the research will be healthy subjects without self-reported impairment or pathologies (age range: 20-60)

2. Recruiting Potential Participants

Participants will be approached by word of mouth or by email and will be recruited among the staff, PhD students and postgraduate researchers of the University of Sheffield and among acquaintances of the investigators.
Any cohersion will be avoided and potential participants will be explicitly given the opportunity to refuse participation

2.1 Advertising methods

Will the study be advertised using the volunteer lists for staff or students maintained by CiCS? No

- not entered -

3. Consent

Will informed consent be obtained from the participants? (i.e. the proposed process) Yes

After a general description of the study, if interested in participating, potential participants will be provided with a written description of the experiments and the aims of the project, and will be given all the needed time to read through this information before consent is obtained.

4. Payment

Will financial/in kind payments be offered to participants? No

- not entered -

5. Potential Harm to Participants

What is the potential for physical and/or psychological harm/distress to the participants?

There is no increased risk of physical harm to the participants. None of the tests are strenuous or dangerous.

How will this be managed to ensure appropriate protection and well-being of the participants?

All participants are free to withdraw from participation at any time without giving reason, and this is clearly explained to the participants. Questions will be related to the test procedure and will not cover any sensitive information.

Section E: About the data

1. Data Confidentiality Measures

Each participant will be assigned a unique code, not directly linkable to their identity.

2. Data Storage

The data generated by the project will be anonymously stored in password protected computer and will only be accessible to the project personnel. Only the PI will have access to a table linking participants to their unique code and will only be accessed in the event that the participant wishes to withdraw from the study and their data destroyed. Explicit permission will be requested for the recording and use of videos and pictures. They will only be used to support the data analysis and for scientific presentations. If at any point the participant decides to withdraw from the project they will be asked if they want their data to be destroyed.

Section F: Supporting documentation

Information & Consent

Participant information sheets relevant to project?
Yes

Participant Information Sheets

- Information-sheet_for_part-II.doc
  (Document 016588)
- AAT_Information-sheet_for_part-I.doc
  (Document 016587)

Consent forms relevant to project?
Yes

Consent Forms

- AAT_Consent-Form.doc
  (Document 016586)

Additional Documentation

None

External Documentation

- not entered -

Offical notes

- not entered -

Section G: Declaration

Signed by: