University of Alberta

TASK ANALYSIS OF HOUSEHOLD ACTIVITIES PERFORMED BY HEALTHY WOMEN

by

MAVIS ANDREW ©

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fulfilment of the requirements for the degree of Master of Science

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ABSTRACT

The purpose of this study was to describe the physical, physiological, and perceptual demands of two physically demanding household tasks, cleaning the bathroom and vacuuming the living room. This study's research methodology was task analysis and the task description technique was decomposition. Seventeen healthy women, between the ages of 30 and 50 years, volunteered as subjects. Study protocol consisted of an interview to gather demographic information and an observation session while the subjects performed each task for 17 to 20 minutes in their own home. The researcher compiled descriptive statistics, comparative and relationship data for body segment postures, whole body postures, heart rate, heart rate reserve, and perceived exertion. It was found that vacuuming the living room had a higher circulatory strain and level of perceived exertion than cleaning the bathroom; the opposite was found for the posture demands. An inverse relationship existed between maximal oxygen uptake and heart rate responses during the two tasks. The researcher discussed several implications for occupational therapists who treat individuals with reduced functional capacity for household tasks.

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Table of Contents

Chapter Page

List of Tables

Table | Page

(Cont'd)

List of Figures

CHAPTER 1. STATEMENT OF THE PROBLEM

Introduction

An individual's loss of ability to perform their usual activities following an injury or illness has great impact on society. It has been reported that the economic cost of injury in the United States represents a multi-billion dollar industry (Rice, MacKenzie & Associates, 1989). The cost for replacement housekeeping service for persons with disabilities is one component of that industry. Housekeeping services have formed an increasingly significant component of claims. The judicial system of Alberta is also beginning to recognize the loss of housekeeping capacity as significant (Roberts, 1995). For example, this service was part of a $229,181 claim in a 1994 Alberta Court of Queens' Bench decision (Roberts, 1995).

Household tasks and the performance of those tasks have substantial costs and benefits to the individual, households, and society (Statistics Canada, 1995). As illustrated by a general social survey, Canadians spend a great deal of time performing household tasks (Harvey, Marshall, & Frederick, 1991). Canadian women spend an average of 2.5 hours per day doing domestic activities, while their male counterparts spend an average of one hour per day. Although many hours are spent by Canadians in the homemaker's role, it has only recently been recognized as having value at a societal level. To date, Statistics Canada has not recognized housework as a form of labour. However, as indicated by Munroe (1995) there were plans underway to include it in the 1996 census.

Occupational Therapists' Role in Returning Individuals to Performance of Household Tasks

Occupational therapists have long ized the value of housework and the homemaker role. They work with women and men, both disabled and able-bodied, who perform household activities as part of their occupational role or their 'work'. Occupational therapists enhance individuals' levels of function so that they may return to their life roles (Mathiowetz, 1993). A homemaker is one of these life roles.

When individuals lose the ability to perform their life roles, the occupational therapist uses a variety of techniques to enhance their level of function. One technique used to achieve this goal is simulation of activity (Hertfelder & Gwin, 1989; & Wilke & Sheldahl, 1985). Simulation of activities can be a part of evaluation and treatment in rehabilitation programs, and in the pre-discharge evaluation and determination of need. Simulations of the three performance components -- activities of daily living, leisure, and work-related tasks -- are used. Occupational therapists rely on observation of task performance during work simulation and on professional judgment for clinical decision making. Accuracy of work simulation programming is improved when task demands are known (Kennedy & Bhambhani, 1991).

Occupational therapists are also involved in the evaluation of an individual's functional capacity, which is then compared with the job task demands (Hertfelder & Gwin, 1989). Functional capacity evaluations are conducted to assist the occupational therapist in the determination of compensation awards in personal injury insurance cases or in Workers' Compensation Board cases. The availability of a task demand database could form part of the basis for clinical decision making.

Several authors have noted the continued importance of household work in society and the obvious lack of data concerning the performance demands of household tasks and their interaction with the environment (Allaire, Meenan & Anderson, 1991; Clark, Czaja & Weber, 1990; Czaja, Weber & Nair, 1993; Grandjean, 1973; Smith, 1990; Varghese, Saha & Atreya, 1994; & Varghese, Saha & Atreya, 1995). Despite this, occupational therapists continue to treat an individual's ability to perform these tasks and to determine an individual's capability in these tasks for the purposes of compensation. It would be useful for occupational therapists to have more information regarding the demands of household tasks. Until such information is available, occupational therapists should exercise caution when making clinical decisions regarding an individual's capacity to perform a household task or when determining compensation awards for loss of capacity to perform household tasks.

Importance of Determining Level of Fitness

A role of occupational therapy is to enhance an individual's functional capacity (Health and Welfare Canada, 1986). While performing this role, the occupational therapist must be cognizant of the components that contribute to an individual's capacity to perform a task. One of those components is fitness level. There is an inverse relationship between the individual's aerobic fitness and their level of circulatory strain in response to the tasks. (McArdle, Katch & Katch, 1991). The less fit individual will experience higher levels of circulatory strain and fatigue will occur sooner. Knowing this relationship, measurement of the individual's level of fitness is important when setting up a rehabilitation program.

One of the best measures of aerobic fitness is the maximal oxygen uptake or VO_2 max. The VO_2 max is defined as the maximum amount of oxygen that can be utilized per unit time. It is expressed as an absolute value in l/min or in relative terms of body weight, ml/kg/min. The VO_2 max is determined by the body's maximal capacity to transport, deliver, and utilize oxygen during task performance (Powers & Howley, 1994). It is considered to be one of the most valid measures of the individual's level of cardiovascular fitness and can be determined using a number of different techniques (Powers & Howley, 1994). The three main techniques for determining VO_2 max are: maximal exercise testing, predictive or submaximal exercise testing (McArdle et al., 1991), and non-exercise methods (Ross & Jackson, 1990).

As the name implies, maximal exercise testing requires the individual to work to their supermaximal level (McArdle et al., 1991). A variety of test protocols exist for this method. Subjects perform the test on a bicycle or treadmill in a laboratory setting with elaborate measuring equipment.

Predictive or submaximal testing involves a standardized exercise format whereby the exercise or post-exercise heart rate is used in a predictive equation to determine VO_2 max (McArdle et al., 1991). Submaximal testing methods include protocols on a bicycle, treadmill, running track, or step test. This type of testing is a less expensive alternative to maximal testing and is more suitable for the general population who may not be accustomed to working to their maximal level.

The third technique, non-exercise method, involves the use of a predictive equation to predict VO_2 max (Ross & Jackson, 1990). Equations include factors such as age, gender, percent body fat or body mass index, and level of activity. Non-exercise methods are suitable for use in the community, where laboratory testing resources are not available, and with a population with a low level of fitness. The researcher's decision regarding which technique to choose is based on the reason for the test, the fitness level of the individual, and the practicality of the test.

Working Postures and Rehabilitation of Individuals with Musculoskeletal Injuries

Occupational therapists are involved in the treatment of people with musculoskeletal injuries. One treatment approach to the enhancement of people with this type of disability is through biomechanics education and joint protection techniques (Hertfelder & Gwin, 1989). In order to implement these techniques, the working postures or physical demands and body postures required to perform the task must be known (Hertfelder & Gwin, 1989). Working postures that place low musculoskeletal demands on a worker are considered good, while postures that place high musculoskeletal demands on a worker are considered poor. Examples of poor working postures include: stooped working posture with the back in a forward bent position, working with the arms in a raised position, and twisted or asymmetric postures (Pheasant, 1991). Not only is it important to recognize poor working postures, but it is also important to know how working in these postures can affect the health of the worker. Over time, working in poor working postures can lead to musculoskeletal injuries (Haslegrave, 1994). Occupational therapists must be aware of this compounding factor and consider it in the rehabilitation of individuals with musculoskeletal injuries.

Statement of the Problem

Despite the existence of household tasks in Canadian society and the occupational therapists' involvement in rehabilitation of individuals' capacity to perform this role, minimal information on the task demands exists. Development of a task demand profile of household work tasks would form part of a basis for clinical program planning, patient treatment, determination of and quantification of loss of capacity, and creation of assessment tools.

The purpose of this study was to describe the physical, physiological, and perceptual task demands of women performing household work in a natural environment: the home. The specific goals were to:

1. describe and compare the physical demands of two household tasks.
2. describe and compare the physiological and perceptual demands of two household tasks.
3. describe relationships between selected physiological, perceptual and physical demands of two household tasks.

Limitations of the Study

Factors that were not controlled in this study were:

1. The variations in the size and type of the subjects' homes.
2. The size, type and weight of the objects used by the subjects to perform the tasks.
3. The layout and arrangement of the living room and bathroom in each of the homes.

Delimitations of the Study

The delimitations or boundaries of this study follow:

1. The study was delimited to 17 healthy female subjects between the ages of 30 and 50 years.
2. Two household tasks were chosen and analyzed according to physiological, physical, and perceptual demands.
3. Recorded and analyzed were: physiological demands or heart rates; physical demands or postures of the back, legs, arms and the amount of effort load; and perceptual demand or rating of perceived exertion.
4. The two tasks chosen for the study were selected based on the criteria of high energy demand, a variety of postures, performed indoors, and performed on a regular basis.

Definitions of Terms

Terms that were used regularly in the study are defined.

1. Physiological demands - subjects' heart rate and heart rate reserve responses to the performance of the household tasks.
2. Perceptual demands - subjects' subjective feeling of strain experienced while performing physical work. As noted in the 'Definitions of Terms No.9', it is expressed as rating of perceived exertion. (Note: in an occupational therapy context perceptual demand refers to the visual-spatial skills of the individual. In this study the term perceptual demand is used in the ergonomic context as defined).
3. Physical demands - subjects' back, arm and leg postures, and effort load assumed when performing the household tasks.
4. Maximum VO_2 or VO_2 max - the maximum amount of oxygen that can be utilized per unit time. It is expressed as an absolute value in l/min or in relative terms of body weight, ml/kg/min. The VO_2 max is determined by the body's maximal capacity to transport, deliver, and utilize oxygen

during task performance (Powers & Howley, 1994).

5. Aerobic capacity - subjects' fitness level expressed in terms of VO_2 max.

6. Heart rate - the pulsation of the heart consisting of a systole (contraction) and a diastole (dilation). Measured in beats per minute (bpm).

7. Age related maximum heart rate (HR max).
   HR max (bpm) = 220 - age in years (McArdle et al., 1991).

8. Work heart rate reserve (work HRR) -
   The steps and equations used to determine work HRR were:
   <u>Step #1</u>: Determine resting heart rate, working heart rate and age related maximum heart rate (HRmax).
   <u>Step #2</u>: Calculate percentage of work HRR using the following equation:

$$\frac{\text{HR work} - \text{HR resting}}{\text{HR max} - \text{HR resting}} \times 100 = \%\text{ of work HRR}$$

(Rodahl, 1989).

9. Rating of perceived exertion - subjective feeling of strain experienced while performing physical work or the perceptual demand. It is measured via a scale called rating of perceived exertion (RPE) (Borg, 1982) (see Appendix A).

10. Ovako Working Posture Analysis System (OWAS) - an observational tool used to record the subjects' back, arm and leg postures assumed while working, and the amount of effort expended (Kivi & Mattila, 1991). This tool is further described in Appendix B.

11. Posture segments - using the OWAS, the position of each of the back, arms, legs, and load effort are assigned a number, which is known as the posture segment.

12. Posture code - using the OWAS, the posture segments are combined into a four-digit unit, called the posture code.

CHAPTER 2. LITERATURE REVIEW

An extensive literature review was conducted to deal with areas related to this study. The results of this review have been grouped into the following topic areas: instrumentation and functional capacity evaluations; measurement of household task performance demands in terms of energy expenditure values, heart rate responses, and the physical postures of the trunk and hands; and the methodology of task analysis and instruments used in this study.

Instrumentation and Functional Capacity Evaluations

The occupational therapists' role in functional capacity evaluations and the associated instrumentation have been documented (Mathiowetz, 1993). Mathiowetz (1993) stated that occupational therapists are involved in assessing role performance (e.g., worker, homemaker, or parent); occupational performance (e.g., activities of daily living); and performance components (e.g., sensation, endurance, and cognition). Simulation of work tasks is used by occupational therapists to evaluate an individual's functional capacity to return to his or her occupational roles (Wilke, Sheldahl, Dougherty, Levandoski & Tristani, 1993).

Occupational therapists also perform analysis of cost of future care for individuals who have incurred a personal injury (Harris, Henry, Green & Dodson, 1994). This analysis is based on the individual's functional capacity. The analysis of cost of future care identifies and quantifies equipment and/or homemaking services that the individual with a disability may require in the present and future. The authors stated that the identification of the amount and type of services required has typically been derived from analysis of the following instruments: medical documents, interview, functional and physical assessment, and assessment of the home. No mention of comparing the individual's functional performance to the task demands was noted.

Authors who have studied the current state of instrumentation in rehabilitation noted that diagnostic tests are needed for planning in rehabilitation programs (Foldspang, 1987). One preliminary step toward developing diagnostic tests is identification of task demands that are then incorporated into test development (Foldspang, 1987). Occupational therapists are often involved in development and implementation of the assessment of performance capacity in simulated settings. However, they have not published psychometric support for the instrumentation practice (Velozo, 1993).

Measurement of Household Task Performance Demands - Energy Expenditure Values and/or Heart Rate Responses

One of the goals of this study was to describe the physiological and perceptual demands of vacuuming the living room and cleaning the bathroom. The results of authors who have studied and documented the physiological and perceptual responses to the performance of household activities are presented. Suggestions that these authors had regarding the analysis of household activity performance demands are discussed.

Energy expenditure values for women performing household tasks were first published by Durnin and Passmore (1967). These authors stated that the nature of housework depends on the type of house and the equipment available, and the manner in which the tasks are performed. They also suggested that objective observation through a 'time and activity' study is more accurate than subjective statements made by the individual.

Many household task require carrying or transporting objects. Two studies were found that examined the energy requirements of carrying tasks pertaining to a household setting. In 1924 Bedale evaluated the energy expenditure of one woman carrying a load using eight different methods. Bedale (1924) reported the energy expenditure level was the least when the woman was carrying the load using a yoke across the shoulders. Energy expenditure was highest when the load was carried on the hip under the arm, a load carriage method used by women when performing household tasks such as carrying young children, laundry baskets, or other large objects. Wilke et al. (1995) evaluated and reported the energy expenditure, RPE and heart rate values of women while they carried and unpacked four bags of groceries. The subjects' average age was 62.2 years and they had documented coronary artery disease (CAD). The results recorded were: oxygen uptake - 8.6 ± 0.5 ml/kg/min (or 2.46 metabolic equivalents or METS); heart rate 101 ± 3 beats per minute; and RPE 11 ± 1. Using the classification system from Shepherd (1987) for industrial work, the MET level is light (cited in Bhambhani, 1993), and using the heart rate response classification system from Rodahl (1989) the heart rate response is moderate. This finding reflects Grandjean's (1973) comment that due to the static nature of housework, the heart rate response can be at a higher level than the energy expenditure level for the same task.

A female subject's heart rate values were recorded while she performed household tasks: her heart rate values ranged from 80 beats per minute (bpm) while preparing meals to 165 bpm while banging rugs (Åstrand & Rodahl, 1970). Grandjean (1973) cited several authors (Åstrand, 1966; Åstrand & Kilbom, 1969; & Stübler, 1970) who reported on the heart rate responses of women who performed household activities. Åstrand (1966) and Åstrand and Kilbom (1969) reported heart rate responses of 82 to 120 bpm during cooking, above 100 bpm during baking, 84 to 120 bpm while washing dishes by hand, 97 to 136 bpm while cleaning windows, and 98 to 117 bpm while cleaning floors (cited in Grandjean, 1973). Unfortunately, no task descriptions were provided. Åstrand (1966) also reported on heart rate values for three women who performed housework for a whole day. The reported mean heart rate values ranged from 99 to 125 beats per minute. These heart rate values were assigned a relative weighting that considered resting and working heart rate, and were expressed as a percent of maximum heart rate. Reported values ranged from 43 to 47 percent of the subjects' maximum heart rate. Stübler (1970) recorded heart rate values from two women who performed a variety of household chores. The subjects' heart rate values ranged from 73 to 108 bpm and from 93 to 135 bpm. Both Åstrand

(1966) and Stübler (1970) concluded that heart rate values during household activities were considered high and were inversely related to the subjects' fitness level.

Varghese et al. (1994) developed a method of determining occupational workload using 120 healthy Indian women performing manual household activities. Lab testing was used to derive regression prediction equations for predicting energy expenditure levels from heart rate and to create a workload job classification system. Ratings of perceived exertion (RPE) were also used in classifying the tasks. The job classification table was also presented. Based on energy expenditure and heart rates, it classified household activities from a very light to very heavy workload. Tasks such as cleaning rice were considered a very light workload, kneading dough moderately heavy workload, and mopping floor heavy workload.

The heart rate, energy expenditure and RPE of women with coronary artery disease (CAD) while they performed household tasks were studied to determine whether or not they could safely return to performing their household chores (Wilke et al., 1995). Twenty-six women with CAD and 10 women without CAD performed the tasks. The average age of the subjects was 62.2 years. Response values from the 10 healthy women (without CAD) are presented in Table 2.1. The metabolic and heart rate responses of the women with CAD and healthy women were similar for these four activities. Two significant differences ($p < 0.05$) were noted between the two groups: the heart rate response when changing beds was higher in the healthy women and the RPE response when washing the floors was lower in the women with CAD. From their data, Wilke et al. (1995), noted that the MET levels for common household tasks ranged from 2 to 4 METS, indicating that women who had achieved a MET level above this level (as determined on a treadmill test) could perform housework. The authors noted that for some individuals, performing housework would provide an exercise training effect and that involvement in a regular program of aerobic exercise would be recommended for these individuals.

Table 2.1

Selected Results from Wilke et al. (1995) Study

Task	Heart rate (beats/min)	Oxygen Uptake (ml/kg/min)	RPE[1]
Vacuum carpet	111 ± 6	10.7 ± 0.9	9 ± 1
Mop floor	116 ± 5	12.2 ± 0.7	10 ± 1
Change bed	125 ± 5	12.7 ± 0.6	10 ± 1
Wash floor	129 ± 6	13.7 ± 0.8	10 ± 1

[1] Refer to Appendix A for verbal ranking.

In 1993 Wilke et al. used the Baltimore Therapeutic Equipment (BTE) and a simulated work (WS) setting to determine the hemodynamic responses of men who performed a variety of household activities. The average of the subjects was 65 years (SD = 5 years) and the subjects had stable coronary artery disease. One of the many tasks evaluated by Wilke et al. was vacuuming carpet. The heart rate, RPE and oxygen uptake values from this task are presented in Table 2.2.

Table 2.2

Selected Results from Wilke et al. (1993) Study

Task	Heart rate (beats/min)	Oxygen Uptake (ml/kg/min)	RPE[1]
Vacuum low pile carpet			
WS	79 ± 14	8.2 ± 1.6	9 ± 2
BTE	80 ± 11	7.8 ± 1.6	10 ± 3
Vacuum high pile carpet			
WS	86 ± 12	10.3 ± 1.6	12 ± 3
BTE	86 ± 14	9.5 ± 2.3	12 ± 3

[1] Refer to Appendix A for verbal ranking.

During vacuuming, the heart rate responses of the women in the Wilke et al. (1993) study were higher (111 beats per minute) compared with the heart rate responses of the men in their subsequent (1995) study (79 to 86 beats per minute). The authors cautioned against using the heart rate values recorded with male subjects for female subjects. They explained that women typically have less upper body strength compared with men. To compensate for this difference, women will work relatively harder, experiencing higher hemodynamic responses to the same task.

Measurement of Household Task Performance Demands - Postures

One of the goals of this study is to describe and compare the physical demands of two household tasks. Articles that have recorded and analyzed trunk, extremity and hand postures assumed by the subjects while they perform household tasks are discussed. Range of motion in the wrist and hand required to perform some household tasks, as documented in the literature, are also presented. For this study, the two tasks chosen were cleaning the bathroom and vacuuming the living room, so emphasis will be placed on these activities.

In 1946 Knowles (cited in Grandjean, 1973) studied trunk postures assumed when ironing. Knowles reported that the degree of forward bending required was directly related to the height of the ironing board and recommended a working level of 'moderate height'. However, values for 'moderate height' were not reported by the author.

Task demands, o[illegible]ts and environmental measures of 25 activities of daily living (ADL) tasks w[illegible] analyzed (Clark, Czaja & Weber, 1990; Czaja, Weber & Nair, 1993; & Weber, 1996). These three sets of authors reported on the results from the same study. The tasks were performed by 60 elderly subjects in their homes and in the community (e.g., a grocery store). The authors used video tapes to record the task performance demands. They analyzed the tapes according to postures, actions, body part involved, and type of grip used. Body postures for cleaning the bathroom and vacuuming floors are provided in Table 2.3 (Weber, 1996). Unfortunately, no definitions for the body postures were provided.

Table 2.3

Body Postures for Cleaning the Bathroom and Vacuuming Floors (Weber, 1996)

Body Posture	Cleaning Bathroom % duration	Vacuuming Floor % duration
Lean reach	36	56
Standard work	23	14
Bend	23	28
Extended high reach	10	0
High reach	7	0
Stoop	1	2

Clark et al. (1990) reported that several components occurred across ADL tasks (e.g., actions, body parts, and postures), and that the environmental components depended on the task. Tasks that the subjects reported as having the highest level of difficulty performing were: housecleaning, transfers, bathing, and grooming. The authors showed applications of task analysis data and suggested dynamic aspects of task performance (e.g., fatigue) should be examined in future studies.

Czaja et al. (1993) used task analysis decomposition, a structured way of breaking down the task and developing a systematic representation of task demands to analyze the demands of household task performance. These authors reported descriptive data for: 1) performance demands of the ADL in three main categories - actions (e.g., lift, lower); postures (e.g., stand, lean, and reach); and hand grips (e.g., precision, power); 2) performance problems in ADL tasks (e.g., bending/reaching, stamina/fatigue, cognitive); and 3) environmental measures (e.g., heights of kitchen counters, force to manipulate a refrigerator handle). Performance demands of meal preparation, grocery shopping, and bathing were reported. The authors then demonstrated how a comparison of the individual's capabilities to the task demands can form the basis for development of intervention strategies to alleviate performance problems in the elderly and for the development of assessment tools. Czaja et al. recommended that more study was required on the demands of everyday tasks.

Electro goniometric and standard goniometric methods have been used to record the range of motion (ROM) of the fingers and wrists while performing ADL tasks (Hume, Gellman, McKellop, & Brumfield, 1990; & Ryu, Cooney, Askew, An, & Chao, 1991). In the study by Hume et al. (1990), two of the 11 activities were related to household tasks: holding a can and unscrewing a jar lid. The authors reported ROM about the metacarpophalangeal and interphalangeal joints for functional activities. They concluded that in general, only a small percentage of the active ROM of the finger joints was required, except for two tasks, holding a can and holding a toothbrush. Ryu et al. (1991) used the same instruments to record ROM of the wrists while performing twenty-four activities of daily living tasks, six of which represented household tasks. The authors concluded that most of the activities could be performed with 70 percent of wrist motion (wrist flexion and extension, and combined ulnar-radial deviation).

Methodology - Task Analysis

The methodology of task analysis and the techniques used to support it are described in this section. The following schematic representation was developed based on task analysis methodology described by Kirwan and Ainsworth (1993) and represents the methodology used in this study. Data collection methods, data description techniques, and task decomposition categories selected for and used in this study are **highlighted** and will be discussed. As well, methods of enhancing their reliability and validity are presented.

<u>Methodology</u> - **Task Analysis**

⇓

<u>Task Data Collection Methods</u>

Activity sampling

Critical incident

Questionnaires

Interview

Observation

⇓

<u>Task Description Technique</u>

Hierarchical task analysis

Time line analysis

Link analysis

Decomposition

⇓

<u>Task Decomposition Categories</u>

Sequence of activity

Error consequence

Required speed

Hardware or tools

Function/subtasks of the task

Physical performance demands

Perceptual performance demands

Physiological performance demands

Several authors have described task analysis and its purpose. Task analysis is the systematic examination of activities and the breaking down of those activities into their components (Baty, Buckle & Stubbs, 1986; Cynkin & Robinson, 1990; Kirwan & Ainsworth, 1993; Rohmert, 1985; & Trombly & Scott, 1977). To appreciate the true job demands, task analysis must consider the individual who performed the work, the environment in which the work is performed, and the performance demands of the task (Cynkin & Robinson, 1990). Task analysis is a useful tool for development of a job description that can then be used as a reference material for other activities (Kirwan & Ainsworth, 1993). In this study task analysis was used to describe the physiological, physical, and perceptual task demands of two household tasks: vacuuming the living room and cleaning the bathroom. Deciding the purpose of the study a priori is important and should be kept in mind for each research decision (Kirwan & Ainsworth, 1993).

Various task data collection methods exist. One of those methods is observation. The purpose of observation is to collect information of a visual nature, by directly observing the activity (Kirwan & Ainsworth, 1993). Observation is used to obtain task data as the task is performed in the natural setting. Examples of tools that can be used to record the data are direct observation, remote observation via a closed circuit television, video camera taping, or written notes.

Task performance by the subject can take place either in the natural environment or in the lab setting. Observation in the natural setting provides context rich data. One reason why a researcher will choose observation, over other data collection methods, is because it allows the data to represent the natural task (Kirwan & Ainsworth, 1993). Considering the purpose of this study, it was decided that observation in the 'natural' environment was the appropriate choice. However, it is also noted that the researcher must then spend many hours sorting, coding and analyzing the data (Kirwan & Ainsworth, 1993).

Conducting a pilot study is a step often used in task analysis. The pilot study can be used in setting of task parameters and task descriptions before starting the observations, and is an important preliminary step to developing or selecting the checklist used (Baty et al., 1986; Elmes et al., 1989; & Kirwan & Ainsworth, 1993). Assessing the practical problems of data collection and developing ways to overcome these problems can be achieved in a pilot study (Kirwan & Ainsworth, 1993). A pilot study was used in this study for these and other purposes, and is elaborated on in the Methods chapter.

Various authors have made suggestions regarding how to enhance validity, reliability and accuracy during observation. Two ways to increase the validity of natural observation are by using unobtrusive participant observation and unobtrusive recording measures (Elmes et al., 1989). Reliability is enhanced by using more than one data gathering technique (Kirwan & Ainsworth, 1993;

Stammers, Carey & Astley, 1990). For example, video and/or audio recording supplemented by written notes.

Inter-rater reliability coefficients ranging from r = .20 for trunk twisting to r = .96 for squatting were reported by Leonard and Keyserling (1989). Baty et al. (1986) reported accuracy for identification of postures ranging from 50 percent to 89 percent. These authors offered the following suggestions for enhancing reliability and accuracy: structured training of the observers until the required level of accuracy and reliability is reached; implementation of specific definitions for the postures; and opportunity for the observers to practice. Baty et al., and Leonard and Keyserling did not test their suggestions.

Description of the tasks can be done by a well-documented type of analysis, entitled decomposition. Using decomposition the researcher takes a task description and transforms it into a series of a more detailed set of data, always keeping in mind the research goal(s) (Kirwan & Ainsworth, 1993). The process of decomposition involved: 1) defining the task; 2) identifying the steps of the task; and 3) identifying the components or actions of the steps into categories (Burke, 1992; Czaja et al., 1993; Kirwan & Ainsworth, 1993; Lim, 1994; Mattila, Karwowski & Vilkki, 1993; Paquet, Buchholz, Punnett, Moir, Lee & Wegman, 1994; Trombly & Scott, 1977; & Wick & Drury, 1994). Various decomposition categories exist. The decomposition categories chosen for this study were function or subtasks of the task, physical performance demands, and hardware or tools used to perform the tasks.

Following the observation, the researcher then analyzes the data. In this study one of the data collection techniques was the use of video camera recording. Video tape analysis can be done by selecting video spots or still video frames on the tape. When determining which video tape frame to analyze the researcher can select: 1) those postures that the researcher considers as 'poor working postures' (Corlett & Bishop, 1976; & Mattila et al., 1993); 2) random points of the tape, for example, three time points chosen within a one minute section (Kanawaty, 1992; and Lim, 1994); or 3) at set intervals, e.g., every 15 seconds (Mattila et al., 1993).

Instrumentation

A researcher has an assortment of instrumentation that can be used in a study. The literature pertaining to the instrumentation used in this study are presented. Instrumentation included non-exercise method of determining subjects' level of fitness, Ovako Working Postures Analysis System (OWAS), rating of perceived exertion (RPE), and heart rate and heart rate reserve measurement.

Non-exercise Method of Determining Aerobic Capacity

The term VO_2 maximum (VO_2 max) is used to refer to the body's maximum capacity to transport oxygen during task performance (Powers & Howley, 1994). It is believed to be the most valid measure of an individual's cardiorespiratory level of fitness or aerobic capacity (Powers & Howley, 1994). The individual's level of fitness affects their ability to perform household tasks (Wilke et al., 1995). The higher their fitness level, the lower their heart rate response to the task, and the longer they are able to perform the task before fatigue sets in. Measurement of the individual's VO_2 max or level of cardiorespiratory fitness level provides important baseline information. This information can then be used to examine the relationship between fitness level and heart rate response to the task.

There are three main methods of determining VO_2 max: maximal testing, submaximal or predictive testing and non-exercise method. Because this study was conducted in the natural environment, the most portable and least obtrusive method of determining VO_2 max was selected: non-exercise method (N-EX). The N-Ex method is based on a physical activity code, age in years, body composition expressed as percent body fat or body mass index (BMI), and a gender specific constant value (Ross & Jackson, 1990) (see Appendix C).

Development of the N-Ex of predicting VO_2 max was reported by Jackson et al., using a sample of fifteen hundred men and women. Predictive regression equations were used to determine the accuracy of the N-Ex method.

Examining the relationship between the N-Ex method and the VO_2 maximal testing method, authors reported multiple correlation coefficients of R = 0.81 for the percent body fat model and R = 0.78 for the body mass index (BMI) model. These values indicated that this method was valid. Cross-validation analysis determined stability of the N-Ex model. The authors concluded that N-Ex models were more accurate than established submaximal treadmill prediction models and were appropriate for the normal adult population. Exceptions were highly fit individuals who have VO_2 max levels greater than 55 ml/kg/min, or 4% of the population.

Heil, Freedson, Ahlquist, Price, and Rippe (1995) conducted a study to develop a more accurate N-Ex model than the one described by Jackson et al. (1990). Using multiple regression equations, this N-Ex model was slightly more accurate (R = 0.88, where R = multiple correlation coefficient) than the Jackson et al. (1990) model, and was as accurate as submaximal exercise-based models. The authors also conducted cross-validation studies, finding the regression prediction equations to be stable across subsamples. Results of a validation group found the N-Ex model to be accurate. Both models were stable, accurate, generalizable and valid predictors of VO_2 max (Heil et al., 1995; & Jackson et al., 1990).

Jacobs, Ainsworth, Hartman and Leon (1993) compared the reliability and validity of 10 physical activity questionnaires used to predict fitness level. They concluded that: 1) a simple logical content related questionnaire was as valid as a long questionnaire; 2) questions should reflect all spheres of daily activity, that is, work, leisure, household tasks and self maintenance; and 3) recent activity is more important than habitual activity in overall fitness level. Jacob et al. did not comment on the N-Ex method of Jackson et al. (1990).

Multiple regression analyses were used to determine which individual characteristics were the strongest predictors for fitness level (Kohl, Blair, Paffenbarger, Macera, & Kronenfeld, 1988). The authors reported age, index of physical activity and frequency of sweating were the strongest predictive variables. These variables had a multiple correlation coefficient of r = 0.65.

Whaley et al. (1993) and Fenster, Kennedy, DeMatos, Smith, and Dalsky (1993) also used multiple regression analysis to determine which individual characteristics were the strongest predictors for fitness level. They reported that the strongest predictive variables were: age, gender, percent body fat, and physical activity status.

Siconolfi, Lasater, Snow, and Carleton (1985) studied the correlation of VO_2 max to the Paffenbarger physical activity index (PAI), and VO_2 max to the frequency of sweat-inducing physical activity (sweat). The authors reported significant correlation between VO_2 max and PAI, and VO_2 max and sweat. The frequency of sweating showed the highest correlation level to VO_2 max ($r = 0.46$, $p < .01$). Authors of the eight articles regarding N-Ex models of determining fitness level recommended that use of this method was practical and inexpensive, and was at least as reliable and valid as submaximal testing methods.

Ovako Working Postures Analysis System (OWAS) of Determining Physical Demands

Knowing the physical demands or working postures required to perform the task can be helpful in the functional capacity evaluation and rehabilitation of individuals with musculoskeletal injuries. Physical demands can provide part of the base for work simulation, biomechanics education, joint protection techniques, and quantification for compensation. Various tools have been designed to record the physical demands. One tool designed to record postures in the work place is the Ovako Working Postures Analysis System (OWAS). OWAS was originally developed in the Finnish steel industry by Karhu, Kansi & Kuorinka (1977). It is used to record, identify and quantify postures that occur during task performance by workers during their normal workplace activities (Heinsalmi, 1986; Karhu et al., 1977; Karhu, Harkonen, Sorvali & Vepsalainen, 1981; & Kivi & Mattila, 1991). The OWAS is a practical tool designed for recording dynamic postures that occur in the workplace. It is not suitable for static postures (see Appendix B).

The OWAS is used to record the position of the back, arms, leg, and load effort. These four factors are known as posture segments and will be referred to as such in this document. The posture segments are then combined to form a four-digit posture code. Karhu et al. (1981) reinforced the importance of analyzing the whole body posture as a unit, combining the postures of the back, legs, arms and force exerted into a posture code.

After identification of the posture segments and posture codes an OWAS action category is assigned to each (Heinsalmi, 1986; Karhu et al., 1977; Jackson & Liles, 1994; & Von Stoffert, 1985). The action categories range from I to IV and are defined in Appendix B. Action categories were originally developed by an expert group of physicians, work analysts and plant workers in the steel industry, and further developed by Von Stoffert (1985). Action categories for the posture segments are based on a percentage of occurrence, and action categories for posture codes are based on the code only. Action categories for posture codes are then related to specific job tasks and are used to identify those tasks for which corrective action is required (see Appendix B).

Of special note, is a recommendation received from M.I. Kuorinka (November 16, 1995), one of the original authors of the OWAS (Karhu et al., 1977). As stated by Kuorinka, the OWAS was originally developed for use in the steel industry, an industry with a variety of postures. He reinforced that household activities did have sufficient variability of postures in order for the OWAS to be appropriate for the posture analysis of household activities. However, he did not support the use of the action categories for household activities, reinforcing that the original development of the OWAS was for the steel industry. Furthermore, the subjects in the present study performed the activity for 17 to 20 minutes, far less than required in a work shift. Considering Kuorinka's recommendation and the fact that the duration of the tasks in the current study was 17 to 20 minutes, the current study's researcher decided that use of the action categories would probably not be appropriate. In view of the above discussion, the OWAS action categories were not used to group the posture segments and posture codes. Alternatively, the OWAS classification system was used to identify the subjects' poor working posture codes.

The OWAS has been used in many industries to record and analyze the dynamic working postures of the workers. Examples of occupations and industries were: welding and mine drilling (Heinsalmi, 1986); automobile mechanics (Kant, Notermans, & Borm, 1990); professional cleaners (Hopsu, Louhevaara, Korhonen, & Miettinen, 1994); grocery store checkout operators (Kayis & Kothiyal, 1994); woodworking industry (Burdorf & van Duuren, 1993); pharmaceutical and textile factory workers (Chavalitsakulchai & Shahnavaz, 1993); ambulance assistants (Doormaal, Driessen, Landeweerd & Drost, 1995); nurses (Engels, Landeweerd, & Kant, 1994); physiotherapy students (Jackson & Liles, 1994); construction trades (Heikkinen et al., Polari & Louhevaara, 1994; Karhu et al., 1981; & Kivi & Mattila, 1991); and hammering in building construction (Mattila, Karwowski & Vilkki, 1993). In these studies the OWAS was used to analyze work postures, identify work postures considered as poor, and develop recommendations for improvement. Some studies implemented recommendations that were reviewed for effectiveness.

OWAS posture analysis results from selected industries: roof joisting, nursing and building construction are presented in table 2.4. Roof joisting was one of the building construction tasks observed and analyzed by Mattila et al. (1993). Eighteen construction workers (gender not reported) with an average age of 41.6 years were observed in 177 posture frames performing roof joisting. Use of the OWAS allowed the authors to identify the critical tasks that required improvements or alterations.

The posture segments of nurses who worked on an orthopaedic ward were analyzed (Engels et al., 1994). Male and female nurses, average age 31.56 years participated in this study. The results are found in table 2.4. The most common activities in which the nurses adopted poor working postures were wound care, patient care and administrative tasks. The authors were surprised that poor postures were also adopted by the nurses during administrative tasks. This finding pointed to the need to analyze the whole job.

Kivi and Mattila (1991) analyzed a total of 6,457 work postures for eight occupations in the building industry. Two of the occupations that they reported on were a cement worker and brick layer. The number of subjects was not provided, however, it was noted that for cement workers, 169 observations (of the 6,457 observations) were analyzed. The authors provided the posture segment results for the cement workers and the extremely harmful codes for the brick layers. The results are noted in table 2.4. It was reported that the OWAS was well suited for analyzing the working postures in the construction industry.

Reliability and validity of the OWAS have been documented. Heinsalmi (1986) reported that poor working posture, as identified by the OWAS, were significantly related to musculoskeletal related sick leave ($p < 0.01$). Mattila et al. (1993) reported inter-rater reliability coefficients for the back postures ($r = .97$), arm postures ($r = 1.00$), leg postures ($r = .98$), and for combined body postures ($r = .97$) for the frequency percent values. A similar reliability value ($r = .90$) was reported by Jackson and Liles (1994). Heinsalmi reported on the historical development of the OWAS and stated that inter-rater reliability for posture identification was 90 percent for all postures, with the greatest difficulty in differentiating between straight and twisted back postures. Kivi and Mattila (1991) reported inter-rater reliability coefficients for the back ($r = .86$), arm ($r = .94$), and leg ($r = .85$) and force ($r = .94$). Kant et al. (1990) reported inter-rater reliability of $r = .96$ for posture combinations and work activities performed by garage mechanics.

Table 2.4

Distribution of Posture Segments and Posture Codes from Other Industries

OWAS[1] Posture Segment		Roof Joisting[2] (%)	Nursing[3] (Orthopaedic) (%)	Building Construction Cement Workers[5] (%)
		Percent Duration		
Back	B1	31.1	75	54.3
	B2	58.8	18	35.2
	B3	0.6	4	8.0
	B4	9.6	3	2.5
Arm	A1	98.9	96	56.8
	A2	1.1	3	35.8
	A3	0.0	1	7.4
Leg	L1	0.0	21	0.3
	L2	23.2	53	53.1
	L3	1.1	8	1.5
	L4	4.0	1	1.2
	L5	1.7	0	0.6
	L6	61.6	0	25.9
	L7	8.5	17	16.7
Effort	E1	96.6	Not Recorded[4]	27.5
	E2	3.4	Not Recorded	61.4
	E3	0.0	Not Recorded	11.1
Poor Working Posture Codes				**Brick Layer**
		(%)	(%)	(%)
4141		.005	Not provided	
4161		.062		
4261		.005		
2343				.018
2242				.006
2243				.018
4233				.006
4243				.018
4143				.018
4162				.012

1 For key and further description of the OWAS refer to Appendix B

2 From Mattila et al., 1993

3 From Engels et al., 1994

4 Not recorded because the forces seldomly exceeded 10 kg and assessing them disturbed the work routine

5 Kivi and Mattila (1991)

Rating of Perceived Exertion

The Borg Rating of Perceived Exertion Scale (RPE) has been used to determine the individual's subjective response to the physical task demands (see Appendix A). The RPE is a simple ratio scale for rating the degree of perceived exertion during physical work (Borg, 1973; & Gamberale, 1985). It was used as an indicator of physical strain to quantify symptoms (Borg, 1982). This scale has been used in a variety of applications: clinical determination of activity tolerance, exercise prescription, and matching between the job demands and the employee (Gamberale, 1985; Noble, 1982; & Watt & Grove, 1993).

This fifteen-point scale ranges from 6 to 20, where the value on the scale represents the subject's subjective response to the physical work (Borg, 1982). The odd numbers on the scale are accompanied by verbal descriptors: 7 equals very, very light; 9 equals very light; 11 equals fairly light; 13 equals somewhat hard; 15 equals hard; 17 equals very hard; and 19 equals very, very hard.

Gamberale (1985) summarized a number of studies that used the RPE and concluded that the RPE was a suitable tool for the assessment of the subjective response to physical work. It represented the linear relationship between heart rate and workload, and was the most frequently used tool for determination of exertion.

RPE can be used to represent the subject's local (arising from the working muscles) and central sensations (arising from the cardiopulmonary system). Both sensations have been found to be important factors during physical work (Pandolf, 1982). Robertson, Gillespie, McCarthy and Rose (1979) studied the perception of exertion and reported that perception was best represented by a composite score from three levels: peripheral, local, and overall.

The RPE scale values can be used to denote heart rate values from 60 to 200 beats per minute. Arstila, Wendelin, Vuori, and Valimaki (1974) reported correlation coefficients of RPE to heart rate, $r = .87$, .83, and .88 for three different test protocols. Coury and Drury (1982) reported a high correlation coefficient, $r = .93$, between RPE and heart rate on a box carrying task. Exercise test methods on the bicycle ergometer, treadmill and stool stepping were compared by Skinner, Hutsler, Bergsteinova and Buskirk (1973); and Stamford (1976). These authors reported validity coefficients between the RPE and heart rate ranging from r = .79 to r = .91.

The reliability and validity of the RPE have been documented. Dunbar et al., (1992) studied the validity of the RPE. They reported less than 2 percent difference between the target intensity of VO_2 using the RPE and the intensity produced using the graded exercise test. Arstila et al. (1974), Skinner et al. (1973), and Stamford (1976) reported test-retest reliability coefficients ranging from r = .76 to r = .91 (significant at $\propto$ = .01) for various exercise test methods (i.e., bicycle ergometry, treadmill walking and jogging, and stool stepping).

Legg (1985) and Legg and Mahanty (1985) recommended that during performance of physical tasks, physiological measures are supplemented by recording subjective response data using standardized methods and rating of perceived exertion scales. Legg and Mahanty's study examined five different methods of load carriage. They reported a significant difference in the subjective responses and no significant difference between the physiological responses to the five different carrying methods. This data suggested that the RPE is recording information beyond the physiological, that is, it records the subject's perceptual response to the task (Legg and Mahanty, 1985). The perceptual response was affected more than the physiological response for this type of task that involved static and dynamic work.

Numerous studies have used the RPE in occupational applications: carrying loads (Goslin & Rorke, 1986; Kirk & Schneider, 1992; Legg, 1985; Legg & Mahanty, 1985; & Robertson, Caspersen, Allison, Skrinar, Abbott & Metz, 1982); lifting tasks (Drury et al., 1989); floor mopping techniques comparing figure-of-eight method with the push method (Hagner, 1989); skiing with a sled or carrying a back pack (Juhani, Pekka & Timo, 1986); and patient lifts performed by hospital workers (Dehlin & Jaderberg, 1982).

The RPE has been used to compare subjects' responses with different types of activities in clinical settings. Morton, Barnett and Hale (1992) compared subjects' physiological and subjective responses to purposeful and nonpurposeful activity and found no significant differences between responses of the two activity formats. The authors suggested that while 'purpose' was added to one task, it was not productive in nature, so did not influence the subjects' response pattern. Bakshi, Bhambhani and Madill (1991) found heart rate and RPE responses in the least preferred tasks of a nonpurposeful nature significantly higher than in the most preferred tasks of a purposeful nature.

The RPE has been used in a variety of applications. Numerous studies have established its validity and reliability. Furthermore, this scale is easily administered (Gamberale, 1985; & Noble, 1982) and lends itself to be used in a natural environment.

Heart Rate and Heart Rate Reserve Measurement

Studying heart rate response to work in the natural environment is an indirect method to examine the proportion of the worker's capacity exerted or the amount of circulatory strain in response to the workload demands (Rodahl, 1989). Continuous measurement of heart rates is a common method to evaluate cardiovascular strain during work (Kilbom, 1990). In order to determine which tasks resulted in the higher level of circulatory strain, heart rate recordings should be accompanied by activity recordings and subjective ratings of exertion (Kilbom, 1990). This information can then be used to: identify the most demanding tasks; analyze the mean heart rate values for each task; and to compare the studied job with heart rate response values of other jobs (Goldsmith et al., 1978; Kilbom, 1990; Rodahl, 1989; & Vitalis et al., 1994).

Grandjean (1973) argued that heart rate recordings during household task performance are preferred to energy expenditure values. He stated that recording heart rate allows for concurrent recording of subjective levels of exertion, providing information regarding the subjective response; and heart rate is a more responsive measure than energy expenditure during the performance of static work found in household tasks.

Heart rate reserve, a relative heart rate workload measurement value, can have different meanings. For this study, the definition provided by Rodahl (1989) will be used. It will be called work HRR in this document. Work HRR tells the researcher how much of the subject's reserve is used to perform the task. It takes into account the subjects' age, resting heart rate, and working heart rate and is expressed as a percent. The steps and equations used to determine work HRR are:

Step #1: Determine resting heart rate, working heart rate and age related maximum heart rate (HRmax).

Step #2: Calculate percentage of work HRR using the following equation:

$$\frac{\text{HR work} - \text{HR resting}}{\text{HR max} - \text{HR resting}} \times 100 = \%\text{ of work HRR}$$

(Rohadl, 1989)

Rodahl et al. (1974) reported that work HRR can be used to determine the degree of circulatory strain. Rodahl suggested two heart rate reserve criterions should be reported: 1) values greater than 50 percent of the subjects' work HRR; and 2) the peak values of work HRR. Matching the work HRR to the job task, the researcher can determine which task poses the highest level of circulatory strain on the worker.

Work HRR has been reported for different occupations (Rodahl, Vokac, Fugelli, Vaage & Maehlum, 1974). Rodahl et al. reported heart rate reserve values for Norwegian coastal fishermen ranging from 0 percent at rest to 95 percent while pulling in a seine (i.e., very long net). These authors demonstrated how some job components of a coastal fisherman had very high cardiovascular demands, and how the subject's age and fitness level affected the percent of heart rate reserve used during the task.

In two studies Rodahl (1989) used HRR to determine which job tasks of Eskimo hunters and Norwegian fishermen required the highest degree of circulatory response by the worker. Similar measurements and applications were used to determine circulatory strain in Greek steelworkers (Vitalis et al., 1994) and vehicle assembly workers (Goldsmith et al., 1978). The results are presented in Table 2.5.

Table 2.5

Work Heart Rate Reserve Values From Other Industries

Author	Industry/Task	Heart Rate Average (bpm) Mean (SD)	Working Heart Rate Reserve Mean (SD) Range
Vitalis et al. (1994)	Steelworkers	97(13)	25(14) 8-57
Goldsmith et al. (1978)	Vehicle assembly line	91(8)	21(7) 4-29
Rodahl (1989)	Trawler foreman		30-38
	Trawler skipper		20[1]
	Deckhand (bank fishing)		25-33
	Cook (fishing boat)		15[1]

[1] Standard deviation not recorded

Other authors have used heart rate values only to assess the subject's cardiovascular response to the task. Heart rate monitoring and the OWAS posture recording method have been used in conjunction to determine the circulatory strain and postural requirements in the job tasks of professional cleaners (Hopsu et al. 1994) and tilesetters (Rohmert, Wakula, & Schaub, 1994). Hopsu et al. studied 94 professional female cleaners whose average age was 46 years. Results from Hopsu et al. are presented in Table 2.6.

Table 2.6

Selected Results From Hopsu et al. (1994) Study on Professional Cleaners

OWAS[1] posture segment		Frequency (%)
Back	B1	61
	B2	33
	B3	2
	B4	4
Arms	A1	73
	A2	26
	A3	1
Heart rate		(bpm)
		93

[1] For key and further description of the OWAS refer to Appendix B. Posture segments for the legs and effort load were not recorded by Hopsu et al.

Summary of the Literature Review

In summary, occupational therapists assess, diagnose, and treat individuals' functional performance in occupational roles, including household tasks. Work simulation is one method used in the determination of an individual's functional capacity. Information regarding the demands of household tasks could give occupational therapists an objective baseline for clinical programming and assessment.

Literature reviewed pertaining to the task demands of household tasks revealed studies that have limited application in Canada in the 1990s. Most of the studies on the energy expenditure demands or heart rate response demands of household tasks were performed before or during the 1960s or 1970s, or in Europe or India. Posture and grip demands, and environmental measures for household tasks, have been studied with a geriatric population in a natural setting (i.e., the home or community). Range of motion studies have been performed in a lab setting on isolated aspects of household tasks on specific body parts. The paucity of current literature relating to the performance task demands of household activities, and more specifically to the task demands as found in the natural setting shows the need for initiating study in this area. The literature itself also documented the need for further study to identify the task demands of household activities. This occupational role is worthy of further study.

CHAPTER 3. METHODS

The methodology used in this research study was a task analysis of the physiological, physical, and perceptual demands of household tasks performed by healthy women. This chapter describes the study's methodology, subjects who participated, instruments, study protocol, data analysis, and statistical analysis. The pilot study's and research study's steps and goals are described in the study protocol.

Task Analysis Methodology

The task analysis method used in this study was based on a model presented by Kirwan and Ainsworth (1993). A number of steps were involved. First, data was collected using observation while the subjects performed the two household tasks of cleaning the bathroom and vacuuming the living room. Tools selected to collect the data were: a video camera, a heart rate monitor with a data storage chip, and written notes. The data were later analyzed. Using a technique called decomposition; the tasks were then broken down into subtasks to provide a more detailed description. The following categories were chosen during the decomposition of the data: function or subtasks of the tasks; physical, physiological, and perceptual performance demands; and hardware or tools used to perform the tasks.

Work Sampling

Work sampling can be used to determine the accuracy of the observations or the number of observations required to reach a certain level of accuracy (Kanawaty, 1992). The basis of work sampling is "when the sample size is large enough and the observations made are indeed at random, there is quite a high probability that these observations will reflect the real situation, plus or minus a certain margin of error" (Kanawaty, 1992, p. 249). In the current study, the nomogram provided by Kanawaty (1990) was used to determine the accuracy or margin of error of the observations. This information was based on the percentage of occurrence and the number of observations (see Appendix D).

Subjects

A pilot study with three subjects and a research study with seventeen subjects were conducted. A sample of convenience was selected. Inclusion criteria were: healthy; between the ages of 30 and 50 years; participated in household activities in their own home; and female. Each subject was prescreened over the phone to ensure a good state of health and absence of medications that may have affected their health. If the subjects cleared the prescreen, they then volunteered their informed consent to participate in this study (Appendix E). Each subject participated in two parts - interview and task performance, both of which are described in the study protocol.

Instruments

1. Heart rate monitor

   Heart rate was recorded using a Polar Vantage XL heart rate monitor (Polar USA, 1991). This model of heart rate monitor has been found to have a high level of validity (r = .93 to .98), and a high level of stability (0% level of doubtful heart rate values and 0.1% level of unrealistic heart rate values) (Léger & Thivierge, 1988). The subject wore the transmitter on her chest. The wrist monitor was attached to a strap and worn by the subject on her back. The position of the wrist monitor allowed the researcher to check it during the subject's task performance without interruption. Heart rate values were stored in memory and subsequently retrieved using the Polar Computer Interface with Vantage XL Software (Polar USA, 1990). This unit was used to determine the subjects' minimum, average and peak heart rate values during the two tasks.

2. Rating of perceived exertion (RPE)

   The RPE (Borg, 1982) was used to record the central and peripheral rating of perceived exertion immediately following completion of each task. Subjects were asked to tell the researcher the rating selected at the hardest point for each task, both central and peripheral. When necessary, verbal cuing was provided to the subjects by the researcher to assist in their understanding of the RPE.

3. Video camera

An RCA Pro Edit Video Camcorder was used to video tape the tasks (Thomson Consumer Electronics, 1990). A PROFECT Video System video cam recorder (VCR) was used to play the video tapes during the posture analysis (Thomson Consumer Electronics, 1993).

4. Ovako Working Posture Analysis System (OWAS)

The OWAS was used as the posture analyzing tool to determine posture segments, posture codes and to identify poor working postures.

5. JAMAR dynamometer

To determine grip strength, a JAMAR dynamometer was used (Preston, 1992). The grip strength testing protocol described by Mathiowetz et al. (1985) was used. The recorded value was calculated as the average value from three trials on each hand.

6. Portable scale

Subjects' weight and the weight of objects were recorded using a portable scale.

7. Non-exercise method

The Non-exercise method of determining aerobic capacity was used (Ross & Jackson, 1990) (see Appendix C).

Study Protocol

This study consisted of a pilot study and a research study. The purpose of the pilot study was to: 1) identify the two tasks that would be analyzed, and 2) establish the test protocol that would be most suitable for the research study. Both the pilot and research studies consisted of two parts.

Part One (Interview)

1. The subject read the Information Sheet, and then completed the consent form (see Appendix D).
2. Subjects' demographic profile and fitness level were recorded. The fitness level was determined using the Non-exercise method (Ross & Jackson, 1990) (see Appendix C).
3. Resting heart rate was recorded using the heart rate monitor. Between the tasks, sufficient time was allowed for the subject's heart rate to return to a resting level or near resting level.
4. Pilot study: subject completed the Task Selection Questionnaire (TSQ) (see Appendix F).
   Research study: subject did not complete TSQ.

Part Two (Observation during Performance of Household Task)

1. Pilot study: subject performed the two tasks that she had selected on the TSQ.
   Research study: subject performed the two tasks that had been selected from the results of the TSQ in the pilot study.
2. Data was collected using the following tools: videotaping, heart rate monitor recording, and written forms.

The goals and results of the pilot study follow.

Goal 1: *To develop a Task Selection Questionnaire.*

The following criteria were used to determine the household cleaning tasks selected for the Task Selection Questionnaire (see Appendix F).

Criterion 1. Selected tasks had a moderate level of energy expenditure. Ainsworth et al. (1993) identified estimated energy expenditures of a variety of household cleaning tasks in metabolic equivalents (METS). The MET values for the tasks ranged from light energy expenditure to moderate energy expenditure values. Examples of tasks that had light energy expenditure values were: food preparation 2.5 METS; dish washing 2.5 METS; folding laundry 2.0 METS; and making beds 2.0 METS. Examples of tasks that had moderate energy expenditure values were: washing windows or floor mopping 4.5 METS; cleaning house (general) 3.5 METS; moving household furniture 6.0 METS; and floor scrubbing 5.5 METS.

Tasks with a moderate energy cost were considered more physically demanding. Based on these estimated energy expenditure values, tasks were selected that had a higher energy cost. If the tasks performed were more physically demanding, then they could serve as a performance baseline for other less demanding tasks.

Criterion 2. Selected tasks involved a variety of gross motor postures, hand movements, and manipulation of objects.

Criterion 3. To overcome environmental constraints only tasks that were performed indoors were selected.

Criterion 4. Tasks that were performed throughout the year were selected.

The results of the Task Selection Questionnaire for the three subjects who participated in the pilot study are given in Table 3.1.

<u>*Goal 2:*</u> *To select and define the two household tasks.*

Table 3.1

<u>Results of the Task Selection Questionnaire from the Pilot Study (n=3)</u>

Task Selection	Pilot subject		
	#1	#2	#3
Vacuuming the living room	1	1	1
Cleaning the kitchen cupboards	2	3	3
Cleaning the bathroom	3	2	2
Cleaning the refrigerator	4	5	4
Washing floors	5	4	5

#1 = most physically demanding, #5 = least physically demanding

On the basis of these results, vacuuming the living room and cleaning the bathroom were selected as the tasks to be analyzed.

The parameters for each of these tasks were:

1. Cleaning the bathroom (CB):
   clean the sink, toilet, and bathtub;
   wash the floor; and
   wipe the mirror.
2. Vacuuming the living room (VL):
   remove the vacuum from storage;
   carry the vacuum to area of use;
   vacuum the living room; and
   move the living room furniture to vacuum underneath it.

<u>*Goal 3:*</u> *To determine if the variables - postures, grips, heart rate and RPE (central and peripheral) - were appropriate to represent the physical task demands during task performance.*

After the data from the pilot study was analyzed, it was determined that these four variables represented the task demands.

<u>Goal 4:</u> *To determine if the above variables could be recorded and measured within the selected methodology.*

The pilot study results indicated that recording and analyzing the heart rate, postures and RPE (central and peripheral) were feasible within the prescribed methodology. Occasionally, the electrical noise from the vacuum interfered with the heart rate monitor readings. The electrical noise was absent during the use of a 'centra-vac' system and variable with an upright or canister vacuum. This problem was overcome by installing new and stronger batteries, and by manually recording the heart rate data at two minute intervals while the subject was vacuuming.

Recording and analyzing the grips, using the selected methodology, gave inadequate data. For example, in the pilot subject #2 none of the grips were visible or identifiable during video tape analysis of CB. For VL, 67.5 percent of the grips were not visible or identifiable. Grip type data was incomplete due to the hand grip being obscured by clothing or other objects. Most of the time, the grips that could be viewed simply represented the cylindrical grip used while holding the vacuum wand. Within the methodology chosen, recording grips was considered not feasible and was deleted from the study.

<u>Goal 5:</u> *To determine the video tape duration that was most representative of the overall tasks.*

During the pilot study, the two tasks were video taped for periods ranging from 10 to 20 minutes. It was found that 10 minutes was too short a duration for performing the task parameters of CB. Fifteen to 17 minutes was a more reasonable duration for this task. Vacuuming, because of the possible ongoing nature of this task, was set at the same duration as CB. An appropriate choice to capture the desired information was determined to be 17 to 20 minutes of recording, using 15 second intervals. This choice is further elaborated in goal #7.

<u>*Goal 6:*</u> *To determine which selection of video tape task sampling is most appropriate for this study, for example, 15 second intervals or 30 second intervals. In the literature reviewed, each of these selection methods has been used, with no particular explanation regarding why a selection was made (Doormaal et al., 1995; Jackson & Liles, 1994; & Mattila et al., 1993).*

The video camera that was used had the option of taping continuously or at manually operated intervals. Using the manually operated interval, the duration video taped for each interval was one second. Using these options, task performance was video taped continuously or at intervals of 10, 15 or 30 seconds. Finding the same spot on the tape was desirable, as it would allow reanalysis of the tape at the same spot if required. When analyzing the continuously recorded tape, it was difficult to re-select the same spot in the tape while using a home [illegible] In view of this finding, continuous taping was ruled out as a viable alternative.

To determine if there was any appreciable difference in the results of the 10, 15 or 30 second intervals, 10 second and 30 second intervals for the same tape were compared. This step was achieved by <u>keeping</u> the analysis from every third posture frame. The percent difference in the posture segment frequency values between the 10 and 30 second intervals ranged from zero to 6.67 percent. A similar comparison was made between a tape of 15 second intervals and 30 second intervals. The differences between these two intervals ranged from 0 percent to 6.41 percent. No appreciable difference among the data collected in 10, 15 or 30 second intervals was found.

The decision about which interval to choose then became a matter of professional judgment. It was decided that 30 second intervals would require an unrealistically long task performance to gain a reasonable number of posture frames. Using 30 second intervals may have required subjects to perform the task for a duration beyond their regular routine. Conversely, taping every 10 seconds would have been more appropriate for analysis of the subtasks. However, since the purpose of the study had been to analyze the overall task, a 15 second taping interval was determined to be the most appropriate time segment for videotaping.

<u>*Goal 7:*</u> *To determine intra-rater reliability.*

The video tapes of pilot subjects #1 and #2 were analyzed to assist the researcher in becoming familiar with the OWAS instrument. The video tape of pilot subject #3 (CB) was then used as the benchmark for establishing intra-rater reliability. This step was accomplished by analyzing and reanalyzing the tape on three separate occasions. Ongoing reliability was ensured by reviewing this tape and its corresponding analysis before beginning each tape analysis session during the research study.

One posture observed in the pilot study video tape analysis was not found in the original OWAS (Karhu, 1977), nor in the version described by Von Stoffert (1985). That posture, full squatting, is described as the subject squatting with the back of her thighs resting on her calves. Closer analysis revealed that full squatting was more similar to kneeling than to both legs bent. Hence, a full squatting position was designated as kneeling or OWAS leg posture segment number 6.

<u>*Goal 8:*</u> *To determine the environmental measures to be recorded in this study.*

The pilot study indicated that it was feasible and desirable to collect data on the weight and type of vacuum used, and the weight and type of objects moved while vacuuming. Only those objects that were manageable to weigh (e.g., a rocking chair or plant) were recorded. Large objects, for example, a couch or an easy chair were not weighed in the research study. The researcher assigned an easy chair or a coffee table an effort code of 2 (greater than 10 kilograms and less than 20 kilograms) and a couch an effort code of 3 (greater than 20 kilograms).

The cleaning supplies used while CB were handled one at a time. They weighed less than the units on the scale would record (i.e., 0.5 kilograms). Therefore, single containers of cleaning supplies were not weighed. If the subject carried the cleaning supplies in a container, then that container and its contents were weighed. The layout of the bathroom was recorded during the video tape analysis.

Goal 9: *Based on the data from the pilot study, determine if the choice of statistical tools remained appropriate.*

It was determined that the statistical tools selected remained appropriate based on the type of data to be collected. Statistical analysis is further discussed later in this chapter.

Research Study

Seventeen healthy female subjects participated in the research study. Each subject participated in the interview and performed both CB and VL for 17 to 20 minutes in their own home. Data was collected over a 1 ½ month period, usually one subject per day. Eight out of 17 subjects were tested in the morning, and the remaining subjects were tested in the afternoon or evening. Study duration per subject ranged from one hour to 1½ hours (not including travel time to and from the subjects' home). Data analysis took 3 to 3 ½ hours per subject. Total number of observations analyzed for VL and CB was 1181 and 1180, respectively.

Data Analysis

As noted in the Literature Review the tasks were described using decomposition task analysis (Kirwan & Ainsworth, 1993). The task decomposition categories selected for this study were: the subtasks or components of the task; the physical, physiological and perceptual performance demands; and the equipment used to perform the tasks.

The subtasks of VL consisted of: preparation; vacuuming the floor; vacuuming the furniture; vacuuming the stairs; moving furniture; and other. The subtasks of CB consisted of: preparation; cleaning the sink or vanity; cleaning the toilet, cleaning the tub; cleaning the mirror or wall; cleaning the floor; and other.

For each task, physical performance demands analyzed were: percent occurrence of the posture segments; percent occurrence of the posture codes; and identification of poor working postures. Physiological performance demands analyzed were: minimum, average and maximum heart rate values; percent of work HRR for average and maximum heart rate values; and perceptual or RPE responses - central and peripheral.

The equipment used to perform the tasks that were recorded in this study consisted of: weight and type of vacuum; weight and type of objects moved while vacuuming; and weight of the containers used to carry cleaning supplies.

Statistical Analysis

Descriptive statistics were used to describe the physical, physiological, and perceptual performance demands, and the equipment used while performing the tasks. Paired t-tests were used to determine significant differences between the tasks for each of the dependent variables. Pearson correlation coefficients were used to study the relationship between: 1) VO_2 max and heart rate, work HRR, and RPE (central and peripheral) for each task, and 2) between the back posture segments and leg postures assumed during VL. Significance of the correlations was determined using a t-test.

CHAPTER 4. RESULTS

This section contains the study's descriptive, comparative, and relationship statistics for the physical demands of vacuuming the living room (VL) and cleaning the bathroom (CB). A description of the results is followed by tables containing the data. Finally, figures representing selected aspects of the data are presented.

Subject Demographics

Characteristics of the seventeen healthy female subjects are reported in Table 4.1a. Many of the subjects had a dual role, that is, homemaker and other employment. Seven of the subjects had children at home, and the average age of the children was 10.65 years. The subjects lived in a variety of types of homes: from apartment to multi-storey.

Physical Characteristics

The physical characteristics of the subjects are reported in Table 4.1b. Mean age (40.4 years) and range of 30 to 49.0 years represented the age range of 30 to 50 years selected for the study. Based on 1980 data, the subjects' average height of 1.65 metres was somewhat above the 50 percentile for Canadian female adults of 1.604 metres (30 to 39 years), and 1.591 metres (40 to 49 years) (Humber College, 1987). Mean fitness level was at the 49.4 percentile, with the range representing the full span (0 to 100). All levels of physical activity, ranging from 0 to 7 (out of 7) were represented by the subjects (see Appendix C). The average value of physical activity, 4.6 (out of 7) was somewhat above the mid-range value of 3.5 (out of 7). Mean grip strength was above average for both left and right hands, although a large range of grip strength was represented in the subjects.

Description of Tools Used to Perform the Tasks and Objects Moved in the Environment

The weights of the tools used and the objects moved are reported in Table 4.2. Objects moved ranged in weight from 2.2 kgs. to 15.0 kgs. The heaviest objects moved by the subjects and weighed were armchairs, end tables, and coffee tables. These objects had a mean weight of 9.6 kgs. The vacuums used by the subjects ranged in weight from: 5.5 kgs for a centra-vac vacuum, to14.4 kgs for a canister vacuum, and the mean weight of all vacuums was 8.9 kgs.

Accuracy of Observations

The accuracy of the observations can be estimated from the nomogram of Kanawaty (1992) (see Appendix D). The baseline was chosen for determining percent error or accuracy was the 99.8% confidence level. Number of observations recorded for VL and CB was 1181 and 1180, respectively. Using these criteria and the nomogram, the accuracy for the reported percent frequency of the postures ranged from ± 1.1% to ± 4.0%. For example, the recorded back straight frequency of 26% during vacuuming is accurate within ± 3.6% with 99.8% confidence level. In other words, if the researcher had performed continuous monitoring, with 99.8% confidence, the frequency occurrence of a straight back would have been between 22.4% and 29.6%.

Comparison Between the Physiological and Perceptual Responses to Vacuuming the Living Room and Cleaning the Bathroom

Physiological and perceptual responses to VL and CB are reported in Table 4.3. All VL heart values were higher than CB heart rate values. Minimum and average heart rate, and work HRR - average were significantly higher in VL than CB ($p \leq 0.05$). Review of the central and peripheral RPE found the average verbal ranking for VL was between 'fairly light' and 'somewhat hard', and for CB was slightly below 'fairly light'. There was no significant difference between central and peripheral RPE during CB and VL. Central RPE during VL was significantly higher than that reported during CB. Differences in peripheral RPE between these two tasks was approaching significance (p = 0.059).

Relationships Between the Subjects' Maximal Oxygen Uptake and Physiological Responses to Vacuuming the Living Room and Cleaning the Bathroom

The relationships between the subjects' VO_2 max (relative = ml/kg/min and absolute = ml/min) and physiological responses during the two tasks are reported in Table 4.4. The following correlations were significant ($p = \leq 0.05$): aerobic capacity and average work HRR (VL); aerobic capacity and maximum work HRR (VL); and aerobic capacity and average work HRR (CB). These relationships are graphically presented in figures 4.1 to 4.3. It should be noted that all of these correlations were negative, and correlations observed for relative aerobic capacity were stronger than those observed for absolute aerobic capacity. As the subjects' level of aerobic capacity increased, the values of their heart rate responses to the tasks decreased.

Relationships Between Maximal Oxygen Uptake and Rating of Perceived Exertion to Vacuuming the Living Room and Cleaning the Bathroom

Relationships between VO_2 max (relative and absolute) and RPE (central and peripheral) during both tasks are reported in Table 4.5. Only the correlation between VO_2 max (absolute) and central RPE VL was significant. As expected, most of the correlations between these two sets of variables were negative, suggesting that subjects with a higher aerobic capacity tended to have a lower central and peripheral RPE. This relationship is graphically represented in figure 4.4.

Relationships Between the Rating of Perceived Exertion and Heart Rate Responses to Vacuuming the Living Room and Cleaning the Bathroom

Table 4.6 reports the relationships between the central and peripheral rating of perceived exertion, and the heart rate responses recorded during VL and CB. Generally, the correlations between these two sets of variables were negative, however, none were significant.

Frequency of Posture Segments During Vacuuming the Living Room and Cleaning the Bathroom

Table 4.7 and figures 4.5, 4.6, 4.7, and 4.8 illustrate the percent occurrence of the body posture segments for the arms, back, legs and effort load during VL and CB. It was found that during both VL and CB the amount that the back was straight (B1) was similar. For VL and CB the back was bent (B2), twisted (B3) or bent and twisted (B4) approximately 75% of the time. Arm position for VL and CB was generally below shoulder height (A1), 82.3 % and 71.5%, respectively. During VL the two most common leg posture segments were both legs straight (L2) and walking (L7), 49.9% and 24.0%, respectively. During CB the two most common leg posture segments were both legs straight (46.2%) and kneeling (36.9%). As expected, all of the effort load for CB was 10 kgs or less. In VL 90.4% of the effort load was 10 kg or less (E1); 8.0% was between 10 kgs and 20 kgs (E2); and 1.6% greater than 20 kgs (E3).

Most Frequently Occurring Posture Codes Observed During Vacuuming the Living Room and Cleaning the Bathroom

The ten most frequently occurring posture codes for both tasks are reported in Table 4.8. The two most frequently occurring posture codes during VL were 2121 at 15.9% and 4121 at 11.3%, and during CB were posture code 2121 at 14.5% and 1121 at 13.9%. Of the ten most frequently occurring posture codes, four were the same in both VL and CB: 2121, 3121, 4121, and 1121. In

CB, five of the remaining six codes involved kneeling (4261, 4161, 2161, 1161, and 3161); while in VL, five of the remaining six codes involved the back posture in either bent, twisted, or bent and twisted (2171, 4221, 3121, 2141, 4171, and 2221). This finding indicates that most of the postures assumed when performing the tasks were different. Thus, each task had different physical demand requirements on the body.

Relationship Between the Back Posture Segments and Leg Walking Posture Segments During Vacuuming the Living Room

Relationships between the back and legs during VL are presented in figures 4.9 and 4.10. There was a strong positive relationship between keeping the back straight (B1V) (r = .719, p = .001) and walking (L7V). A strong negative relationship exists between walking and the total of the back bending (B2V), twisting (B3V), and bending and twisting (B4V) (r = - .712, p = .001). That is, if the subjects 'walked' with the vacuum, they had a decreased tendency to bend, twist, or bend and twist their back while vacuuming.

Poor Working Posture Codes

The posture codes that the OWAS considers poor working postures, or in need of correction or alteration, are presented in Table 4.9. Only those posture codes that occurred at a frequency higher than 0.51% of the total number of observations are presented. Twelve different posture codes were recorded as poor working posture codes. Extremely harmful postures assumed were the same in both tasks: 4241, 4141, 4261, and 4161. As noted, in each of these postures the back was in a bent and twisted posture and the leg posture either was both legs bent (L4) or kneeling (L6). The total percentage was higher during CB (26.53%) than VL (11.54%), and a higher number of poor postures codes were recorded in CB (10 posture codes) than VL (8 posture codes).

Subjects Whose Work Heart Rate Reserve was Greater Than 50% During Vacuuming the Living Room and Cleaning the Bathroom

Work HRR values at 50% or higher are considered taxing (Rodahl, 1989) Table 4.10 presents those subjects who had a work HRR greater than 50%. The durations that the subject worked at this level or higher were also noted. Two of the seventeen subjects had a work HRR greater than 50% during VL and CB. Four subjects reached this level during VL only and one subject reached this level during CB only, for a short duration (i.e., 1%).

Subjects Whose Heart Rate was Greater Than 70% of Age Related Maximum Heart Rate During Vacuuming the Living Room and Cleaning the Bathroom

Seventy percent of age related maximum heart rate is considered within a training zone (McArdle et al., 1991). Subjects whose heart rates reached 70% of their age related maximum during VL and/or CB are shown in Table 4.11. Among the seventeen subjects, four of them attained this value during both CB and VL, one during VL only, and two during CB only.

Table 4.1a

Subject Demographics

		n
Occupation	Homemaker	17
Other Occupation	Health care industry	7
	Service industry	3
	Management	2
	Consultant	2
	Homemaker	2
	Unemployed	1
Other Occupation Status	Fulltime	8
	Parttime	6
	Not employed outside home	3
Number of children at home	Zero	7
	One	1
	Two	5
	Three	4
Average age of all children	10.65 years	
Type of house	Bungalow	4
	Multi-story	10
	Apartment	1
	Townhouse	2
Average square feet per house	1829 square feet	

Table 4.1b

Physical Characteristics

Variable	Mean (SD)	Range
Age, yr	40.4 (5.3)	30.0-49.0
Weight, kg	72.8 (19.3)	44.2-136.0
Height, m	1.65 (0.06)	1.53-1.75
B M I[1]	26.6 (6.2)	18.9-47.0
P-AR[2]	4.6 (1.7)	1.0-7.0
VO_2 Max ml/kg/min[3]	30.1 (6.6)	17.4-41.3
VO_2 Max ml/min[4]	2115 (416)	1430-3058
Percentile Rank[3]	49.4 (28.7)	0.0-100.0
Verbal Rank[3]	3.1 (1.3)	1.0-5.0
Grip Strength Right, kg	35.2 (5.8)	26.0-46.2
Right Percentile[5]	69.9 (28.4)	10.0-99.0
Grip Strength Left, kg	32.7 (5.8)	21.9-44.8
Left Percentile[5]	73.2 (27.3)	27.0-99.0

1 BMI or Body Mass Index - calculated as wt. (kg)/h^2 (m)

2 PA-R or Physical Activity Code - used as an indicator of level of activity.
1 = low, and 7 = high (Appendix C)

3 VO_2 Max = maximal oxygen uptake. Based on Non-Exercise Model (Appendix C).
Norms from Minster of State, Fitness and Amateur Sport (1986)
Verbal rank 1.00 = Poor (low), 5.00 = Excellent (high)

4 Absolute VO_2 Max - Calculated as Aerobic Capacity x kg

5 Norms from Mathiowetz et al. (1985)

Table 4.2

Description of Tools Used and Objects Moved in the Environment

Object	n	Weight (kg)	
		Mean	Range
Vacuum - Canister	10	10.4	8.0 - 14.4
Vacuum - Centra-vac	5	6.1	5.5 - 7.6
Vacuum - Upright	2	8.2	6.0 - 10.4
Vacuum - All types	17	8.9	5.5 - 14.4
Plant	8	7.4	4.4 - 12.2
Armchair	7	9.6	5.8 - 17.2
End/coffee table	5	9.6	4.0 - 12.2
Kitchen/dining chair	7	8.7	4.4 - 15.0
Container of cleaning supplies (bathroom)	2	2.7	2.2 - 3.2
Miscellaneous	8	6.8	3.2 - 12.6

Table 4.3

Comparison between the Physiological and Perceptual Responses During Vacuuming the Living Room and Cleaning the Bathroom

Variable	VL		P	CB	
	Mean (SD)	Range		Mean (SD)	Range
Min. HR[1] (bpr	[illegible] (8.2)	70 - 104	P=.009	88 (8.8)	66 - 102
Av[illegible] HR[2] (bpm)	[illegible]05 (10.5)	81 - 126	P=.000	101 (10.4)	73 - 118
Max HR[3] (bpm)	122 (9.9)	99 - 142	P=.139	119 (11.1)	93 -137
HRR Ave[4] (%)*	30.5 (6.4)	21.8-45.0	P=.000	26.5 (5.7)	15.0-37.2
HRR Max[5] (%)	46.7 (9.4)	28.6-65.7	P=.120	43.7 (8.5)	27.7-63.4
CRPE[6] *	11.8 (1.6)	8.0-14.0	P=.027	10.9 (1.6)	7.0-13.0
PRPE[7]	11.8 (1.4)	10.0-15.0	P=.059	10.8 (1.9)	7.0-14.0

1 Min HR - minimum heart value recorded during performance of the activity
2 Ave HR - average heart value recorded during performance of the activity
3 Max HR - maximum heart value recorded during performance of the activity
4 HRR Ave % =

$$\frac{\text{average working heart rate - resting heart rate}}{\text{age related maximum heart}^{8}\text{ - resting heart rate}} \times 100$$

5 HRR Max % =

$$\frac{\text{maximum working heart rate - resting heart rate}}{\text{age related maximum heart}^{8}\text{ - resting heart rate}} \times 100$$

6 CRPE - Central rating of perceived exertion
7 PRPE - Peripheral rating of perceived exertion
8 Age related maximum heart rate = 220 beats per minute - age

**P* <0.05 clean the bathroom vs. vacuum the living room; paired t-test

Table 4.4

Pearson Correlations Between the Maximal Oxygen Uptake and Physiological Responses to Vacuuming the Living Room and Cleaning the Bathroom

	Maximal Oxygen Uptake (VO_2 max)			
	VL		CB	
Physiological Response	Relative ml/kg/min	Absolute ml/min	Relative ml/kg/min	Absolute ml/min
Min HR[1]	-.413 (P=.099)	-.271 (P=.293)	-.407 (P=.108)	-.255 P=.323
Ave HR[2]	-.359 (P=.157)	-.311 (P=.224)	-.362 P=.154	-.175 P=.501
Max HR[3]	-.470 (P=.057)	-.243 (=.348)	-.284 P=.270	-.072 P=.783
HRR Ave. %[4]	-.529* (P=.029)	-.376 (P=.136)	-.563* (P=.019)	-.209 (P=.421)
HRR Max %[5]	-.519* (P=.033)	-.274 (P=.287)	-.406 P=.106	-.119 P=.650

1 Min HR - minimum heart value recorded during performance of the activity
2 Ave HR - average heart value recorded during performance of the activity
3 Max HR - maximum heart value recorded during performance of the activity
4 HRR Ave % = $\frac{\text{average working heart rate - resting heart rate}}{\text{age related maximum heart}^6\text{ - resting heart rate}} \times 100$
5 HRR Max % = $\frac{\text{maximum working heart rate - resting heart rate}}{\text{age related maximum heart}^6\text{ - resting heart rate}} \times 100$
6 Age related maximum heart rate = 220 beats per minute - age

* P <0.05 clean the bathroom vs. vacuum the living room

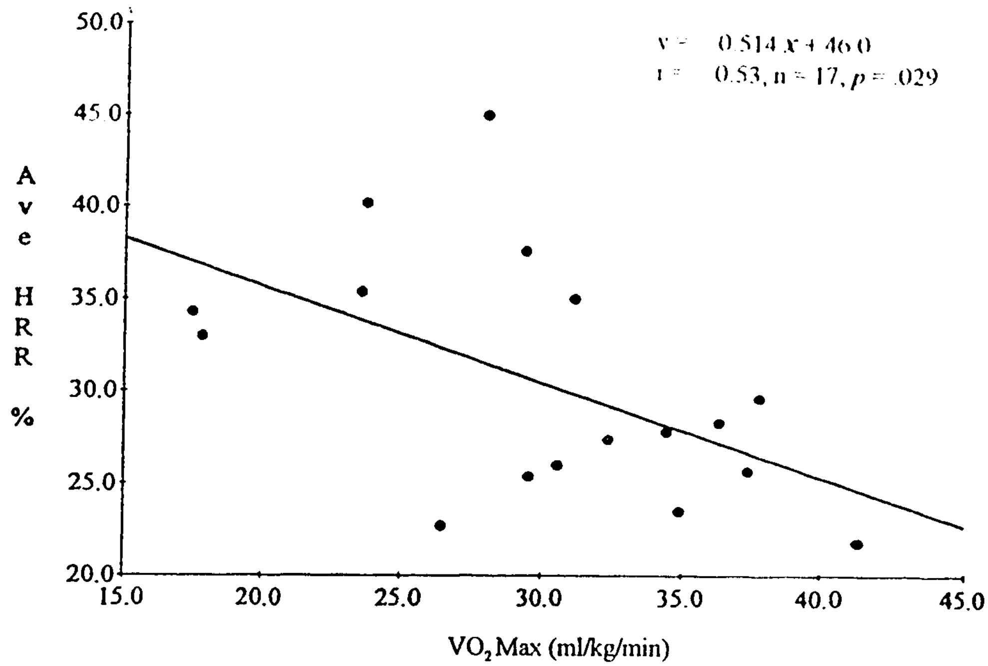

Figure 4.1: Relationship between relative maximal oxygen uptake and average heart rate reserve for vacuuning the living room

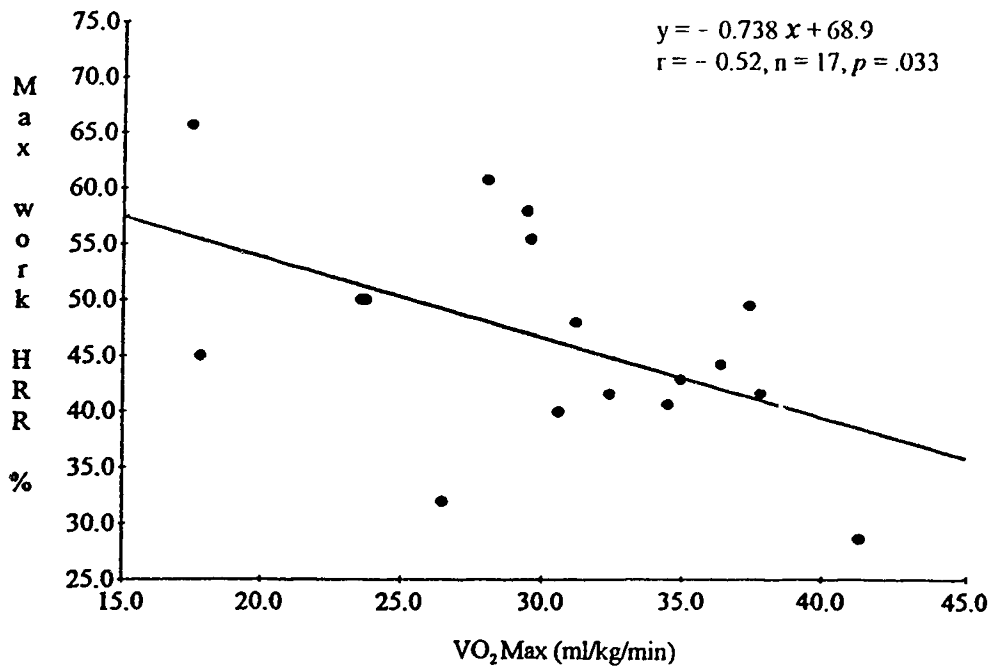

Figure 4.2: Relationship between relative maximal oxygen uptake and maximum heart rate reserve for vacuuming the living room

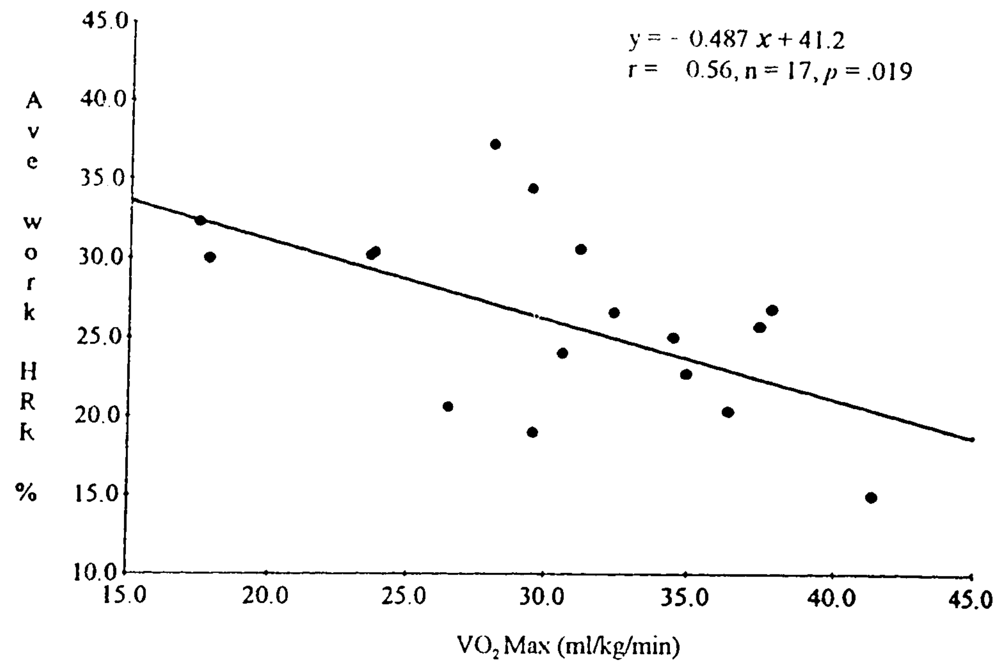

Figure 4.3: Relationship between relative maximal oxygen uptake and average heart rate reserve for cleaning the bathroom

Table 4.5

Pearson Correlations Between Maximum Oxygen Uptake and Rating of Perceived Exertion During Vacuuming the Living Room and Cleaning the Bathroom

VO_2 max	Central RPE CB	Central RPE VL	Peripheral RPE CB	Peripheral RPE VL
Relative (ml/kg/min)	-.162 (P=.534)	-.293 (P=.253)	-.149 (P=.569)	-.281 (P=.275)
Absolute (ml/min)	-.223 (P=.390)	-.552* (P=.022)	.164 (P=.531)	.230 (P=.374)

* $P < 0.05$

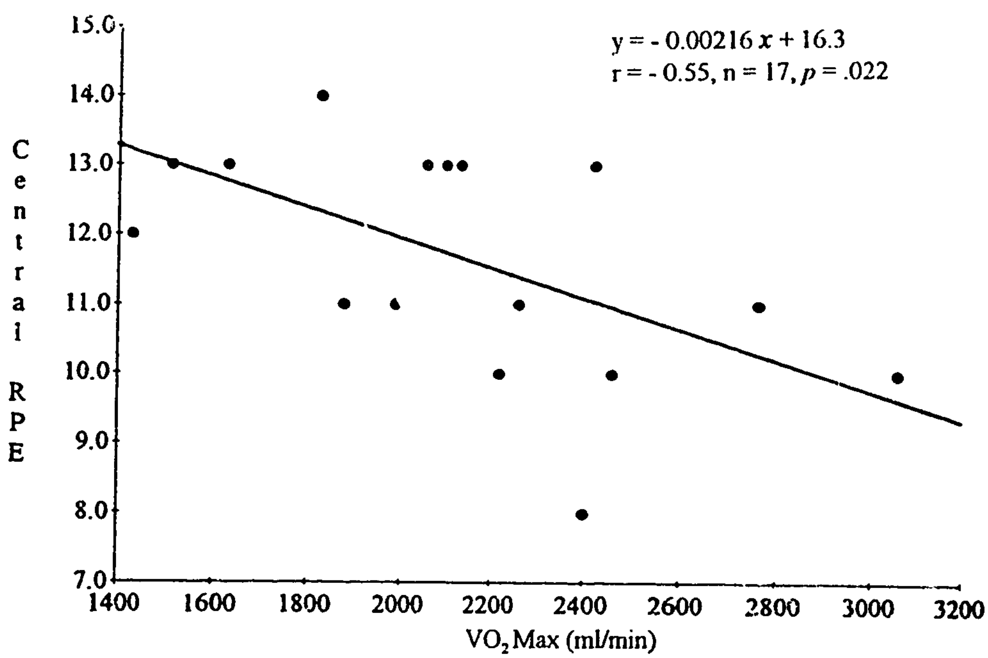

Figure 4.4: Relationship between absolute maximal oxygen uptake and central RPE for vacuuming the living room

Table 4 6

Pearso . Correlations Between the Rating of Perceived Exertion and Heart Rate Responses for Vacuuming the Living Room and Cleaning the Bathroom

Physiological Response	Central[6] RPE VL	Peripheral[7] RPE VL	Central RPE CB	Peripheral RPE CB
Min HR[1]	.072 (P=.785)	-.106 (P=.687)	-.045 (P=.862)	.087 (P=.739)
Ave HR[2]	-.030 (P=.910)	-.168 (P=.520)	-.069 (P=.793)	.122 (P=.641)
Max HR[3]	-.240 (P=.353)	-.089 (P=.733)	-.316 (P=.217)	-.100 (P=.701)
HRR Ave %[4]	.033 (P=.900)	-.045 (P=.865)	-.159 (P-.542)	.017 (P=.949)
HRR Max %[5]	-.200 (P=.441)	-.006 (P=.983)	-.369 (P=.145)	-.222 (P=.393)

1 Min HR - minimum heart value recorded during performance of the activity
2 Ave HR - average heart value recorded during performance of the activity
3 Max HR - maximum hea value recorded during performance of the activity
4 HRR Ave% = (average working heart rate - resting heart rate) / (age related maximum heart[8] - resting heart rate) × 100
5 HRR Max % = (maximum working heart rate - resting heart rate) / (age related maximum heart[8] - resting heart rate) × 100
6 Central RPE - Central rating of perceived exertion
7 Peripheral RPE - Peripheral rating of perceived exertion
8 Age related maximum heart rate = 220 beats per minute - age

Table 4.7

Frequency of Posture Segments During Vacuuming the Living Room and Cleaning the Bathroom

OWAS[1] Posture Segment		VL Mean (SD) %	VL Range %	CB Mean (SD) %	CB Range %
Back	B1	25.6 (10.4)	4.3-42.9	27.2 (7.3)	12.9-40.0
	B2	35.4 (12.8)	11.4-68.6	29.3 (9.2)	18.6-58.6
	B3	10.0 (9.3)	0.0-35.7	11.3 (5.2)	0.0-20.0
	B4	29.0 (11.4)	10.0-52.9	32.2 (4.9)	22.9-40.3
Arm	A1	82.3 (7.8)	68.6-94.3	71.5 (7.6)	52.9-82.9
	A2	17.0 (7.6)	5.7-30.0	27.0 (7.0)	17.1-44.3
	A3	0.7 (1.0)	0.0-2.9	1.5 (1.7)	0.0-5.8
Leg	L1	0.3 (0.8)	0.0-2.9	2.1 (4.0)	0.0-12.9
	L2	49.9 (10.0)	34.3-70.0	46.2 (12.6)	22.9-75.4
	L3	8.4 (4.3)	1.4-14.3	6.2 (4.0)	1.4-14.5
	L4	8.8 (4.8)	1.4-20.0	4.7 (3.7)	0.0-14.3
	L5	2.5 (2.4)	0.0-8.6	0.8 (1.2)	0.0-4.3
	L6	6.1 (6.9)	0.0-23.9	36.9 (14.8)	0.0-61.4
	L7	24.0 (9.7)	10.0-51.4	3.1 (2.3)	0.0-7.2
Effort	E1	90.3 (16.2)	27.1-100.0	100.0 (0.00)	100.0-100.0
	E2	8.0 (16.6)	0.0-72.9	0.00 (0.0)	0.0-0.0
	E3	1.5 (1.7)	0.0-5.7	0.0 (0.0)	0.0-0.0

1 For key and further description of the OWAS refer to Appendix B.

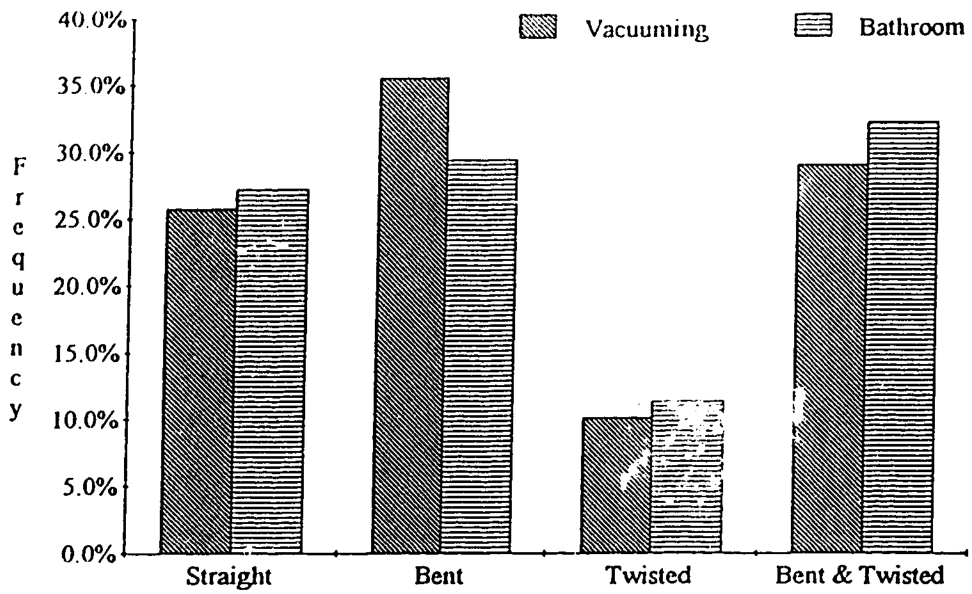

Figure 4.5: Frequency of back postures during vacuuming the living room and cleaning the bathroom.

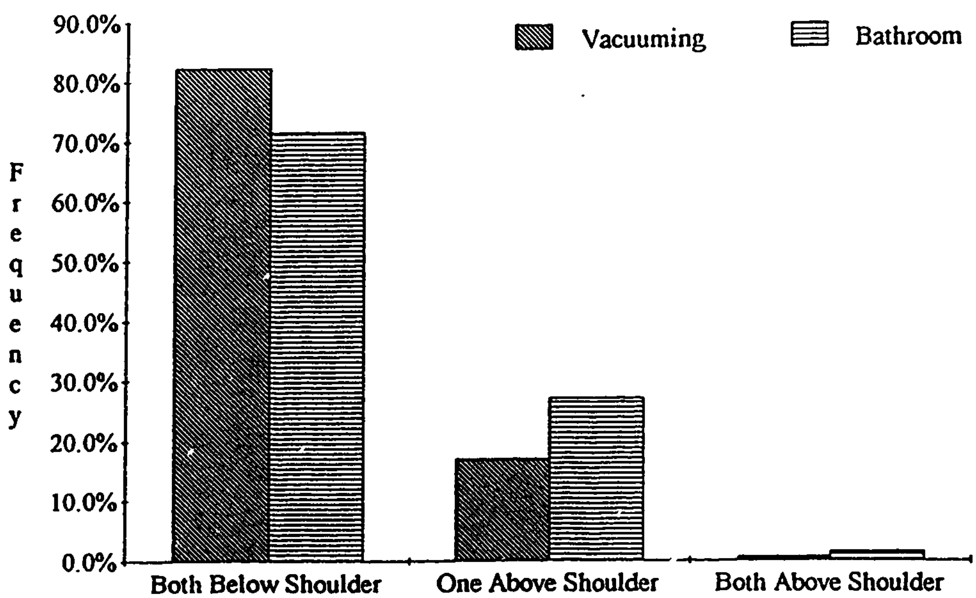

Figure 4.6: Frequency of arm postures during vacuuming the living room and cleaning the bathroom.

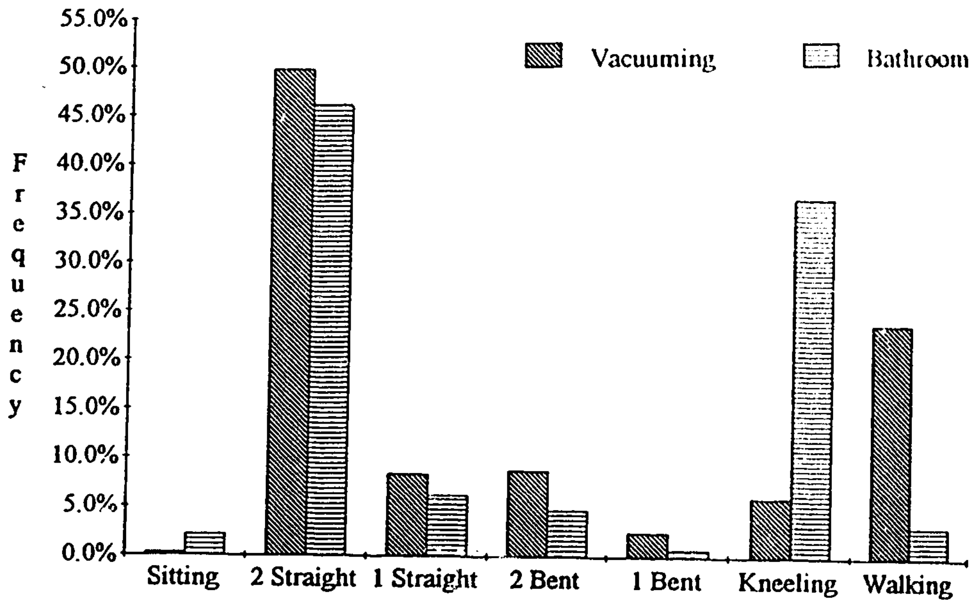

Figure 4.7: Frequency of leg postures during vacuuming the living room and cleaning the bathroom.

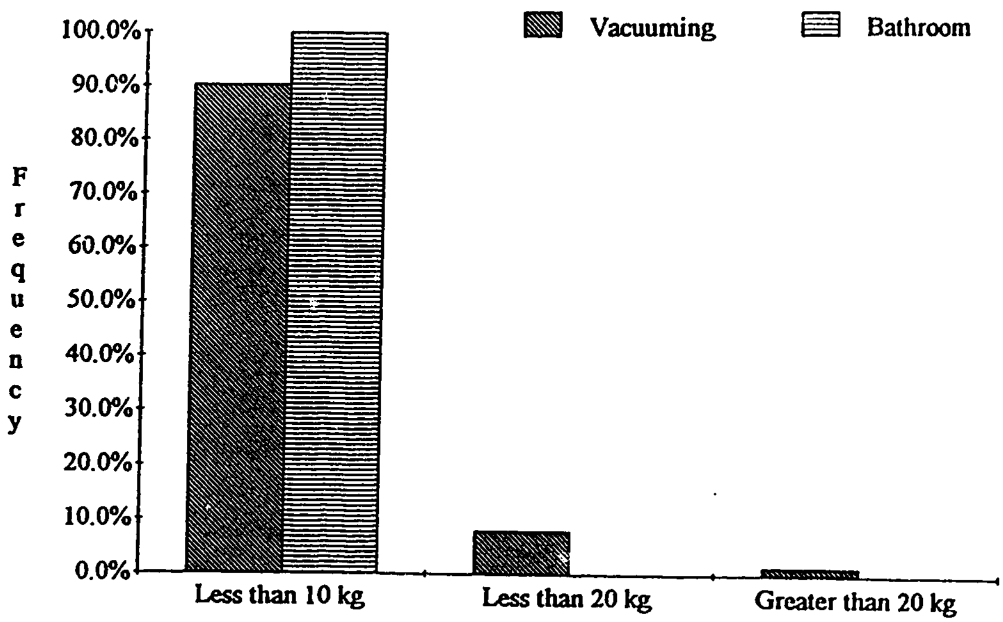

Figure 4.8: Frequency of effort load during vacuuming the living room and cleaning the bathroom.

Table 4.8

Most Frequently Occurring Posture Codes Observed During Vacuuming the Living Room and Cleaning the Bathroom

Posture Code[1]	VL %	CB %
2121	15.9	14.5
4121	11.3	5.8
1121	8.9	13.9
1171	8.8	
2171	5.1	
4221	4.4	
3121	3.2	2.9
2141	2.9	
4171	2.6	
2221	2.2	
4261		10.0
4161		7.0
2161		6.4
1161		6.2
3161		3.3
1221		2.5

1 For key and further description of the OWAS refer to Appendix B.

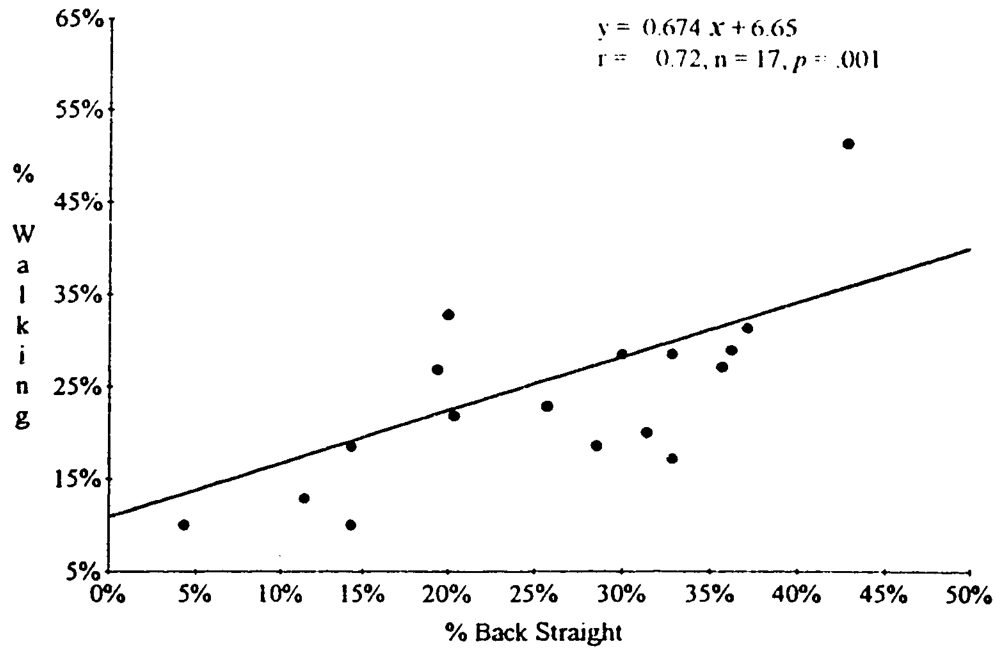

Figure 4.9: Relationship between the back straight posture segment and the walking leg posture segment during vacuuming the living room

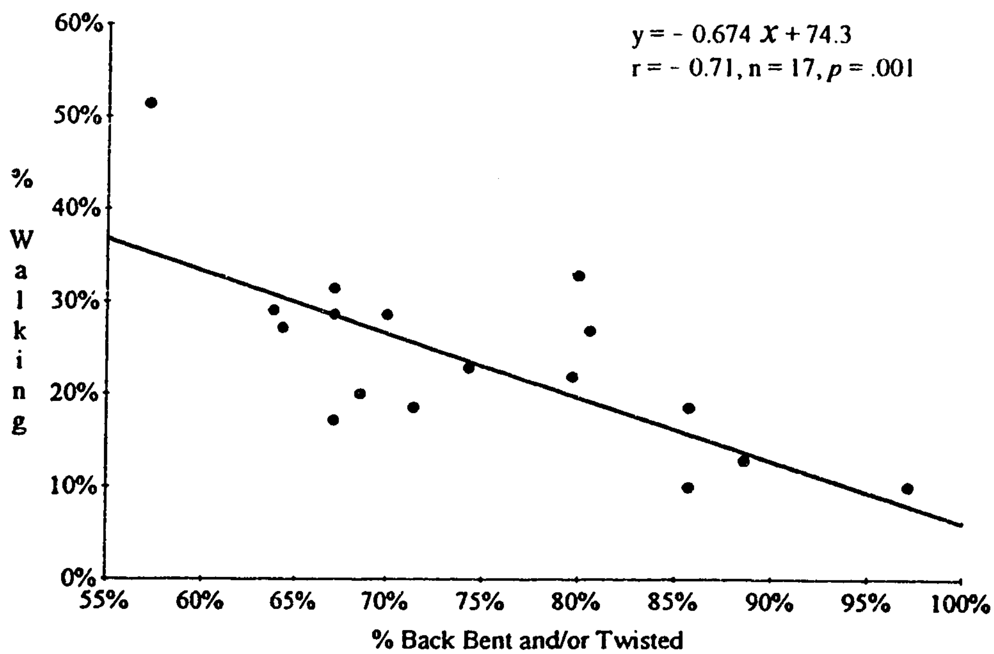

Figure 4.10: Relationship between the total of back bent and/or twisted posture segments and walking during vacuuming the living room

Table 4.9

Poor Working Posture Codes During Vacuuming the Living Room and Cleaning the Bathroom[1]

Posture Code	% Occurrence	
Extremely Harmful[2]	VL %	CB %
4241	1.53	0.76
4141	1.19	0.85
4261	1.02	10.17
4161	1.02	7.03
Harmful[3]		
2141	2.88	1.78
4231	1.78	1.02
2142	1.27	
2151	0.85	
2261		1.86
2241		1.02
3261		1.02
4231		1.02
TOTALS	11.54	26.53

[1] Only those posture codes which occurred more than .50% frequency
[2] Working postures with an extremely harmful effect on the musculoskeletal system (as identified by the OWAS)
[3] Work posture has a distinctly harmful effect on the musculoskeletal system (as identified by the OWAS)

Refer to Appendix B for further information regarding the OWAS

Table 4.10

Subjects Whose Work Heart Rate Reserve was Greater Than 50% During Vacuuming the Living Room and Cleaning the Bathroom

Subject Number	Aerobic Capacity Percentile Rank	VL % Duration	CB % Duration
6	0	1	
7	60		1
8	10	30	8
10	25	1	
11	55	28	16
13	55	1	
15	20	1	

Table 4.10

Subjects Whose Work Heart Rate Reserve was Greater Than 50% During Vacuuming the Living Room and Cleaning the Bathroom

Subject Number	Aerobic Capacity Percentile Rank	VL % Duration	CB % Duration
6	0	1	
7	60		1
8	10	30	8
10	25	1	
11	55	28	16
13	55	1	
15	20	1	

CHAPTER 5. DISCUSSION

This chapter discusses the physiological, physical or postural, and perceptual responses to vacuuming the living room (VL) and cleaning the bathroom (CB). The sections of this chapter include interpretation of the physiological and perceptual responses; physical responses; comparison of this study's results to other studies; and relationships between maximal aerobic power and task performance. The next part looks at the limitations of the study. Finally, implications for Occupational Therapists are presented.

Physiological and Perceptual Responses to Vacuuming the Living Room and Cleaning the Bathroom

Using heart rate values as an indicator of workload, Rodahl (1989) categorized workload from light work to extremely heavy work. According to Rodahl's classification system, the average heart rate values for VL (105 bpm) and CB (101 bpm) indicate that these activities were at a moderate level of workload. The individual average heart rate values (81 to 126 bpm) for VL ranged from light to heavy workload. The individual maximum heart rate values for VL (99 to 142 bpm) ranged from moderate to very heavy workload. For CB the individual average heart rate values (73 to 118 bpm) ranged from light to heavy workload, and individual maximum heart rate values (93 to 137 bpm) ranged from moderate to very heavy workload.

Powers and Howley (1994) presented a comparison table that illustrated a direct relationship between percent of HRR (age related maximum heart rate - resting heart rate) and percent of VO_2 max during treadmill and bicycle tests. For example, if an individual was working at 50 percent of her HRR that value approximates 50 percent VO_2 max (Powers & Howley). Rodahl (1989) noted that if an individual was working at 30 to 40 percent of their VO_2 max for an eight hour day, then the workload was taxing. For both VL and CB, seven subjects' average work HRR values were greater than 30 percent, and sixteen subjects' maximum work HRR values were greater than 30 percent. Using the 30 percent cut off point, the circulatory stress of VL and CB could be considered taxing, if maintained for an eight hour day.

When comparing the RPE values with the absolute heart rate values, a linear relationship is expected (Borg, 1973). The heart rate at a given intensity roughly corresponds to 10 times the RPE (Borg, 1982). Results in this study did not show a consistent linear relationship between the RPE and heart rate. Many factors can affect the subjective and physiological responses to a task. Three factors that may have affected these responses in this study were the type of activity, anxiety, and duration of the task (Borg, 1982; Gamberale, 1985; Kirk & Schneider, 1992; & McArdle et al., 1991). For VL and CB the activity involved use of both the arms and legs, while the RPE was developed using the legs only on a bicycle test (Borg, 1973). Relative to the same work load performed by the legs, tasks requiring the use of the arms are known to increase both the heart rate and perception of effort (McArdle et al., 1991). Presence of the researcher may have produced some anxiety for the subjects, influencing their RPE and heart rate responses. Kirk and Schneider (1992) found that for the same tasks, as the duration of the activity increased, the rating of perceived increased. Perhaps the duration of the task in CB and VL influenced the RPE in the current study. Thus, when performing household tasks, many factors that could have affected the linear relationship between RPE and heart rate. Caution is advised in using the RPE as an indicator of heart rate response during performance of household tasks. Alternatively, the RPE may be used with the heart rate as an indicator of subjective strain to provide the client with a reference point in gauging their level of work.

Nature of the work factors impact on the subjects' physiological and perceptual responses to the tasks (Rodahl, 1989). Examples of factors describing the nature of the work are task duration, weight and characteristics of equipment used or objects handled, type of work (static, dynamic or combination), and work pace. All of the heart rate responses and central and peripheral RPE values were higher for VL than for CB. Several factors pertaining to the nature of the work may have contributed to this trend. Both VL and CB required a combination of static and dynamic work. However, the equipment used in the two tasks differed. In VL the piece of equipment used was the vacuum, average weight of 8.9 kg. The subject transported the vacuum from one location to another. Pushing and pulling the vacuum, including the vacuum wand and head, over a carpeted floor increased the effort required to manoeuvre the vacuum. Conversely, during CB the subject used few pieces of equipment that were of minimal weight. This factor was commented on by one subject who rated peripheral RPE (VL) at 15, or "hard." She stated that she "rated VL high because of the required pushing and pulling of her heavy upright vacuum (10.4 kg.) by her arms." Subtasks were another factor contributing to the difference in the responses between VL and CB. For example, subjects moved furniture and other heavy objects during VL, whereas this subtask was not a requirement of CB.

Physical Responses to Vacuuming the Living Room and Cleaning the Bathroom

Posture segments

Using average values, the subjects spent a considerable amount of time in a forward bent, or twisted, or bent and twisted posture: 74.3 percent for VL and 72.8 percent for CB. According to Corlett and Bishop (1976), working with the back in a bent and/or twisted posture is stressful for the structures of the back. The large amount of time spent in this posture points to the need for teaching alternative approaches for performing these tasks, particularly for individuals with the diagnosis of back strain.

Technique or skill is one factor that influences the degree of strain incurred by the individual performing the task (Pheasant, 1991). The large range of the frequencies of back postures and large standard deviation (table 4.7), suggested that different techniques were used when performing these tasks. During analysis of the video tape it became apparent that some individuals walked with their vacuum, using their legs to propel the vacuum to and fro. Other subjects bent forward at their waist and used their arms to propel the vacuum. The latter group tended to work with their back in a forward bent posture, rather than in an upright posture. Statistical correlation supported this observation (figures 4.9 and 4.10). That is, the more the subject walked while she pushed and pulled the vacuum, the more she assumed a straight back posture. One of the biomechanical principles that is recommended to reduce back strain is to work with the back in an upright posture. Two of the subjects complained that they experienced back pain during performance of VL. Clearly, some of the subjects. by virtue of their technique incurred strain in their backs while performing the task.

The relationship between back posture and leg postures was not examined in CB. During CB, the leg posture assumed by the subject was a function of the layout of the task (i.e., kneeling beside the tub or toilet to clean them), not a function of the subjects' technique.

Sustained or repetitive work with the arms at or above shoulder height can promote upper spine or shoulder problems (Pheasant, 1991). Based on this description, and the arm postures recorded using the OWAS, it did not appear that the subjects placed strain on their shoulders while performing these tasks. For the most part, both arms were below shoulder height: 82.3 percent and 71.5 percent for VL and CB, respectively. During CB the subjects worked with one or both arms above shoulder height while cleaning the bathtub, mirror, and walls.

Leg postures assumed by the subjects differed between the two tasks. During VL the two most common leg postures, both legs straight and walking, accounted for 73.9 percent of the leg postures. The two most common leg postures in CB were both legs straight and kneeling, for a total of 83.1 percent. Over time, sustained kneeling is considered a harmful working posture. CB placed more strain on the legs than did VL. One of the subjects verified this finding in her comment: "I rated the peripheral RPE on CB as 15 because of the required kneeling."

One of the ways to reduce the amount of strain incurred by the body is through the use of equipment designed for the task (Konz, 1995). Interestingly, only one subject used a brush to clean the toilet: the same subject used a mop to wash the bathroom floor. Using a brush to clean the toilet, or mop to clean the floor would extend the individual's reach and reduce the need for kneeling and/or forward bent position of the back. Furthermore, as illustrated in Table 5.1, subjects had a higher heart rate response when washing the floor on their hands and knees than when using a mop, indicating a higher level of circulatory strain with the former approach (Wilke et al., 1995). Another subject rinsed the tub with the hand held (telephone) shower head. She stated that "she prefers this method as she can work in an upright posture in standing, rather than rinsing it with water from the tub" (the latter approach would require her to kneel and bend over the tub). These observations indicate that one way to reduce the strain on the body is by incorporating the appropriate tool for the task.

Effort loads of CB and VL were negligible and minimal, respectively. Due to the nature of the task in CB, all of the time was spent in an effort load less than 10 kgs. In VL, 90.4 percent of the task had an effort load less than 10 kgs. If measurement of the amount of effort exerted by the subject while operating the vacuum had been possible, different effort load values may have been recorded. Unfortunately, there was no practical way of measuring this force

Posture Codes

Looking at the most frequently occurring posture codes in both tasks it was apparent that the posture codes assumed by the subjects were considerably different. During VL, subjects primarily placed strain on their backs, and during CB, the subjects placed strain on both their backs and legs. Refer to Appendix B for an explanation of the OWAS posture codes.

Action categories of the OWAS were used to identify the extremely harmful and harmful posture codes for both tasks. The incidence of harmful and extremely harmful postures was greater during CB than during VL. Several factors contribute to the posture that a person adopts when performing a task (Haslegrave, 1994). Some of those factors are: workplace constraint (e.g., space, obstructions); task demands (e.g., vision, reach, manipulation and force exertion demands); and type of task (e.g., duration, repetition). During CB, the subject was often required to work in a poor posture because of the layout of the bathroom and the fixtures being cleaned, or 'workplace constraint.' That is, the subject was required to kneel at the side of the tub, bend and/or twist her back to reach into or across the tub, and apply force while cleaning the tub. Some of the subjects reduced the amount this posture was required by either sitting on and straddling the side of the tub, or going into the tub and cleaning it from inside. Also, rather than reaching around the sliding tub doors, the subject shifted her position from one end of the tub to the other, reducing the overall amount of forward bending and extended reaching. Subjects displayed creative ways of working around the externally posed factor of workplace constraint. This observation indicates that the old phrase of 'bending the knees and keeping the back straight' in order to protect the back seldom works in the CB. Alternatively, more creative problem solving that is task dependent and involves the individual is required (Pheasant, 1991).

VL also required the subjects to work in poor postures, although to a lesser extent than CB. During posture analysis, various approaches to the task were observed. One approach that required the subject to work in a forward bent position was holding onto the vacuum wand halfway between the top of the wand and the vacuum head. Reaching down to a low level the subject was forced to go into a forward bent position of the back. This technique forced the subject to work in a poor posture. It could have been easily corrected by holding onto the top of the wand.

One desirable whole body posture for exerting force is with the trunk upright, forward facing and the application of the force in line with the limbs performing the work (Haslegrave, 1994). This whole body posture describes that assumed by the subjects who walked with their vacuum. In contrast, some subjects applied the force to the vacuum while standing with her trunk parallel to the vacuum and performed the pushing-pulling motion with the shoulder joint. Using this technique, repetitive forces would have been transmitted through the subject's shoulder joint. This posture was in direct contradiction to that noted above by Haslegrave (1994). Clearly, some of the subjects assumed poor working postures during VL, when a more advantageous posture could have been assumed. It appears then that workplace constraint posed a large external factor affecting the working posture during CB, whereas the individual's technique appeared to be the stronger influencing factor determining the posture during VL.

Comparison of the Data to Other Studies

Heart rate responses, RPE and postural responses were compared to data recorded by other authors. Table 5.1 contains a summary of these results.

Heart rate

Grandjean (1973) cited several authors who had studied heart rate responses to performance of household activities (Åstrand, 1966; Kilbom & Åstrand, 1969; & Stübler, 1970). Unfortunately, Grandjean did not provide adequate details about the task demands and/or subject characteristics to be able to make valid comparisons. (Note: these articles were written in a Scandinavian language and hence the original articles were not accessed.) Åstrand and Rodahl (1970) provided a line graph of the heart rate values of a housewife throughout a variety of daily activities. No subject or task description values were provided.

As recorded in Table 5.1, the heart rate and RPE responses in Wilke et al. studies (1993, 1995) were different that those recorded in the current study. In their initial study on older men (1993), the authors reported heart rate values that were below those recorded in this study. This discrepancy could be due to several factors. 1) nature of the task; 2) medications taken by the subjects; 3) gender difference; and 4) age difference. In the present study, the subjects performed the tasks for 17 to 20 minutes; the subjects lifted and carried the vacuum from

Table 5.1

Summary of Studies That Have Examined Heart Rate and Rating of Perceived Exertion During Household Tasks

Researchers	Subjects	Tasks	HR	% of Work HRR	% of Age-Related Max. Heart Rate	RPE Central	RPE Peripheral	RPE Overall
Current Study	• 17 healthy females • Mean age = 40.4 yrs	1. Vacuum the living room	105 (10.5)	30.5 (6.4)	58.5	11.8 (1.6)	11.8 (1.4)	
		2. Clean the bathroom	101 (10.4)	26.5 (5.7)	56.2	10.9 (1.6)	10.8 (1.9)	
Wilke et al. (1995)[1]	• 10 healthy females • Mean age = 62.2 yrs	1. Vacuum carpet	111 (6)	Not calculated[2]	70.3			9 (1)
		2. Mop floor	116 (5)		73.5			10 (1)
		3. Wash floor	129 (6)		81.7			10 (1)
Wilke et al. (1993)	• 12 males with stable coronary artery disease • Mean age = 65.5 yrs	1. Vacuum carpet low pile						
		WS[3]	79 (14)	Not calculated[2]	51.1			9 (2)[1]
		BTE[4]	80 (11)		51.8			10 (3)
		2. Vacuum carpet high pile						
		WS	86 (12)		55.7			12 (3)
		BTE	86 (14)		55.7			12 (3)
Hopsu et al. (1994)[5]	• 30 healthy females • Mean age = 46 yrs	1. Professional cleaners	93		53.4			

[1] Simulated setting. Task duration = 6 minutes
[2] Not calculated because resting heart rate not available
[3] Simulated work. Task duration = 5 to 6 minutes
[4] Baltimore Therapeutic Equipment. Task duration = 5 to 6 minutes
[5] Data for % of work HRR and RPE not recorded in article

storage; pulled or pushed the vacuum over the floor; and moved furniture or otherobjects while vacuuming. From the task description provided in Wilke et al., the subjects worked for a shorter duration, and were not required to transport the vacuum and/or lift objects. A second possible contributing factor may have been the medications (e.g., β blockers, calcium channel blockers) taken by the subjects in the Wilke et al. study, which would have lowered their heart rate. The third possible explanation was that men, having more upper body strength (Wilke et al.), would not have to work as hard to do the same task. Therefore, they would most likely display lower absolute heart rate values. The difference in the average age of the two groups must also be considered. When comparing heart rate expressed as a percent of age related maximum heart rate, the subjects in both studies were working at a similar intensity.

As noted in Table 5.1, the absolute heart rate values in the Wilke et al. (1995) study are somewhat higher than those recorded in current study. However, it should be noted that the women in the Wilke et al. study were older than the subjects in the current study. Therefore, the older women were working at a higher level of their age related maximum heart rate, indicating a higher level of circulatory strain than their younger counterparts in the current study. This discrepancy was particularly apparent in the tasks mopping the floor and washing the floor on the hands and knees: two tasks that were performed by the subjects in the current study as subtasks of CB. Average heart rate and percent of age related maximum heart rate values in the current study were comparable to that of professional cleaners while cleaning (Hopsu et al., 1994).

Studies that reported the percent of HRR attained while performing household tasks were not found. However, researchers have reported work HRR values recorded in other industries. A comparison of the circulatory strain of the household tasks in this study to that of other industries is provided in Table 5.2. The average HRR in VL and CB were surprisingly similar to that found in steelworkers (Vitalis et al., 1994), vehicle assembly line workers (Goldsmith et al., 1978) and workers on fishing boats (Rodahl, 1989). It must be remembered

Table 5.2

Work Heart Rate Reserve Values from Other Industries (Mean ±SD)

Author	Subjects	Industry/Task	Heart Rate Average (bpm)	Working Heart Rate Reserve	Range
Current Study	• 17 healthy females • Mean age = 40.4 yrs	• Vacuum the living room	105 (10.5)	30.5 (6.4)	21.8 - 45.0
		• Clean the bathroom	101 (10.4)	26.5 (5.7)	15.0 - 37.2
Vitalis et al. (1994)	• 19 healthy males • Mean age = 43 yrs	Steelworkers	97(13)	25(14)	8-57
Goldsmith et al. (1978)	• 20 healthy males • Mean age = 31.4 yrs	Vehicle assembly line	91(8)	21(7)	4-29
Rodahl (1989)	• 1 male[1]	Trawler foreman			30-38[2]
	• 1 male[1]	Trawler skipper		20[2]	
	• 3 males[1]	Deckhand (bank fishing)			25-33[2]
	• 1 male[1]	Cook (fishing boat)		15[2]	

1 Age not provided
2 Mean and/or standard deviation not provided

that the workers in the latter industries presumably worked for an entire shift. None of the studies in Table 5.2 recorded average percent of heart rate reserve values that were high enough to be considered taxing, i.e., 30% for an entire shift (Rodahl, 1989).

The average work HRR values recorded during VL and CB were comparable to the average values recorded by Vitalis et al. (1994) in male steelworkers. The range for the work HRR was much broader in the steelworkers. Vitalis et al. explained this large range by noting the tasks that required high levels of physical exertion, e.g., moving the hot slabs or unblocking the furnace; and the tasks that required low levels of exertion, e.g., observing the furnaces and gauges. Rodahl's (1989) recorded, work HRR percent values were similar or lower than VL and CB observed in the present study. Rodahl noted that each of these occupations had built in rest periods, a probable explanation for these occupations having similar circulatory strain as the current study.

The heart rate and heart rate reserve values reported by Goldsmith et al (1978), were well below those recorded during performance of VL and CB in the current study. Goldsmith et al. did not give a description of the task demands; therefore, it was difficult to explain why this difference existed.

Rating of Perceived Exertion

RPE values for vacuuming low pile carpet in the Wilke et al. (1993) study and vacuuming in the Wilke et al (1995) study were considerably lower than central RPE values recorded in the current study (Table 5.1). A shorter task duration and lower task demands may have contributed to this difference. Vacuuming the high pile carpet, where the RPE values are comparable to the current study, may have been more similar to the task demands imposed in this study, and hence the similarity in these values. RPE values recorded during mopping and washing the floor by Wilke et al.(1995) were close to the values recorded in CB the current study. Perhaps a closer approximation in the natural task demands was met in these two tasks.

Postures

Only one published study reported on the posture demands of CB and VL (Weber, 1996). No operational definitions were available for Weber's findings; therefore, direct comparisons have been made with caution. If one assumes that Weber was referring to 'bend' as bend the back, the values for the two tasks in the current study were higher. Weber used the term high reach and extended high reach, which may be comparable to working with the arms overhead in the current study. Comparing the percent frequency of this posture in the two tasks, it was found that there was a higher percent frequency in the current study than in the Weber study. One possible factor contributing to this difference was Weber's use of the term 'lean reach'. This term may have referred to working with the arms overhead.

As noted in the literature review, several studies have used the OWAS to analyze the working postures in many different industries. Results from other industries are reported in Tables 5.3 and 5.4 and are compared to the current study.

Frequency proportion of the back posture segments in roof joisting (Mattila et al., 1993) and cement workers (Kiva & Mattila, 1991) were similar to that observed in this study. However, nurses (Engels et al., 1994) spent a much higher proportion of the time with their back straight. Arm posture segments in this study were similar to roof joisting and nursing, while the cement workers spent a higher proportion of time with one of their arms above shoulder height. The two most common leg posture segments in CB, VL, roof joisting and cement workers were kneeling and both legs straight. Nurses' most common leg posture segments were both legs straight and sitting. Effort load for VL was similar to that recorded in roof joisting. Cement workers spent a much higher proportion of time in the effort load 10 or more kilograms, compared to the two tasks analyzed in this study.

Poor working posture codes that occurred in roof joisting and brick laying were similar to those recorded during VL and CB. The effort load value (last

Table 5.3

Summary of Studies That Have Examined the Distribution of Posture Segments

OWAS[1] Posture Segment		Current Study Vacuum the Living Room (%)	Current Study Clean the Bathroom (%)	Professional Cleaners[2] (%)	Roof[6] Joisting[3] (%)	Nursing (Orthopaedic)[4] (%)	Building Construction Cement Workers[5] (%)
Back	B1	25.7	27.2	61	31.1	75	54.3
	B2	35.5	29.4	33	58.8	18	35.2
	B3	10.1	11.3	2	0.6	4	8.0
	B4	29.0	32.2	4	9.6	3	2.5
Arm	A1	82.3	71.5	73	98.9	96	56.8
	A2	17.0	27.0	26	1.1	3	35.8
	A3	0.7	1.5	1	0.0	1	7.4
Leg	L1	0.3	2.1	Not recorded[7]	0.0	21	0.3
	L2	49.9	46.2	Not recorded	23.2	53	53.1
	L3	8.4	6.2	Not recorded	1.1	8	1.5
	L4	8.8	4.7	Not recorded	4.0	1	1.2
	L5	2.5	0.8	Not recorded	1.7	0	0.6
	L6	6.1	36.9	Not recorded	61.6	0	25.9
	L7	24.0	3.1	Not recorded	8.5	17	16.7
Effort	E1	90.3	100.0	Not recorded	96.6	Not recorded[6]	27.5
	E2	8.0	0	Not recorded	3.4	Not recorded	61.4
	E3	1.5	0	Not recorded	0.0	Not recorded	11.1

1 For key and further description of the OWAS refer to Appendix X
2 Hopsu et al., 1994
3 From Mattila et al., 1993
4 From Engels et al., 1994
5 Kivi and Mattila (1991)
6 Not recorded because the forces seldomly exceeded 10 kg and assessing them disturbed the work routine
7 Not recorded in article

Table 5.4

Summary of Studies That Have Examined Poor Working Postures According to the Ovako Working Postures Analysis System (OWAS) (% Duration)

OWAS[1] Poor Working[2] Posture Codes	Current Study: Vacuum the Living Room	Current Study: Clean the Bathroom	Roof Joisting[3]	Nursing (Orthopaedic)[4]	Building Construction Brick Layer[5]
4141	1.19	0.85	.005	Not provided	
4161	1.02	7.03	.062		
4261	1.02	10.17	.005		
2343					.018
2242					.006
2243					.018
4233					.018
4243					.012
4143					.018
4162					.012
4241	1.53	0.76			

1 For key and further description of the OWAS refer to Appendix X
2 Working posture codes from Action Category IV of OWAS
3 From Mattila et al., 1994. Based on an entire working shift
4 From Engels et al., 1994. Based on an entire working shift
5 Kivi and Mattila (1991). Based on an entire working shift

digit) of brick laying differed from VL and CB. Poor working postures during brick laying all had an effort load of 2 or 3. In comparison, only one of the poor working postures in VL and CB had an effort code 2, and no effort code 3 was recorded in any of the participants.

Professional cleaners (Hopsu et al., 1994) spent more time working with their back straight, than the present study's subjects. While the arm postures in CB and the professional cleaners were similar, those observed during VL were more often below shoulder height.

Relationships Between Maximal Aerobic Power and Task Performance

As expected, the relationships (correlation) between VO_2 max and heart rate response to VL and CB were negative, and three of these relationships were significant ($\alpha \leq 0.05$): VO_2 max and work HRR average for VL; VO_2 max and work HRR average for CB; and VO_2 max and work HRR maximum for VL. Generally, the more fit the subject, the less circulatory strain they experienced. In this study, subjects 6, 10 and 15 had a low aerobic capacity and worked at a high level of circulatory strain. These observations are consistent with the findings of Åstrand (1966) and Stübler (1970) who concluded that heart rate values during household activities were considered high and were inversely related to the subjects' fitness level (cited in Grandjean, 1973).

Åstrand and Rodahl (1970) stated that people were self-regulatory in their working pace. Their selected rate of work and spacing of rest breaks was a reflection of their aerobic capacity. In the current study, the subjects' heart rate did reach a steady state while performing both of the tasks. This trend was illustrated in the computer printout from the computer interface software program (see Appendix G). The illustrated steady state also reflected the submaximal level of the circulatory strain and the self-regulated working pace for most subjects. An example of self-regulation was characterized by Subject 10 (VO_2 max at the 25 percentile). She stated that "she would have stopped the activity sooner, switching to another less strenuous activity (e.g., laundry) in order to give her body a rest."

In the current study, there were seven different subjects who experienced high levels of circulatory strain during VL and CB. Degree of circulatory strain can be examined using a number of methods: upper value of and duration of percent work HRR, and percent of age related maximum heart rate. Rodahl et al. (1974) reported that the recommended upper limit of work HRR for prolonged work is 50%. This upper limit was recorded in seven of the subjects. Rodahl (1989, p. 202) stated that "working at greater than 50% of one's work HRR, for more than 30 minutes per day is enough to produce a training effect." Because of the delimitation of the study -- 17 to 20 minute for task duration -- none of the subjects worked with their heart rates at 50% of work HRR for 30 minutes. If the subjects had continued performing the task, a 30 minute duration of work HRR above 50% may have been reached. Although heart rate recovery was not formally recorded, it appeared that for some subjects their heart rate was slow to recover after completing the task.

Another way to identify the degree of circulatory strain is by using the training sensitive zone, or 70% to 90% of the age related maximum heart rate (McArdle et al., 1991). Using this zone, it was found that none of the seventeen subjects' average heart rate for VL and CB was greater than 70% of their age related maximum. There were seven subjects who had maximum heart rate values above 70% for both VL and CB. The VO_2 max for these subjects ranged from the zero percentile to the 60 percentile. Even the relatively more fit subjects who had a higher percentile rank of maximum oxygen uptake (60, 55, and 55 percentile) experienced a high level of circulatory strain.

As recorded in Tables 4.10 and 4.11 there was an overlap in the subjects who experienced the level of circulatory strain described above: work HRR greater than 50% and age related maximum greater than 70%. Of the subjects listed in each of these tables, there were six subjects whose circulatory response was high enough to fit into both groups: subject 6, 7, 8, 10, 11, and 15. The fitness level of these individuals ranged from low (zero percentile) to moderate

(60 percentile). This finding suggests that fitness level, pace and type of work influenced their circulatory response.

Limitations of the Study

The sample consisted of healthy women. When applying the results to a rehabilitation population, the subject's state of health and functional status must be kept in mind. Age range of the study's subjects was from 30 to 50 years. Age related changes affect a person's physiological and physical responses to a task (McArdle et al., 1991). In view of this factor, different responses may have been recorded with different age groups. Gender of the subjects was restricted to females. There are many differences in physiological capacity between males and females. The results from this study apply most directly to women, and must not be applied to a male population.

An example of a physiological difference between men and women that may affect the ind[illegible] response to the task demands is that men tend to have a higher level [illegible] ength (McArdle et al., 1991). Thus when performin[illegible] lving the arms, the physiological responses of the men w[illegible] n. Both CB and VL involved the use of the arms and [illegible] ay have been observed.

[illegible] exist, and many components contribute to perform[illegible] only two household tasks, CB and VL, were analyzed [illegible] study. The two tasks selected were considered physically demanding, according to metabolic demands (Ainsworth et al., 1993). The physical and physiological responses to the two tasks may serve as a performance benchmark for other less demanding household tasks. However, many other performance components exist, e.g., sociocultural. For example, if the individual places a great deal of importance on having a clean house, then she will be more motivated to perform the tasks and may experience a lower level of physiological and perceptual responses to the task. The therapist cannot use the results to look at other task performance components.

Data collection in the natural environment can have its own drawbacks (Kirwan & Ainsworth, 1993). One of the data collection methods was videotaping in the subjects' home. In response to videotaping, the subject's physiological response to the task may have been affected by performance anxiety. At times, naturally occurring factors in the environment (e.g., back lighting or house wall obscuring the subject), affected the visibility of the subject's body postures. When the visibility of the video freeze frame was reduced, the frame was not used.

The posture analysis instrument used was the OWAS (Karhu et al., 1977). It has four back postures: straight, bent, twisted, and bent and twisted. During task performance, the degree to which the subject's back was bent and/or twisted varied. For example, the subject's back may be in 20^0 or 80^0 of forward flexion or bent according to the OWAS, and both positions would be classified as bent. The OWAS was not sensitive enough to record this difference. It appeared that the posture segments for the arms, legs, and effort load were fairly represented.

The VO_2 max of the subjects was determined using the Non-exercise method (Ross & Jackson, 1990). In the current study, the subjects' VO_2 max was not validated by the use of maximal testing. However, the inverse relationship between the subjects' VO_2 max and the heart rate during the tasks did support the validity of this instrument. For the current study, conducted in a natural environment, it proved to be a very useful instrument. However, it appeared to inaccurately estimate the VO_2 max of subjects whose BMI was at the extreme ends. For example, one subject whose BMI was very low (e.g., 18.9) was at the 100 percentile for her VO_2 max and another subject whose BMI was very high (e.g., 47.0) was at the zero percentile for her VO_2 max. Hence, this instrument must be used cautiously for individuals who have a very low or very high BMI. Generally, this instrument worked well in this setting with these subjects. It may also be useful in other settings, where more sophisticated instrumentation (e.g., a metabolic cart for direct measurement of oxygen uptake), is not available.

Implications for Occupational Therapy

The results of this study have several implications for occupational therapists. First the implications for health promotion programming are discussed. The range of average heart rate values was from light to heavy for VL and CB (Rodahl, 1989). The relatively high level of heart rate response was further reinforced by the following. For some of the 'healthy' subjects who had a low or moderate level of aerobic capacity, performing these household activities required the subject to work above 70% of their age related maximum heart rate. Over time, activity at this level is sufficient to lead to a training effect (McArdle et al., 1991). The task demands of CB and VL are high enough that healthy individuals may experience a (relatively) high level of circulatory strain. Occupational therapists can validate the healthy individual's ability to cope with the homemaker role by recognizing that these chores may require a relatively high level of circulatory strain. Knowing that performing these tasks may be taxing for some individuals, the importance of teaching the principles of energy conservation is reinforced. One such principle that could apply in this situation is alternating between these tasks and other less physically demanding tasks, e.g., dusting (Ainsworth et al., 1993). Another example of a principle is breaking the task into components, e.g., vacuuming one section of the home on one day and another section on another day.

Health promotion for healthy individuals who perform household tasks is warranted to assist in reducing the risk of musculoskeletal injury. It was found that during both tasks, an extensive amount of time was spent working with the back bent, twisted, or bent and twisted. It is known that sustained periods of poor working postures can promote the risk of injury (Haslegrave, 1994) and working with the back in a forward bent posture is considered a poor working posture (Corlett & Bishop, 1976). Given the high frequency of the back working in a bent and/or twisted posture in both of these household tasks, it is important that therapists incorporate appropriate principles of back care education into health promotion programs. Because of the nature of household work, the old adage end the knees, keep the back straight' often does not apply. The occupational erapist must problem solve, with the individual, to find alternative approaches the task. Those alternative approaches can be based upon biomechanics inciples such as those provided by Corlett and Bishop (1976) and Haslegrave 994). In the biomechanics education programming, occupational therapists ust be cognizant that it takes a long time for an individual to learn a new skill ackson & Liles, 1994). The use of a task appropriate tool to reduce usculoskeletal and circulatory strain is also indicated (Trombly & Scott, 1977). or example, using a long handled brush and mop to reduce the amount of rward bending and/or required kneeling in CB, or using a mop to reduce the rculatory strain when washing the floors in CB.

Individuals in a rehabilitation program have a reduced functional capacity perform activities. Enabling the individual in a rehabilitation program to esume their household tasks is one occupational therapy treatment approach he enabling can occur through the following treatment approaches: teaching nergy conservation techniques; teaching biomechanics education that is task ependent and specific to the individual's needs; and implementing an exercise rogram to enhance their level of fitness. Examples of energy conservation echniques and suggestions for making the biomechanics education applicable to he situation are given above. Incorporating a low intensity exercise regime into rehabilitation program would assist in increasing the individual's aerobic apacity and their ability to tolerate the physiological requirements of physically lemanding household chores. An example of such a exercise regime is found in owers and Howley (1990, p. 339). Also, advocacy for lifestyle change could orm a part of the rehabilitation program (Letts, Fraser, Finlayson, & Walls, 993).

In order for the occupational therapist to know the fitness level of the ndividual and their inherent physiological capacity to perform the tasks, letermination of maximal oxygen uptake is recommended. When direct testing of naximal oxygen uptake is not available or appropriate, the non-exercise method of determining VO_2 max (Ross & Jackson, 1990) can be incorporated by occupational therapists into their evaluation format. Knowing that VL and CB require a relatively high level of circulatory strain, determination of the subject's maximal oxygen uptake is necessary in order to establish an exercise program of appropriate intensity. Also, if the individual's VO_2 max is relatively low, then teaching the principles of energy conservation and work simplification is even more important.

The OWAS was used to determine the gross motor postural demands of CB and VL. If one of the purposes of the project is to obtain an in depth picture of the task demands of an occupation, then the OWAS could be a useful tool for the occupational therapist. Use of this instrument in similar applications is recommended. It is noted, however, that the process of videotaping in the natural environment and analyzing the videotape according to the defined postures is time consuming.

Use of the RPE did not show an expected positive correlation with the heart rate responses during CB and VL. Because many performance components (e.g., sociocultural) can influence the performance of household tasks (Health and Welfare Canada, 1983), the RPE should be used with caution in this area. Use of the RPE to predict heart rate response to an activity is not recommended in the performance of household tasks. Alternatively, it may be used in conjunction with heart rate to teach the individual how to gauge their level of activity intensity (Morton et al., 1992).

The two tasks in this study, CB and VL, differed in their physical, perceptual, and physiological performance responses to the task. The equipment used and objects moved also differed. This finding reinforces the importance of having a good task description in order to set up a work simulation setting (Kennedy & Bhambhani, 1991). An example of how occupational therapists could apply this information is presented. Using the Baltimore Therapeutic Equipment (BTE), the therapist could instruct the individual to propel the attachment with their legs, rather than pushing it with a bent back and their arms.

Also, in a graded treatment program, the resistance on the BTE and the individual's pace could be adjusted so that their heart rate responses reach levels recorded in the current study.

Society is beginning to recognize the value of household work (Munroe, 1995; & Roberts, 1995). Occupational therapists consider the performance of household tasks an important role (Trombly, 1983). However, there is little documentation regarding its task demands. Only two of the many household tasks, have been studied in this research. More basic task description information is required for the occupational therapist in order to make sound judgments. Further research into the other performance components (e.g., sociocultural) and the many other household tasks is recommended.

CHAPTER 6. SUMMARY AND CONCLUSIONS

Purpose

The goals of the current study were to: (1) describe and compare the physical demand responses of healthy women to two household tasks; (2) describe and compare their physiological and perceptual responses to these two household tasks; and (3) describe relationships between selected physiological, physical, and perceptual demands of the two household tasks.

Method

Task analysis was the methodology used in this study. A pilot study was carried out to: 1) to identify the two tasks that would be analyzed, and 2) establish the test protocol that would be most suitable for the research study. From the pilot study the two tasks chosen for the research study were: cleaning the bathroom (CB) and vacuuming the living room (VL). A pilot study with three subjects and a research study with seventeen subjects were conducted. Healthy women, between the ages of 30 and 50 years, volunteered as subjects.

Both the pilot study and research study consisted of two parts: an interview and an observation session. During the interview demographic data was recorded, and during the observation session the subjects performed the two tasks. Subjects performed CB and VL in their own home for 17 to 20 minutes each. During this phase, heart rate was recorded using a wireless monitor and postures were video taped. Upon completion of each task, subjects rated their level of perceived exertion (RPE) using the Borg scale. Subjects' maximal oxygen uptake was determined using a non-exercise predictive equation method. Heart rate and heart rate reserve (HRR) were used to determine the cardiovascular strain during the tasks.

From the video tapes, postures were analyzed using the Ovako Working Posture Analysis System (OWAS). Poor working postures were identified according to the OWAS. The posture segments were combined to identify the working posture codes. The ten most frequently occurring posture codes and the poor working posture codes were identified. Descriptive statistics, comparative and correlational data were compiled on the physical, physiological and perceptual responses to VL and CB.

Results

All heart rate responses were higher during VL than during CB, and three of these responses were significantly different ($P \leq 0.05$). The average heart rate responses for VL and CB were at the moderate level of work load for circulatory strain. Seven of the subjects experienced heart rate responses during the two tasks that were high enough to lead to a training effect (more than 70% of age related maximum heart rate). Seven subjects experienced a short term degree of work HRR greater than 50%, indicating a high level of circulatory strain. As expected, an inverse relationship existed between the subjects' maximal oxygen uptake level and their heart rate response during both the tasks.

Central and peripheral RPE values were higher for VL than for CB. Central RPE during VL was significantly higher than central RPE during CB ($P \leq 0.05$). No consistent pattern was found in the correlations between the RPE responses and the circulatory responses during VL and CB, and none of them were significant.

Tables and frequency bar graphs containing the posture segment data for each task were presented. Frequency values for the posture segments of the back, arms, and legs indicated a large individual variation in approach to each task. In response to the difference in task demands, the effort load differed for the two tasks. A large portion of time was spent in poor working postures: 27% and 12% for CB and VL, respectively. Postural strain between the two tasks differed: during CB strain was placed on both the back and legs, while during VL it was primarily placed on the back. It appeared that the strong influencing factor for poor working postures was the subjects' technique in VL, and workplace constraints in CB.

Conclusions

Within the limitations of this study, the following conclusions can be made.

While performing the tasks, some of the healthy subjects experienced a high level of circulatory strain. For some subjects the level of circulatory strain was high enough to lead to a training effect. These findings reinforce the need to incorporate exercise into a rehabilitation program. It also suggested that the principles of energy conservation and pacing oneself have value in rehabilitation programs. The non-exercise method of determining maximal oxygen uptake is a practical tool for occupational therapists who work in the field, and its use is recommended.

Perceptual responses to these two tasks were inconsistent. Use of the RPE, in conjunction with the heart rate, could be used to gauge level of exertion when performing these two tasks. The OWAS could be a useful instrument for similar applications, and its use is recommended.

Posture code analysis indicated that CB had more postural strain than VL, and that the area of postural strain for each task differed. This finding is important to consider when working with healthy individuals for health promotion, and for individuals in rehabilitation with an illness and injury. The large amount of variation in the subjects' working postures suggests that there are alternative approaches to these tasks that incur less postural strain on the body. Because of the nature of these two tasks, creative problem solving based on biomechanical principles is required to suggest alternative approaches to the tasks. Biomechanics education for individuals who perform household tasks is indicated.

In summary, this study contributed to the scant body of knowledge on the task demands of vacuuming the living room and cleaning the bathroom. The information recorded can be used by occupational therapists in health promotion and rehabilitation programming. Occupational therapists can apply the data in treatment planning, work simulation, and in determining loss of capacity to perform such tasks. Research on the other performance components of these two household tasks and on the many other household tasks, is recommended.

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APPENDICES

APPENDIX A

RATING OF PERCEIVED EXERTION SCALE (RPE)

RATING OF PERCEIVED EXERTION SCALE (RPE)

Purpose: The 15-point Rating of Perceived Exertion Scale is a means of measuring the individual's subjectively perceived level of physical exertion. It consists of numbers from 6 to 20 with accompanying verbal descriptions as indicated below. This scale was developed on the basis of research on the bicycle ergometer. With median age groups, it was found to have a linear relationship to intensity of exercise (oxygen consumption) and to heart rate. The heart rate at a given exercise intensity roughly corresponds to 10 times the RPE (Borg, 1982).

Instructions: Please tell the researcher the rating that you would assign for the hardest point in the task that you just completed for your:

1. arms and legs; and
2. heart and breathing

RATING OF PERCEIVED EXERTION SCALE (RPE)

6

7 Very, very light

8

9 Very light

10

11 Fairly light

12

13 Somewhat hard

14

15 Hard

16

17 Very hard

18

19 Very, very hard

20

APPENDIX B

INSTRUCTIONS FOR USING THE OVAKO WORKING POSTURES ANALYSIS SYSTEM

Instructions for using the Ovako Working Postures Analysis System (OWAS)

OWAS is a practical tool designed for recording, identifying and quantifying dynamic postures that occur during task performance of workers carrying out their normal work place activities. The process includes: (1) video taping task performance, (2) frame-by-frame analysis and identification of posture segments, and (3) combining the four posture segments to determine posture codes. Each frame is viewed, and a two-step process is applied to identify the segments and codes. Posture codes are then compared with action categories to determine poor working postures (Karhu et al., 1981; & Mattila et al., 1993).

STEP 1 (Video taping task performance): Task performance was taped for 17 - 20 minutes. (Note: Approximately 70 frames were recorded during this period.) This period is far less than an actual work shift and so the use of action categories to determine tasks for which corrective action is required, is not recommended. More appropriately, the OWAS classification system will be used to identify subjects' poor working postures (See step 4).

STEP 2 (Frame-by-frame analysis of posture segments): For each frame, compare the actual postures and load effort with the drawings and effort categories listed below. Assign a number for each of the four posture segments - back, arm, leg, and load effort - accordingly:

For posture segment 1 (back posture), assign:
1 if the back is straight
2 if the back is bent
3 if the back is twisted
4 if the back is bent and twisted

For posture segment 2 (arm posture), assign:
1 if both arms are below shoulder level
2 if one arm is above shoulder level
3 if both arms above shoulder level

For posture segment 3 (leg posture), assign:

1 if sitting with both legs bent
2 if standing on both legs (both legs are straight)
3 if standing on one leg that is straight
4 if standing with both legs bent
5 if standing on one leg that is bent
6 if kneeling
7 if walking

For posture segment 4 (load effort), assign:

1 if the force is ≤ 10 kg
2 if the force is ≤ 20 kg
3 if the force is > 20 kg

STEP 3 (Combining posture segments to determine posture codes): Each posture will be assigned a four-digit posture code by combining the posture segments. For example, if posture segments were analyzed as:

2 for the back posture (back is bent)
1 for arm posture (both arms are below shoulder level)
6 for leg posture (kneeling)
2 for load effort (force is ≤ 20 kg)
Then, the posture is recorded as a 2162 posture code.

See diagrams, next page.

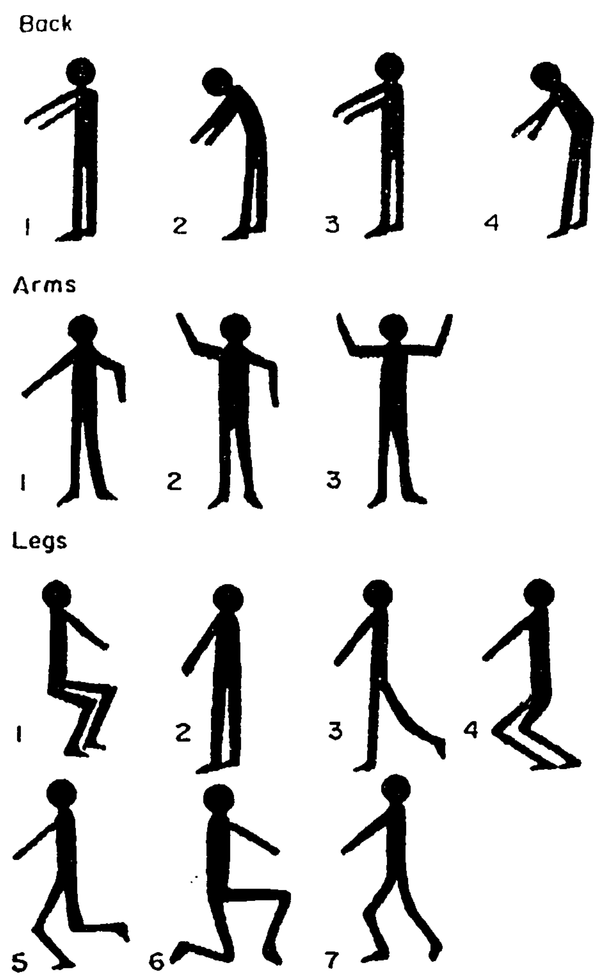
STEP 4 (Identifying poor working postures): According to a classification chart, each posture code was then classified into one of the four action categories defined below (Jackson & Liles, 1994; & Von Stoffert, 1985). (Note: Since the taping period was far less than an actual work shift, the use of action categories to determine tasks for which corrective action is required is not recommended. In this study, only the identification of the subject's poor working posture is carried out.)

Action Category I: Work postures are considered usually to have no particular harmful effect on the musculoskeletal system. No actions are needed to change work postures.

Action Category II: Work postures have some harmful effect on the musculoskeletal system. Light stress, no immediate action is necessary, but changes should be considered in future planning.

Action Category III: Work postures have a distinctly harmful effect on the musculoskeletal system. The working methods involved should be changed as soon as possible.

Action Category IV: Work postures with an extremely harmful effect on the musculoskeletal system. Immediate solutions should be found to change these postures.



An Example
Posture 2162

APPENDIX C

UNIVERSITY OF HOUSTON NON-EXERCISE TEST FOR DETERMINING AEROBIC CAPACITY

UNIVERSITY OF HOUSTON NON-EXERCISE TEST

FOR DETERMINING AEROBIC CAPACITY

Non-Exercise Test Using Body Mass Index (BMI) Model

Female:

VO_{2peak} = 56.363 + 1.951(PA-R) - 0.381(Age) - 0.754(BMI)

<u>56.363</u> = the constant for females using the BMI model

<u>PA-R</u> = the physical activity rating recorded using the "Code for Physical Activity". Refer to next page. (Ross & Jackson, 1990, p.109).

<u>Age</u> = to the last year.

<u>BMI</u> = Weight/ $Height^2$ measures body composition.

Exa...

PA-R = 7, Age = 28, BMI = 19.40

VO_{2peak} = 56.363 + 1.951 (PA-R) - 0.381 (Age) - 0.754 (BMI)

= 56.363 + 1.951 (7) - 0.381(28) - 0.754 (19.40)

56.363 + 13.657 - 10.668 - 14.62

= 44.7 ml/kg/min

(Ross & Jackson, 1990, pp. 108-110)

CODE FOR PHYSICAL ACTIVITY

Use the appropriate number (0 to 7) which best describes your general ACTIVITY LEVEL for the PREVIOUS MONTH.

DO NOT PARTICIPATE REGULARLY IN PROGRAMMED RECREATION SPORT OR HEAVY PHYSICAL ACTIVITY.

0 • Avoid walking or exertion, e.g., always use elevator, drive whenever possible instead of walking.
1 • Walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration.

PARTICIPATED REGULARLY IN RECREATION OR WORK REQUIRING MODEST PHYSICAL ACTIVITY, SUCH AS GOLF, HORSEBACK RIDING, CALISTHENICS, GYMNASTICS, TABLE TENNIS, BOWLING, WEIGHT LIFTING, YARD WORK.

2 • 10 to 60 minutes per week.
3 • Over one hour per week.

PARTICIPATE REGULARLY IN HEAVY PHYSICAL EXERCISE SUCH AS RUNNING OR JOGGING, SWIMMING, CYCLING, ROWING, SKIPPING ROPE, RUNNING IN PLACE OR ENGAGING IN VIGOROUS AEROBIC ACTIVITY TYPE EXERCISE SUCH AS TENNIS, BASKETBALL OR HANDBALL.

4 • Run less than one mile per week or spend less than 30 minutes per week in comparable physical activity.
5 • Run 1 to 5 miles per week or spend 30 to 60 minutes per week in comparable physical activity.
6 • Run 5 to 10 miles per week or spend 1 to 3 hours per week in comparable physical activity.
7 • Run over 10 miles per week or spend over 3 hours per week in comparable physical activity.

Scale of rating physical activity for use with the University of Houston Non-Exercise VO_2 Test. The directions are to select one value that best represents your physical activity for the previous month. The scale was developed for use at NASA/Johnson Space Center, Houston, Texas (Ross & Jackson, 1990, p.109).

APPENDIX D

NOMOGRAM METHOD OF DETERMINING THE REQUIRED NUMBER OF OBSERVATIONS

NOMOGRAM METHOD OF DETERMINING THE REQUIRED NUMBER OF OBSERVATIONS

Work sampling is a method of finding the percentage occurrence of a certain activity by statistical sampling and random observations. When the number of observations is large enough and made at random intervals, there is a high probability that the observations reflect the real situation.

A nomogram using:
1. percentage of occurrence (p) of an activity; and
2. error or recording accuracy required (α) can be used for this purpose.

Example:

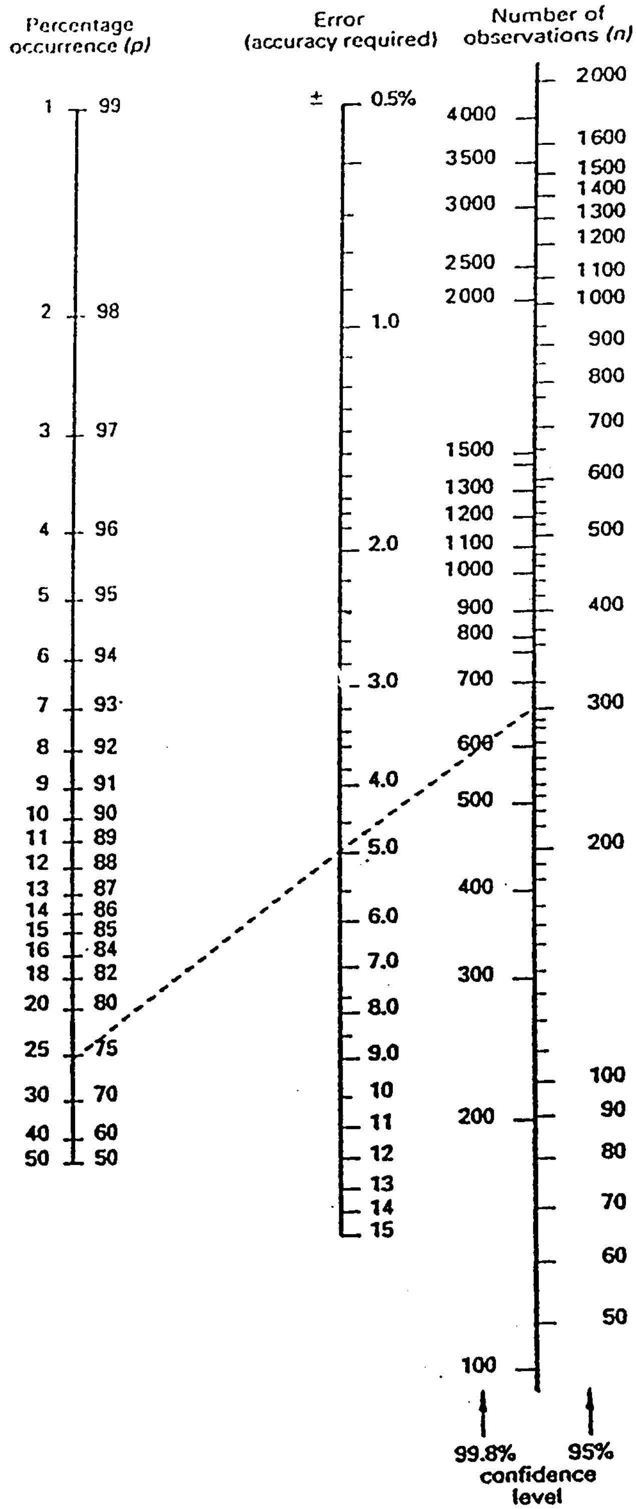
p = 25% not occurring and 75% occurring
α = .05 or 5 percent
n = number of required observations is 300

In this study the method work sampling was used to determine the accuracy of the observations based on the percent occurrence, α = .05 and the number of observations.

The nomogram is located on the next page.

(Kanawaty, 1992, p. 254-255)

Nomogram for determining number of observations



APPENDIX E

INFORMED CONSENT FORM AND INFORMATION SHEET

INFORMED CONSENT FORM

Title of Study: **Task Analysis of Household Activities Performed by Healthy Women**

I, ______________________________, agree to take part in the study, **Analysis of Household Tasks Performed by Healthy Women**, conducted by Mavis Andrew and supervised by Dr. Y. Bhambhani and Dr. J. Wessel, Faculty of Rehabilitation Medicine, University of Alberta.

I am aware that the study will take place in my home and consist of two parts:

1. interview (approximately 15 to 30 minutes); and
2. observation while I do two household tasks (1 hour to 1.5 hours).

I have read and understand the information sheet.

I have seen the heart rate monitor and have had it explained to me.

I know the type of data that will be recorded.

I know that my participation is voluntary, and that I can end my participation in the study at any time without consequence.

I know that the information gathered from my participation will be kept confidential and if information is published my identity will not be revealed.

I would like to receive a copy of the summary of results:

Yes ____ No ____

If yes, mailing address:

____

____

By signing this form, I agree to participate in this study to the best of my ability. I understand that I will receive a copy of this form and the information sheet (see reverse).

Signature of participant: ______________________ Date: ______________

Signature of researcher: ______________________ Date: ______________

For further information contact:

Researcher:	Mavis Andrew Bachelor of Science in Occupational Therapy (1983)	Supervisor:	Dr. Jean Wessel
Position:	Graduate Student Dept. of Occupational Therapy University of Alberta	Position:	Associate Professor Dept. of Physical Therapy University of Alberta
Contact:	Phone: (403) 434-6955	Contact:	Phone: (403) 492-2812

INFORMATION SHEET - Pilot Survey

Background: Occupational therapists often work with women who perform household tasks as a part of their daily routine. The occupational therapist must make decisions regarding the person's ability to perform these tasks and then plan treatment. At this stage occupational therapists do not have a good picture about the physical demands of household tasks.

Purpose: To gather information about the physical demands of household chores as performed by healthy women.

You may not personally gain from the study. However, the information gathered will be helpful to the public and to occupational therapists. The benefits of this study are: identifying the demands of household tasks which can then be used in occupational therapy treatment programming; and future development of a tool to determine a person's ability to perform the household tasks.

Procedure: The study will consist of two parts. The first part will be a 15 to 30 minute interview. During the interview, I, Mavis Andrew, will use a form to collect information about you (eg. age, weight, height) and your home (eg. number of square feet and type of home). You will be asked to complete a form called the "Code for Physical Activity". This form will indicate how active you are (see attached).

The second part of the study is a 1 to 2 hour session in which you will be observed completing two household tasks. You will complete the attached survey and from your answer the two activities will be decided.

During the second part I will record your body postures and heart rate as you do the two household chores in your home. A video camera will be used to record information about 'how' your body moves for example, walking, reaching over head, or kneeling. A heart rate monitor will be used to record your heart rate. The monitor includes a strap which you will wear around your chest and watch which you will wear on your wrist (see heart rate monitor).

There is little risk to you because you will perform the two household tasks the same as you usually do.

The information will be kept confidential. Only myself and my supervisors will know that the data came from you. Your data will be coded and your name removed. Information will be summarized into group results. According to the University of Alberta regulations, the video tape and recording forms will be stored in a locked cabinet for five years, after which time the information will be destroyed.

INFORMATION SHEET - Research Project

Background: Occupational therapists often work with women who perform household tasks as a part of their daily routine. The occupational therapist must make decisions regarding the person's ability to perform these tasks and then plan treatment. At this stage occupational therapists do not have a good picture about the physical demands of household tasks.

Purpose: To gather information about the physical demands of household chores as performed by healthy women.

You may not personally gain from the study. However, the information gathered will be helpful to the public and to occupational therapists. The benefits of this study are: identifying the demands of household tasks which can then be used in occupational therapy treatment programming; and the future development of a tool to determine a person's ability to perform the household tasks.

Procedure: The study will consist of two parts. The first part will be a 15 to 30 minute interview. During the interview, I, Mavis Andrew, will use a form to collect information about you (eg. age, weight, height) and your home (eg. number of square feet and type of home). You will be asked to complete a form called the "Code for Physical Activity". This form will indicate how active you are (see attached).

The second part of the study is a 1 hour to 1.5 hour session in which you will be observed completing two household tasks. The two tasks are:

1. Cleaning the bathroom
   - Clean the sink, toilet, and bathtub;
   - wash the floor; and
   - wipe the mirror.
2. Vacuuming
   - Remove the vacuum from storage;
   - Carry the vacuum from storage to the living room;
   - Vacuum in the living room; and
   - Move the living room furniture to vacuum under the furniture.

During the second part I will record your body postures and heart rate as you do the two household chores in your home. A video camera will be used to record information about 'how' your body moves for example, walking, reaching over head, or kneeling. A heart rate monitor will be used to record your heart rate. The monitor includes a strap which you will wear around your chest and watch which you will wear on your wrist/waist (see heart rate monitor).

There is little risk to you, because you will perform the two household tasks the same manner as you usually do.

The information will be kept confidential. Only myself and my supervisors will know that the data came from you. Your data will be coded and your name removed. Information will be summarized into group results. According to the University of Alberta policy, the video tape and recording forms will be stored in a locked cabinet for five years, after which time the information will be destroyed.

APPENDIX F

TASK SELECTION QUESTIONNAIRE

TASK SELECTION QUESTIONNAIRE - Pilot Study

The purpose of this questionnaire is to obtain your opinion about which household cleaning activities you think are the most "physically demanding". "Physically demanding tasks" are those tasks among which you may experience a faster rate of breathing, a faster heart rate, and require you to use your arms, trunk and legs and/or strength. Judge the following tasks based on your body's reaction to the tasks, not on whether or not you "like" the tasks.

Listed below are a number of household cleaning activities which occur around the home. As you will notice the activities listed are ones which occur inside the house and over a duration of at least 10 to 15 minutes.

Please rank the activities from one to five -

1 = the most physically demanding task
5 = the least physically demanding task

Ranking — Activity Description

___ Cleaning the refrigerator:

1. Take the items out of the refrigerator
2. Wipe the fridge walls and shelves
3. Return the items to the refrigerator.

___ Vacuuming:

1. Remove the vacuum from storage
2. Carry the vacuum from storage to the living room
3. Vacuum in the living room
4. Move the living room furniture to vacuum under the furniture

___ Cleaning the bathroom:

1. Clean the sink, toilet, and bathtub;
2. Wipe the walls around the bathtub
3. Wash the floor

___ Cleaning kitchen cupboards:

1. Remove the items in storage
2. Place the stored items on a nearby counter
3. Clean the shelves and walls in the cupboard
4. Replace the items in the storage cupboard

___ Washing floors:

1. Sweep the area to be washed
2. Remove the furniture from the area to be washed
3. Replace the furniture items to the area

___ Other: (Describe)

____

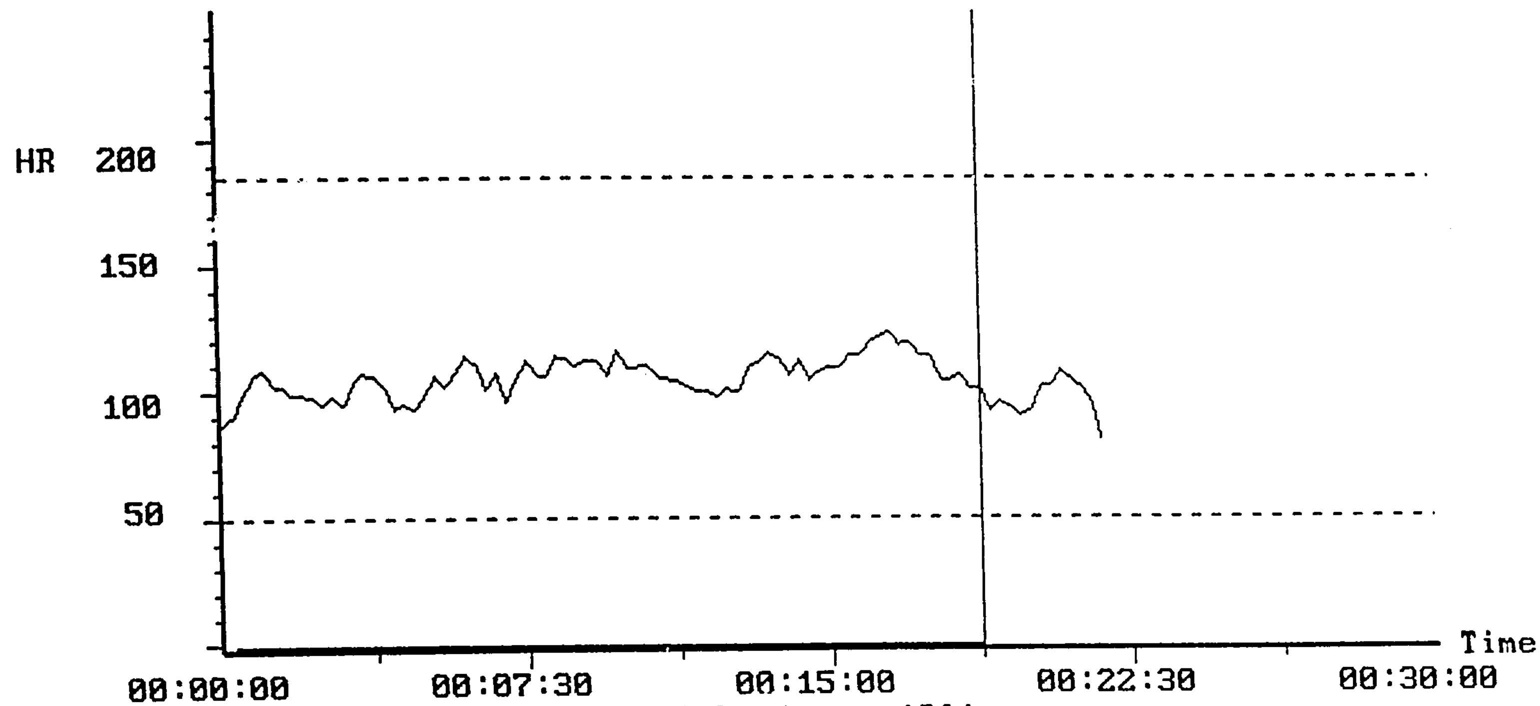
____________________ ____________________

____

APPENDIX G

EXAMPLE OF STEADY STATE HEART RATE FROM THE POLAR INTERFACE PROGRAM

HEART RATE CURVE



Average:106 Maximum:123 Heart beat sum:1961
Time:00:18:45 Heart Rate:101 bpm