Université d'Ottawa · University of Ottawa

Predictors of Physical Activity in Residents of Ontario: An Analysis of the 1990 Ontario Health Survey

by

©Alain D. Mayhew

Thesis submitted to
the School of Graduate Studies and Research
in partial fulfillment of the requirements for the
MSc degree in Epidemiology

University of Ottawa

May 1999

0-612-45238-7

Predictors of Physical Activity in Residents of Ontario.

Alain Mayhew

The purpose was to identify predictors of leisure time physical activity (LTPA) for Ontario adults. A sample of 20,606 subjects from the 1990 Ontario Health Survey was analyzed using multiple linear regression. LTPA included 20 different activity specific scores. Nineteen of 26 variables were found to be significant predictors. The best model was a 5 variable model, which included Proportion of Friends Who Exercise, Marital Status, Perceived Health Status, Age and Gender as predictors. This information can be used to guide further research and to identify target groups.

ABSTRACT

Background

Physical activity has been established as an important healthy behaviour. Yet, there remains up to 45% of the population who are inactive. In order to increase the level of physical activity for individuals, determinants of physical activity need to be established. Previous studies on determinants of physical activity have been done in studies with small sample sizes, and have examined specific samples such as university students.

The 1990 Ontario Health Survey (OHS) was a cross-sectional survey of over 40,000 subjects. The sample was selected using a multi stage sampling design, including stratification into urban and rural strata. Data was collected on many variables that were potential predictors of physical activity. This thesis will treat physical activity as a continuous variable and examine the predictors in specific subgroups of the population.

Objectives

The primary objective of this study is to identify predictors of leisure time physical activity (defined as the reported level of energy expenditure in non-work activities) in the adult population of Ontario.

The secondary objective of this study is to compare the predictors in different subgroups of the Ontario population. Subgroups divided by age group, gender and whether the subject lived in a rural or an urban area will be examined specifically.

Methods

Two different software packages were used for this thesis. Statistical Analysis Software (SAS) was used for preliminary analyses. Final models were tested using Statistical Analysis for Correlated Data (SUDAAN) software which is designed to adjust for the multi-stage sampling design.

Subjects were included in this study if they were over the age of 18. *Energy expenditure (NEW)*, the outcome variable, was calculated by summing the 20 different activity specific scores. Twenty-nine independent variables were considered as potential predictors. Three variables were excluded because they were found to be collinear with other potential predictors.

The main statistical method used was multiple linear regression. A stepwise procedure was chosen, and regression assumptions of homoscedasticity, linearity and normality were assessed graphically. An initial regression was done as a preliminary screening to test regression assumptions using only *age* and *gender* as potential predictors. These two variables were chosen because they have been identified in the literature as common predictors of physical activity.

The initial regression and the testing of the assumptions suggested that *the energy expenditure (NEW)* variable was not entirely suitable for this type of analysis. Therefore, *energy expenditure (NEW)* was transformed using a cube root transformation. A multiple regression analysis using the new outcome variable, cube root of energy expenditure, and age and gender as predictors was performed and the assumptions were met. Least squares means testing was done to assess if there were similar cube root of energy expenditure scores for adjacent levels of the categorical variables. This provided rationale to collapse some of the categorical variables into fewer levels, which meant that less 'dummy' variables would be included in the prediction models.

Sub-group analyses were also done testing models in 4 age groups, both genders and in urban and rural stratum.

Results

The stepwise regression was done using the cube root of energy expenditure and 26 potential predictors. Nineteen of the 26 variables were found to be significant predictors of cube root of energy expenditure. Assumptions for multiple linear regression were done and the assumptions were interpreted as being met for homoscedasticity, linearity, and normality.

The 19 variables were significant predictors of physical activity were: *Proportion of Friends Who Exercise, Marital Status, Perceived Health Status, Education Level, Activity Accident, Work Type, Occupational Status, Gender, Drinking Status, Ethnic Group*, *Well Being Score*, *Mobility Limitations*, *Age*, *Household Size*, *Smoking Status*, *Household Income*, *Body Mass Index*, *Number of Health Problems* and *Household Type*.

Three models were tested including three variables *(Proportion of Friends Who Exercise, Marital Status, Perceived Health Status)*, five variables *(Proportion of Friends Who Exercise, Marital Status, Perceived Health Status, Age, Gender)*, and all nineteen variables. Although the 19 variable model was statistically significantly improved over the five and three variable models, the increase in R^2 was very small.

Proportion of Friends Who Exercise was found to be a predictor in every subgroup. *Age* was found to be a predictor in both gender and in the urban and rural subgroups. *Gender* was found to be a predictor in all four age groups and in the urban and the rural strata.

Discussion

There are potential explanations for all 19 predicting variables. However, it is unlikely that all 19 are causal variables. Causal explanations can be justified for age, gender, marital status, education level and marital status. The 'best' model for overall prediction and justification was felt to be the model with *Proportion of Friends Who Exercise, Marital Status, Perceived Health Status, Age* and *Gender.*

There remains a need for future research in this area. Further examination of the differences in predictors in different subgroups requires further research. As well, there is a need for study of determinants of adoption, and maintenance and cessation of physical activity. Finally, there may be two or more models that are required to explain physical activity at different intensities.

Acknowledgements

I would like to acknowledge the assistance of the following individuals, without whom completion of this thesis would not have been possible:

- my wife, Adele, for her support, encouragement, assistance and love over the past 5 years.
- my thesis supervisors, Dr. N. Birkett. Dr. R. Plotnikoff, and Dr. J.G. Fodor, whose guidance kept me on the right path towards completion of this undertaking.
- my examiners, Dr. Y. Chen, Dr. R. Nair and Dr. S. Hotz for their helpful comments.
- Dr. N. Edwards and the Community Health Research Unit, University of Ottawa for providing the data for this analysis.
- Dr. W. Dafoe, Pat O'Farrell and the rest of the staff at the University of Ottawa Heart Institute Prevention and Rehabilitation Centre for their ongoing support.
- Dr. P. Huston, for her role as a writing mentor.
- my friends, classmates and colleagues, who provided editorial assistance, statistical and computer advice and general encouragement to keep me going through the tough times. I'd specifically like to thank Linda, Laura C., Louise, Sandra, Bob, Travis, Faye, Krista, Ben, Christine, Martine, Laura M., Kirsten, Kristy, Brenda, Debbie, Shirley, Dave, Don, Lana, Peter and Cindy, and any one else I might have missed.
- the contribution of two people who have moved on to another world since I started graduate school; my mother, and my mother-in-law, Mrs. G. They are both still encouraging me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

1.1 Study Objectives

Primary Objective

The primary objective of this study is to identify predictors of leisure time physical activity (defined as the reported level of energy expenditure in non-work activities) in a representative sample of the adult population of Ontario.

Secondary Objectives

The secondary objective of this study is to compare the predictors of physical activity in different subgroups of the sample. Age group, gender and whether the subject lived in a rural or an urban area, defined the subgroups.

1.2 Background

Regular physical activity is strongly recommended by numerous organizations for its health benefits. Recent publications such as the Surgeon General's Report on Physical Activity and Health (1), the Consensus Development Conference Statement on Physical Activity and Health from the National Institute of Health (2), the joint recommendation from the Centres for Disease Control and Prevention and the American College of Sports Medicine (3) and the 1997 Physical Activity Benchmarks Report published by the Canadian Fitness and Lifestyle Research Institute (4) have highlighted the importance of physical activity.

The benefits of physical activity have been well documented. These benefits include decreased mortality, both from cardiovascular disease and all causes, improved control of weight, blood sugar and blood pressure, and an improved sense of well being and quality of life (5-8). In addition, people who exercise regularly are more likely to have other habits that contribute positively to their overall health (9).

Current data indicate that the majority of individuals are not doing enough physical activity. Data from 1992 indicate that only 22% of Americans over the age of 18 participate in regular physical activity (10). According to the 1988 Campbell Survey, 43% of Canadians are inactive in their leisure time (11, 12). More recent surveys estimate that between 37% and 48% of Canadians are considered 'active' (4).

It may be possible to increase the amount of physical activity an individual does through intervention. In order to target appropriate groups, determinants of physical activity must be identified. Previous research on determinants of leisure time physical activity has examined demographic predictors, cognitive predictors, and social influences (13, 14). Very little data have been collected assessing environmental influences on physical activity. Among the most common predictors are gender (males perform more physical activity than females), age (younger people are more active than older people), social support (more social support is associated with higher levels of physical activity), and self-efficacy (higher self-efficacy is associated with higher levels of activity) (13-16). Much of the research has been conducted on samples of individuals participating in special studies. The results of the research on specific samples are not necessarily generalizable to all individuals in the community (14).

Physical activity is difficult to measure and quantify. Many studies have evaluated physical fitness, but attributed the results to benefits of physical activity (17). Although there is a correlation between physical activity and physical fitness, there are other factors such as genetics, which contribute to an individual's fitness level as measured by tests of maximal exertion (18). Physical activity has been measured by occupational status, self-report, or by a mechanical device measuring movement (19). Self-report methods include diaries, interview and many self-administered questionnaires; different self-report methods may give conflicting results (19).

Once physical activity data are collected, the analyses depend on whether physical activity is treated as a categorical or a continuous variable. There are some methods of physical activity data collection that categorize subjects into active or inactive, depending on their response to one (or a few) questions. Other studies have collected the data as continuous ratio data, but categorize the subjects into two or more groups based on the physical activity level. Another option is to collect and analyze the data as a continuous variable, which is the approach that will be taken in this thesis.

This thesis will use data from the 1990 Ontario Health Survey (OHS) to assess the level of physical activity in the province of Ontario, and determine predictors of physical activity, including sub-group comparisons. Chapter Two will provide basic definitions, and review the literature on the health benefits of physical activity, design and measurement issues in physical activity research, and identify what is known about determinants of physical activity to date. Arguments will be presented justifying the treatment of physical activity as a continuous variable. Chapter Three will describe the OHS in detail because the 1990 OHS data set was analyzed to address the thesis objectives. Chapter Four will outline the methods used for the analyses of the OHS data to assess the predictors of physical activity. Chapter Five will present the results. Chapter Six will explore the interpretation of the findings and the implications.

CHAPTER 2 LITERATURE REVIEW

2.1 Chapter Overview

This chapter will review the current literature on physical activity. Evidence supporting the health benefits of physical activity will be described, followed by a review of the issues pertaining to collecting data on and measuring physical activity. Literature on the determinants of physical activity will be reviewed and summarized. The assessment of determinants when the outcome variable is categorical versus continuous will be discussed.

2.2 Definitions and Related Issues

2.2.1 Operational Definitions

Different units have been used to measure the amount of physical activity. For comparison, all units of physical activity measurement were converted to kilocalories of energy expended per kilogram of body weight per day (KKD). If body weight was not available, (e.g., the units described are kilocalories of energy per day) the units reported were converted to KKD for a 70-kilogram person. (The weight of 70 kilograms was used because it is the mean weight of subjects in the OHS.)

For the purposes of this thesis, determinants and predictors will be used synonymously. 'Levels' will be consistently used to refer to categories of nominal or ordinal variables (e.g., gender will have two levels, 'males' and 'females').

2.2.2 Physical Fitness, Physical Activity and Exercise

Three terms are commonly used in the field of physical activity and health: 'physical activity', 'physical fitness', and 'exercise'. For clarity, these three terms will be defined as follows (1). 'Physical activity' refers to performing a movement, which requires energy expenditure. Many researchers will distinguish between leisure time physical activity and work related physical activity. 'Physical fitness' is a measure of maximum capacity. 'Exercise' refers to a planned structured type of physical activity.

Although physical activity is closely related to physical fitness, it is important to recognize that a measure of one does not necessarily predict the other. A study by Eaton et al found that self-reported physical activity levels had a "modest but statistically significant" correlation with physical fitness levels (R^2 = .13 for males and .19 for females) (20). For their study, the self-report of physical activity level was based on a single question, and physical fitness was measured using a sub-maximal step test. The step test is not regarded as the most accurate method of determining physical fitness (21).

Both physical activity and physical fitness have been studied to assess their relationships to morbidity and mortality and health. Hein et al attempted to evaluate the beneficial effects of physical activity and physical fitness separately (22). Over 4900 men between the ages of 40 and 59 were recruited from 14 work sites in Copenhagen. Physical fitness was assessed using a sub-maximal exercise bike test. Leisure time physical activity was evaluated using a questionnaire specifically designed for the study. As expected, the lowest quintile of physical fitness scores was found to be the group with the highest percentage of people reporting a 'mostly sedentary lifestyle'. If only the group with the lowest level of physical fitness are considered, the mortality rate (both from ischaemic heart disease and all-causes) was higher for the sedentary subjects than for the active men (relative risk 1.6, 95% CI of 1.1-2.2). The study concluded that a high level of physical fitness is not protective for an inactive individual, but increased physical activity does offer a benefit for those individuals with low levels of fitness. However, with no validity or reliability testing of the measures used to determine the level of physical activity, it is difficult to draw conclusions. The paper does not describe the time sequence of the examination (i.e., if all the individuals tested completed the physical activity measures before or after the fitness testing) . Physical activity is more subjective and therefore, more likely to be biased by a prior test. Nonetheless this research suggests that reported leisure time physical activity might be an appropriate measure to evaluate the risk of premature mortality.

There is variation in measurement techniques among studies evaluating the benefits of physical activity. As described above, longitudinal cohort designs are commonly used to establish the relationship between physical activity and cardiovascular disease. Although longitudinal cohort study designs are suitable for following a large sample over time, physical activity is not usually monitored continuously in this type of study. It has been reported that individuals do not behave in the same manner throughout the study period as they did at the time of the measurement of their physical activity ; up to 50% of people who start an exercise program will not continue with the program for a full year (16). There are also problems with multiple measures. Assessing physical activity of subjects on an ongoing basis might affect the activity level of the participants in the study and subsequently bias the results (19).

2.2.3 Amount of Physical Activity Required For Health Benefits

There are a wide variety of recommendations available about how much exercise is required for health benefits. Haskell concluded that, for the inactive individual, a slight increase in the amount of physical activity results in significant health benefits (23). To support his conclusion, he identified five different studies, with different cut-points separating the active from the inactive; the cut-points ranged from 1.2 KKD to 5.7 KKD. Each of these five studies showed a protective effect of physical activity. Guidelines published by the American College of Sports Medicine recommend 20 to 60 minutes of exercise, three to five times per week at an intensity of 50 to 85% of maximum capacity (24). For a very low-level functioning individual, the physical activity level could be as low as 0.9 KKD. Paffenbarger (25) in his analyses of the benefits of physical activity interpreted 4.0 KKD to be the threshold; people exercising above this threshold receive health benefits.

Recent recommendations from the 1997 Surgeon General's Report suggest that individuals should exercise "at a moderate intensity" for 30 minutes on most days of the week (1). This report defines moderate intensity of exercise as a walking speed of 2.6 to 5.2 miles per hour. If most days of the week refer to at least five, the amount of recommended exercise is equal to 1.1 KKD to 1.9 KKD. Given that the majority of people fall into the 'inactive' category, encouraging people to increase their activity a small amount may have important public health implications. The report also concludes that higher levels of energy expenditure will result in more health benefits. Others believe that reaching a threshold is not the critical issue and that health benefits will occur with any increase in physical activity (26). Proponents of the moderate activity recommendations suggest that more people will adopt the behaviour if the objectives are more easily obtainable. There is support for the opposing view that moderate amounts of exercise are not sufficient to achieve health benefits, particularly if the activity is spread out over the course of a day (26).

2.3 Health Benefits of Physical Activity

Physical activity has been shown to be beneficial in the prevention of numerous diseases (e.g., cancer, diabetes, cardiovascular disease) and conditions (e.g., obesity, hypertension, osteoporosis) (1). The abundance of research demonstrating the beneficial effects of physical activity on cardiovascular disease provides sufficient evidence to justify recommending physical activity. The literature review will focus specifically on the relationship between cardiovascular disease and physical activity.

The hypothesis, correlating physical activity and decreased mortality, originated in England where an increase in coronary deaths was noted after 1930. The disease was more common in professional workers compared to unskilled labourers who were more physically active in their occupations (27). Specific studies were conducted examining comparable groups in different occupational categories. One of the most commonly quoted studies was conducted by Morris et al who examined male workers in the London transit system (28). The comparison was made between the conductors who moved around the buses all day collecting tickets, and the drivers who remained seated. The results showed that the drivers had three times as many sudden deaths as the conductors. A similar protective effect of increased activity was shown in a study of longshoremen, demonstrating that those individuals in occupations requiring a higher level of energy expenditure had a lower risk of fatal heart attack (29, 30). All three of these studies were focused on occupational classifications, and the two groups used in each study may have differed in ways other than their activity levels at work. Thus, it is possible that any benefit might be due to causes other than physical activity.

A retrospective study of 568 case-control pairs was conducted in Florida in the 1970s assessing the relationship between physical activity and heart disease (31). Married men who had died from coronary heart disease were recorded as cases for the study and the controls were age and neighbourhood matched married men. Information about the men in both groups was obtained from the wives. The results demonstrated a strong protective effect of leisure time physical activity, significant at the $p<0.001$ level, even when other risk factors were taken into account. Although spousal reporting and historical recall may bias this study, it provides evidence of health benefits of leisure time physical activity.

Haapanen et al showed that Finnish men who expended 1.6 KKD or less had a 2.7 times higher risk for all cause mortality and 3.6 times higher risk of cardiovascular mortality as compared to individuals who expended four kilocalories or more (32).

Paffenbarger et al conducted a large longitudinal cohort study to evaluate leisure time physical activity and mortality (25, 33, 34). A sample of 16,000 Harvard University Alumni was recruited from university entrants between 1916 and 1950. Subjects in the sample were followed until one of the following events occurred: heart attack or death from any cause, the subject reaching the age of 75, or study completion. Data were collected through three mailed surveys about physical activity level and other health issues. Initial surveys were mailed out in 1962 and 1966 and follow-up surveys were sent out in 1972. Results indicated that those individuals who expended less than 4.1 KKD had a relative risk of 1.6 for coronary heart disease as compared to those individuals who expended greater than 4.1 KKD. Results also indicated that the benefit was achieved through ongoing physical activity and that athletic participation during school years had no protective effect. A similar effect was shown for all-cause mortality, with a relative risk of 1.4 for those individuals expending less than 4.1 KKD, compared to those individuals expending more than 4.1 KKD. The increased relative risk for the less active individuals was independent of smoking, hypertension or body weight. Using a sample of university graduates may have biased this study, and the threshold of 4.1 KKD requires further justification.

A Canadian study on physical activity and all cause mortality, followed 691 subjects for a seven year period (35). A population based sample of individuals between the ages of 30 and 69 were included in this study. Baseline testing included both fitness and physical activity assessments. Those people who were classified as 'inactive' had an adjusted relative risk of 1.8 for all cause mortality and 1.6 for cardiovascular disease as compared to the 'very active' group, but the confidence intervals of the relative risks included 1.0 in both analyses. The authors attribute the wide confidence limits to the relatively small sample size.

A meta-analysis published by Berlin and Colditz (36) quantified the findings of an earlier review paper (37) which examined physical activity and heart disease. Data from 20 studies evaluating the relationship between heart disease and non-occupational physical activity demonstrated pooled relative risks for onset of coronary heart disease, myocardial infarction or death from coronary heart disease ranging from 1.3 to 2.9 for the less active group. Higher relative risks were found when only those studies that were judged to be of a higher quality were included. The authors found no evidence of any publication bias in the included articles.

The high prevalence of inactivity results in a major impact of inactivity on the population attributable risk. A recent publication involving the population of Ontario demonstrated the potential impact of low levels of physical activity on mortality (38). Using a relative risk of 1.9 for inactive subjects as compared to active subjects (10, 39), and a prevalence of inactivity of 55%, the authors concluded that the population attributable risk of mortality for physical inactivity was 33%. In comparison, the population attributable risk of mortality for smoking was only 27% in the same population. The higher population attributable risk for inactivity compared to smoking is due to the higher prevalence of inactivity in the Ontario population. This report emphasizes the need to address the issue of inactivity.

2.4 Design and Measurement Issues

2.4.1 Measuring Physical Activity

Different methods are available for measuring physical activity. Although external monitoring by a third person may be the most accurate method (40), it is not a feasible option for extended periods of time or for a large sample size. There are electronic monitoring devices available, but these devices are costly and not accurate for all types of exercise (e.g., swimming) (19). Questionnaires provide a method of assessing of physical activity levels of a large number of people in a short period of time (19). Standards have been established for surveys measuring physical activity and are listed in Table 2.1 (1).

A clear explanation of how the physical activity level is derived is fundamental to the interpretation of the reported physical activity level. Some studies collect data only on vigourous activity; and other studies use measures such as the frequency of sweat producing activities (41). Information on the validity and reliability of the measures, when available, provides checks to ensure data accuracy.

Data on physical activity should be based on measurement in individuals. Group activity analysis assumes that all individuals within a group are performing the same amount of activity. This assumption is generally inaccurate as the physical activity levels of group members may differ substantially not only during the group activity, but during times when the individuals are on their own.

Physical activity is best measured as the total amount of energy expended. The total amount will depend on duration, frequency, intensity and the nature of the activity. Categorical classification of subjects based on self-report of being active or inactive loses much of the precision of a physical activity intensity level and may also result in inaccurate classification on the part of the respondent.

Measures of previous physical activity and adherence to physical activity can provide an indication of long-term maintenance of a physical activity program. The need to evaluate adoption, dropout and readoption of physical activity has been previously identified (16).

Methods employed to measure physical activity in surveys include: diaries, retrospective recall questionnaires and retrospective quantitative histories. Diaries provide accurate information but require extensive planning and are costly to use, as they tend to produce large amounts of data, which need to be interpreted and coded prior to being analyzed. Diary records are also influenced by subject compliance. Because of these factors, diaries tend to be used for short time periods (few days) which limits the generalizability. In addition, diary keeping may influence the behaviour being measured (19).

Table 2.1 Seven Criteria for Measuring Physical Activity

1) There should be a clear definition of how the physical activity is measured and determined.

2) There should be a description of the validity and the reliability of the tool used.

3) The activity of individuals should be measured directly and not based on mean group activity.

4) The measurement should consider the frequency, intensity and the duration of the activity.

5) Past physical activity should be evaluated.

6) Adherence should be measured for cohort studies.

7) The collection method should be well described.

Source: Surgeon General's Report, 1996 (1).

Retrospective methods are much less costly and easier to administer, but these methods are less precise than other methods. The recall questionnaire, for example, does not usually identify specific activities about which the subject should answer questions; the recall questionnaire relies on the subject's responses to open-ended questions. Recall bias is a definite limitation with this method; vigorous exercise tends to be recalled more than light exercise (42). Recall questionnaires such as the Seven Day Recall specifically focus on higher intensity activities which the respondents describe as 'hard' (43). Although these activities tend to be easier to recall, what is described as 'hard' for a younger and an older person may vary.

The retrospective quantitative history consists of specific activity questions addressed to the respondent. This type of history requires more time and effort on the part of the respondent, but supplies more accurate data. By asking the subject questions about specific activities, the accuracy of the recall may be improved. However, the longer the time period of recall being addressed, the greater the chance of inaccurate responses. Seasonal variation is a potential limitation, particularly if the time period over which the survey is administered is short (i.e., a few weeks in length). The retrospective quantitative history also limits the responses to the particular questions posed. Physical activity can include many different components, and there is always a concern that some of the elements may be missed in the questionnaire. On the other hand, it is not possible to include all activities that an individual might do for exercise. A greater number of questions may lead to more missing data as subjects may tire or be less willing to complete longer questionnaire.

A well-accepted gold standard against which physical activity measurement can be validated does not exist. Third party observation has been used rarely in validation studies; therefore most physical activity assessments are validated against fitness testing, or questionnaires or surveys. There is no agreement on which tool or method as the most valid and reliable method of collecting physical activity data.

There is a tendency for subjects to over estimate their physical activity time when completing surveys. For example, in a small study by Klesges et al, 44 subjects were asked to participate in a physical activity programme (40). Following the exercise session subjects were asked to record the number of minutes they had spent performing physical activity at intensities of light, moderate and heavy exercise. A trained observer also visually monitored the subjects and recorded the subject's activity without them knowing. The subjects reported spending less time in sedentary activities than they actually did and they exaggerated the time spent doing aerobic activities by over 300%. The short duration of the exercise time and the expectation presented to the subjects that they were to perform exercise may have affected the subsequent over-reporting of the physical activity. Over-reporting of physical activity has also has also been documented in a study of overweight women, particularly in those women who are unsuccessful at weight loss (44). The potential for overestimation of the amount of physical activity must be considered in the assessment of physical activity levels of all subjects.

In summary, there are many different methods of physical activity assessment, but there does not appear to be one well-accepted tool. The data collecting method must be considered in deciding the measurement approach; also, the nature of the study, the size of the sample and whether physical activity is the only component or one of many components will affect the choice of measurement device. A retrospective quantitative history, including frequency and duration for many activities is one method of measuring physical activity in a large population survey. Although there are limitations, the retrospective quantitative history provides a great deal of information about physical activity patterns.

2.4.2 Quantifying Physical Activity

Questionnaires can either simply identify which activities are performed or try to record the duration, frequency and intensity of each activity; the duration, frequency and intensity information then needs to be quantified. If the questionnaire does not collect intensity information, then an underlying assumption has to be made that all people are doing a given activity at the same physical intensity; this assumption may be faulty. Cross country skiers, for example, vary their intensity depending on which technique they use, the speed they travel at, the conditions they are skiing in and their level of competence. Some questionnaires ask about the intensity of a given activity (light, moderate, or hard) but the grading of the intensity is not necessarily consistent across respondents. The other common approach is to assume that all activities are performed at a low intensity when calculating the total energy expenditure; the effect of this approach is to produce a physical activity score that may be lower than the true value.

Physical activity intensities are tallied in units of metabolic equivalents (METS). One MET is equal to the amount of energy an individual consumes at rest; this amount of energy used is 3.5 millilitres of oxygen per kilogram of body weight per minute, or 1 kilocalorie of energy expended per kilogram of body weight per hour. MET levels of numerous activities have been well documented (45). For example, golfing without a cart has an estimate workload of 5.0 METS, while walking three miles per hour has a MET level of 3.3 METS. Estimates of frequency (i.e., number of times per week) and duration (i.e., number of minutes per session) of the activity should also be assessed. By incorporating the duration and the frequency of the activity, the MET level can be converted into a 'score' for that activity, the activities can then be summed to estimate the level of physical activity of the individual. The calculations to perform this conversion are described in Appendix 3.

Once the activities have been quantified, and summed, they can be analyzed as part of the survey. The score can either be maintained as a continuous variable or converted to categories using various cut-points. Categorization can be useful as long as the cut-points are well justified (i.e., validated in the literature).

Ideally assessment of an individual's total amount of physical activity would include energy expended at work. For most professionals, physical activity at work is minimal and it is very difficult to quantify the physical activity performed at work for non-professionals. Currently, it is common practice to only assess leisure time physical activity (46).

2.5 Determinants of Physical Activity

The interpretation and characterization of determinants of physical activity level has been identified as an important focus for current and future research (15). Demographic variables, cognitive factors, health behaviours and physical and social environmental factors have all been assessed as determinants (13, 14, 47).

Studies evaluating predictors of physical activity can evaluate the predictors of either supervised 'class format' physical activity, or 'free-living' physical activity. It is easier to obtain a study sample in a supervised physical activity study; however, the results may not be as generalizable to the whole population (13, 14). Since physical activity does not have to be done in a supervised group setting to be beneficial, studying 'free living' physical activity is important. Current level of activity is important, but studies are also required to evaluate adoption of physical activity, and dropout and resumption of activity. However, practical issues in study design dictate that most data on predictors is obtained from cross-sectional studies.

2.5.1 Review Articles

A recently published review paper by Dishman and Sallis considered potential predictors which were not discussed in the review here (14). Although many of these predictors can not be addressed in a population-based survey, it is useful to be aware of other directions in the field.

One approach is to apply psychological theories, such as the stages of change theory, personal investment theory and self-schemata, which have been examined and shown to contribute to the prediction of physical activity (15). There have been studies done comparing different psychological theories which could help to identify which of these theories is the best to predict physical activity , but more comparison work needs to be done (15).

Although research on determinants of physical activity has been done in the past, there remains a need to do further research on determinants. For example, some constructs that are potential determinants have been evaluated in different ways. The variation in methods of measuring constructs may lead to conflicting results.

There is recent evidence suggesting that moderate levels of physical activity may be adequate for health; yet there is a scarcity of research evaluating the predictors of moderate level activity benefits (1). Hovell (48) examined the predictors of walking and Johnson (9) evaluated predictors of moderate and vigourous activity. However, predictors of moderate levels of physical activity need to be studied in more depth than has been done to date.

Dishman and Sallis also describe the need to address adoption as well as maintenance of physical activity (14). The level of inactivity in the population is still high and the public health benefits that would be achieved by having the inactive segment become physical active merits the study of factors, which would affect the adoption. Unfortunately, adoption of physical activity can not be studied in a cross-sectional study.

2.5.2 Selection of Articles Reviewed

In order to be included in this literature review of determinants of physical activity, a study had to meet all of the following four criteria:

- the outcome evaluated in the particular study had to be free living physical activity, measured by a questionnaire;
- the sample had to be population based with at least 300 adults (studies of fitness class participants or university students were excluded);
- the study design had to be cross-sectional;
- the determinants examined had to be applicable to a large population based study.

These criteria were designed to ensure that the studies reviewed were comparable to the analysis of this thesis (i.e., the 1990 Ontario Health Survey, see Chapter 3).

Searches were done on the Medline, PsycINFO, SPORTDiscus and Eric databases using the OVID search engine. The time period searched was from January 1987 up to and including January 1998. English language articles were retrieved using the keywords, 'exercise', or 'physical activity' and their derivatives. 'Exercise' was also searched as a MESH heading, using the exploded feature on the search engine. A second search was performed using the text words 'determinants' or 'predictors'. The two searches were combined using the 'AND' modifier to identify articles that would have appeared in both searches. These collected articles were manually assessed for inclusion in this review. Additional articles were found be personal recommendations or by reviewing references quoted in a review paper (14).

Of the 89 articles found using the search strategy, 20 papers were selected for review. Sixty-eight excluded studies either did not address the question of determinants, or studied a non-generalizable sample. One study was excluded because of apparently inaccurate data (the mean level of physical activity reported suggested that subjects would have to be exercising at a moderate intensity more than 20 hours per day (49). The 20 remaining articles were reviewed and are discussed below.

Articles were divided into two groups. One group consisted of 'large studies' which have a sample size of 2000 subjects or more. Ten of the 20 articles fit into the 'large study' category. (Note: These 10 articles represent seven studies; one study produced four separate articles.) The methods and results of these 10 articles are described in Table 2.2. (Note: In both the text and the tables, the studies are listed in order of decreasing sample size.) The 10 remaining articles were designated as 'small studies' and are reviewed later.

2.5.3 Large Studies

A report of the determinants of physical inactivity using the 1990 Ontario Health Survey (OHS) was published by Allison (50, 51). The objective of Allison's research was to identify predicting factors for inactivity and to develop a profile of the inactive people of the population. The OHS sample was selected using a multi-stage stratified cluster sample approach (See Section 3.1 and Section 4.1). Data were collected through an interview with one member of the household and a self-completed questionnaire for all members of the household 12 years of age and over. The outcome variable used by Allison was a derived variable, the Physical Activity Index (PAI). PAI was calculated from data collected from the self-administered questionnaire. Subjects were asked if they participated in any of 20 different physical activities (e.g. walking, bicycling, and swimming); for each activity that the subject reported doing, they were asked the duration and the frequency of their participation. All the activity specific scores were calculated using a specified MET level for each activity and the total energy expenditure (EE) was calculated by summing the individual activity specific scores. PAI was categorized into two groups: an 'active group', with an EE greater than 1.5 KKD and an inactive group, with an EE less than 1.5 KKD. Twenty-five independent variables were

Table 2.2 Summary of Cross Sectional Studies Evaluating Predictors of Leisure Time Physical Activity - Large Studies

Study (first author, year)	Sample and Sample Size	Activity Measurement Method	Statistical Methods	Significant Independant Variables	Non-significant Independent Variables
Allison, 1996	Population based sample, 43,954 subjects	Self completed questionnaire, asking about 20 different activities	Multivariate Logistic Regression	Age (-), male (+), friends participation (+), excellent health (+), percieved future health problems umlikely (+)	Education, occupation, income, Household size and type. marital status, urban or rual stratum residence, health conditions, number of health problems, visits to health professional or MD, percieved well being, BMI, smoking or drinking status, stress, family functioning, social support.
Bauman, 1990	Population based sample, 17,053 subjects	Interview, questioned about leisure time activity	Logistic regression	Male (+), age (-), educati\on (+), number of children (-).	City living, season tested, income.
Johnson, 1995	Population based sample 9.279 subjects	Self completed questionnaire, 3 yes/no questions about intensity of exercise	Logistic regression	Education (+), Australian birthplace (+), special diet (+), age (-), alcohol consumption (-), Smoker (-), Single marital status (+), BMI (-), male (+).	
Shea, 1991	Population based sample, 4,179 subjects	Telephone survey	multiple logistic regression	High school education in the Hispanic race (+), white and black race (+), New York city residents(+).	Race.

Table 2.2 Summary of Cross Sectional Studies Evaluating Predictors of Leisure Time Physical Activity (continued) - 'Large' Studies

Study (first author, year)	Sample and Sample Size	Activity Measurement Method	Statistical Methods	Significant Independant Variables	Non-significant Independent Variables
Macera, 1995	Population, based sample, 3,223 subjects	Questionnaire, type and frequency of physical activity	Logistic regression	'Uaing exercise to lose weight" (+), physician advice (+), education (+), current participation in a program (+).	Age, education, "trying to lose weight", smoking status, exercise knowledge.
Fogelholm, 1996	Population based sample, 2,746 subjects	Questionnaire	Gender comparison (test not reported)	Gender	
Sallis, 1989	Population based sample, 2,053 subjects	Question about frequency of vigourous activity	Multiple linear regression	Self efficacy (+) modelling (+), friend support (+),barriers (-), benefits (+), home equipment (+), age (-), education (+), smoking (-), healthy diet (+), coordination (+), prxoimity of facilities (+).	Family support, exercise knowledge, mormative beliefs, sports media, gender, alcohol, BMI, exercise history, modeling history, neighbourhood environment, home equipment, community access to facilities.
Hovell, 1989	Population based sample, 2,053 subjects	Total number of minutes of walking	Multiple linear regression	Age (+), vigourous exercise (+), heart healthy diet (+), edcuation (-) family support (+), self efficacy (+), exercise history (-), neighbourhood environment (+).	Modelling, friend support, barriers, benefits, exercise knowledge, normative beliefs, sprts media. home equipment, sex, smoking, alcohol, BMI, modeling history, injury.

Table 2.2 Summary of Cross Sectional Studies Evaluating Predictors of Leisure Time Physical Activity (continued) - 'Large' Studies

Study (first author, year)	Sample and Sample Size	Activity Measurement Method	Statistical Methods	Significant Independant Variables	Non-significant Independent Variables
Hofstetter, 1991	Population based sample, 2,053 subjects	Frequency of vigourous exercise and total minutes of walking	Analysis of Variance	No illness (+) for vigourous exercise, long term illness (+) for minutes of walking.	
Sallis, 1990	Population based sample, 2,053 subjects	Categorization of active/inactive and count of facilities close to home	Analysis of covariance adjusting for gender, age and income	Number of facilities within one kilometre (+).	

used in this analysis: sociodemographic variables (age, sex, education, occupation, household income, working status, household size, household type, marital status, rural or urban strata) health related variables (conditions, number of health problems, visits to health professional, visits to medical doctor, perceived well being, perceived health status, body mass index, smoking and drinking status, perceived likelihood of future health problems), and social context variables (perceived stress, family functioning, social support, and participation of friends in exercise). The data were analyzed by descriptive methods, examining the relationship between PAI and the independent variables. Multivariate analysis consisted of a multiple logistic regression. Results of the multivariate analysis demonstrated that a friend's participation in exercise was the strongest predictor of inactivity in this sample. An individual was 7.4 times as likely to be active if all of his/her friends exercise than if none of his/her friends exercise. The other major predictors in this analysis were age (negative relationship), gender (males), income (favouring higher income), household type (favouring single parent with children), perception that future health problems were unlikely, and excellent perceived health. Odds ratios for these five variables range from 1.5 to 2.7. Subgroup analyses were also done in three different age groups and in males and females. Age, gender, perception of future health problems, perceived health status and friends participation were reported to be predictors in the subgroup analyses.

Bauman et al examined determinants of exercise participation in 17,053 respondents in Australia (52). Data were collected in five separate surveys between 1984 and 1987. Subjects were selected using cluster sampling of households. Respondents were interviewed by a trained individual and asked to report all the physical activities performed in the past two weeks. Subjects were asked about the type of activity, frequency, duration, and perceived intensity of the activity. Respondents were grouped into aerobically active, (the subject's level of energy expenditure exceeded 1600 kilocalories per week, 2,536 subjects or 14.9% of the total sample); moderately active, (subjects not exceeding 1600 kilocalories per week, but still performing large muscle types of activities (e.g., tennis) on a less frequent basis than recommended, 3,331 subjects or 19.5%); low level of activity (subjects exercising at a lower intensity than recommended, 6,108 subjects or 35.8%); and totally sedentary, (subjects who reported performing no physical activity during the two weeks, 5,078 or 29.7%). The analysis conducted was a logistic regression, comparing those individuals who were in the highest categories of physical activity to all of the other respondents. Significant predictor variables were gender (males were 1.2 times as likely to reach the recommended level of activity), age (subjects between the ages of 20 to 29 were almost three times as likely to reach the desired level of activity as compared to those over the age of 50), education (subjects with post secondary education were almost 1.5 times as likely to be active as those without high school) and number of children (those subjects with no children were 1.2 times more likely to be active as those with three children).

A study by Johnson et al of 9279 subjects examined the relationship between leisure time physical activity and other health behaviours (9). This study was a cross-sectional study, which analyzed data from The National Heart Foundation of Australia 1989 Risk Factor Prevalence Survey. Random sampling was done in nine defined geographical areas, stratifying by age, sex, and electoral division. There was a 74% response rate. Data were collected by a self-completed questionnaire, physical measurements and blood work. Leisure time physical activity was assessed by asking three questions; one about engaging in vigorous exercise, one about performing less vigorous exercise and one about walking for exercise. Subjects who responded 'yes' to any of the three questions were categorized as active. A second analysis was done excluding those subjects who responded 'yes' to the vigorous exercise item; this second analysis provided information on the predictors of moderate levels of leisure time physical activity. Independent variables included smoking status, diet, alcohol consumption, body mass index, education, age, marital status, gender, and country of birth. Both analyses were done using multiple logistic regression. Variables found to predict leisure time physical activity were education (higher education, more likely to be active), birthplace (those individuals born in Australia were more active), diet (those people following a special diet were more likely to be active), age (as age increased, leisure time physical activity decreased), alcohol consumption (no-risk or low-risk drinker were the most active), smoking status (ex-smokers and non-smokers were more active than smokers), marital status (not married were more active), body mass index (acceptable weight subjects were more active) and gender (males were more active). In a second analysis considering only those subjects who performed light to moderate leisure time physical activity as compared to those who performed no leisure time physical activity found education, diet, birthplace, smoking status, marital status, alcohol consumption, and age to be significant predicting variables, all in the same direction as the first analysis with the exception of age. Age was positively associated with performing light to moderate physical activity. Exclusion of the vigorous exercisers affects the external validity of the results; many of the younger subjects were likely eliminated from the analysis when vigourous exercisers were excluded. Underweight or normal weight individuals, for example, were 1.25 times as likely to be doing light-to-moderate leisure time physical activity and 1.35 times as likely to be doing any leisure time physical activity compared to overweight individuals.

Shea et al performed a telephone survey of 4,179 subjects evaluating ethnicity and education with cardiovascular disease risk factors, including physical activity (53). Subjects were asked if they exercised, and how frequently and what type of exercise they did. The responses were coded as 'active' or 'inactive'. Multiple logistic regression, with adjustment for age and sex was the method of analysis. Education was statistically significant for the comparison of subjects with 'some college' being more likely to exercise 3 times per week as compared to those with less than a high school education (OR 1.4, 95% CL 1.0-1.8). New York City 'whites' were 1.8 times (95% CL1.1 to 2.9) as likely to exercise as compared to upstate New York 'whites'.

Macera et al assessed predictors of both the current level of physical activity and the adoption of physical activity in the future (54). The sample consisted of white and African-American adults, 18 years of age or over. The sample was chosen using random-digit dialing procedures and city directories. The final sample included in the analysis was 2,533 Whites and 690 African-Americans. All data was collected by a retrospective questionnaire. Physical activity assessment included type and frequency of leisure time physical activity. Subjects were categorized into an active group if they participated in a leisure time physical activity such as walking or jogging three or more times a week; otherwise they were categorized as inactive. Other data collected included sociodemographics, health behaviours (including smoking status), education and cardiovascular risk factor knowledge. All analyses were stratified for race and sex. Analysis of potential cross-sectional predictors was done using logistic regression models, but each variable was only evaluated with age and sex as covariates. A multiple logistic regression model using all variables was not reported. The current use of "physical activity to lose weight" was the strongest positive predictor of physical activity for the white women, (Odds ratio of 2.5, 95% confidence interval of 2.0 -3.2), white men (OR 2.3, 95% CI 1.6 - 3.3) and for African-American men (OR 4.1, 95% CI 1.9 - 8.7). The use of "physical activity to lose weight" was also a significant positive predictor for African-American women (OR 3.0, 95% CI 1.9 - 4.9) but the strongest positive predictor was a physician recommendation to exercise (OR 3.1, 95% CI 2.0 - 4.8). Discussion with a physician about increasing physical activity was a significant positive predictor for all four groups. Other significant positive variables for all four groups include education level, and current participation in an exercise program.

Fogelholm et al reported on predictors of physical activity in Finland (55). A random sample was chosen with stratification by age and sex from the national population register in Finland, including urban and rural areas (the 1982 and 1992 Finmonica Risk Factor Surveys). A subset of subjects between the ages of 25 and 64 were extracted from this large sample to evaluate the predictors of physical activity (n = 2746). Subject ages ranged from 25 to 64 years. Subjects were selected for the subset if their birthdays fell between the first and twelfth day of the month. Agreement to participate in the study ranged from 57 to 73% across age-year subgroups. Physical activity was measured by a questionnaire. Estimates of energy expended at work, in travelling to and from work, in leisure time physical activity and at rest were made for this particular study. Leisure time physical activity was calculated as the product of the reported frequency and the duration of leisure time physical activity. A MET level of six METS estimated for all leisure time activities. Total physical activity was calculated as the sum of the four estimates. Potential predictor variables included education, smoking status and year of analysis. Results suggest that men perform more leisure time exercise (531±615 SD kilojoules/day) than women (418±477 SD kilojoules/day) ($p<0.05$). Results also demonstrate that both men and women had increased leisure time physical activity levels in 1992 (569 kilojoules per day for men, 389 kilojoules per day for women) as compared to 1982 (431 kilojoules per day for men, 238 kilojoules per day for women) ($p<0.001$ level). Unfortunately, the effects of the other potential predictor variables are not examined in the study. In addition, the assumption that all leisure-time physical activity had an intensity of six METS may be an overestimation of the intensity. This study by Fogelhom suggests that gender is a predictor of physical activity level.

Sallis et al conducted a large cross-sectional study in the United States of America evaluating predictors of vigorous physical activity (56). A random sample of 6,000 households was initially chosen from a mail survey, but 1,271 subjects within the households were not available due to moving or relocation and were excluded from the sample. Of the remaining 4,729 adults, 2,053 subjects (43.4%) responded. Missing data and removal of subjects with long-term illnesses resulted in a final sample of 1,789 subjects. A single question- "How often is activity performed which increases the heart rate and breathing?" was used to assess frequency of vigourous activity. Predictor variables for the outcome were chosen based on a variety of psychological and social theories relevant to the determination of physical activity. Potential predictor variables included self-efficacy, modeling of physical activity behaviour, friend and family support, barriers to physical activity, benefits of physical activity, exercise knowledge and beliefs, age, sex, education, alcohol consumption, diet, body mass index, coordination, previous exercise, presence of an injury, sports media, home exercise equipment, history of modeling exercise behaviour and community access to facilities. Analyses were done using multiple regression. The strongest predictor of physical activity in the univariate analysis was self-efficacy (positive), (correlation of 0.48). Self-efficacy was not included in the multiple regression model because the authors were assessing those variables which could be causal to both self-efficacy and vigorous exercise. Multiple regression models found the following significant predictors: barriers (negative), healthy diet (positive), age (negative), modeling (positive), friend support (positive), home equipment (positive), perceived benefits (positive), smoking (negative), coordination (positive), and education (positive). All of these variables predicted vigorous physical activity in the expected direction, explaining 27% of the variance. The strongest four predictors from the multiple regression model were modeling of physical activity, friend support, barriers and age, with all four of these variables reaching a statistical significance level of $p<0.00001$. Subgroup analyses demonstrated that only barriers and diet were significant in all four age and sex subgroups and that age and modeling of physical activity behaviour were significant in three out of four age and sex subgroups.

Hovell et al examined this same data set to evaluate predictors of walking(48). Subjects reporting long-term illness were excluded from this analysis. Using the same set of predictors, and total number of minutes walked per week as the dependent variable, they reported that age, vigourous exercise, healthy diet, family support, self-efficacy and neighbourhood environment were all positively associated with amount of walking and exercise history and education were negatively associated with walking.

A third analysis assessed the effect of injury and sickness on both vigorous exercise and walking as reported by the subjects in the study (57). Vigorous exercise was quantified as the number of times per week an individual exercised, using the method described previously as the number of times the heart rate and breathing increased substantially. Total minutes of walking per week and frequency of vigorous exercise were compared between those individuals who reported no illness or injury, those individuals who reported temporary illness or injury, and those individuals who reported long term illness or injury. Activity levels were compared using analyses of variance. Individuals who reported no illness or injury reported doing aerobic exercise 2.06 sessions per week, which was more frequently than any of the other groups ($p<0.05$). However, the number of minutes per week of walking was the highest in those individuals who suffered from a temporary or a long-term illness ($p <0.005$). This may be due to the use of walking as a substitute for more vigorous activity when a subject is injured or sick. Multivariate regression to assess predictors of physical activity within groups demonstrated that self-efficacy was the strongest predictor in three out of the five groups but not a significant predictor in either of the illness groups. Unfortunately, a multivariate analysis of the entire sample, assessing whether injury or illness status would be a significant predictor, was not performed.

A fourth report on the same sample of 2,053 subjects assessed the proximity of exercise facilities to subject's homes and the effects on the subject's exercise programme (58). The authors compared sedentary individuals (those who reported no activity) to the vigourous exercisers (those who reported exercising three or more times per week) on the number of facilities that were free to users, the number of fee-paying facilities, and the total number of facilities in the group. All analyses were adjusted for age, education and income. Data were analyzed using analysis of covariance. The total number (both free and fee-paying) of facilities within 1 kilometre of a subject's household was 1.5 for the active group and 1.3 for the non-active group ($p< 0.01$). The difference in total number of facilities was quite small and likely not clinically significant. This study differs from the other three which examine the same data set, in that physical activity is the independent variable and number of facilities is the dependent variable; however, this article addressed an issue which is not well examined in the literature.

2.5.4 'Small Studies'

Although the following studies are not as similar to the proposed thesis as the previous ten articles reviewed, some of the information presented in these studies is useful in addressing the field of predictors of physical activity. The ten 'small studies' are reviewed below and are presented in Table 2.3.

Verhoef and Love selected a random sample of women between the ages of 20 and 49 years (n = 1,113, 88.7% of those approached) (59). Subjects were selected by random digit dialing from the population of Calgary. All data were collected by a mail survey. Physical activity was measured by the validated '7 day recall' instrument which had been previously used in physical activity research (43). The amount of time exercising was also assessed. Independent variables included parenthood, marital status, employment status, and variables describing the role of the individual, social support, perceived importance of exercise, interest in exercise and perceived barriers to exercise participation. Age, education, perceived health status and perceived stress were also considered. Two separate logistic regressions were used for the analysis. First, subjects were divided into an exercising group and a non-exercising group. The exercising group was used as the reference group for the analysis. Role overload (OR 0.46, 95%CI 0.31-0.71), perceived barriers (OR 0.18, 95%CI 0.07-0.53), social support (OR 0.64, 95%CI 0.46-0.88), interest in exercise (OR 0.35, 95%CI 0.20-0.75), perceived importance (OR 0.50, 95%CI 0.31-0.65), and health status (OR 0.43, 95%CI 0.34-0.64) all reached statistical significance. A second analysis was done only including those individuals who were

Table 2.3 Summary of Cross Sectional Studies Evaluating Predictors of Leisure Time Physical Activity - 'Small' Studies

Study (first author, year)	Sample and Sample Size	Activity Measurement Method	Statistical Methods	Significant Independant Variables	Non-significant Independent Variables
Verhoef, 1992	Random sample of women, 1,113 subjects	Mail Survey, 7 day recall questionnaire	Logistic regression	Role overload (-), percieved barriers (+), social support (+), interest in exercise (+), non-parent status, percieved importance (+) health status (+).	Marital status, employment status, age.
McPhillips, 1989	1,140 adults, 50 to 93 years old	self-administered exercise questionnaire, 2 week recall	students t-tests	Age (+) for light exercise, (-) for heavy exercise, physical and mental functioning (+), obesity (-), smoking (-), disease history (-).	
Cauley, 1991	Population based sample, 917 subjects	College Alumni Survey	Multiple inear regresion and multiple logistic regression	Age (-) FEMALES: body mass index (-).	Smoking status, socioeconomic status and alcohol consumption. MALES: body mass index.
Folsom, 1991	Population based sample, 907 subjects	Minnesota Leisure Time Physical Activity Questionnaire	Linear regression	Male (+), education (+), white race (+).	Body mass index
Horne, 1994	Homemakers in small communities, 630 subjects	Interview	Discriminant function analysis	Intention (+), self efficacy (+), barriers (-), social support (+).	Attitude, behavioural control, subjective norms and beliefs.

Table 2.3 Summary of Cross Sectional Studies Evaluating Predictors of Leisure Time Physical Activity (continued) - 'Small' Studies

Study (first author, year)	Sample and Sample Size	Activity Measurement Method	Statistical Methods	Significant Independant Variables	Non-significant Independent Variables
Lochen, 1992	Random sample, 609 subjects	Questionnaire and ranking of physical activity on a I-IV scale.	Multiple regression	MEN: cholesterol level and physical fitness WOMEN: Smoking, physical fitness, heart rate.	Age, body mass index, systolic blood pressure, infarction history, high density lipoprotein, triglycerides, physical activity at work. MEN: Smoking, heart rate. WOMEN: Cholesterol level.
Treiber, 1991	230 teachers, community sample of 238 subjects	Baecke questionnaire	maximum likelihood factor analysis	WHITE FEMALES: family and friend support (+). BLACK FEMALES: Family Support (+).	MALES: Neither family nor friend support.
King, 1990	399 randomly selcted employees	Self categorization as part of a mail survey	Two way analysis of variance and chi square analyses	Age (-), percieved health (+), safety concerns (-), exercise myths (-), physical discomfort (-), social support (+).	Relative weight, smoking, knowledge.
Myers, 1989	Convenience Sample, 382 subjects	Self completed Questionnaire, report number of activity sessions	Group comparisons	Age (-), single marital status (+), children (-).	Gender.
Desmond, 1993	Convenience sample, employees, 325 subjects	Baecke self completed questionnaire	Multiple regression	Self efficacy (+), clerical or management job category	Age, percieved barriers, health status, education, income

classified as 'exercisers' in the initial analysis (n = 558), separating the 'exercisers' into very active and moderately active groups, with the very active group being the reference group. Results show that parenthood (OR 0.60, 95%CI 0.29-0.85), role overload (OR 0.54, 95%CI 0.33-0.90), age (OR 0.20, 95%CI 0.08-0.53), perceived importance (OR 0.15, 95%CI 0.05-0. 46), health status (OR 0.53, 95%CI 0.30-0.90), and perceived barriers (OR 0.37, 95%CI 0.20-0.64) are predictors for very active level of exercise.

McPhillips et al examined a sample of older adults, 50 to 93 years of age, in southern California (60). Physical activity was recorded as number of hours of exercise performed over a two-week period obtained from a personal interview. Univariate analysis of the data was performed using Students t-tests and chi-squares. The authors found that age had a negative effect on the amount of vigourous exercise performed, but a positive effect on the amount of light exercise performed. Chronic disease, obesity, and smoking were negatively associated with physical activity, but self-rated health, and physical and emotional functioning were positively associated with the amount of physical activity performed.

Cauley evaluated physical activity levels of two separate population cohorts of different socioeconomic status (61). Physical activity was measured using the interview administered Harvard Alumni Questionnaire. Independent variables consisted of age, smoking status, BMI, socioeconomic status and alcohol consumption. Analyses were performed using both stepwise multiple regression techniques, for predictors of the total amount of physical activity and logistic regression for predictors of sport participation. All multiple regressions were done in gender specific groups. Age was negatively associated with physical activity in both males (partial R^2= 0.12, $P<0.001$) and females (partial R^2 =0.17, $P<0.001$) of kilocalories per week of energy expenditure; Body mass index was negatively associated with physical activity in females (partial R^2 =0.01, $P<0.01$), but not in males.

Folsom et al assessed the determinants of physical activity in black and white individuals (62). Two samples were selected; one sample was selected using a two-stage cluster sampling of households in Minnesota; all black residents between the ages of 35 and 74 in five predominantly black census tracts comprised a second sample. A home interview was conducted with all subjects, to assess sociodemographic variables, medical history, health behaviours and knowledge. All subjects were then invited to attend a clinic visit, where 50% of them, chosen systematically, were given the Minnesota Leisure Time Physical Activity questionnaire. The final sample size consisted of 561 whites and 346 blacks. Participation rates were over 60% for both the home interview and the clinic visits in the two samples. The distribution of the physical activity variable was log transformed so that the distribution could be normalized. Results show that leisure time physical activity decreased as age increased for both blacks and whites; males performed more leisure time physical activity than females in both groups as well. Within each age/sex group, whites performed more leisure time physical activity than blacks, with the only exception being women aged 55 to 64. Overall, age adjusted values were higher in white women and men as compared to the black groups ($p<0.05$). Education had a small effect on leisure time physical activity, the only significant finding was that white men and women with less than a high school education performed more leisure time physical activity then black men and women without a high school education respectively. No other predicting variables were reported in this study. Other studies have also shown that race affects physical activity level, favouring whites (63).

Horne sampled 630 homemakers from lists of all households with children under six years of age in four small Alberta communities (64). Homemakers were contacted by telephone and asked to participate in the study; the final response rate was 85.6%. Subjects were classified as 'active' if they participated in moderate or vigorous physical activity twice a week or more; otherwise they were coded as 'inactive'. Potential predicting variables were items based on planned behaviour theory, (i.e., attitude, perceived behavioural control, subjective norms, beliefs, and intention). Subjective norms included elements of social support. Self-efficacy was also assessed. Discriminant function analysis was used to assess differences between active and inactive homemakers. The only variables that distinguished the active from the inactive groups was intention (high), self-efficacy (positive), barriers (negative) and social support (positive).

Lochen and Rasmussen evaluated the effect of certain predicting variables on physical activity in a randomly selected sample of 609 subjects from 21,826 subjects who initially agreed to participate in the survey (65). The study involved physical fitness testing, which is more costly and likely explains why the sample size was relatively small. Physical activity was graded on a 'one' to 'four' scale where 'one' was for activities requiring no physical activity and 'four' represented hard training or participation in high level sports. Independent variables assessed included age, cholesterol and triglyceride levels, medical history, body mass index, systolic blood pressure, heart rate, smoking habits, and physical fitness level as assessed by a bicycle exercise test. Multiple regression analyses were done separately for men and women. Comparison of subjects by age and gender indicated that 41.5% of men between the ages of 20 and 29 reported participating in moderate or heavy levels of physical activity during their leisure time and only 10% of women in the same age group reported the same. In comparison, 21.2% of men and 3.1% of women in the 50 to 59 age group reported participating in moderate or heavy levels of physical activity during their leisure time. Results of the multiple regression showed that cholesterol level (negative) ($p = 0.008$) and physical fitness (positive) ($p = 0.04$) were the only significant predictors of physical activity in men; and that smoking (negative), ($p = 0.009$) physical fitness (positive) ($p = 0.0001$) and heart rate (negative) ($p = 0.04$) were the only significant predictors of physical activity in women. The total explained variance was only 12% and 16% for men and women respectively.

Treiber et al were specifically interested in the relationship of social support with exercise (66). Two different samples were studied, one of teachers and one of community residents. Physical activity was measured using a questionnaire and recorded as a continuous variable. Maximum likelihood factor analysis was used for the analysis. Analyses were done in age and gender specific groups. In white men and white women, actively level was positively associated with family and friend support. In black women, only family support was associated with physical activity level.

King et al studied 399 employees of an aerospace employer in California (67). The authors used a "gross estimate" of physical activity level, where the subjects were asked to rate themselves as regular exercisers, previous exercisers, or non-exercisers. Univariate analyses were done, either two-way analysis of variance using exercise status and age groups as factors, or chi-square analyses on categorical variables. Items examined included demographic data, knowledge about exercise, attitudes, and preferences. Perceived health and social support were both found to be positive influences and age, safety concerns, myths about exercise, and physical discomfort all were associated with non-exercisers.

Myers et al used a convenience sample of 382 subjects selected from visitors to a museum who completed a questionnaire at an exhibit (68). Subjects self-reported the number of times per week they were involved in physical activity. Those who reported 2 or fewer sessions per week were classified as inactive and those who reported three or more times per week were classified as active. Independent variables collected included: demographic variables, attitudes towards physical activity, and unspecified influences on participation. Analyses were done using chi-square testing. No multivariate analyses were conducted. Analysis of the demographic variables indicated no difference in physical activity between genders, but there was an effect of marital status with unmarried individuals being more likely to participate in physical activity ($p < 0.001$). There was a significant difference between activity level and age group, ($p<0.001$). The trend was for older individuals to exercise less except for the oldest group (individuals over the age of 50). The 'over 50' group had 42% of the subjects classified as active, similar to the 20 year old subjects (47%). Active people reported that the cardiovascular benefits were the most likely reason to stay active, whereas inactive people ranked weight control as the most likely reason to become active.

Desmond et al evaluated a convenience sample of 325 male employees at a utilities company (69). Physical activity was measured by a self-completed questionnaire developed by Baecke (70). Independent variables include perceived barriers to physical activity, perceived self-efficacy and perceived health status, as well as age, education, income and job category. Multiple regression analysis demonstrated that self-efficacy (positive) and job category (clerical and management workers) were the only two predicting variables to reach statistical significance using either total physical activity or leisure time physical activity as the outcome ($p<0.05$). The relatively small and specific sample may have limited the chance for other variables to enter the model.

2.5.5 Summary of Determinants Literature

The challenge of summarizing the literature on determinants of physical activity is daunting for several reasons. First, not all the studies assessed similar populations. Second, because physical activity is coded in different ways, there was some discrepancy in the reported physical activity (e.g., one of the studies (48) only evaluated the determinants of walking). Third, the number of subjects in the studies varied from less than 400 to over 10,000. Despite these limitations, there are still some similarities in the findings that can be noted. Variables are summarized in Table 2.4.

Predictor variables for the summary were grouped into four categories: environmental variables; social variables; physiological variables; and other personal variables. The same categorization of predictor variables has been used previously in studies of determinants of physical activity (16). Only determinants, which were studied in at least three reviewed studies, are included in the summary in the text.

Table 2.4 Summary of Predictors

Variable	Percentage of Studies in Which Variable Was Found to be a Predictor	Percentage of Studies in Which Variable Was Not Found to be a Predictor	Total Number of Studies Which Examined the Variable
Age	82	18	11
Alcohol Intake	25	75	4
Attitude	0	100	1
Barriers to Exercise	60	40	5
Birthplace/Ethnic Background	100	0	1
Blood Pressure	0	100	1
Body Mass Index/Obesity	38	62	8
Cholesterol Level/Lipids Levels	100	0	1
Coordination/Physical Fitness	100	0	2
Currently In Exercise Programme	100	0	1
Desire for Weight Loss	100	0	1
Education Level	67	33	9
Employment/Student Status	50	50	2
Environment/Exercise Facilities	50	50	4
Exercise History	50	50	2
Exercise Intention/Interest	100	0	2
Exercise Knowledge/Myths	25	75	4
Family Function	0	100	1
Family Support/Participation	67	33	3
Friend Support/Participation	75	25	4
Gender	63	37	8
Health Professional Advice/Visits	50	50	2
Home Equipment	50	50	2
Household Size/Type/Children	80	20	4
Illness/Discomfort/Injury/History	60	40	5
Income	33	67	3
Location of Residence	0	100	2
Marital Status	50	50	4
Modelling/Modelling History	50	50	2
Normative Beliefs	0	100	3
Perceived Benefit of Exercise	50	50	2
Perceived Health Status/Health Status	75	25	4
Perceived Importance of Exercise	100	0	1
Perceived Stress	0	100	1
Perception of Future Health Problems	100	0	1
Physical/Mental Functioning	100	0	1
Race	100	0	2
Role Overload	100	0	1
Safety Concerns	100	0	1
Self Efficacy	100	0	4
Smoking Status	50	50	8
Social Support	67	33	3
Socioeconomic Status	100	0	1
Special Diet	100	0	3
Sports Media	0	100	2

Environmental Variables

Variables assessing the potential prediction of the environment or neighbourhoods were significant predictors in two of four studies. The study predicting vigourous exercise by Sallis et al (58), found proximity of facility to be a predictor, but not the neighbourhood. The study by Hovell et al utilizing the same data set examining predictors of walking found neighbourhood/environment to be a positive predictor (48). Dishman and Sallis point out that measured access and perceived access to facilities may differ; the findings here may be limited by the self-report (14). Neighbourhood safety and environmental factors have not been examined as determinants (71).

Social Variables

Social support was found to be a predictor in two of three studies. Two other variables, the support of family and the support of friends were significant determinants in two of three studies and three of four studies respectively. Friends support was a predictor in the Sallis (58) study of vigourous exercise, but not in the walking study by Hovell (48). On the other hand, family support was a predictor of walking, but not vigourous exercise. In this review, support of friends and family was grouped with participation of friends and family, which may not be the same construct.

Marital status, indicating that single people are more likely to be exercisers, was a predictor in two of four studies. This may be due to the effect of age, or may be related to time availability due to other obligations or responsibilities. Income was found to be a predictor in one of the three studies in which this variable was examined.

Physiological Variables

Age and gender are the two most commonly evaluated predictors in this collection of studies. Age was found to be a predictor in nine studies out of eleven in which it was assessed as a predictor. Age predicts in a positive direction in Hovell's study of walking

(48), and in a negative direction in Sallis's study of vigourous exercise (56), even though both studies examine the same data set. The studies by Johnson et al (9), and McPhillips et al (60) both found that age was positively associated with physical activity if moderate physical activity was the outcome variable rather than vigorous. This positive relationship is likely due to exclusion from the analysis of those subjects who perform vigorous activity. (If only subjects who perform no physical activity or perform light or moderate physical activity are considered, then the factors, which will predict vigorous activity, will not be identified. The lack of generalizability of this limited sample must be recognized as well.)

Gender was examined in eight different studies. Five studies demonstrated that males performed more physical activity than females. It is possible that the difference is due to vigorous exercise as the study by Hovell et al (48) evaluating predictors of walking was one of the studies where no effect of gender was shown. Earlier studies have shown no effect of gender for light or moderate levels of exercise (72).

Body mass index, or obesity, was found to be a significant predictor in three of the eight studies in which it was examined. The differing findings may be due to the different methods used to define obesity and the treatment of body mass index as a continuous or a categorical variable.

Cognitive Variables

Self-efficacy has been described as a major predictor variable for physical activity (15). The four studies which examined self-efficacy all found it to be a significant predictor. Sallis et al (56) excluded self-efficacy from the independent variables included in the multivariate analysis because the prediction associated with self-efficacy would limit the number of other predictors which would be identified.

Only one of four studies found both exercise knowledge/myths to be predictors. King et al (67) assessed both knowledge and myths and found knowledge to be a positive predictor and myths to be a negative predictor. Studies of the data set used by Sallis (56) did not find knowledge of exercise to be a significant predictor.

Perceived barriers to exercise were found to be a predictor in three of five studies. Once again, there is a difference in the study by Sallis (56) (perceived barriers was not a predictor) and the study by Hovell (48) (perceived barriers was a significant predictor). The two other studies that identified barriers as a predictor were both studies of only women (59, 64).

Other Personal Variables

Five variables that were classified as 'other personal variables' were studied frequently. Smoking status, reported in the results of eight studies, was found to be a predictor in four studies, but not significant in four studies. Alcohol consumption was only a predictor in one of four studies. Race was examined in two studies, and both studies demonstrated that 'whites' were more likely to be active than 'non-whites'. Higher levels of education predicted higher levels of physical activity in six of nine studies.

Perceived health or health status was associated with three out of four studies in which the relationship was examined. From these studies, it is impossible to determine whether health status predicts or is predicted by physical activity level. The one study where there was no relationship between the two variables was a small study of employees at a worksite (69). Following a special diet was associated with a higher physical activity level in all three studies that examined the relationship.

2.5.6 Subgroup Analyses

Subgroup analyses have been conducted in only a few assessments of determinants of physical activity. As described earlier, the sample sizes for many of these studies have been small which has limited the potential for the subgroup analyses.

Urban and rural dwellers may have different predictors of physical activity. There are differences in the two populations, but also differences in the communities in which they live. Facilities for physical activity, and media exposure (which may provide education about benefits of physical activity) are likely to be different in the two groups. These differences may lead to different predictors for physical activity in the two groups.

There is almost no evidence assessing whether or not the predictors of physical activity differ for those living in urban settings and those living in rural settings. One of the studies described earlier demonstrated that proximity of exercise facilities influenced the level of physical activity(58). Two Canadian studies have examined a difference in health status between urban and rural settings, but neither study described predictors of physical activity in the urban or the rural population (73, 74).

As noted in the described studies, gender and age group are commonly assessed as predictors of physical activity. Yet, there are minimal data available comparing genders. Shea compared predictors of physical activity in men and women, but examined only a few demographic predictors (53). Lochen also compared predictors in the two groups, but only a few cardiac risk factors were examined (65). Gender specific analyses have been done, but without comparison to the other gender (59, 64). Allison examined both age and gender subgroups for association with physical activity, and reported that the subgroups were not different from the findings of the whole sample(51).

Studies have been done evaluating predictors of physical activity in specific age groups, such as children, university students, and older subjects (71). Unfortunately, many of these studies have assessed a particular type of physical activity such as attendance at an exercise class. In the reviewed studies, only Allison examined the relationship between predictors of physical activity and different age groups, and the results suggest that there was no differences in the predictors of physical activity in different age groups(51).

2.6 Scale of Measurement of Physical Activity Data

Using the retrospective survey methods, physical activity can be recorded as either an ordinal or a continuous variable. One approach is to ask the subjects if they participate in vigorous, moderate or light exercise. The available data for analysis is then an ordinal variable. Another method is to use the frequency of a type of physical activity (e.g. number of times a week a subject walked, or number of times a month the subject exercised so hard that they were sweating) as a continuous outcome variable; frequency of vigorous physical activity (56) or walking (48) have both been used as a measure of physical activity. A third approach is to ask a set of questions, and determine the physical activity from the responses using a formula including frequency, duration and intensity, once again resulting in a continuous variable (75, 76). In some studies, an outcome variable is collected as a continuous variable, and converted into a categorical variable (51).

Continuous data maintains the actual value of the data points being examined in the analysis. A categorical transformation groups all of the data points into two or more groups. Groupings draw attention to the proportion of subjects who are in a category; continuous data focuses more on the average value of the variable, (i.e., physical activity) for the entire data set (77).

Categorizing continuous data is very useful for presenting and interpreting data trends. Categorizing may also make the data more easily understood. The larger the sample size in a particular study, the more beneficial categorizing a variable will be (78). Categorization tends to remove some of 'the noise' associated with large data sets. Categorization of continuous data may actually decrease the measurement error associated with a given variable. The cut points used for categorization, (i.e. the data values separating the categories) should be justified by the particular variable's distribution or else justified in the literature.

Categorization provides a ranking of subjects but no quantitative difference between subjects (79). In the case of physical activity categorization, the results indicate that those subjects who are in the active category perform more exercise than those in the inactive group do, but do not quantify the amount of the difference. For example, Subject A in the higher level may perform twice as much activity as Subject B in the lower level; but Subject C in the higher level could perform ten times as much activity as Subject B. The wider the range of the category boundaries, the less precise the categorization becomes. In a continuous data set, the number of values is limited by the accuracy and the precision of the measurement tool (77, 80). Measurement error will likely have a greater effect on a given data point if the variable is a continuous one than if it is categorized. A variable with measurement error may be categorized properly, but the continuous value may be imprecise.

In a study evaluating the predictors of physical activity, the type of outcome variable determines the appropriate analysis. A multiple linear regression can be performed if the outcome variable is continuous, but multiple linear regression can not be used if the outcome variable is ordinal or nominal. One commonly used method of analysis to assess predictors of ordinal or nominal variables is logistic regression. Logistic regression is a statistical method that can be used when assessing predictors of a categorical outcome variable. Logistic regression can only predict that there will be improvement in the outcome variable but the method is unable to predict the amount of improvement (81). Linear regression is used when the outcome variable is a continuous variable. Certain assumptions must be met for linear regression method to be valid. If the assumptions are met, then multiple regression for a continuous variables is likely a more powerful tool than logistic regression for the same variable categorized (82).

2.7 Summary

There is no doubt that physical activity has a positive effect on health. Unfortunately, the determinants of physical activity have not been well established. Defining the determinants of physical activity has been limited by study issues such as including variability in the measurement and calculation of physical activity, the treatment of physical activity as an ordinal variable, the lack of consistency in choice of independent variables and the small, specific samples used in many of the studies. Work remains to be done in assessing determinants of physical activity in large population-based samples, treating physical activity as a continuous variable. There is also a need to compare determinants of physical activity in subgroups within the same population.

CHAPTER 3 ONTARIO HEALTH SURVEY

The 1990 Ontario Health Survey (OHS) examined a probability sample of the non-institutionalized Ontario population in 1990. The objectives of the study included measuring the health status of the population, and collecting data on the determinants of the major causes of morbidity and mortality in Ontario, as well as data related to social, economic, demographic and geographic variations in health.

The OHS consisted of three major components: a household record form, an interviewer-administered questionnaire and a self-completed questionnaire. There were two versions of the self-completed questionnaire: an adult version and a youth version (with fewer questions for subjects between the ages of 12 and 15). Physical activity questions were included in both versions of the self-completed questionnaire.

3.1 Sampling Methods

A two stage stratified probability sample was selected. The province was divided into 42 strata, one per public health unit, with further stratification into urban and rural areas within each public health unit. This sampling frame ensured that all regions of the province would be covered and that there would be adequate urban and rural sample sizes to conduct separate specific analyses. Within each stratum, an average of 46 enumeration areas (EA) was selected. A random selection of households within each EA comprised the second stage of the sampling process. Fifteen to 20 households per EA were surveyed. Each EA was randomly assigned to a quarter of the year to be surveyed and each dwelling within the EA was assigned a survey month; the use of different survey months minimized the seasonal bias. (The impact of the sampling design on data analysis will be discussed in Chapter 4.)

The sample size for the OHS was based on three criteria. The coefficient of variation, which is a measure of the precision of the survey, was set at 25%, similar to the value used for previous Canadian household surveys (75). The design effect (DEFF), a measure of the impact of the clustering, was estimated at 2.0, the same DEFF that was used in the Quebec Health Survey (75). The minimum estimate, (the minimum proportion for which the sample could give a reliable estimate), was set at three percent at the public health unit level. In order to meet these criteria, the sampling frame was designed to obtain 1000 completed responses per public health unit. A total of 35,479 households in Ontario were surveyed.

Interviewers were instructed to obtain information using the household record form and interview questionnaire from a responsible member of the household about the household in general and about all members of the household. Copies of the self-completed questionnaire were left for all members of the household 12 years of age or older. Households were contacted at least three times to obtain the interviews. Senior interviewers contacted those respondents who refused to participate in the interview process; the senior interviewers attempted to persuade the respondent to agree to the interview.

Initially, the self-completed questionnaire was to be mailed back once the forms were completed. The response rate was less then expected, so the collection method was changed so that the interviewers arranged a time to retrieve the surveys. The change in collection method increased the response rate. The overall response rate was 87.5% for the two components involving an interviewer and 77.2% for the self-completed questionnaire. Fewer than five percent of the households contacted refused to complete the survey. The remainder of the household record form missing subjects was due to language difficulties, absence or other circumstances. Item non-response was the greatest in the Sexual Health Section. Respondents had difficulty with the multiple part questions, such as the questions on physical activity, with a non-response rate between 10% and 15%. Skip patterns also increased the non-response rate, possibly due to the perceived complexity of these questions.

3.2 Physical Activity Measurement

The OHS had a section designed to evaluate leisure time physical activity (see Appendix 1). The section included retrospective quantitative history type questions for 19 different activities, plus one question about 'other activities'. (Retrospective quantitative history type questions were discussed in Section 2.4.1)

All activities included a question about the frequency and duration of the particular activity, but there was no question about the relative intensity of a given activity. The frequency of the activities was recorded as the number of times an individual performed the activity over the past month. The duration of the activity was categorized into 15-minute intervals with a maximum category of 'more than one hour' which was coded as 60 minutes. The categorization of duration is a less precise measurement, but limiting the choices may have made the process easier for the respondent. For the intensity of the activity, the strategy adopted in the OHS was to use the MET level for a low intensity level of a given activity. For example, walking was assigned a MET level of two; however, the American College of Sports Medicine assigns walking a MET level ranging from two to four (21). This approach used by the OHS may result in an underestimation of the overall energy expenditure, but it is justified in the OHS documentation by the tendency of subjects to overestimate their physical activity (75). The MET levels assigned by the 1990 OHS for the activities included are listed in Appendix 2.

There is no mention of either the validity or reliability of the leisure time physical activity questions in the OHS documentation. The OHS questions were patterned after the Quebec Health Survey and the Canadian Health Survey. Neither of these two surveys reported any validity testing for the physical activity items (75). OHS physical activity questions have been compared to the previously validated Minnesota Leisure Time Physical Activity Questionnaire (MLTPA) (19, 50, 83). However, there are major differences between the MLTPA and the OHS physical activity questions; the most notable difference is that the MLTPA is an interview administered questionnaire and the OHS is self-completed. The similarities between the MLTPA and the OHS are not sufficient to validate the OHS physical activity section.

The items comprising the physical activity section of the 1990 OHS referred to 20 different physical activities. The use of 20 separate activities may have provided a more thorough evaluation of physical activity than surveys which measure physical activity only by the frequency of self-reported vigourous activity (56).

3.3 Derivation of Energy Expenditure (OHS)

The summary variable, *energy expenditure (OHS)* was the summary variable derived by the OHS office to represent the total amount of physical activity reported by the respondent. *Energy expenditure (OHS)* was expressed in units of KKD and was derived by calculating activity-specific energy expenditure scores and summing them for each individual. Activity specific energy expenditure scores were calculated by multiplying the frequency of the activity by the duration of the activity, and then multiplying the product by the estimated intensity (MET level) of the particular activity (45).

The 1990 OHS documentation of the derivation of energy expenditure does not describe how missing values were dealt with. Examination of the data files suggests that subjects with missing responses were treated as if they had reported not doing the activity (i.e., they were assigned an activity specific energy expenditure of zero). The issue of missing data is discussed further in the next chapter (Section 4.2.1) in the description of the derivation of the outcome variable for the present study.

The maximum allowable score for *energy expenditure (OHS)* was 20 KKD. Subjects whose calculated *energy expenditure (OHS)* score exceeded 20 KKD were assigned a score of 20 KKD.

3.4 Previous Analysis of Predictors of Physical Activity Using the OHS

As described in Section 2.4.2, the OHS has been previously analyzed for predictors of physical activity. The analysis, conducted by Allison was done using logistic regression methods, and the outcome variable, *energy expenditure (OHS)*, was categorized into two groups to assess the determinants (51). Those subjects with an *energy expenditure (OHS)* score of 1.5 KKD or higher were classified into the 'active group'. All the remaining subjects with an *energy expenditure (OHS)* score of less than 1.5 KKD formed the 'inactive group'.

The cut-point used by Allison to separate the active group from the inactive group has been previously recommended in the literature. The 1996 Surgeon General's Report recommends that all people should be performing 1.5 KKD of activity or more. The Canada Fitness Survey used 1.5 KKD as a threshold to separate the inactive from the minimally active; however, individuals performing between 1.5 KKD and 3.0 KKD of physical activity were classified as minimally active or as performing insufficient activity to achieve cardiovascular health benefits (84). Other authors have recommended an exercise level of 2.0 KKD (85), 3.0 KKD (4) or 4.0 KKD (34). As described earlier (Section 2.6) there are advantages to using a continuous variable which merit repeating this analysis using multiple linear regression techniques.

3.5 Summary

The OHS was a large survey done to assess the health of the residents of Ontario. The multistage sampling design and the large sample size add scientific credence to the study. There is a thorough, although not validated, assessment of physical activity, and the range of potential predicting factors provide a solid base to assess predictors of physical activity in the Ontario population. Finally, the large sample provides enough data to address the secondary objectives with a large sample included in each group.

CHAPTER 4 METHODS

The methods section will explain the sampling procedure associated with the OHS. The procedures will be described which were done to prepare the data set for the analyses. The specific methods used to address both objectives will be explained.

4.1 Sampling Design

Sampling is a commonly used method of collecting data used to evaluate public health aspects of a population. The advantages of sampling include saving time, money and labor. More data can be collected from each individual if there are fewer individuals surveyed (86). The main limitation of sampling is that findings are not necessarily representative of the population (87). The multistage OHS design was used to ensure adequate representation from all regions of the province. However, the sampling design must be accounted for in any analyses that are done.

As described in Section 3.1, the OHS initially used a random sampling procedure with stratification and clustering. Stratification was used to divide the province into 42 PHU and further into urban and rural stratum. This stratification guaranteed that the 1990 OHS sample would include members from all areas of Ontario.

Clustered sampling were also used in the 1990 OHS design. Clustering is the selection of an area, or a group of subjects, for potential participation in the survey (88). Clustering is very cost effective, as less time is required to contact individuals who live close together. However, people selected using clustered sampling tend to be more similar than expected which would lead to an underestimation of the true variance if the sample is treated as if the subjects were independent.

There are two issues from the design that need to be considered in the analysis of a multi-stage survey such as the 1990 OHS. The first is the issue of weighting.

If the entire population of Ontario were surveyed for the 1990 OHS, then the data would be both representative and accurate. However, surveying all Ontario residents is not a reasonable option. The multi-stage sampling design ensured that there would be representation of all geographic regions of the province, and at the same time kept expenses and resources reasonable. Individuals surveyed would each represent a number of members of the population studied. In order to determine accurate population estimates, each individual subject was assigned a weight. The weights adjusted the point estimates so that the individual would represent the subjects he or she was supposed to.

Weights were included in the OHS data set and are strongly recommended for use in OHS analyses by the supporting documentation (75). Statistics Canada generated the weights for the 1990 OHS. Essentially, each weight was equal to the inverse of the probability of being selected for the sample, with adjustments made for non-response at the person and household level, and further adjustments made for population totals of age and gender groups at the PHU level. Three different weights were available (relative weight, expansion weight and population weight). The weight that was used for this analysis is the relative weight, which summed to the total number of subjects in the sample.

Although weights are useful to adjust the point estimates, the weights do not control the loss of independence introduced by clustering. In fact, using the weights without adjusting the variances may result in an underestimation of the true variance, which may lead to false positive results when comparing groups within the samples.

The clustering described above is also more likely to result in similar individuals being surveyed, which may also increase the variance of the estimate of the mean value. Usual statistical procedures assume random sampling and independent observations, which is not the case in the OHS. If the change in variance between simple random sampling and multistage technique is not accounted for, then there is a stronger likelihood that significant differences will be falsely detected (i.e., the incidence of Type 1 error will increase). The ratio of the variance of a variable when the sampling methods are correctly allowed for in the analysis divided by the variance that would be obtained from simple random sampling with the same size sample is referred to as the design effect (DEFF). Although an estimate of the mean DEFF was used for the derivation of the initial sample size, the true DEFF for each variable cannot be established until the data have been collected. Furthermore, the DEFF is not necessarily consistent across all variables. The variance is best adjusted for by using appropriate software, which incorporates the design effect to analyze the data.

4.2 Software Used for Data Analysis

Two software packages were used: Statistical Analysis Software (SAS) and Software for the Statistical Analysis of Correlated Data (SUDAAN).

Although all the data could be analyzed using SAS, the variances would be underestimated (Section 4.1). This is an issue in the analysis, both in examining if statistical differences exist between groups as well as assessing the potential predictors in a regression equation. SAS is not the best choice of software to analyze multi-stage survey data. SAS does not take the survey design into consideration. However, while SAS does not include the effect of clustering to estimate the correct variance, SAS does permit the use of sample weights. The point estimates of means, parameters, and regression slopes, obtained from a weighted SAS analysis and from a SUDAAN analysis are identical. Therefore, SUDAAN is only required to obtain valid variance estimates. SUDAAN software incorporates the survey design features into the statistical programs.

Stepwise regression is available in SAS, but not in SUDAAN. SAS allows the weighting of the variables to be included by using a 'weight' statement in the SAS coding for analyses. Procedures for diagnostic testing to assess the assumptions for multiple regression analysis are not available in SUDAAN but are available in SAS.

The approach taken here was to use SAS to obtain the point estimates and when the analysis was not concerned with generalizability and external validity, but only with data in the OHS data set (e.g., missing values, collapsing levels of categorical variables). SAS was also used when the procedure was not available in SUDAAN, such as stepwise regression models and diagnostic testing of the residuals, for practical reasons. Since the regression slopes in SAS and SUDAAN are the same while the SAS variances are lower; the SAS analysis will overestimate the statistical significance of the results. SUDAAN was used whenever the results of the analysis were meant to be externally valid, (such as comparison of the OHS demographic variables to Census data) and for the final regression models. SUDAAN was also used for a manual backward stepping procedure for the final multiple regression models. Descriptive statistics such as mean, standard deviation or frequency tables, of independent and dependent variables were produced for the entire sample with SUDAAN. Point estimates and 95% confidence level limits were calculated using SUDAAN.

The core SUDAAN programming statements are described in Figure 4.1. All estimates of regression slopes and residuals will be identical whether SAS or SUDAAN are used, as long as the weighting factors are used. All SUDAAN programmes used in this thesis contain three statements: a 'design' statement, a 'nest' statement and a 'weight' statement. The 'design' statement refers to whether the sampling design is with replacement or without replacement. Although the OHS was conducted without replacement, the programme is written as 'with replacement' because the analyses are similar unless the sample is a very large proportion of the total population (89).

The 'nest' statement provides information about the variables that identify the design stages of the survey. In the OHS, public health units were chosen initially, then stratification occurred at the stratum level and finally enumeration areas (referred to by EAID) were selected. Finally the 'weight' statement describes the variable which 1990 OHS suggests should be used for weighting in the analysis.

Figure 4.1 Program Statements for SUDAAN Software

```
Design = WR;
Nest PHU Stratum EAID/psulev = 3;
Weight relwght;
```

4.3 Preparation of the OHS Data

This study was conducted using the OHS data set. Data from the OHS questionnaires were captured on computer tapes by Statistics Canada (90). From this master data set, a subset was created of ASCII data containing variables pertinent to this analysis. Variable labels and formats were added by modifying the Statistical Analysis Software (SAS) code provided by the OHS staff. This subset was converted into a SAS database. Variable values indicating missing data were recoded. The SAS database included potential dependent and independent variables for the analysis, as well as variables describing the sampling design. The database was placed on a UNIX SUN Workstation, on which the analyses were performed.

Since the primary objective was to assess predictors of physical activity in adults, respondents were included in this analysis only if they were 18 years of age or older. This resulted in a sample size of 43,954 subjects (89% of the total sample). The main analysis was a multiple regression, which requires subjects to have values for the dependent and all of the potential independent variables (casewise deletion). Therefore, the final sample size used for the analysis was less than the original sample size.

4.3.1 Assessment of Representativeness of OHS Data

The OHS data set was compared to 1991 Census data for the province of Ontario (91). These analyses were performed using SUDAAN software. Variables examined for comparisons were gender, age group, marital status and household size. For this analysis only, subjects included only if they were over the age of 20. Means or proportions and 95% confidence intervals were reported for the three variables.

4.3.2 Derivation of the Outcome Variable

The OHS data set contained a derived variable that represented leisure time physical activity. OHS staff consolidated the physical activity responses into a summary variable, *energy expenditure (OHS)* (Section 3.2).

Examination of the original data revealed many missing fields in the physical activity questions. A missing field could have occurred within an activity (e.g., neglecting to complete the frequency of a particular activity) or all the fields of an activity could have been missing (e.g., neglecting to complete the section on ice-skating). There are two possible reasons as to why respondents may have left the responses for an entire activity blank. First, individuals may have chosen to leave an activity blank because they did not do the activity, or second, because they did not fully complete the survey. In the absence of further information, it is impossible to distinguish between these two reasons. It appeared from an examination of the raw data and the *energy expenditure (OHS)* derived scores that the OHS assumed that a completely blank activity meant that the activity was not performed. This assumption likely underestimated the energy expenditure for some people. An alternate approach was adopted for this thesis. In certain situations, the value of the missing fields could be logically imputed (e.g., if a subject left the 'yes/no' field blank for a specific activity, but reported a frequency and a duration, a value of 'yes' could be imputed.) In other cases, the pattern of responses to the 20 items provided clues as to how to interpret the missing fields. For example, if a subject checked 'yes' responses to three specific activities with frequency and duration reported but left all other fields in the physical activity section blank, it is reasonable to assume that the subject did not perform those activities left blank. Based on these considerations, the *energy expenditure (OHS)* score was recalculated for use in this thesis. The new derived variable will be referred to as *energy expenditure (NEW).*

Activities were included in the total score if the frequency, intensity and duration sections were completed. If the 'Yes/No' question was left blank for a specific activity, but all of the other sections were completed, a 'Yes' response was imputed. If either or both the frequency and duration for a specific activity were missing, imputation was not done and the subject was excluded from further analysis.

The following approach was taken when all of the activities were tallied: if the subject responded with complete data (with all of the components completed for the 'Yes' answers, and all questions answered either 'Yes' or 'No'), then their responses were included. If the subject responded fully to all questions with the 'Yes' box checked and left all other activities completely blank, then they were included with the missing activities imputed as 'No'. Subjects were not included if they responded 'No' to some questions and left other items completely blank. The only exception was for the question about 'other activity'. It was accepted that subjects could leave all the fields in this item blank, and still be included if all of the other activities were coded as 'Yes' or 'No'.

For each activity, the reported variable scores (the frequency of the activity per month, and the duration in minutes) were multiplied together and multiplied by the activity specific MET score (as provided in the OHS manual) to produce the activity specific score in units of KKD. An example of this calculation is given in Appendix 3. The total score, *energy expenditure (NEW)*, was calculated by summing all of the activity specific scores.

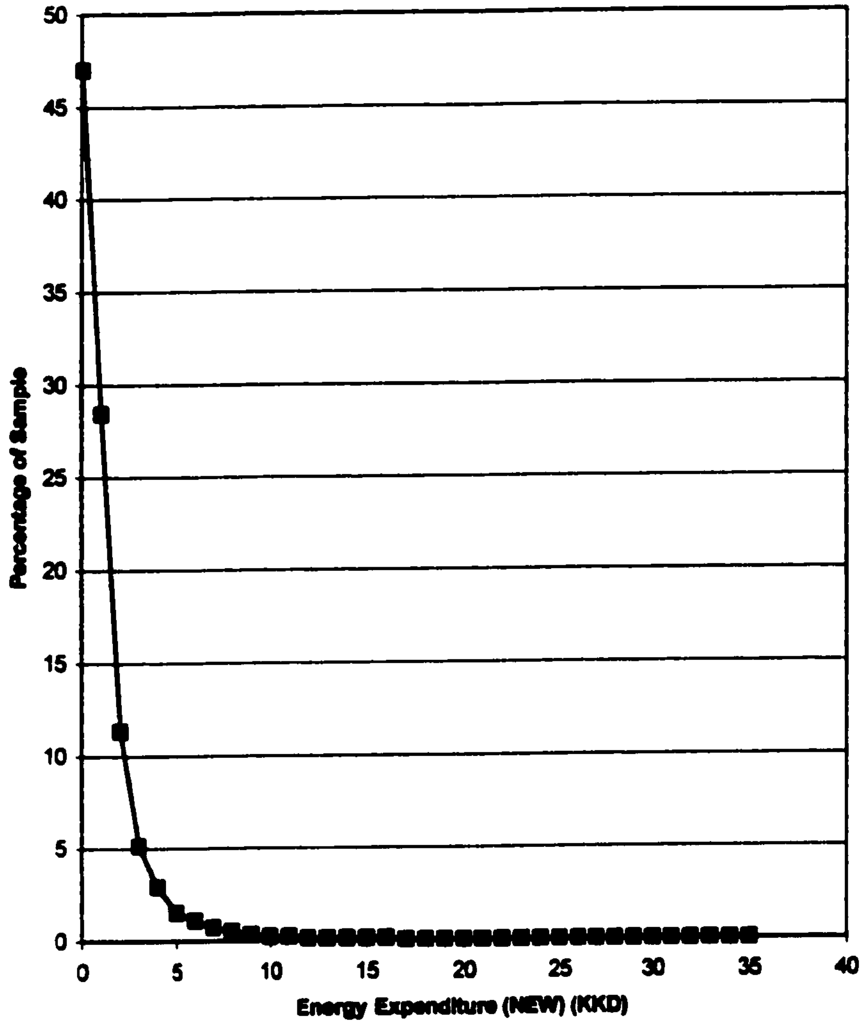
4.3.3 Impact of Derivation of *Energy Expenditure (NEW)*

Given that *energy expenditure (NEW)* is a newly derived variable for this thesis, it was necessary to compare the values to the *energy expenditure (OHS)* scores. This comparison provided a sense of whether there could be any effect present by changing the outcome variable. The algorithm used for the new derivation is different from the one used for *energy expenditure (OHS)*; the new algorithm may affect the number of subjects included in the analysis. A comparison of *energy expenditure (OHS)* and *energy* *expenditure (NEW)*, is presented in Appendix 4. The distribution of *energy expenditure (NEW)* is demonstrated in Figure 4.2.

The number of subjects with valid scores for *energy expenditure (NEW)*, and *energy expenditure (OHS)* differs substantially. Of the 31,030 subjects who had *energy expenditure (NEW)* scores, 30,955 also had *energy expenditure (OHS)* scores. Of the 35,333 who had *energy expenditure (OHS)* scores, 4,378 subjects did not have *energy expenditure (NEW)* scores.

The mean *energy expenditure (OHS)* score for the sample was 1.3±1.9 KKD (SD) and the median value for *energy expenditure (OHS)* was 0.60 KKD. The variable derived for this analysis, *energy expenditure (NEW)*, had a similar score of 1.3±2.5 KKD (SD) and a median value of 0.57 KKD. The standard deviation was less for *energy expenditure (OHS)* because people with scores of greater than 20 KKD were assigned a score of 20 KKD. Both of these variables indicate low levels of physical activity for this sample. The median values represent an activity level of walking 18 minutes per day.

Figure 4.2 Distribution of Energy Expenditure (NEW)



* Percentage of sample with Energy Expenditure (NEW) score of 0 KKD is inflated because of rounding.

4.3.4 Assessment of Outliers

The outcome variable was evaluated for outliers. A cut-point was considered above which individuals would be excluded. Such a procedure would affect the generalizability of the results by limiting the sample for the analysis. However, subjects with extreme scores may influence the regression line inappropriately. The distribution of *energy expenditure (NEW)* was examined to evaluate the potential outliers.

Given the non-normal distribution of *energy expenditure (NEW)*, it is possible that those subjects with a high *energy expenditure (NEW)* score may exert significant influence on the potential regression line. Three possibilities of truncating the dependent variable and thus restricting the sample size, were considered: no truncation (i.e., include all subjects with valid *energy expenditure (NEW)* scores), n=31,030; truncation at *energy expenditure (NEW)* = 20 KKD (i.e., only including subjects with scores of 20 KKD or less), n=30,955; and truncation at *energy expenditure (NEW)* = 10 KKD (i.e., only including subjects with scores of 10 KKD or less, n=30,701).

Those subjects with *energy expenditure (NEW)* scores of greater than 20 KKD were considered for exclusion from the data set used for this thesis for two reasons. First, the subjects who perform 20 KKD of exercise were different from the majority of subjects in the sample. Individuals who report a score of 20 KKD must be jogging or running or doing an equivalent amount of activity at least two and one half hours every day, or walking more than 10 hours per day. Second, the effect on the sample size of using a cut point of *energy expenditure (NEW)* less than 20 KKD is a decrease of less than 0.25% of the sample. Limiting the sample to those subjects with *energy expenditure (NEW)* scores of 10 or less has the effect of removing over 300 subjects (1.1 %) from the sample and decreases the mean value on *energy expenditure (NEW)* by 15%, from 1.3 KKD to 1.1 KKD. Therefore, the decision was made to exclude those subjects with *energy expenditure*

(NEW) scores greater than 20 KKD. (Inclusion of the excluded subjects demonstrated minimal impact on the final regression models for the entire sample; the data is not presented in this thesis.). The approach of excluding the subjects with *energy expenditure (NEW)* scores greater than 20 KKD differs from the approach taken by Allison in the earlier analysis (50, 51). In Allison's analysis, all subjects with *energy expenditure (OHS)* scores of 20 KKD or greater were given a score of 20 KKD and included in the analysis. This transformation would have no effect on Allison's findings because the categorization of all subjects with an *energy expenditure (OHS)* of 1.5 KKD or greater were in the 'active' group for the logistic regression analysis.

4.3.5 Selection of Independent Variables - Inclusion Criteria

A number of potential predictors of physical activity were included as variables in the OHS database. To limit the potential predictors to a manageable number, selection criteria, which had been used in a previous study were used (56). Only one of the following criteria had to be met for the potential predictor to be included:

1) Variables which had been identified in previous research as determinants;
2) Variables which were theoretically potential determinants;
3) Variables which could be affected by intervention; or
4) Variables considered 'major' demographic variables.

Independent variables for this analysis were grouped into four categories: environmental variables; social variables; physiological variables; and other personal variables. This categorization has been recommended and used previously in studies of determinants of physical activity (16). Variables included in the analysis will be described using these four categories and are listed in Table 4.1, including the type of variable and the method by which the data were collected in the OHS. In total, 29 variables were considered for inclusion as potential predictors.

Table 4.1

List of Potential Included Variables

	Name of Variable	How Obtained	Type of Variable	Number of Levels
Dependent Variable	Energy Expenditure	DER/SCQ	Continuous	
Independent Variables				
Environmental Variables	Stratum	HRF	Categorical	2
Social Variables	Proportion of Friends Who Exercise	SCQ	Categorical	5
	Household Size	HRF	Continuous	
	Household Type	DER/HRF	Categorical	3
	Marital Status	HRF	Categorical	4
	Household Income	IAQ	Continuous	
	Ethnic Group	DER/IAQ	Categorical	3
	Family Functioning Score	DER/SCQ	Continuous	
	Social Support Index	DER/SCQ	Continuous	
Physiological Variables	Age	HRF	Continuous	
	Gender	HRF	Categorical	2
	Body Mass Index	DER	Continuous	
	Weight	SCQ	Continuous	
Other Personal Variables	Occupational Status	IAQ	Categorical	4
	Work Type	SCQ	Categorical	4
	Education Level	DER/IAQ	Categorical	5
	Smoking Status	DER/SCQ	Categorical	3
	Drinking Status	DER/SCQ	Categorical	3
	Physician Visits	DER/IAQ	Continuous	
	Well Being Score	DER/SCQ	Continuous	
	Perceived Stress	SCQ	Categorical	4
	Number of Health Problems	DER/IAQ	Continuous	
	Illness	DER/IAQ	Categorical	2
	Activity Accident	IAQ	Categorical	2
	Mobility Limitations	IAQ	Categorical	2
	Painfree	IAQ	Categorical	2
	Pain Limitations	SCQ	Categorical	5
	Perceived Health Status	SCQ	Categorical	5
	Health Professional Visits	SCQ	Continuous	

Legend

DER	Derived Variables
SCQ	Self Completed Question
IAQ	Interviewer Administered Question
HRF	Household Record Form

4.3.6 Selection of Included Variables

Environmental Variables

Stratum was the only environmental variable included in this analysis and was used to categorize subjects for the separate urban and rural analyses. Whether the respondent lived in an urban or rural part of the province (*Stratum*) was documented as part of the Household Record Form. Urban stratum consisted of the core and fringe components of Census Metropolitan Areas and Census Agglomerations. Rural stratum consisted of those areas that were not designated urban stratum.

Social Variables

Social Support Index was designed to measure participation in a social support network for subjects under the age of 60 and social participation of elders for subjects 60 years of age and older. For the under 60 group, the variable was derived by summing six different items to arrive at the *Social Support Index*. For the older group, six items were also added together to attain the index; however, two of the items included in this scale were different from the items used in the younger group. In both groups, a higher score indicated a higher degree of participation in social activities. For this analysis, the *Social Support Index* was treated as a unitary concept; subjects were assigned the appropriate score depending on their age category and the assumption made that the variable is measuring a similar construct in all individuals.

In the self-completed questionnaire, subjects were asked to report the proportion of their friends who exercise (*Proportion of Friends Who Exercise*). *Proportion of Friends Who Exercise* was scored as a categorical five level variable, ranging from 'all of them' (all of one's friends exercise) to 'none of them' (none of one's friends exercise).

Household Size was recorded as the number of individuals currently residing in the dwelling. *Household Type* recorded whether individuals lived by themselves, with children or other family members or other situations. *Marital Status* was also recorded in the OHS and included in this analysis, and subjects were classified as 'married or living common law', 'single', 'divorced or separated' or 'widowed'. *Household Size, Household Type* and *Marital Status* were all obtained from the Household Record Form.

Ethnic Background was obtained from the interview portion of the questionnaire and documented as a variable with more than 20 categories. Although the ethnic background is an interesting construct to examine, the number of categories and the small number of subjects in some of the categories made the analysis difficult and the findings challenging to interpret. A new variable *Ethnic Group*, was developed from recoded data from *Ethnic Background* into three categories: Canadian (those subjects who reported their ethnic background as Canadian), Canadian and other (subject who reported two ethnic backgrounds, and one was Canadian) or other (all other responses). The same classification of ethnicity was used by Allison and was coded by the OHS staff as part of the data set (51).

Household Income was reported as an annual figure. *Household Income* was collected from the Household Record Form and grouped as a categorical variable. *Household Income* is unique as a categorical variable because the distance between categories is quantifiable. *Household Income* was treated as a continuous variable for this analysis.

Family Functioning Score is an indicator of family functioning. The variable is derived from the responses to twelve items. Subjects responded to the items with a score between one and four for each item, with a higher score indicating a higher level of dysfunction for each item and for the summary variable. The mean of the twelve items was used in the analysis. A subject who did not complete two thirds or more of the items was given a score of missing. If less than one third of the items were missing, then the completed items were averaged to obtain the individual's scale score.

Physiological Variables

Age was coded as both a continuous variable (in years) and as an ordinal variable in groups of 10 years in the OHS. The continuous variable will be used for this analysis. *Age* and *Gender* were both items collected in the Household Record Form.

Subjects were asked to record their height and their weight on the questionnaire. Metric or imperial measurements were used and transformations performed if necessary. *Weight* and the derived variable, *Body Mass Index (BMI)* were considered as potential predictor variables for this analysis. *BMI*, a well accepted indicator of obesity, is equal to the weight of the subject divided by the square of the height, and is reported in kg/m^2 (92). The OHS gave respondents the option of reporting *Weight* in imperial or metric values. The OHS documentation indicated that some of the respondents recorded weights in the kilogram field in pounds (75). This was identified prior to release of the data tape and correction was done. However, there were still subjects with BMI values of less than 15, which is likely false. Excluding these subjects had no impact on the final prediction models. Average BMI values were 25.4 kg/m^2 (95%CL 25.3, 25.5) for males and 23.7 kg/m^2 (95%CL 23.6, 23.8) for females.

Other Personal Variables

Summing 14 self-completed items derived the *Well Being Score*. As with *Family Functioning Score*, if one third or more of the composite items were incomplete, then the variable was assigned a 'missing' score. If less than one third of the items were missing, then the non-missing items were averaged to calculate the *Well Being Score*. *Perceived Stress*, also self-completed, was a categorical variable with four levels where the subject described how stressful their lives were, with responses ranging from 'very stressful' to 'not at all stressful'.

There were many health-related variables available and included in the analysis. *Number of Health Problems* was derived by the interviewer asking the respondent if they had any of 19 different medical conditions (Appendix 4). The interviewer asked specific questions about up to eight different medical conditions, including the length of time the individual concerned had suffered from the problem and which health professionals had been contacted about a given problem. The *Number of Health Problems* variable was calculated by summing the number of conditions an individual suffered from that were discussed in detail with the interviewer, with a maximum possible score of eight.

A second health variable included in this analysis, *Illness*, was derived from 12 of the 19 questions about medical conditions. Only medical conditions which had a possible impact on physical activity were included in the derivation for *Illness*: variable: serious back pain, arthritis or rheumatism, other bone or joint problems, paralysis or speech problem due to stroke, asthma, emphysema or chronic bronchitis or persistent cough, high blood pressure or hypertension, circulatory problems, heart disease, diabetes, cancer, and other long term health problem. Conditions excluded were: skin allergies, hay fever or other allergies, epilepsy, urinary problems or kidney disease, stomach ulcer, other digestive problems, goitre or thyroid trouble and eye problems. If a subject answered 'yes' to any of the 12 included items, then the variable *Illness* was coded with a score of 'yes'.

Other health related items included a question about a previous accident while walking, biking or playing sports (*Activity Accident*) and an inquiry about current limitations in mobility (*Mobility Limitations*). Both of these variables were dichotomous variables, obtained from the interview. Body pain was addressed in two separate items; one interviewer administered item and one self-completed item. *Painfree* was collected by the interviewer, asking if the subject 'was usually free of pain and discomfort', with possible responses of 'Yes' or 'No'. The second item, *Pain Limitations*, was a self-completed question that asked for a description of the pain or discomfort experienced. Responses ranged from 'free of pain and discomfort' to 'limiting most activities', with five levels in total. Both *Pain Limitations* and *Painfree* were included as potential predictors. Subjects also reported their *Perceived Health Status* as part of the self-completed questionnaire. *Perceived Health Status* was a categorical variable with five levels, with response options ranging from 'excellent' to 'poor'.

Occupational Status, a categorical variable with four levels, was administered by the interviewer. The variable contained information about the subject's current employment status (i.e., whether they were working, looking for work, attending school, working part-time or not working). A separate self-completed item, *Work Type*, inquired about the type of work that was done during the day. *Work Type* had 4 possible responses, ranging from 'sitting all day' to 'carrying heavy loads'.

Education Level was derived from an item asking the amount of education a subject had received. Nine categories from this interview item (excluding 'don't know' and 'not stated' responses) were collapsed into five categories for *Education Level:* 'primary school education', 'some secondary school education', 'completion of secondary education', 'some post-secondary education' and 'completion of post secondary education' categories. Since the analyses included all individuals 18 years of age and over, some subjects in the sample would not have completed their schooling at the time they were surveyed.

Both *Smoking Status* and *Drinking Status* were derived from self-completed questions asking about cigarette and alcohol use. Both *Smoking Status* and *Drinking Status* were classified into 'never', 'former', 'current occasional user' and 'current user'.

The number of visits to a physician (*MD Visits*) and the total number of visits to any health professional (*HPro Visits*) in the last year were obtained from the interview. Subjects were asked the number of times they had seen a general practitioner or a specialist in the last year and these two items were summed to derive *MD Visits*. The subject was asked the number of times they had visited a specific health professional (e.g., doctor, nurse, optometrist, physiotherapist, etc.). The total number of visits defined *HPro Visits*. *HPro Visits* included *MD Visits*.

4.3.7 Excluded Variables

Two variables used in the analysis by Allison were excluded from the analysis in this thesis (51). One variable was a question in the self-completed questionnaire asking whether the subject felt that their current level of physical activity would lead to future health problems. This belief could be interpreted in one of two ways. Subjects might believe that a low level of activity could lead to a cardiac event or that a high level of activity would predispose an individual to develop arthritis or other orthopedic conditions. Since it is impossible to assess how the subject interpreted the question, the item was excluded from the analysis.

The other variable that was included in the analysis by Allison but excluded from this thesis, was *Vocational Status*. Inclusion of *Vocational Status* would have decreased the sample size by more than 4000 subjects because many subjects did not complete this section of the questionnaire. *Occupational Status* and *Work Type* remained in the analysis as potential independent variable to provide an indication of the subject's work status.

4.3.8 Assessment of Collinearity

Collinearity occurs when an independent variable is nearly linearly dependent on one or more of the other independent variables. When collinearity occurs between independent variables of a multiple regression model, then at least one of the variables must be excluded in the analysis. Including variables which are collinear can yield unstable regression estimates (82). Screening of independent continuous variables for collinearity was done using a correlation analysis for paired collinear variables. Variance Inflation

Factors (VIF) analysis was done to examine multiple variable collinearity in all remaining variables (93).

A correlation analysis was done to assess only the continuous variables for collinearity. Any pairs of variables resulting in a Pearson Correlation Coefficient (PCC) with an absolute value of greater than 0.7 meant that one of the two variables would have to be removed from the analysis (82). Once the pairs were identified, the two variables were examined to assess which of the two was a better choice to remain as a potential predictor. This decision was made based on qualitative assessment of the two variables. Sixty of the 66 pairs of variables had PCCs of less than 0.4 and three pairs had PCCs between 0.4 and 0.7. Three pairs of variables resulted in PCCs of 0.7 or more.

Weight and *BMI* were found to have a correlation of 0.81. The variable removed from the analysis was *Weight*, as *BMI* is a better overall measure of obesity than Weight because it uses both height and weight in its derivation. *Social Support Index* and *Age* had a PCC of 0.7. *Age* was left in as a potential predictor variable, because it is reported in other studies as a strong predictor of energy expenditure. In addition, the derivation of *Social Support Index*, as reported by the OHS office was questionable. *HPro Visits* and *MD Visits* were also strongly correlated with a PCC of 0.74. *HPro Visits* was considered a better variable to keep in the model because it is an overall measure of use of the health care system. However, *HPro Visits* had over twice as many missing observations (n=1783) as *MD Visits* (n=781). Therefore, the decision was made to exclude *HPro Visits* from the list of independent variables.

VIFs were calculated for all the remaining potential independent variables (93). If the VIF exceeded a score of 10, then the variable would be considered for exclusion from the model. None of the VIF values exceeded 10.

Once these variables were excluded, the final sample size available for the analysis was 20,606 subjects. A summary of the procedures to arrive at the sample size is available in Appendix 6. The final list of variables is included in Table 4.2.

Table 4.2

Final List of Included Variables

	Name of Variable	How Obtained	Type of Variable	Number of Levels
Dependent Variable	Energy Expenditure	DER/SCQ	Continuous	
Independent Variables				
Environmental Variables	Stratum	HRF	Categorical	2
Social Variables	Proportion of Friends Who Exercise	SCQ	Categorical	5
	Household Size	HRF	Continuous	
	Household Type	DER/HRF	Categorical	3
	Marital Status	HRF	Categorical	4
	Household Income	IAQ	Continuous	
	Ethnic Group	DER/IAQ	Categorical	3
	Family Functioning Score	DER/SCQ	Continuous	
Physiological Variables	Age	HRF	Continuous	
	Gender	HRF	Categorical	2
	Body Mass Index	DER	Continuous	
Other Personal Variables	Occupational Status	IAQ	Categorical	4
	Work Type	SCQ	Categorical	4
	Education Level	DER/IAQ	Categorical	5
	Smoking Status	DER/SCQ	Categorical	3
	Drinking Status	DER/SCQ	Categorical	3
	Physician Visits	DER/IAQ	Continuous	
	Well Being Score	DER/SCQ	Continuous	
	Perceived Stress	SCQ	Categorical	4
	Number of Health Problems	DER/IAQ	Continuous	
	Illness	DER/IAQ	Categorical	2
	Activity Accident	IAQ	Categorical	2
	Mobility Limitations	IAQ	Categorical	2
	Painfree	IAQ	Categorical	2
	Pain Limitations	SCQ	Categorical	5
	Perceived Health Status	SCQ	Categorical	5

Legend	
DER	Derived Variable
SCQ	Self Completed Question
IAQ	Interviewer Administered Question
HRF	Household Record Form

4.4 Comparison of Included versus Excluded Samples

By using *energy expenditure (NEW)* as the dependent variable and eliminating subjects who do not have scores for the chosen list of independent variables, the resulting effect on the data set was that 20,606 subjects remained in the analysis and 23,348 subjects were excluded. Table 4.3 and 4.4 demonstrate how all of the variables differed between subjects included in the analysis and those not included. Table 4.3 describes the continuous variables and Table 4.4 examines the categorical variables.

Table 4.3 demonstrates that those subjects included in the analysis: lived in larger households, had higher family incomes, reported higher scores in Family Functioning and Well Being, were younger and had fewer health problems and fewer visits to a physician in the last year than those subjects who were not included in further analyses. All of the continuous variables except for *BMI* were significantly different between the two groups. The variable with the largest difference was *Age*, where those subjects included were on average, seven years younger than those subjects not included.

The categorical variables demonstrate that those subjects included were more likely to be married with children, have friends who exercise, describe their ethnic background as Canadian, and were likely to be 'not stressed' as compared to those not included. Subjects who were included in the analyses were more likely to be male, less likely to have a chronic illness, limitations in their mobility or be in pain, and more likely to perceive their health status as excellent. Those included were more likely to have had a previous accident walking or bicycling or playing sports, more likely to be working, and more likely to describe their daily activities as sitting most of the day and more likely to be consumers of alcohol, and more likely to have completed post-secondary education. Chi-square analysis demonstrates that all of the categorical variables listed in Table 4.4, except *Smoking Status* and *Stratum* were significantly different at the $p<0.05$ level.

Table 4.3

Comparison of Subjects Included Versus Those Not Included In the Analysis - Continuous Variables

Category	Name of Variable	Included Subjects N=20,606		Excluded Subjects N=23,348		Significance
		Mean Score	95% Confidence Limits	Mean Score	95% Confidence Limits	
Social Variables	Household Size	3.17	3.13, 3.21	3.06	3.00, 3.12	*
	Household Income	7.69	7.59, 7.79	6.90	6.8, 7.0	*
	Family Functioning Score	2.77	2.77, 2.78	26.88	26.78, 26.98	*
Cognitive Variables	Well Being Score	31.70	31.52, 31.88	30.99	30.79, 31.19	*
Physiological Variables	Age	40.18	39.81, 40.55	46.80	46.33, 47.27	*
	BMI	24.55	24.45, 24.65	24.57	24.47, 24.67	NS
	Number of Health Problems	1.45	1.41, 1.49	1.59	1.55, 1.63	*
Other Personal Variables	Physician Visits	4.66	4.48, 4.84	5.55	5.24, 5.86	*

* $p<0.01$
NS Non Significant

Table 4.4

Comparison of Subjects Included Versus Those Not Included In the Analysis - Categorical Variables

Category	Name of Variable	Included Subjects N=20,606		Not Included Subjects N=23,348		Significance
		Proportion	95% Confidence Level	Proportion	95% Confidence Level	
Environmental Variables						
Stratum	Rural	87.7	87.1, 88.3	86.9	86.4, 87.4	NS
	Urban	12.3	11.7, 12.9	13.1	12.6, 13.6	
Social Variables						
Proportion of Friends Who Exercise	None of them	12.7	11.8, 13.6	16.2	15.1, 17.2	*
	Few of them	54.5	53.3, 55.7	52.9	51.7, 54.1	
	Half of them	18.4	17.5, 19.3	15.6	14.8, 16.5	
	Most of them	13.0	12.1, 13.8	13.0	12.1, 13.8	
	All of them	1.4	1.2, 1.6	2.2	1.8, 2.7	
Household Type	Head & Spouse With No Children	38.1	36.7, 39.4	41.9	40.5, 43.2	*
	Head & Spouse With Children	42.0	40.4, 43.6	32.0	31.5, 34.3	
	Other	19.9	18.6, 21.2	25.2	23.9, 26.5	
Marital Status	Married	71.7	70.5, 72.9	67.2	66.1, 68.3	*
	Single	20.5	19.4, 21.6	19.4	18.5, 20.3	
	Widowed	3.3	2.9, 3.7	8.10	7.5, 8.7	
	Separated or Divorced	4.6	4.1, 5.1	5.30	4.8, 5.8	
Ethnic Group	Canadian	44.5	42.8, 46.2	38.9	37.4, 40.4	*
	Canadian and Other	20.3	18.9, 21.7	21.0	19.7, 22.3	
	Other	35.2	33.3,37.1	40.1	38.3, 41.9	
Physiological Variables						
Gender	Male	50.3	49.4, 51.1	46.8	46.0, 47.6	*
	Female	49.7	48.8, 50.6	53.2	52.4, 54.0	

* p<0.01 NS Non Significant

Table 4.4

Comparison of Subjects Included Versus Those Not Included In the Analysis - Categorical Variables

Category	Name of Variable	Included Subjects N=20,606		Not Included Subjects N=23,348		Significance
		Proportion	95% Confidence Level	Proportion	95% Confidence Level	
Other Personal Variables						
Occupational Status	Working	68.9	67.8, 70.1	55.70	54.6, 56.8	*
	Looking For Work	1.3	1.1, 1.5	1.50	1.2, 1.8	
	Going To School	8.1	7.4, 8.7	6.8	6.2, 7.4	
	Other	21.7	20.7, 22.7	36.0	34.8, 37.2	
Work Type	Usually Sit	26.6	25.5, 27.7	22.2	21.2, 23.2	*
	Stand	51.6	50.5, 52.7	55.9	54.8, 57.0	
	Lift, Carry or Climb	17.0	16.2, 17.8	17.0	16.2, 17.8	
	Carry Heavy Loads	4.7	4.3, 5.1	4.9	4.4, 5.4	
Education Level	Primary Education	6.6	6.0, 7.2	15.5	14.5, 16.5	*
	Some Secondary Education	18.7	17.8, 19.6	24.7	23.7, 25.7	
	Completed Secondary Education	26.5	25.7, 27.5	25.8	24.8, 26.8	
	Some Post Secondary Education	15.3	14.4, 16.2	12.6	11.9, 13.3	
	Completed Post Secondary Education	32.9	31.5, 34.3	21.4	20.3, 22.5	
Smoking Status	Never Smoked	44.7	43.5, 45.9	45.2	44.0, 46.4	NS
	Former Smoker	23.7	22.7, 24.7	22.9	21.9, 23.9	
	Current Smoker	31.6	30.6, 32.6	31.9	30.8, 33.0	
Drinking Status	Never Drank	6.6	5.9, 7.4	13.6	12.6, 14.6	*
	Former Drinker	6.3	5.8, 6.8	8.7	8.1, 9.4	
	Current Drinker	87.0	86.1, 87.9	77.7	76.5, 78.9	
Perceived Stress	Very Stressed	8.3	7.7,8.9	9.1	8.4, 9.8	*
	Fairly Stressed	47.9	46.7, 49.1	41.2	40.1, 42.3	
	Not Very Stressed	37.3	36.1, 38.4	38.5	37.4, 39.6	
	Not Stressed	6.5	5.9, 7.1	11.2	10.4, 12.0	

* $p<0.01$ NS Non Significant

Table 4.4

Comparison of Subjects Included Versus Those Not Included In the Analysis - Categorical Variables

Category	Name of Variable	Included Subjects N=20,606		Not Included Subjects N=23,348		Significance
		Proportion	95% Confidence Level	Proportion	95% Confidence Level	
Ilness	Yes	34.5	33.3, 35.7	43.8	42.6, 45.0	*
	No	65.5	64.3, 66.7	56.2	55.0, 57.4	
Activity Accident	Yes	3.8	3.4, 4.2	2.4	2.1, 2.7	*
	No	96.2	95.8, 96.6	97.6	97.3, 97.9	
Mobility Limitations	Yes	98.0	97.7, 98.3	96.0	95.6, 96.4	*
	No	2.0	1.7, 2.3	4.0	3.6, 4.4	
Painfree	Yes	86.4	85.6, 87.2	82.6	81.8, 83.4	*
	No	13.6	12.8, 14.4	17.4	16.6, 18.2	
Pain Limitations	Painfree	38.7	37.5, 39.9	35.5	34.4, 36.6	*
	Pain Prevents No Activities	35.7	34.6, 36.8	33.4	32.4, 34.4	
	Pain Prevents Few Activities	17.7	16.8, 18.6	19.0	18.2, 19.8	
	Pain Prevents Some Activities	5.8	5.3, 6.3	8.0	7.4, 8.6	
	Pain Prevents Most Activities	2.1	1.8, 2.4	4.1	3.7, 4.5	
Perceived Health Status	Excellent Health	21.8	20.8, 22.8	20.3	19.4, 21.3	*
	Very Good Health	41.7	40.6, 42.8	35.5	34.5, 36.5	
	Good Health	28.2	27.2, 29.2	30.5	29.5, 31.5	
	Fair Health	6.8	6.2, 7.4	10.9	10.2, 11.6	
	Poor Health	1.6	1.3, 1.9	2.90	2.5, 3.3	

* $p<0.01$ NS Non Significant

4.5 Contrasting Groups Analysis

Testing was done to assess if there was any relationship between the extreme levels of the outcome variable and the predictor variables. This testing was done to assess if a regression analysis was warranted. The outcome variable, *energy expenditure (NEW)*, was divided into two groups, those subjects with *energy expenditure (NEW)* score of 0 KKD, and those subjects with *energy expenditure (NEW)* scores of 10 KKD or greater. The low category was chosen because it includes subjects who report performing no leisure time physical activity at all. The higher category includes those subjects who were performing a very high level of physical activity. If there was no difference in any predicting variables between the two groups as classified by high and very low *energy expenditure (NEW)*, then there would be no need in pursuing the regression analysis.

The comparison of extreme groups of *energy expenditure (NEW)* was done using SUDAAN software. All independent variables that were potentially included in the regression models were compared using either t-tests or chi-square analyses.

4.6 Regression Analyses

Multiple linear regression was used to search for predictors of *energy expenditure (NEW)*. It is a statistical technique used to examine the relationship between a dependent variable and multiple independent variables (93). Although a relationship may be found, the findings do not necessarily indicate a causative relationship between the independent variables and the dependent variable.

The goal of the regression procedure is to determine regression coefficients for each variable in an equation. Together, these coefficients predict a value for the outcome variable (based on the values of the independent variables) that is as close as possible to the value of the outcome variable obtained by measurement (82). The independent variables can be either continuous or categorical; however, the dependent variable must be continuous.

Regression analysis can be used for one of three purposes: description of a relationship, control of a relationship or for prediction (94). The use of regression in this thesis is to describe the relationship, or to identify the predictors of physical activity.

Multiple linear regression requires certain assumptions about the data to be met. One method of assessing if the assumptions have been met is to analyze the residuals. The residuals are the 'difference' between the predicted and measured dependent variable score (82).

The initial approach taken here was to attempt a regression of *energy expenditure (NEW)* with only two independent variables, *Age* and *Gender*. This regression procedure was performed as a preliminary screening of the data to assess if the assumptions associated with multiple linear regression could be met. This regression with only two independent variables would result in a more simplified model than a full model with 26 potential variables. *Age* and *Gender* were chosen as the independent variables because these two variables have been commonly reported in the literature as being predictors of physical activity (9, 50, 51)

The residuals from the regression with the two independent variables were examined to assess if the assumptions were met. If the assumptions were not met, one possible approach is to transform the outcome variable (82). Some suggested transformations include using the log, or the square root of the outcome variable. If a transformation is performed, then testing for the assumptions must be performed afterwards to ensure that the model is sound.

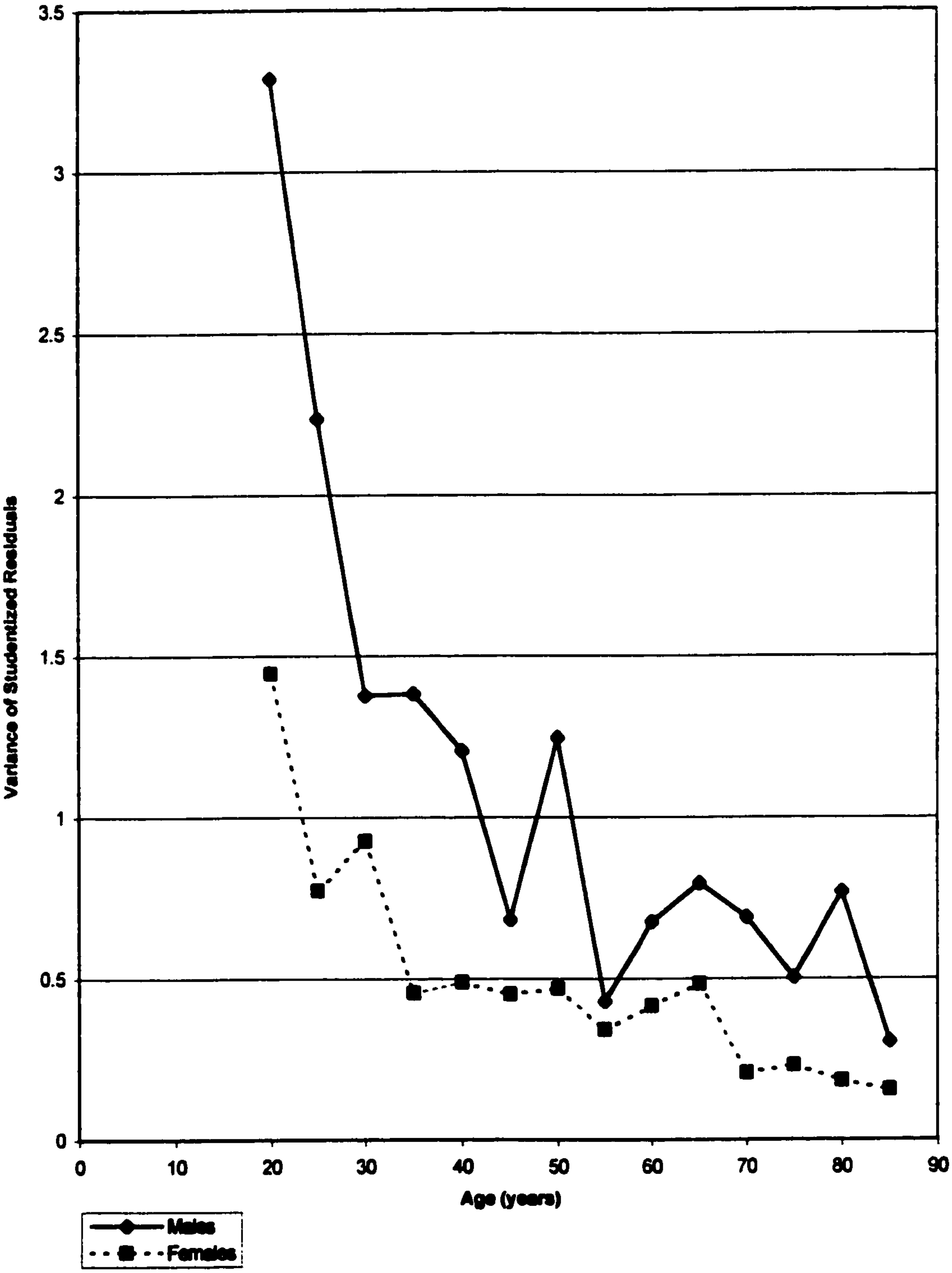
The results of this preliminary regression demonstrated that both *Age* and *Gender* were significant predictors of physical activity. The coefficient of determination (R^2) for this preliminary regression however was very small, only 0.05.

4.6.1 Assumptions and Diagnostics and Transformation of the Outcome Variable

Four assumptions were considered for the regression analysis (Kleinbaum, 1998). The first assumption, independence, is the assumption that all observations are independent of each other. Perhaps those individuals living in the same households are more likely to be similar than different. Individuals living in clusters of households (i.e., the same neighbourhoods) may also be similar. It was assumed that use of SUDAAN for final modeling would appropriately adjust for the potential lack of independence in the results, by taking the sample design into consideration (89).

Homoscedasticity (the assumption that the variance of the outcome variable is the same for all levels of the predictor variables) can be assessed graphically using a scatter plot (82). If the assumption is met, then the residuals should be distributed normally around the line. Unfortunately, it is very difficult to test for homoscedasticity using a scatter plot with over 20,000 data points. Therefore, the variance of the studentized residuals of *energy expenditure (NEW)* was plotted at different values of age. If the assumption of homoscedasticity is met, then the plotted line should be straight and horizontal. As demonstrated in Figure 4.3, the plotted line is neither straight nor horizontal. The variance of the residuals was over 3.5 for 20 year old male subjects and less than 0.01 for 90 year old subjects. It would appear that the assumption of homoscedasticity is not met in this analysis.

Figure 4.3 Comparison of the Variance of the Residuals By Age and Sex for the Regression Analysis Of Age and Sex on Energy Expenditure (NEW)



Normality is the assumption that the residuals are normally distributed conditional on the set of predictors. Examining a normal probability plot, shown in Figure 4.4 assesses if the criteria for normality have been met. If the criteria for normality were met, then the normal probability plot should follow a straight line from the bottom left hand side of the graph to the top right. This was not the case, as demonstrated in Figure 4.4.

Linearity is the assumption that a linear relationship exists between the independent variables and the dependent variable. The linearity assumption was only tested in the final model.

The criteria for the assumptions of homoscedasticity and normality were not met. Two options were considered. Some data points could be removed from the analysis. However, already over half of the available sample had been eliminated because of missing data, and further removal of subjects would only dilute the sample further. The other option was to attempt a transformation of the outcome variable. Different transformations were attempted. A log transformation and an inverse transformation, which have both been used in previous studies could not be used here because of the large number of subjects with a score of zero for *energy expenditure (NEW)*. The best transformation to the outcome variable appeared to be a cube root transformation.

The outcome variable, now the cube root of *energy expenditure (NEW)*, will be referred to as the *cube root (EE)*. The range of the *cube root (EE)* values was from zero to approximately 2.7 units.

The distribution of the *cube root (EE)* is shown in Figure 4.5. The distribution of the *cube root (EE)* is different from the distribution of the *energy expenditure (NEW)* variable. There was still a large peak on the left hand side of the graph representing those

Figure 4.4 Normal Probability Plot – Assessing Normality of Residuals for Regression Analysis Of Age and Sex on Energy Expenditure (NEW)

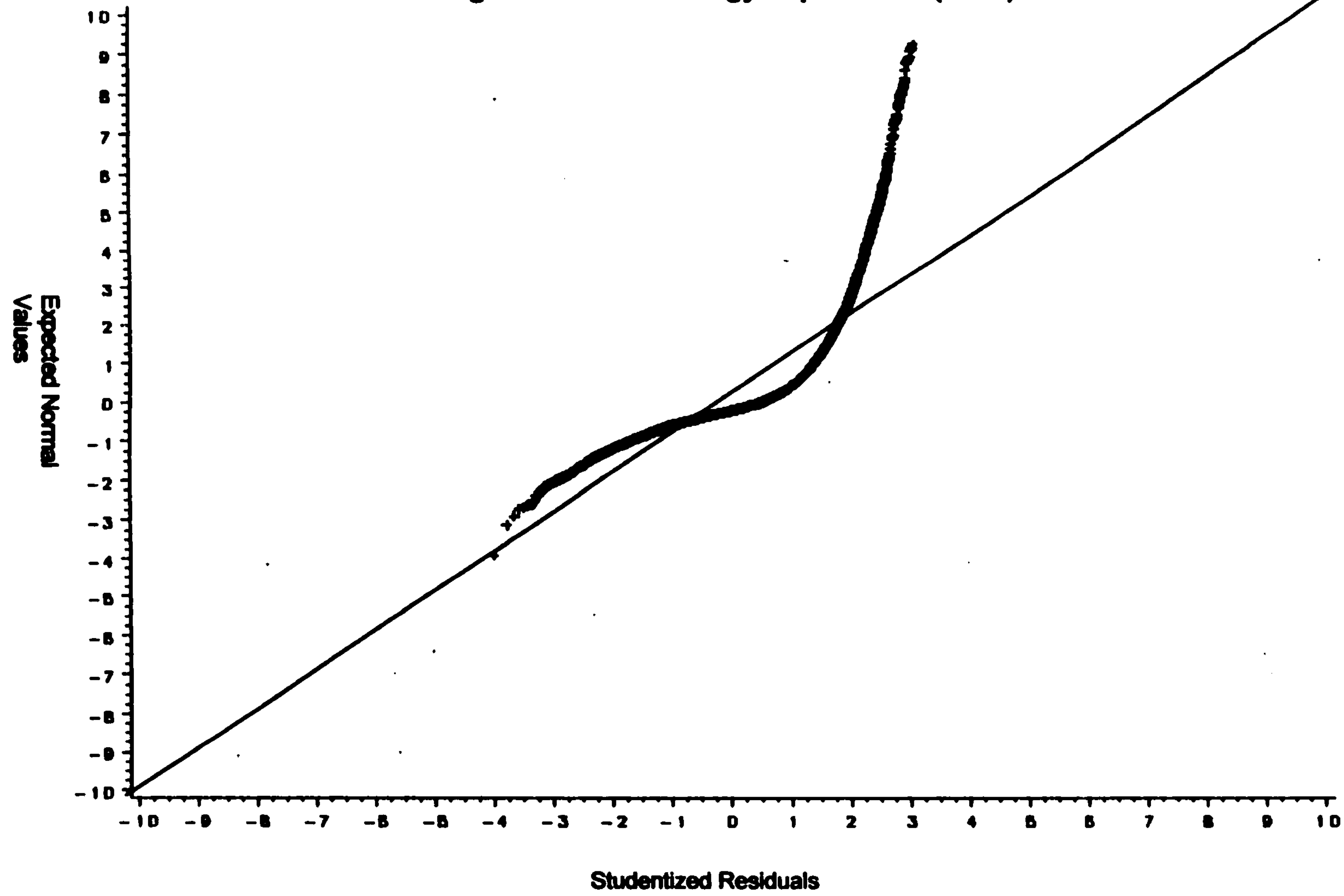
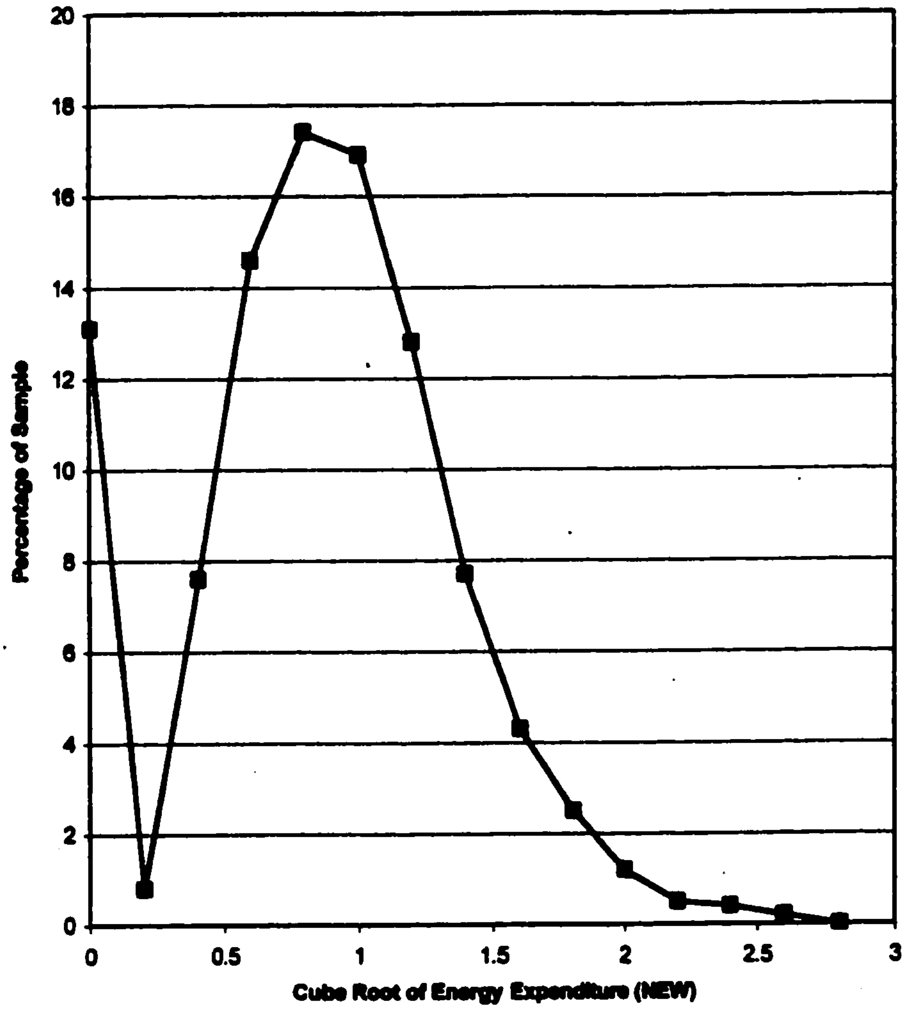


Figure 4.5 Distribution of Cube Root of Energy Expenditure (NEW)



subjects who report performing no physical activity, but the data follows a normal-like distribution to the right of the peak. Excluding individuals who have *energy expenditure (NEW)* scores of zero from further analysis would eliminate over 10% of the remaining sample. These individuals who report doing no physical activity are an important group to remain in the analysis. Although there is over 10% of the sample with a *cube root (EE)* score of zero, the next highest score is 0.24. The *cube root (EE)* score of 0.24 equates to an *energy expenditure (NEW)* score of 0.014, which was the lowest score (other than zero) reported in this thesis.

The regression was run using only *Age* and *Gender* as independent variables and the *cube root (EE)* as the dependent variable. In Figure 4.6, the assumption of homoscedasticity is tested, in the same manner as described earlier. The lines plotted in Figure 4.6 are much more horizontal and relatively straight, indicating homoscedasticity. The normal probability plot for the residuals of the transformed variable regressed against the variables of *Age* and *Gender* followed an acceptable pattern in Figure 4.7, which was much improved over the original distribution, although there is still evidence of non-normality in the tails. The decision was made to accept the cube root transformation as the best possible solution for subsequent analyses.

Figure 4.6 Comparison of the Variance of the Residuals By Age and Sex for the Regression Analysis Of Age and Sex on Cube Root Of Energy Expenditure (NEW)

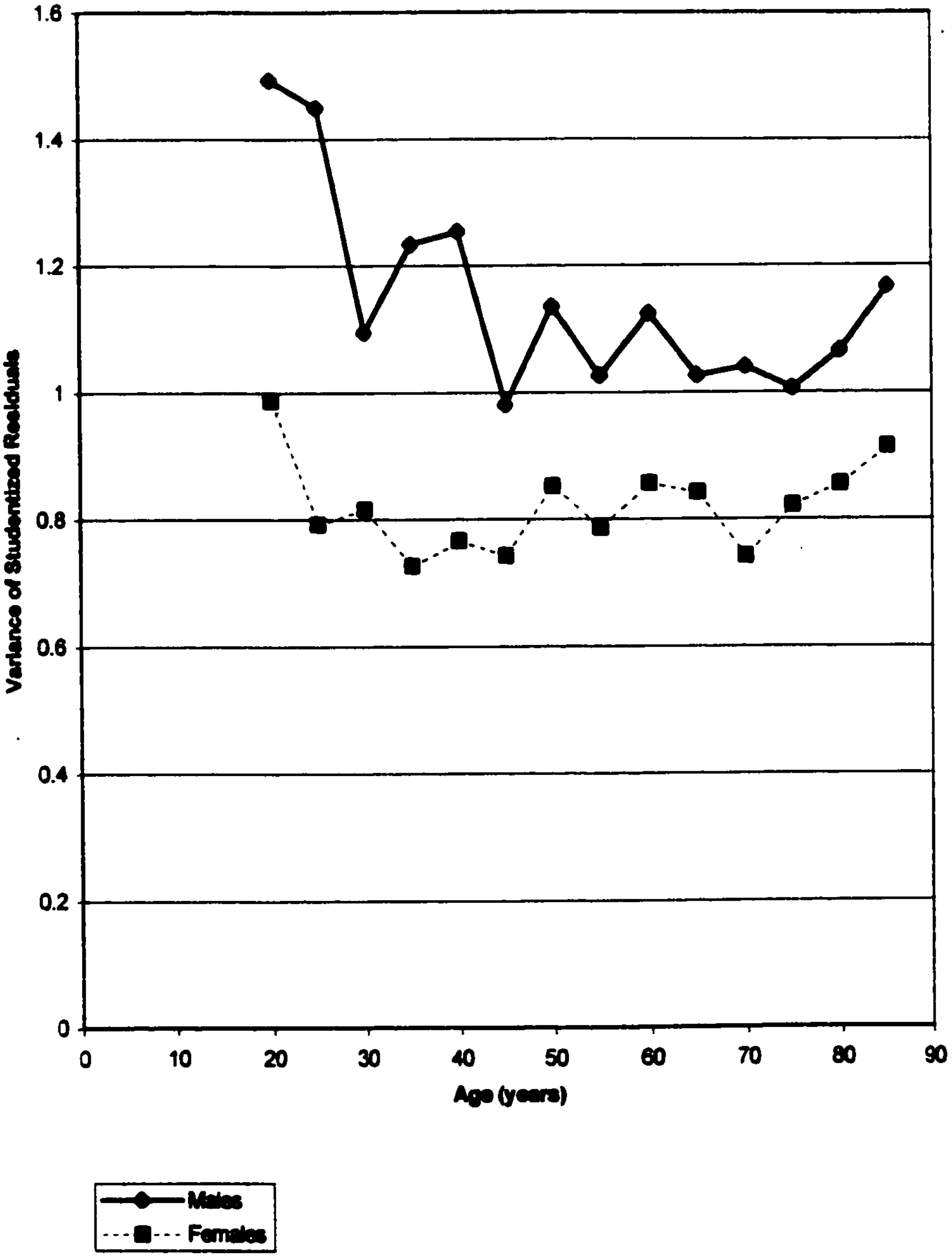
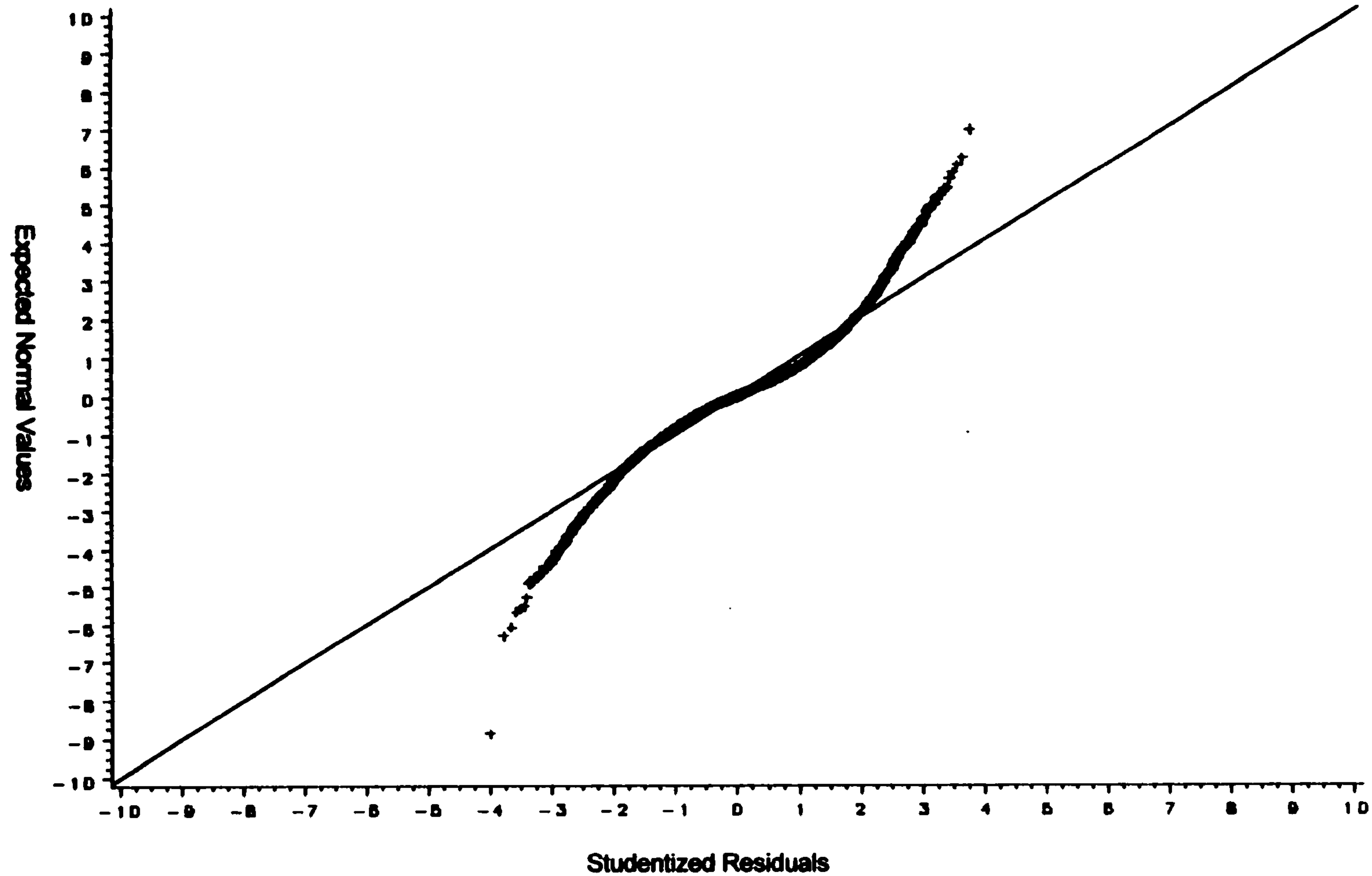


Figure 4.7 Normal Probability Plot –
Assessing Normality of Residuals for Regression Analysis
Of Age and Sex on Cube Root of Energy Expenditure (NEW)



4.7 Collapsing of Levels of Independent Variables

Incorporation of categorical variables into a multiple regression requires a 'dummy' variable approach (95). Each categorical (ordinal or nominal) variable with 'r' levels is entered into the model as 'r-1' variables. It was essential that all dummy variables associated with an original variable are entered into the model together; otherwise interpretation is not possible for the underlying construct. The dummy variable approach substantially increases the number of variables in the model, which has implications concerning the parsimony of the model.

In order to decrease the number of 'dummy' variables, all independent categorical variables with more than two levels were assessed for their effect on the outcome variable with *Age* and *Gender* included as covariates. All testing was done using an analysis of covariance (ANCOVA). Post hoc least squares means of the categorical variables being tested were calculated. If no significant differences in energy expenditure between two adjacent levels of a categorical variable were found, the two levels of the variable were collapsed into one level, producing a more parsimonious model. Using *Perceived Health Status* as an example, if there was no difference in the outcome variable for respondents who reported 'excellent health' and for those respondent who reported 'very good health', then the *Perceived Health Status* variable would be collapsed from five levels down to four, reducing the number of dummy variables for *Perceived Health Status* by one. Table 4.5 describes the findings of this analysis.

Five variables had no change in the number of levels included in the model. These variables were *Proportion of Friends Who Exercise, Pain Limitations, Drinking Status, Household Type* and *Ethnic Group.* There was not a statistically significant difference between the *Marital Status* levels of 'married' and 'widowed'; these two levels of *Marital Status* were combined for the multiple regression. *Occupational Status* levels of 'working at a job' and 'looking for work' had similar *cube root (EE)* scores and these two levels

Table 4.5

Assessment of Differences Between Levels of Categorical Variables

Category	Name of Variable	Initial Number Of Levels	Final Number Of Levels	Comments
Social Variables	Proportion of Friends Who Exercise	5	5	
	Household Type	3	3	
	Marital Status	4	3	"Widowed" and "Married" combined to one level
	Ethnic Group	3	3	
Physiological Variable	Pain Limitations	5	5	
	Perceived Health Status	5	4	"Poor Health" and "Fair Health" were combined
Other Personal Variables	Occupational Status	4	3	"Working" and "Looking for Work" were combined
	Work Type	4	3	"Lift/carry or climb" combined with "Stand"
	Education Level	5	4	"Some Post-Secondary Education" and "Post-Secondary" combined
	Smoking Status	3	2	"Never Smoked " and "Former Smoker" were combined
	Drinking Status	3	3	
	Perceived Stress	4	2	"Fairly Stressed" and "Very Stressed" were combined; "Not Very Stressed" and "Not Stressed" were combined

were combined. There were also similar *cube root (EE)* scores between 'working' and 'keeping house'. However, because 'working at a job' and 'looking for work' were more similar in their *cube root (EE)* scores (and represent similar populations), they were the only levels combined in this variable. This statistical significance was less than as 'working at a job' and 'looking for work'. Therefore, 'working' and 'keeping house' were kept as two distinct variable levels and *Occupational Status* was changed to a three level variable.

Education Levels of 'some post secondary' and post secondary' were merged as were Perceived Health levels of 'poor' and 'fair'. For *Perceived Stress*, there were similar energy expenditure scores for 'fairly stressed' and 'very stressed' and also for 'not stressed' and 'not very stressed'. The final decision was to combine the four level variable into a two level variable. Never and former smokers were also combined to one level based on similar energy expenditure scores between the two levels.

Work Type was a difficult variable to assess in terms of collapsing levels. Similar levels of energy expenditure were noted for 'lift/carry or climb' and 'standing' levels. There was also a non-statistically significant difference between the 'sit all day' and 'carry heavy loads' levels. The final decision was to combine the 'lift/carry or climb' and 'standing' levels, but not to merge the 'sit all day' and 'carry heavy loads' levels. The former two levels describe work activities that are more similar in nature than the latter two levels. Therefore, *Work Type* was treated as a three level variable.

4.8 Stepwise Regression: The Primary Objective

The regression analysis using all 26 potential predicting variables commenced with a stepwise procedure. Stepwise regression adds or removes one variable (which may be a group of 'dummy' variables) at a time. The procedure of stepwise regression starts by entering the strongest predictor into the model. The strength of the predictor variable (i.e., whether the variable is added to the potential model) is determined by the partial F-statistic. The partial F-statistic is a measure of the significance of the prediction of a given variable. A variable was entered into the regression model only if the partial F-statistic (F to Enter) reached a significance level of 0.15. Once a variable was entered, the model was reevaluated to ensure that all variables in the model have sufficient statistical significance ($p < 0.15$) to remain in the model. If the partial F statistic (F to Remove) did not reach statistical significance for a given variable, then that variable was removed from the model.

Residual testing was more difficult to perform with the larger models of all the predicting variables. Homoscedasticity was tested by calculating the variances of the residuals at different levels of the predicted outcome variable. If the assumption of homoscedasticity was met, then the plot should follow a straight horizontal line, indicating that there is a consistent variance of the residuals across all combinations of the independent variables. A normal probability plot was used to test for normality.

4.8.1 Modeling in SUDAAN

Once the stepwise procedure was completed using SAS, testing was done to determine if the variables identified as predictors remained predictors using SUDAAN. A manual backwards stepping procedure was performed using SUDAAN. A significance level of 0.15 was used for consistency with the SAS stepwise procedure. All levels of a particular categorical variable were grouped together for the stepwise regression analysis.

If the highest p value associated with the beta coefficient for a particular variable (or all levels of a categorical variable) was greater than 0.15, then testing was done to assess if the model was improved by including the variable. This testing was done using a partial Satterthwaite Adjusted F statistic. This statistic was used because it adjusts for the sampling design. If the F statistic reached the inclusion threshold ($p < 0.15$) then the model was judged to be improved by including the variable being tested and the variable was kept in the model. No further testing was done of the model in this case. If the F statistic did not reach the inclusion threshold ($p>0.15$), then the tested variable was removed from the model. The remaining variables were tested in a new model and the process repeated for the next least significant variable with a p value associated with the beta coefficient greater than 0.15. If the p value for the beta coefficients was less than 0.15 for all the variables, then no further testing was done.

Once all the significant predicting variables were identified using SUDAAN, models were developed and tested. The testing was done to assess if one model was an improved predictor over another model. This testing was also done using Satterthwaite Adjusted F statistic. Significance for this test was set at a p-value of 0.05.

Three potential models were tested. The first model only included predictor variables for which the partial R^2 was greater than 0.01. The second model contained those variables in the first model, plus *Age* and *Gender*. (As described earlier, *Age* and *Gender* have been commonly reported as predictors of physical activity.) The final model developed included all of the variables that were statistically significant in the stepwise analysis.

4.9 Subgroup Analyses – The Secondary Objective

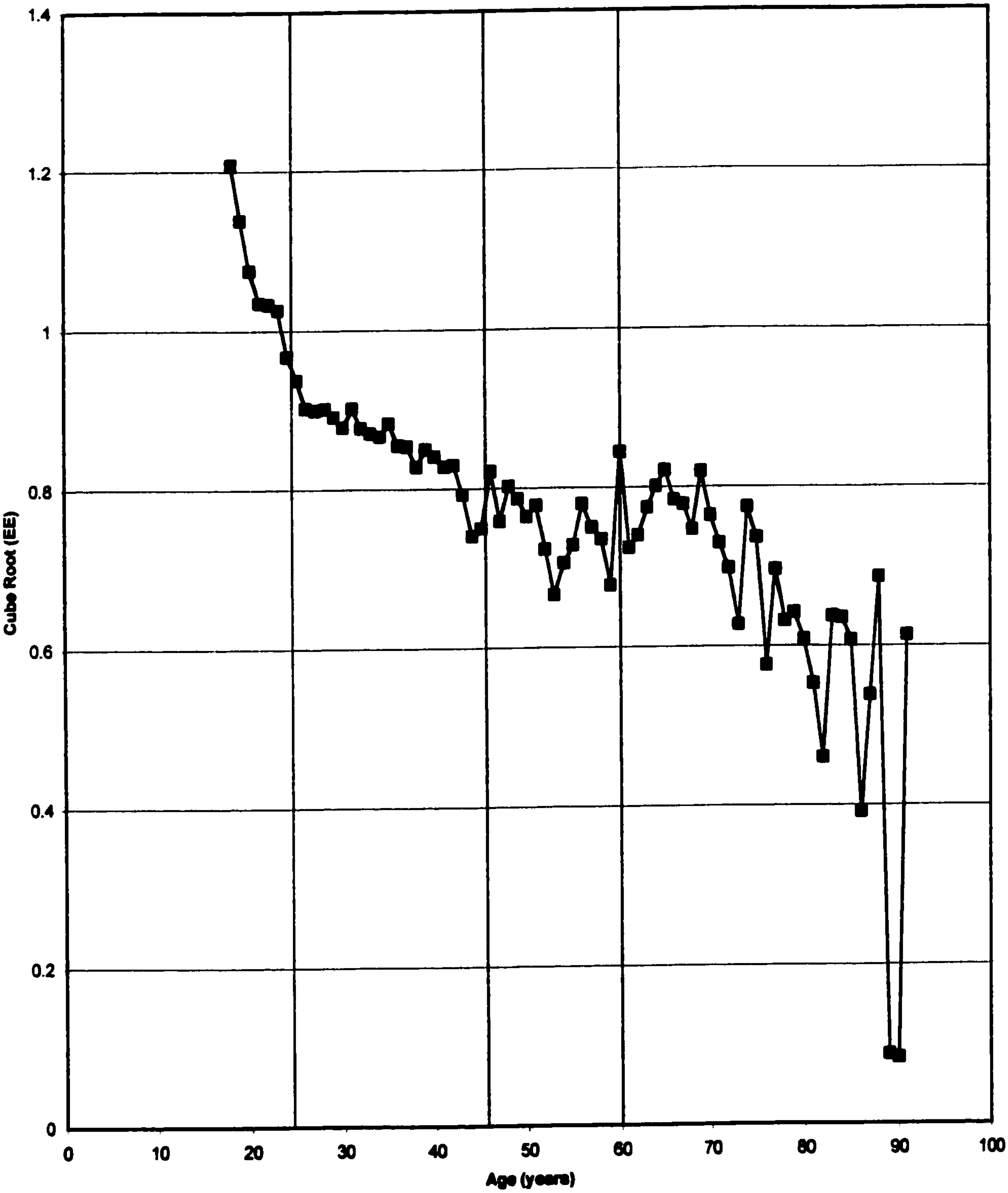
To test the secondary objectives, stepwise regression procedure was conducted using SAS software for each subgroup. All 26 variables were included as potential predictors of physical activity. The outcome variable used was cube root (EE). The decision was made that *cube root (EE)* would likely be the best choice of outcome variable. No residual testing was done for any of the subgroup analyses.

Designation of subjects into the urban or rural strata was described earlier (Section 4.3.6). Division based on *Gender* is self-explanatory. The age groups were determined based on the mean values of energy expenditure for each age. A plot of age versus *cube root (EE)* is shown in Figure 4.8. The cut-points for age groups were determined by assessing the inflection points on the graph. From Figure 4.8, four age groups were identified: subjects 25 years of age or less, subjects between the age of 25 and 45, subjects between the ages of 45 and 60 and subjects over the age of 60. Although the inflection point separating the two older age groups is not obvious, the decision was made not to group all individuals over the age of 45 together because of numerous differences in social situation, work status, living arrangements, health status and other variables.

Age was tested as an independent variable in each age group. Even with the subgroup divisions, there still remained a range of 15 or more years in each age subgroup. Therefore, we felt that *age* could be a potential predictor of physical activity within these age groups.

Stepwise regression was conducted using SAS software within each subgroup. Only one model per subgroup was tested, this was the model, which contained all of the significant predicting variables for that particular group. Final model testing was done in SUDAAN, using the same method of backwards stepping described in Section 4.9.

Figure 4.8 A Plot of the Mean Cube Root of Energy Expenditure (NEW) by Age



CHAPTER 5 RESULTS

5.1 Description of OHS Sample

As described in Section 4.4, 20,606 subjects were included in the final analysis. All subjects who were 18 years of age and over and who were surveyed for the 1990 OHS were eligible for inclusion in this sample. This sample only includes subjects who had scores for the outcome variable and all of the independent variables, resulting in a sample size of 20,606 suibjects.

The sample is described in Table 5.1 and 5.2. (The numbers in Table 5.1 and 5.2 were previously presented in Table 4.3 and 4.4, and are presented again here for ease of reference.) All independent variables are described in the tables using means or proportions, and 95% confidence limits. The findings are summarized below.

The sample consisted of 50.3% males and 49.7% females. Values in this section are presented as mean or proportion plus and minus the standard error. The mean age of the subjects was 40.2 years. The average BMI was 24.6 kilograms of body weight per squared metre of height (kg/m^2).

Over 80% have the respondents lived in urban neighbourhoods and 12.3% lived in rural neighbourhoods.

The average household size was 3.2 individuals and 71.1% of the subjects were married. The average household income was between $40,000 and $50,000 annually. Over 44% of the subjects reported their ethnic background as Canadian, and 80% of the subjects reported living in households of married couples with or without children. *Family Functioning Score* was 2.73±0.03 out of a possible score of 4.0, and 14.4% of the subjects reported that none of their friends exercise.

Table 5.1

Description of Subjects Included in the Analysis - Continuous Variables

Category	Name of Variable	Mean Score	95% Confidence Limits
Social Variables	Household Size	3.2	3.1, 3.2
	Household Income	7.7	7.6, 7.8
	Family Functioning Score	2.8	2.8, 2.8
Physiological Variables	Age	40.2	39.8, 40.6
	BMI	24.6	24.5, 24.7
	Number of Health Problems	1.5	1.4, 1.5
Other Personal Variables	Physician Visits	4.7	4.5, 4.9
	Well Being Score	31.7	31.5, 31.9

Table 5,2

Description of Subjects Included in the Analysis - Categorical Variables

Category	Name of Variable	Proportion	95% Confidence Level
Environmental Variables			
Stratum	Rural	87.7	87.1, 88.3
	Urban	12.3	11.7, 12.9
Social Variables			
Proportion of Friends Who Exercise	None of them	12.7	11.8, 13.6
	Few of them	54.5	53.3, 55.7
	Half of them	18.4	17.5, 19.3
	Most of them	13.0	12.2, 13.8
	All of them	1.4	1.2, 1.6
Household Type	Head & Spouse With No Children	38.1	36.7, 39.4
	Head & Spouse With Children	42.0	40.4, 43.6
	Other	19.9	18.6, 21.2
Marital Status	Married	71.7	70.5, 72.9
	Single	20.5	19.4, 21.6
	Widowed	3.3	2.9, 3.7
	Separated or Divorced	4.6	4.1, 5.1
Ethnic Group	Canadian	44.5	42.8, 46.2
	Canadian and Other	20.3	18.9, 21.7
	Other	35.2	33.3, 37.1
Physiological Variables			
Gender	Male	50.3	49.4, 51.1
	Female	49.7	48.8, 50.6

Table 5.2

Description of Subjects Included in the Analysis - Categorical Variables

Category	Name of Variable	Proportion	95% Confidence Level
	Other Personal Variables		
Occupational Status	Working	68.9	67.8, 70.1
	Looking For Work	1.3	1.1, 1.5
	Going To School	8.1	7.4, 8.7
	Other	21.7	20.7, 22.7
Work Type	Usually Sit	26.6	25.5, 27.7
	Stand	51.6	50.5, 52.7
	Lift, Carry or Climb	17.0	16.2, 17.8
	Carry Heavy Loads	4.7	4.3, 5.1
Education Level	Primary Education	6.6	6.0, 7.2
	Some Secondary Education	18.7	17.8, 19.6
	Completed Secondary Education	26.5	25.7, 27.5
	Some Post Secondary Education	15.3	14.4, 16.2
	Completed Post Secondary	32.9	31.5, 34.3
Smoking Status	Never Smoked	44.7	43.5, 45.9
	Former Smoker	23.7	22.7, 24.7
	Current Smoker	31.6	30.6, 32.6
Drinking Status	Never Drank	6.6	5.9, 7.4
	Former Drinker	6.3	5.8, 6.8
	Current Drinker	87.0	86.1, 87.9
Perceived Stress	Very Stressed	8.3	7.7,8.9
	Fairly Stressed	47.9	46.7, 49.1
	Not Very Stressed	37.3	36.1, 38.4
	Not Stressed	6.5	5.9, 7.1
Ilness	Yes	34.5	33.3, 35.7
	No	65.5	64.3, 66.7
Activity Accident	Yes	3.8	3.4, 4.2
	No	96.2	95.8, 96.6
Mobility Limitations	Yes	98.0	97.7, 98.3
	No	2.0	1.7, 2.3
Painfree	Yes	86.4	85.6, 87.2
	No	13.6	12.8, 14.4
Pain Limitations	Painfree	38.7	37.5, 39.9
	Pain Prevents No Activities	35.7	34.6, 36.8
	Pain Prevents Few Activities	17.7	16.8, 18.6
	Pain Prevents Some Activities	5.8	5.3, 6.3
	Pain Prevents Most Activities	2.1	1.8, 2.4
Perceived Health Status	Excellent Health	21.8	20.8, 22.8
	Very Good Health	41.7	40.6, 42.8
	Good Health	28.2	27.2, 29.2
	Fair Health	6.8	6.2, 7.4
	Poor Health	1.6	1.3, 1.9

The *Well Being Score* was an average of 31.7 out of 42. Over 50% reported that they were very or fairly stressed. A secondary school education was the highest level completed for 26.5% of the subjects. Almost 70% of the respondents were working, and most respondents described spending most of their day sitting or standing, with a smaller proportion carrying heavy loads. The mean *Number of Health Problems* per subject reported was 1.5±0.1 problems, out of a maximum possible number of 8 problems. 39.3% reported having a long term *Illness*. Slightly over three percent of the respondents reported a previous accident while walking, bicycling or playing sports, the same percentage who reported difficulties with mobility. Over 80% of the subjects reported being usually free of pain and discomfort, but in a separate item, only 74.4% reported being free of pain, or having pain or discomfort which does not prevent most activities. Only 21.8% perceived their health as excellent. Subjects included in the study made an average of 4.7 visits to their family doctor in the previous year.

5.2 Comparison Of OHS To 1991 Ontario Census

Table 5.2 reports a comparison between the OHS data set and data from the 1991 Canadian Census. 95% confidence limits are reported for the OHS data, which were calculated from the standard errors from the adjusted OHS means and proportions obtained from SUDAAN. Design effects are also reported.

The *Gender* proportions are both close to 50%, even though the confidence limits of the OHS do not include the Census values. Age group comparisons were also similar with differences ranging between one and two percent.

Table 5.3

A Comparison of 1991 Canadian Census Data With 1990 Ontario Health Survey (OHS) Data

		Census Percentage*	OHS Percentage (Adjusted)	95% Confidence Level	Design Effect
Gender	Male	49.1	48.6	48.1 , 49.1	1.1
	Female	50.9	51.4	50.9 , 51.9	1.1
Age Group	15 - 19	8.5	9.5	9.0 10.0	3.1
	20 - 24	9.2	8.8	8.3 , 9.3	3.4
	25 - 29	11.3	10.2	9.7 , 10.7	3.6
	30 - 34	11.4	11.1	10.6 , 11.6	3.5
	35 - 39	10.3	10.7	10.2 , 11.2	3.5
	40 - 44	9.6	9.9	9.4 , 10.4	3.1
	45 - 49	7.5	7.5	7.1 , 7.9	2.8
	50 - 54	6.2	6.4	6.0 , 6.8	2.8
	55 - 59	5.7	5.7	5.3 , 6.1	3.1
	60 - 64	5.6	5.5	5.1 , 5.9	3.0
	65- 74	8.9	9.5	9.0 , 10.0	3.5
	75 +	5.9	5.1	4.7 , 5.5	2.9
Household Size	1 person	21.8	19.4	18.2 , 20.6	5.2
	2 persons	31.1	31.7	30.8 , 32.6	2.3
	3 persons	17.4	18.5	17.8 , 19.3	2.4
	4 or more persons	29.8	30.4	29.3 , 31.5	3.4
Marital Status	Single	28.8	24.2	23.5 , 24.9	3.6
	Married	56.4	65.6	64.7 , 66.4	3.6
	Separated/Divorced	8.2	4.7	4.3 , 5.1	3.3
	Widowed	6.5	5.6	5.2 , 6.0	3.3
Sample Size		10,084,885.0	48,862.2 (weighted count)		

All values are reported as percentages of OHS sample, except for Sample Size, which is reported as the actual number, and Design Effect.
* Source: Statistics Canada, 1994 (91).

A small discrepancy occurs in the *Marital Status* category. This item includes all subjects over the age of 15 in both the Census and the OHS. The OHS defines the 'married' category as 'married or living common-law' whereas the Census questionnaire refers to 'legally married' and asks a separate question about 'living with a common law partner' (75). This likely accounts for the difference in the results of the two surveys.

The design effect is reported for the variables in this table. For all variables the design effect exceeds one, which indicates that the variance of the mean of the sample variable is greater than the estimated variance of the mean of the same variable for the population.

5.3 Contrasting Groups Analysis

There were 2701 subjects in the *energy expenditure (NEW)* equals 0 KKD group. 0 KKD is the mode of the distribution of *energy expenditure (NEW)* representing over 13% of the sample used for this thesis. There were 178 subjects in the *energy expenditure (NEW)* > 10 KKD group. In order to be included in the *energy expenditure (NEW)* > 10 KKD group, an individual would have reported walking a minimum of five hours per day or cross country skiing (or performing an equivalent activity) over two hours every single day (i.e., a very high level of activity). A comparison of the subjects in the higher group compared to those in the lower group is presented in Table 5.4 (Continuous Variables) and in Table 5.5 (Categorical Variables).

Table 5.4

Comparison of Extreme Groups of Energy Expenditure - Continuous Variables

Variable	Level	Low Group Energy Expenditures = 0 kcal/kg/day N=2701		High Group Energy Expenditure >= 10 kcal/kg/day N=178		Significance
		Mean Score	95% Confidence Limits	Mean Score	95% Confidence Limits	
Social Variables	Household Size	3.3	3.2 ,3.4	3.1	2.9, 3.3	NS
	Household Income	7.2	7.0, 7.4	8.0	7.5, 8.5	*
	Family Functioning Score	27.4	27.2, 27.6	27.8	30.2, 33.0	NS
Physiological Variables	Age	45.2	44.1, 46.3	31.1	28.9, 33.3	*
	BMI	25.2	25.0, 25.5	24.9	24.2, 25.8	NS
	Number of Health Problems	1.6	1.5, 1.7	1.4	1.2, 1.6	NS
Other Personal Variables	Physician Visits	5.6	5.0, 6.2	3.5	2.6, 4.4	*
	Well Being Score	29.6	29.1, 30.1	31.6	28.9, 33.3	*

* p<0.01
NS Non Significant

Table 5.5

Comparison of Extreme Groups of Energy Expenditure - Categorical Variables

Variable	Level	Low Group Energy Expenditures = 0 kcal/kg/day N=2701		High Group Energy Expenditure >= 10 kcal/kg/day N=178		Significance
		Proportion	95% Confidence Level	Proportion	95% Confidence Level	
Environmental Variables						
Stratum	Rural	14.5	13.0, 16.0	17.6	14.9, 23.2	NS
	Urban	85.5	84.0, 87.0	82.4	76.8, 88.0	
Social Variables						
Proportion of Friends Who Exercise	None of them	29.8	26.8, 32.8	6.8	1.5, 12.1	**
	Few of them	57.6	54.4, 60.8	44.9	33.5, 55.2	
	Half of them	8.4	6.8, 10.0	17.7	10.7, 24.7	
	Most of them	4.0	2.9, 5.1	25.2	17.0, 33.2	
	All of them	0.34	0.12, 0.60	5.5	1.8, 9.2	
Household Type	Head & Spouse With No Children	40.1	36.8, 43.4	30.2	21.0, 39.4	**
	Head & Spouse With Children	43.6	40.3, 46.9	35.8	26.8, 44.8	
	Other	16.3	13.7, 18.9	33.9	23.6, 44.2	
Marital Status	Married	78.9	76.2, 81.6	46.9	36.9, 56.9	**
	Single	10.9	9.7, 12.1	46.4	36.2, 56.6	
	Widowed	5.3	4.1, 6.5	0.24	0.01, 0.72	
	Separated or Divorced	4.9	3.7, 6.1	6.50	2.2, 10.8	
Ethnic Group	Canadian	37.9	36.7, 41.1	57.8	47.8, 67.8	**
	Canadian and Other	19.1	16.6, 21.6	20.3	11.3, 29.3	
	Other	43.0	39.0, 47.0	21.9	13.9, 29.9	
Physiological Variables						
Gender	Male	52.3	49.4, 55.1	74.9	66.7, 83.1	**
	Female	47.8	45.0, 50.6	25.2	16.9, 33.5	

* p<0.05
** p<0.01
NS Non Significant

Table 5.5

Comparison of Extreme Groups of Energy Expenditure - Categorical Variables

Variable	Level	Low Group Energy Expenditures = 0 kcal/kg/day N=2701		High Group Energy Expenditure >= 10 kcal/kg/day N=178		Significance
		Proportion	95% Confidence Level	Proportion	95% Confidence Level	
Other Personal Variables						
Occupational Status	Working	68.4	65.4,71.4	69.60	60.4, 68.8	**
	Looking For Work	1.2	0.6, 1.7	1.60	0.01, 4.2	
	Going To School	3.7	2.4, 5.0	25.1	16.3, 33.9	
	Other	26.8	24.0, 29.6	3.6	1.2, 6.0	
Work Type	Usually Sit	31.4	28.4, 34.4	18.0	9.3, 26.7	*
	Stand	45.4	42.5, 48.3	50.6	40.6, 60.6	
	Lift, Carry or Climb	15.3	14.3, 16.3	22.1	14.1, 30.1	
	Carry Heavy Loads	7.9	6.5, 9.3	9.3	4.3, 14.3	
Education Level	Primary Education	16.6	14.3,18.9	1.1	0.1, 2.5	**
	Some Secondary Education	25.8	23.1, 29.5	24.7	16.0, 33.4	
	Completed Secondary Education	27.9	25.1, 30.7	32.4	22.8, 42.0	
	Some Post Secondary Education	9.7	8.1, 11.3	17.8	14.3, 21.2	
	Completed Post Secondary Education	19.9	16.9, 22.9	23.8	14.9, 32.7	
Smoking Status	Never Smoked	39	35.8, 42.2	41.4	31.8, 51.0	NS
	Former Smoker	23.7	21.1, 26.3	20.2	12.2, 28.2	
	Current Smoker	37.3	34.5,40.1	38.4	28.6, 48.2	
Drinking Status	Never Drank	13.1	10.5, 15.7	1.5	0.1, 2.9	**
	Former Drinker	9.4	7.8, 11.0	6.3	1.5, 11.1	
	Current Drinker	77.5	74.5, 80.5	92.2	87.1, 97.3	
Perceived Stress	Very Stressed	8.8	7.2, 10.4	11.1	3.5, 18.7	NS
	Fairly Stressed	44.0	40.8, 47.2	47.4	36.72, 57.6	
	Not Very Stressed	38.9	35.9, 41.9	37.2	27.3, 47.1	
	Not Stressed	8.3	6.5, 10.1	4.4	0.8, 8.0	
Iiness	Yes	44.1	40.9, 47.3	23.9	15.5, 32.3	**
	No	55.9	52.6, 59.1	76.2	67.8, 84.6	
Acitivity Accident	Yes	1.5	0.7, 2.3	15.0	7.6, 23.4	**
	No	98.5	97.7, 99.3	85.8	76.6, 93.4	
Mobility Limitations	Yes	5.3	4.0, 6.6	0.13	0.01, 0.39	**
	No	94.7	93.3, 96.0	99.9	99.6, 99.9	
Painfree	Yes	80.3	77.8, 82.8	94.2	90.8, 97.6	**
	No	19.7	18.2, 21.5	5.8	2.4, 9.2	
Pain Limitations	Painfree	31.8	28.7, 34.7	40.7	30.7, 50.7	**
	Pain Prevents No Activities	34.7	31.7, 37.7	41.3	31.3, 51.3	
	Pain Prevents Few Activities	18.0	15.6, 20.4	15.1	8.3, 21.9	
	Pain Prevents Some Activities	9.8	8.0, 11.6	2.0	0.1, 4.0	
	Pain Prevents Most Activities	5.8	4.4, 7.2	0.9	0.1, 3.0	
Perceived Health Status	Excellent Health	14.3	13.2, 15.4	36.5	26.5, 46.5	**
	Very Good Health	36.8	34.1, 39.5	38.1	28.4, 47.8	
	Good Health	32.6	29.8, 35.4	22.6	15.0, 30.2	
	Fair Health	12.0	9.6, 14.4	2.5	0.1, 5.0	
	Poor Health	3.7	2.5, 4.9	0.30	0.01, 0.74	

* $p<0.05$
** $p<0.01$
NS Non Significant

The subjects in the group who expended 10 KKD or more were much younger (31.1 years (28.9, 33.3)) than the other group (45.2 years (44.1, 46.3)). Subjects in the over 10 KKD group had less visits to physicians, had a higher total *Household Income*, reported a higher wellness score, were more likely to be higher educated, were more likely to have friends who exercised, were more likely to be single, less likely to have jobs where they sit all day, more likely to have been in an accident from walking or cycling, less likely to require mobility assistance, more likely to be pain free and less likely to have had a target *Illness*, more likely to describe their ethnic background as Canadian, more likely to have a self-perception of good health, and more likely to be male. These were all significant at $p < 0.05$ level.

Smoking Status, *Perceived Stress*, *Stratum*, *Number of Health Problems*, *BMI*, *Family Functioning Score*, and *Household Size* were not found to be statistically significant between the two groups.

5.4 Regression Analyses - The Primary Objective

As described in Section 4.2, stepwise regressions and diagnostic tests for the regressions were performed using SAS software. SUDAAN software was used for a final backward stepping procedure and for model testing. The outcome variable for the analyses was the *cube root (EE)* (the basis for the transformation was described in Section 4.6).

5.4.1 Stepwise Regression

The stepwise regression involved 26 potential predicting variables (or groups of variables in the case of 'dummy variables') with both entry and exit levels set at $p < 0.15$. Nineteen variables entered the model, and none were subsequently removed. The backwards stepping in SUDAAN resulted in no variables being removed from the model. The results of this procedure are shown in Table 5.6. The increase in the R^2 was less than one percent per variable after the first three variables had entered the model.

The strongest predictor of the *cube root (EE)* was *Proportion of Friends Who Exercise* with an R^2 of 0.11. This R^2 was over four times the change in R^2 resulting from adding the next strongest predictor, *Marital Status*. The only other independent variable in this model which resulted in an increase in R^2 greater than 0.01 was *Perceived Health Status* (R^2 increase of 0.02). The other 16 variables which were added to the model using the stepwise approach were: *Education Level, Activity Accident, Work Type, Occupational Status, Gender, Drinking Status, Ethnic Group, Well Being Score, Mobility Limitations, Age, Household Size, Smoking Status, Household Income, BMI, Number of Health Problems* and *Household Type*.

5.4.2 Diagnostic Testing

Homoscedasticity was tested by assessing the variance of the residuals at different values of the predicted dependent variable. Although homoscedasticity by definition is a constant variance of the dependent variable for all values of the independent variable, testing is done at different values of the dependent variable because it would be extremely difficult to test at all levels of the combinations of the 19 independent variables. The plot in Figure 5.1 illustrates the variances of the residuals at multiple levels of the dependent variable. The variance is equal to 0.1 when the predicted *cube root (EE)* is equal to zero,

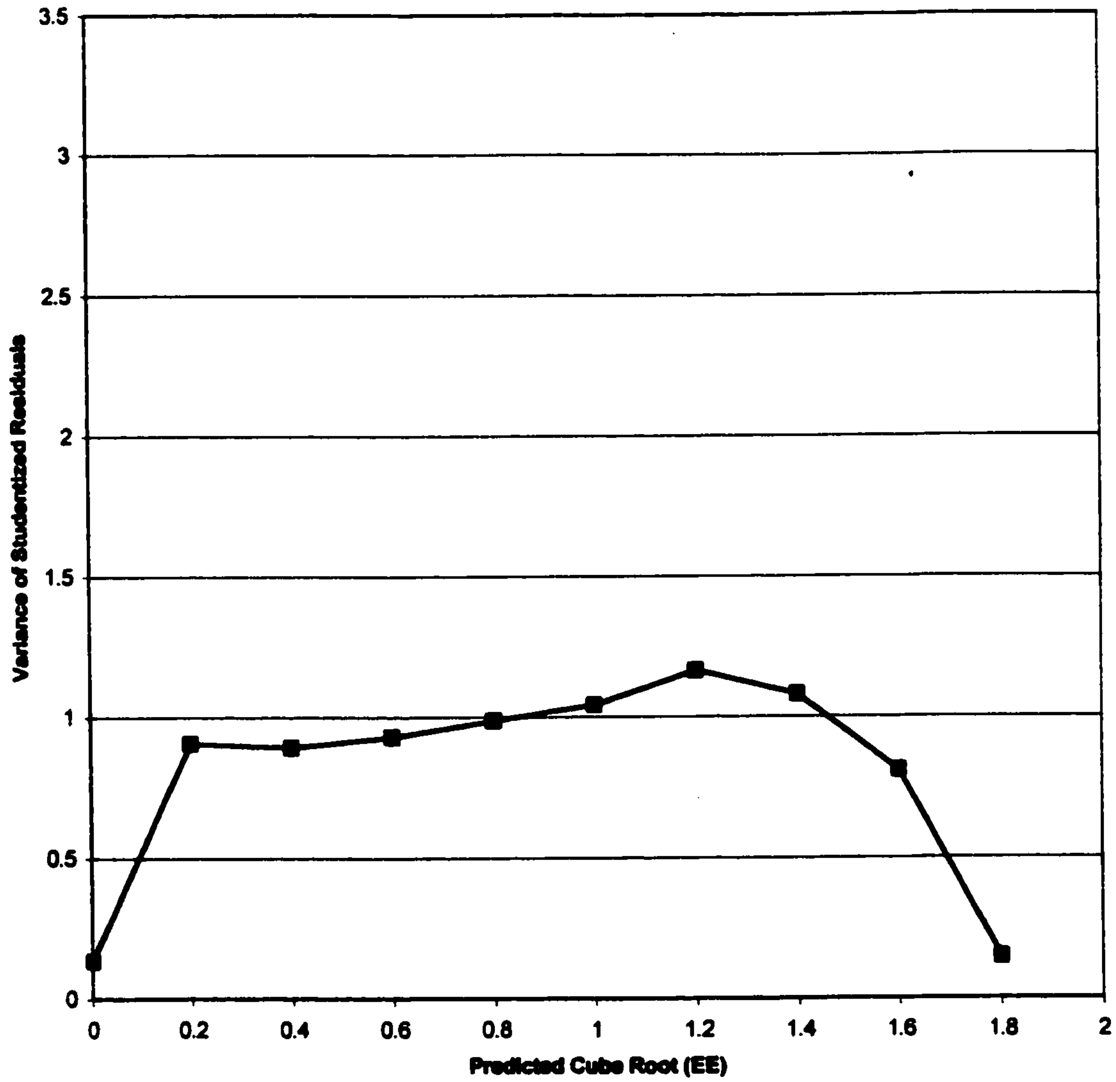
Table 5.6

Variables Entered Into the Whole Model Using Stepwise Methods

Name	Partial R^2	Model R^2	Significance
Proportion of Friends Who Exercise	0.111	0.111	**
Marital Status	0.027	0.138	**
Perceived Health Status	0.023	0.161	**
Education Level	0.010	0.170	**
Activity Accident	0.008	0.178	**
Gender	0.006	0.184	**
Work Type	0.006	0.190	**
Occupational Status	0.005	0.195	**
Drinking Status	0.006	0.201	**
Ethnic Group	0.002	0.203	**
Well Being Score	0.002	0.205	**
Mobility Limitations	0.002	0.206	**
Smoking Status	0.001	0.207	**
Age	0.002	0.209	**
Household Size	0.002	0.211	**
Household Income	0.001	0.212	**
Body Mass Index	0.001	0.212	**
Number of Health Problems	0.001	0.213	*
Household Type	0.001	0.213	*

* $p<0.0001$
** $p<0.00001$

Figure 5.1 Comparison of the Variance of Residuals for Regression Analysis Of 19 Variables on Cube Root of Energy Expenditure (NEW)



increases to a value of 1.2 and returns back down to 0 when the predicted *cube root (EE)* equals 1.8.

The normal probability plot (Figure 5.2) that assesses the residuals for the multivariate analysis also deviates from the 45-degree line. The deviation occurs at the two ends of the distribution, similar to where the deviation occurs in the homoscedasticity plot. Linearity for the continuous variables was tested in the 19 variable model by using partial residual plots. Partial residual plots have been recommended in the literature as a suitable test for linearity (96, 97). A straight line in the graph indicates that the assumption of linearity has been met. In order to make the patterns interpretable with 20,606 data points, a lowess smoothed curves were plotted (96).

The six plots are included in Figure 5.3. The plot for *Age* and *Number of Health Problems* appear to meet the requirements for linearity. The plot for *Household Size* deviates from the straight line, but only 0.3% of the sample have a *Household Size* of greater than eight, where the deviation occurs. There is also a major deviation from the straight line in the Income plot, but this deviation represents four percent of the sample.

Wellness score and BMI both have apparent major deviations from the straight line. In both cases, the deviations represent approximately 10% of the data. It would appear that activity is underestimated in the lower range of *BMI* and in the upper range of *BMI.* The plot for *Wellness Score* is more difficult to interpret. It appears that there is a deviation at *Wellness Score* of 38 and 39. This is a difficult to explain.

It would appear that *cube root (EE)* is not a perfect choice of outcome variable, but the analysis using the *cube root (EE)* variable more closely meets the assumptions associated with the statistical procedure of multiple linear regression than *energy expenditure (NEW)*. A major transformation has already been performed with the data and *cube root (EE)* will be accepted as the outcome variable for this analysis.

Figure 5.2 Normal Probability Plot – Assessing Normality of Residuals for Regression Analysis Of 19 Variables on Cube Root of Energy Expenditure (NEW)

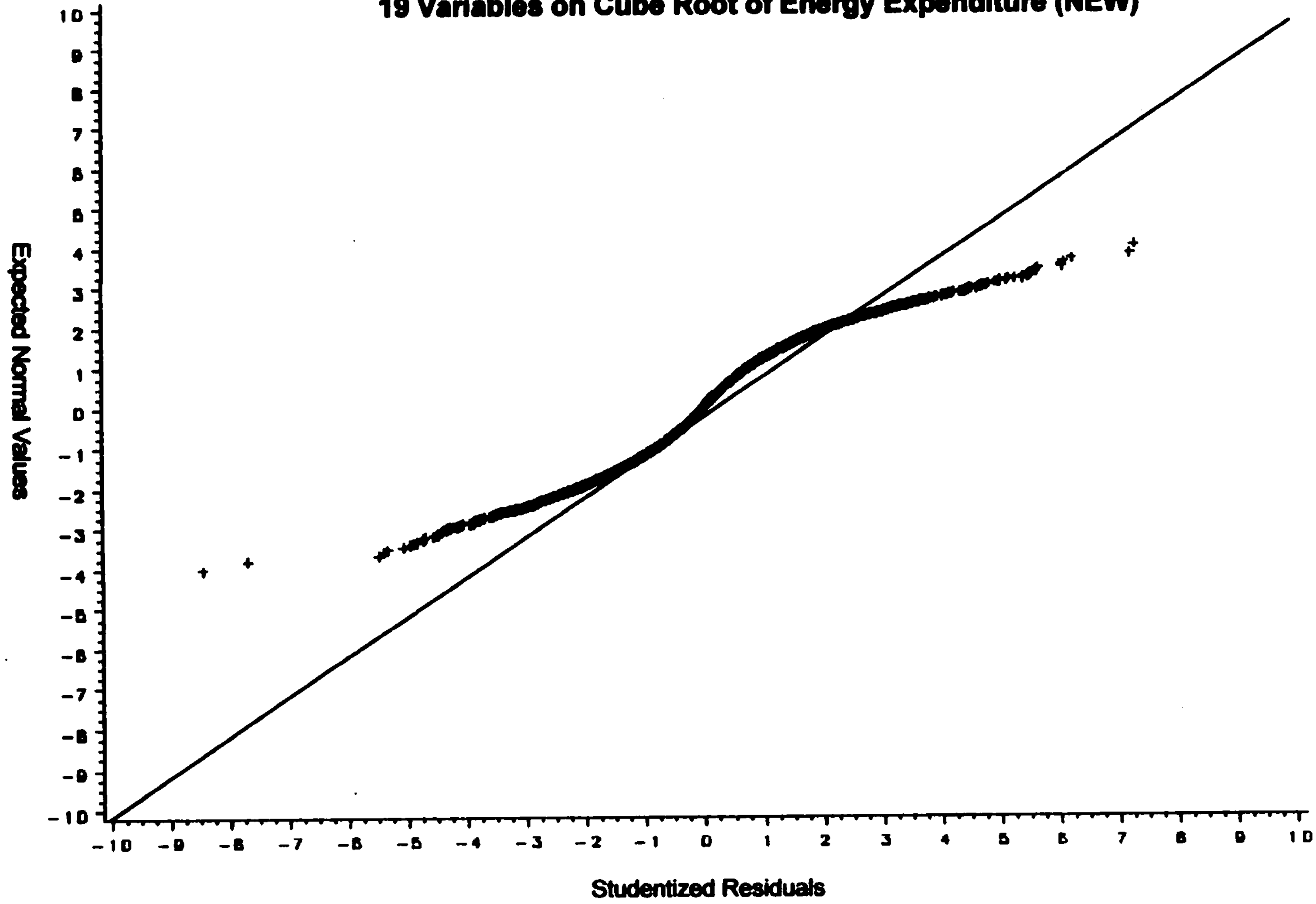
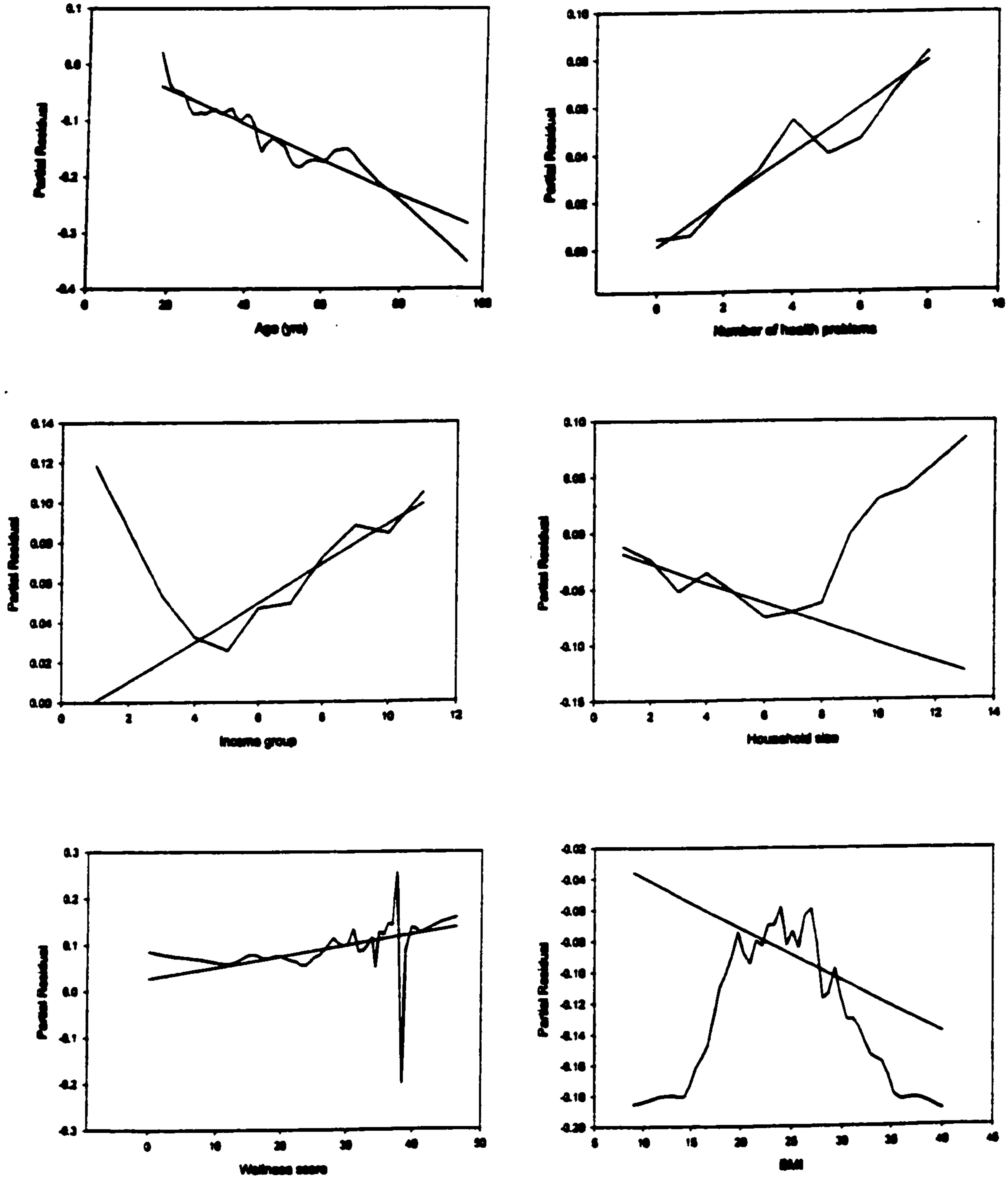


Figure 5.3

Partial Residual Plots



5.5 Model Testing – The Primary Objective

From the stepwise regression analysis, three models were evaluated. The first model included only the three strongest predictors: *Proportion of Friends Who Exercise, Marital Status* and *Perceived Health Status.* The model with three variables was selected because the fourth variable (*Education Level*) had an R^2 of 0.010, which was less than one-half the R^2 of each of the previous three variables. The second model included *Proportion of Friends Who Exercise, Marital Status* and *Perceived Health Status,* plus *Age* and *Gender. Age* and *Gender* were added because they have been extensively studied and proven in the literature to be predictors of energy expenditure (Section 1.5). The third model included all 19 of the variables that reached statistical significance in the stepwise model. All model testing was done using SUDAAN software; beta coefficients and confidence limits for the three models are listed in Table 5.7.

As described in the Chapter 4, all model comparisons were done using SUDAAN software with statistical significance determined by the Satterthwaite Adjusted F statistic to compare the models. Comparisons were done between Model 1 and Model 2 and between Model 2 and Model 3. The comparison of Model 1 (three independent variables) to Model 2 (Model 1 plus *Age* and *Gender*) demonstrated that Model 2 was a statistically significant improvement compared to Model 1 (Wald F statistic 54.7, $p<0.0001$). Model 3 (all nineteen variables) was a statistically significant improvement compared to Model 2 (Wald F statistic 23.5, $p <0.0001$).

Table 5.7

Comparison of Variables in Three (3) Models

Variable	Level	Model 1 Beta Coeffient	Model 1 95% Confidence	Model 2 Beta Coeffient	Model 2 95% Confidence	Model 3 Beta Coeffient	Model 3 95% Confidence
Intercept		0.46	(040, 0.52)	0.73	(0.65, 0.81)	1.4	(1.22, 1.58)
Social Variables							
Proportion of Friends Who Exercise	None of Them						
	All of them	0.63	(0.55, 0.71)	0.61	(0.53, 0.69)	0.55	(0.47, 0.63)
	Most of them	0.49	(0.45, 0.53)	0.47	(0.43, 0.51)	0.40	(0.6, 0.44)
	Half of them	0.34	(0.30, 0.38)	0.33	(0.29, 0.37)	0.27	(0.23, 0.31)
	Few of them	0.19	(0.15, 0.23)	0.19	(0.15, 0.23)	0.14	(0.10, 0.18)
Household Size						-0.01	(-0.02, 0.00)
Household Type	Other						
	Head and Spouse/no children					-0.03	(-0.07, 0.01)
	Head and Spouse/children					-0.0500	(-0.07, -0.01)
Marital Status	Separated or Divorced						
	Married or Widowed	-0.05	(-0.09, -0.01)	-0.07	(-0.11, -0.03)	-0.05	(-0.11, 0.01)
	Single	0.15	(0.11, 0.19)	0.10	(0.06, 0.14)	0.06	(0.00, 0.12)
Household Income						0.01	(0.01, 0.01)
Ethnic Group	Other						
	Canadian					0.05	(0.03, 0.07)
	Canadian and other					0.04	(0.02, 0.06)
Physiological Variables							
Age				-0.002	(-0.003, - 0.001	-0.003	(-0.004, -0.002)
Gender	Males						
	Females			-0.08	(-0.10, -0.06)	-0.11	(-0.13, -0.09)
Body Mass Index						-0.0037	(-0.0054, -0.0020)

Table 5.7

Comparison of Variables in Three (3) Models

Variable	Level	Model 1		Model 2		Model 3	
Other Personal Variables							
Occupational Status	Retired or keeping house						
	Working/ looking for work					-0.09	(-0.11, -0.07)
	School					0.04	(-0.02, 0.10)
Work Type	"Heavy work",						
	Sitting around much of day					-0.03	(-0.09, 0.03)
	"Standing, lifting, carrying					0.05	(0.01, 0.09)
Education Level	Post Secondary Education						
	Primary Education					-0.16	(0.20, -0.12)
	Some Secondary Education					-0.03	(-0.05, -0.01)
	Completed Secondary Education					0.005	(-0.02, 0.03)
Smoking Status	Current Smoker						
	Never Smoked/Former Smoker					0.05	(0.03, 0.07)
Drinking Status	Current drinker						
	Never Drank					-0.13	(-0.17, -0.09)
	Former drinker					-0.03	(-0.07, 0.01)
Well Being Score						0.003	(0.002, 0.003)
Number of Health Problems						0.01	(0.01, 0.01)
Activity Accident	Yes						
	No					-0.20	(-0.24, -0.16)
Mobility Limitations	None						
	Yes					-0.14	(-0.20, -0.08)
Perceived Health Status	Fair or Poor Health						
	Excellent Health	0.28	(0.24, 0.32)	0.26	(0.22, 0.30)	0.18	(0.14, 0.22)
	Very Good Health	0.17	(0.13, 0.21)	0.16	(0.12, 0.20)	0.09	(0.05, 0.13)
	Good Health	0.11	(0.07, 0.15)	0.10	(0.06, 0.14)	0.05	(0.01, 0.09)

The three variables that were included in all three models (*Proportion of Friends Who Exercise*, *Marital Status* and *Perceived Health Status*.) have consistent beta values across all the models. The results show that as the subjects report a higher proportion of their friend's exercising, the amount of leisure time physical activity that is done is higher. In all three models, the *cube root (EE)* increases as *Perceived Health Status* increases; for *Marital Status* (with separated or divorced as the reference category), a lower physical activity level is associated with subjects who are married or widowed, and a higher level of energy expenditure is associated with subjects who are single.

Age and *Gender*, the only other variables that are in both Model 2 and Model 3, follow the same trend in the two models in which they are included. Older people tend to have lower levels of physical activity than younger people do. The beta coefficient for age is close to zero for both models, -0.002 for the five variable model, -0.003 for the nineteen variable model). In both models, being male is associated with a higher level of physical activity.

Model 3 contains 14 additional variables that are not included in either of the other models. Five of these 14 variables are continuous variables, three are dichotomous variables and six are multi-level categorical variables. *Well Being Score*, *Household Income* and *Number of Health Problems* have a positive relationship with the *cube root (EE)*, and *BMI* has an inverse relationship with the outcome variable. *Household Size* also appears to have an inverse relationship, but the confidence limits of the beta-coefficient include zero. Positive relationships with the outcome variables are found for those subjects who reported a previous accident walking, bicycling or playing sports (compared to those who reported not having had an accident), those subjects who were never smokers or former smokers compared to current smokers; and subjects who reported having no *Mobility Limitations* as compared to those subjects who reported limitation in their mobility.

Of the six multi-level categorical variables, three variables follow an inconsistent pattern. Subjects who reported having completed 'some post secondary or having completed post secondary' education exercise more than subjects who have only completed primary or only some secondary education, but exercise less than subjects who have completed only secondary education. Subjects who reported that they perform 'heavy work' exercise more than subjects who 'sit around much of the day' but less than those subjects who 'stand, lift or carry light loads'. Subjects who were retired exercise a similar amount to those subjects who are in school but more than those subjects who are working or looking for work do. A *Drinking Status* of 'occasional or current drinker' all have the most positive influence on the *cube root (EE).* An *Ethnic Group* type of 'Canadian', and a *Household Type* which is not 'a head and spouse with or without children' were both associated with a higher level of physical activity.

5.6 Sub-group Analyses: The Secondary Objective

All the sub-group analyses are described in Tables 5.8, 5.9, and 5.10. Comparisons between comparable groups (e.g., urban dwellers versus rural dwellers) are summarized below. In the sections remaining in this chapter, independent variables are discussed only if they were found to have a significant relationship with the outcome variable. The terms, 'positive relationship' or 'negative relationship', indicate in which direction the outcome variable is associated with the predictor variable. Categorical variables are described by identifying which level of the independent variable (in brackets) is associated with the highest level of physical activity.

Age Group Comparisons

There were 2,675 subjects in the 18-25 age group, 11,231 subjects in the 25-45 age group, 4,165 subjects in the 45-60 age group and 2,535 in the 60+ age group. The *energy expenditures (NEW)* reported for these groups were 2.15 KKD, 1.26 KKD, 0.98 KKD and 0.95 KKD respectively. The significant independent variables and the beta coefficients are compared between age groups in Table 5.8.

In the 18-25 age group, 13 variables were identified in the SAS analysis, but *MD Visits* was excluded in the SUDAAN testing. The R^2 for the remaining 12 predicting variables was 0.21. There were no predictors in this age group that were not identified in at least one other age group. The 12 variables that were identified as predictors were: *Proportion of Friends who Exercise* (positive relationship), *Marital Status* ('Separated or divorced'), *Education Level* ('Some secondary school'), *Activity Accident* ('Yes'), *Work Type* ('Standing, lifting or carrying') *Occupational Status* ('School'), *Gender* ('Male'), *Drinking Status* ('Current drinker'), *Smoking Status* (' Never smoked or former smoker'), *Ethnic Group* ('Canadian'), *Age* (negative relationship), and *Perceived Health Status* ('Excellent Health'). The confidence limits for four variables (*Ethnic Group, Age, Occupational Status* and *Work Type*) all included zero.

Table 5.8

Comparison of Beta Coefficients in Different Age Groups

Variable	Level	Age <25		Age 25-45		Age 45-60		Age 60 +	
		Beta Coefficient	95% Confidence	Beta Coefficient	95% Confidence	Beta Coefficient	95% Confidence	Beta Coefficient	95% Confidence
Intercept		1.56	1.03 , 2.09	1.36	1.12 , 1.60	0.92	0.43 , 1.41	0.88	0.47 , 1.29
Social Variables									
Proportion of Friends Who Exercise	None of Them								
	All of them	0.60	0.47 , 0.73	0.47	0.35 , 0.59	0.47	0.35 , 0.59	0.60	0.44 , 0.76
	Most of them	0.42	0.31 , 0.53	0.38	0.33 , 0.43	0.43	0.35 , 0.51	0.38	0.28 , 0.48
	Half of them	0.24	0.14 , 0.34	0.25	0.20 , 0.30	0.29	0.22 , 0.36	0.32	0.23 , 0.41
	Few of them	0.17	0.08 , 0.26	0.12	0.074 , 0.17	0.13	0.073 , 0.19	0.17	0.11 , 0.23
Household Size						-0.014	-0.036 , 0.0076	-0.047	-0.072 , -0.022
Household Type	Other								
	Head and Spouse/no children			-0.076	-0.14 , -0.016	-0.11	-0.21 , -0.010		
	Head and Spouse/children			-0.11	-0.17 , -0.052	-0.11	-0.22 , -0.00024		
Marital Status	Separated or Divorced								
	Married or Widowed	-0.22	-0.42 , -0.024	0.0017	-0.074 , 0.078	0.048	-0.087 , 0.18		
	Single	-0.14	-0.34 , 0.056	0.048	-0.018 , 0.11	0.13	-0.0052 , 0.27		
Household Income						0.015	0.0046 , 0.03	0.018	0.0049 , 0.031
Ethnic Group	Other								
	Canadian	0.065	0.00032 , 0.13	0.054	0.022 , 0.086	0.044	-0.0030 , 0.091		
	Canadian and other	0.052	-0.69 , 0.80	0.049	0.009 , 0.089	0.028	-0.023 , 0.079		
Family Functioning Score						0.0062	-0.00 , 0.01		
Physiological Variables									
Age		-0.012	-0.028 , 0.0045	-0.0023	-0.0047 , 0.00010			-0.0060	-0.010 , -0.0017
Gender	Males								
	Females	-0.14	-0.19 , -0.085	-0.090	-0.12 , -0.062	-0.69	-0.73 , -0.65	-0.14	-0.19 , -0.095
Body Mass Index				-0.0050	-0.0084 , -0.0016	-0.0042	-0.0093 , 0.00090		

Table 5.8

Comparison of Beta Coefficients in Different Age Groups

Variable	Level	Age <25 Beta Coefficient	Age <25 95% Confidence	Age 25-45 Beta Coefficient	Age 25-45 95% Confidence	Age 45-60 Beta Coefficient	Age 45-60 95% Confidence	Age 60 + Beta Coefficient	Age 60 + 95% Confidence
Other Personal Variables									
Occupational Status	Retired or keeping house								
	Working/ looking for work	-0.0048	-0.10 , 0.093	-0.035	-0.073 , 0.0030	-0.10	-0.15 , -0.051	-0.18	-0.25 , -0.11
	School	0.061	-0.053 , 0.17	0.072	-0.030 , 0.17	-0.11	-0.30 , 0.076	0.10	-0.31 , 0.51
Work Type	Heavy work								
	Sitting around much of day	-0.065	-0.17 , 0.039	-0.0015	-0.070 , 0.067	0.037	-0.075 , 0.15	-0.054	-0.27 , 0.16
	Standing, lifting, carrying	0.061	-0.037 , 0.16	0.048	-0.016 , 0.11	0.076	-0.032 , 0.18	0.17	-0.046 , 0.39
Education Level	Post Secondary Education								
	Primary Education	0.011	-0.20 , 0.23	0.19	0.10 , 0.28	-0.20	-0.27 , -0.13	-0.16	-0.24 , -0.084
	Some Secondary Education	0.081	0.012 , 0.15	-0.064	-0.10 , -0.026	-0.092	-0.15 , -0.035	-0.092	-0.17 , -0.018
	Completed Secondary Educatio	0.016	-0.055 , 0.087	-0.020	-0.054 , 0.014	-0.031	-0.084 , 0.022	-0.0081	-0.083 , 0.066
Smoking Status	Current Smoker								
	Never Smoked/Former Smoker	0.58	0.53 , 0.63			0.11	0.063 , 0.16	0.059	-0.0018 , 0.12
Drinking Status	Current Drinker								
	Never Drank	-0.18	-0.29 , -0.074	-0.17	-0.23 , -0.11	-0.12	-0.20 , -0.042		
	Former Drinker	-0.049	-0.16 , 0.067	-0.015	-0.071 , 0.041	-0.40	-0.46 , -0.34		
Physician Visits									
Well Being Score				0.0026	0.00060 , 0.0046	0.0059	0.0024 , 0.0094	0.0037	-0.0006 , 0.0080
Stress	Fairly/Very Stressed								
	Not Very/Not Stressed					0.028	-0.015 , 0.071		
Number of Health Problems				0.013	0.0020 , 0.024				
Activity Accident	Yes								
	No	-0.17	-0.25 , -0.088	-0.21	-0.28 , -0.14	-0.27	-0.40 , -0.14		
Mobility Limitations	None								
	Yes			-0.096	-0.21 , 0.016	-0.11	-0.26 , 0.039		
Pain Limitations	Pain Prevents Most Activities								
	Painfree					0.099	-0.060 , 0.26	0.16	0.035 , 0.29
	Pain Prevents No Activities					0.12	-0.039 , 0.28	0.13	0.014 , 0.25
	Pain Prevents Few Activities					0.10	-0.059 , 0.26	0.12	0.0083 , 0.23
	Pain Prevents Some Activities					0.062	-0.091 , 0.21	0.030	-0.080 , 0.14
Perceived Health Status	Fair or Poor Health								
	Excellent Health	0.17	0.05 , 0.29	0.25	0.18 , 0.32	0.053	-0.033 , 0.14	0.079	-0.031 , 0.19
	Very Good Health	0.12	0.00 , 0.24	0.14	0.076 , 0.20	-0.020	-0.10 , 0.06	-0.020	-0.11 , 0.070
	Good Health	0.045	-0.073 , 0.16	0.092	0.030 , 0.15	-0.034	-0.11 , 0.04	-0.041	-0.12 , 0.039

In the 25-45 age group, 19 variables were identified as potential predictors in the SAS procedures and three variables (*Smoking Status*, *Household Size*, and *Household Income*) were excluded in the SUDAAN testing. The total R^2 for this model was only 0.16. *Household Type* ('Other'), *BMI* (negative relationship), *Mobility Limitations* ('None'), *Number of Health Problems* (positive relationship) and *Well Being Score* (positive relationship) were included in this model and not in the younger age group model. *Smoking Status* was the only variable in the under-25 age group model that was not included in this model. The confidence limits for the beta coefficients of *Marital Status, Age, Occupational Status, Work Type,* and *Mobility Limitations* all included zero.

The 45 - 60 age group had 20 predicting variables. None were removed in the SUDAAN testing. The R^2 was 0.21. Nine variables were included in this model which were not included in the youngest age group: *Household Type* ('Other'), *Household Income* (positive relationship), *Family Functioning Score* (Positive relationship), *Mobility Limitations* ('None') *Household Size* (negative relationship), *BMI* (negative relationship), *Well Being Score* (positive relationship), *Perceived Stress* ('Not stressed') and *Pain Limitations* ('Pain prevents no activities'). *Age* was the only variable which was included in the youngest studied age group, but was not significant in the '45 - 60' group model. *Household Size, Marital Status, Ethnic Group, Work Type, Mobility Limitation, Family Functioning Score, BMI, Pain Limitations* and *Perceived Health Status* all have beta coefficients that included zero.

The 60+ age group model had 16 variables identified in the SAS testing, but four were excluded in the SUDAAN testing (*Ethnic Group, Drinking Status, Number of Health Problems*, and *Mobility Limitations*). The remaining 12 variables resulted in an R^2 of almost 0.30, the largest R^2 of any age group evaluated in this study. Four variables were included in this model which were not in the youngest age group model: *Pain Limitations* ('Painfree'), *Household Size* (positive relationship), *Well Being Score* (positive relationship) and *Household Income* (positive relationship). *Marital Status, Ethnic Group,* *Drinking Status* and *Activity Accident* were all included in the '< 25' model, but were not significant in the oldest group studied. The confidence limits for the beta coefficients of *Work Type, Perceived Health Status,* and *Smoking Status* all included zero in the 60+ age group.

Six variables were included in the models of all four age groups. Only two of these six variables are associated with the outcome variable in the same direction in all four age group models. *Proportion of Friends Who Exercise* ('All of them") is consistently associated with a higher level of the outcome variable. *Gender* ('Males') also has a consistent relationship with the outcome variable across all four models.

Occupational Status ('School') is included in each of the four age groups as a predictor, but the confidence limits of the beta coefficients limit the interpretations of the findings. It appears that the level, "Working/Looking for Work" is associated with the lowest level of physical activity in all age groups, but only in the older two groups are the confidence limits less than zero.

Three out of the four models indicate the same pattern for the *Education Level* variable, with the 'Post Secondary Education' level being associated with the highest level of physical activity. However in the youngest age group, 'Some Secondary Education' is associated with the highest level of physical activity.

The *Work Type* variable appears to have a questionable relationship with physical activity within the age groups. In the 45 - 60 age group the 'Heavy Work' level is associated with the lowest amount of activity, but in all the three other groups, 'Sitting around much of the day' is associated with the lowest level of activity. The confidence limits of all the individual levels include zero, suggesting that there is little actual difference in physical activity between the three levels of *Work Type* within age groups.

The variable, *Perceived Health Status* ('Excellent Health') is consistently associated with a higher level of physical activity. In the two younger age group models, the category of perceived health associated with the lowest level of physical activity is the 'Fair or Poor

Health'; in the older two age groups, the "Good Health' is associated with the lowest level of physical activity. The confidence limits cross zero for the beta coefficient of *Perceived Health Status* ('Excellent Health') in the models for the two older age groups.

Gender Comparison

There were 9,830 males in this study with a mean *energy expenditure (NEW)* of 1.5 KKD. The 10,776 females in the study had a mean *energy expenditure (NEW)* of 1.1 KKD.

In the males, nineteen variables were initially selected in the SAS modeling, but two variables (*Household Type*, *Pain Limitations*) were removed as a result of the SUDAAN analyses. The remaining 17 variables in the model for the male group predict 22.7% of the variance.

The 17 variables were: *Household Income* (positive relationship), *Household Size* (negative relationship) *Smoking Status* ('Never Smoked'), *Stratum* ('Urban Stratum'), *Ethnic Group* ('Canadian'), *Perceived Health Status* ('Excellent Health'), *Proportion of Friends Who Exercise* ('All of Them'), *Drinking Status* ('Current Drinker'), *Activity Accident* ('Yes'), *Mobility Limitations* ('None'), *Marital Status* ('Single'), *Age* (negative relationship), *BMI* (negative relationship) and *Well Being Score* (positive relationship), *Occupational Status ('Retired' or 'School'), Work Type ('Standing, lifting and carrying'), and Education Level. Smoking Status* beta coefficients include zero.

Table 5.9

Comparison of Beta Coefficients in Different Genders

Variable	Level	Males		Females		
		Beta Coefficient	95% Confidence	Beta Coefficient		95% Confidence
Intercept		1.33	1.0948 , 1.5652	1.23	0.13	0.98 , 1.48
Environmental Variables						
Stratum	Urban					
	Rural	-0.028	-0.059 , 0.0034			
Social Variables						
Proportion of Friends Who Exercise	None of Them					
	All of them	0.50	0.42 , 0.58	0.64	0.072	0.50 , 0.78
	Most of them	0.38	0.32 , 0.44	0.42	0.026	0.37 , 0.47
	Half of them	0.25	0.20 , 0.30	0.29	0.023	0.24 , 0.34
	Few of them	0.12	0.075 , 0.17	0.18	0.019	0.14 , 0.22
Household Size		-0.019	-0.031 , -0.0068			
Household Type	Other					
	Head and Spouse/no children			-0.016	0.022	-0.059 , 0.027
	Head and Spouse/children			-0.064	0.024	-0.11 , -0.017
Marital Status	Separated or Divorced					
	Married or Widowed	-0.069	-0.15 , 0.013	-0.020	0.032	-0.083 , 0.043
	Single	0.093	0.0048 , 0.18	0.038	0.031	-0.023 , 0.099
Household Income		0.014	0.0073 , 0.021			
Ethnic Group	Other					
	Canadian	0.081	0.048 , 0.11	0.025	0.014	-0.0024 , 0.052
	Canadian and Other	0.068	0.029 , 0.11	0.0016	0.017	-0.032 , 0.035
Family Functioning Score						
Physiological Variables						
Age		-0.0030	-0.0045 , -0.0015	-0.0026	0.00055	-0.0037 , -0.0015
Body Mass Index		-0.0040	-0.0079 , -0.00010	-0.0035	0.0017	-0.0068 , -0.00017

Table 5.9

Comparison of Beta Coefficients in Different Genders

Variable	Level	Males		Females		
		Beta Coefficient	95% Confidence	Beta Coefficient		95% Confidence
Other Personal Variables						
Occupational Status	Retired or keeping house					
	Working/ looking for work	-0.17	-0.23 , -0.11	-0.051	0.014	-0.078 , -0.024
	School	-0.069	-0.16 , 0.019	0.077	0.034	0.010 , 0.14
Work Type	Heavy work					
	Sitting around much of day	-0.0088	-0.064 , 0.046	-0.19	0.06	-0.31 , -0.072
	Standing, lifting, carrying	0.069	0.018 , 0.12	-0.11	0.059	-0.23 , 0.0056
Education Level	Post Secondary Education					
	Primary Education	-0.21	-0.27 , -0.15	-0.083	0.024	-0.13 , -0.036
	Some Secondary Education	-0.046	-0.083 , -0.0088	-0.026	0.018	-0.061 , 0.0093
	Completed Secondary Educatio	0.0057	-0.030 , 0.041	-0.16	0.015	-0.19 , -0.13
Smoking Status	Current Smoker					
	Never Smoked/Former Smoker	0.072	-0.24 , 0.39			
Drinking Status	Current Drinker					
	Never Drank	-0.17	-0.24 , -0.10	-0.12	0.24	-0.59 , 0.35
	Former Drinker	-0.023	-0.076 , 0.030	-0.044	0.025	-0.093 , 0.005
Well Being Score		0.0032	0.00085 , 0.0056	0.0029	0.00094	0.0011 , 0.0047
Number of Health Problems				0.012	0.0046	0.0030 , 0.021
Activity Accident	Yes					
	No	-0.22	-0.28 , -0.16	-0.18	0.044	-0.26624 , -0.09376
Mobility Limitations	None					
	Yes	-0.10	-0.20 , -0.0030	-0.15	0.038	-0.22 , -0.076
Pain Limitation	Pain Prevents Most Activities					
	Painfree			0.14	0.052	0.038 , 0.24
	Pain Prevents No Activities			0.13	0.052	0.028 , 0.23
	Pain Prevents Few Activities			0.11	0.050	0.012 , 0.208
	Pain Prevents Some Activities			0.062	0.05	-0.036 , 0.16
Perceived Health Status	Fair or Poor Health					
	Excellent Health	0.20	0.13 , 0.27	0.13	0.029	0.073 , 0.19
	Very Good Health	0.088	0.021 , 0.15	0.065	0.026	0.014 , 0.12
	Good Health	0.066	-0.00064 , 0.13	0.011	0.025	-0.038 , 0.060

The SAS analyses for the females also produced 19 variables, but three were removed in the SUDAAN testing (*Household Size*, *Smoking Status*, and *Family Support Score*). The remaining 16 variables explain 19.4% of the variance. The variables that were not included in the female model but were in the male model, were: *Household Income*, *Household Size*, *Smoking Status* and *Stratum*. The variables that were in only the female model were: *Number of Health Problems* ('positive relationship'), *Pain Limitations* ('Painfree') and *Household Type* ('Other'). The beta coefficients include zero for *Marital Status*, *Ethnic Group*, *Work Type*, and *Drinking Status*.

Variables which follow a similar pattern in the two gender specific models were: *Perceived Health Status* ('Excellent Health'), *Proportion of Friends Who Exercise* ('All of Them'), *Activity Accident* ('Yes'), *Mobility Limitations* ('None'), *Age* (negative relationship), *BMI* (negative relationship) and *Well Being Score* (positive relationship).

Three variables follow different patterns in the two groups. *Occupational Status* ('Retired or keeping house' or 'School') is associated with the highest level of activity for men, but *Occupational Status* ('School') is associated with the highest level of activity for women. *Education Level* ('Completed Secondary Education') is associated with the highest level in men, but *Education Level* ('Post Secondary Education') is associated with the highest level of activity in women. *Work Type* ('Standing, lifting, carrying') in men is associated with high levels of physical activity, but in women, the level associated with the highest level of physical activity is *Work Type* ('Heavy Work').

Urban and Rural Stratum Analyses

There were 14990 subjects in the urban stratum and 5616 in the rural stratum. The mean energy expenditure was 1.3 KKD in the urban population and 1.2 KKD in the rural population.

In the urban stratum, 19 variables were selected in the SAS analysis. None excluded in the SUDAAN testing. The 19 variables were: *Occupational Status* ('School'), *Perceived Health Status* ('Excellent Health'), *Proportion of Friends Who Exercise* ('All of them'), *Drinking Status* ('Current Drinker'), *Work Type* ('Standing, lifting, carrying'), *Activity Accident* ('Yes'), *Mobility Limitations* ('None'), *Age* (negative relationship), *Gender* ('Males'), *Household Type* ('Other'), *Household Size* (negative relationship), *Number of Health Problems* (positive relationship), and *Household Income* (positive relationship), *Ethnic Group* ('Canadian'), *Marital Status* ('Single'), *Educational Status* ('Post Secondary'), *BMI* ('negative'), *Well Being Score* ('positive') and *Smoking Status* ('never or former smokers'). Beta coefficients include zero for the *Work Type* and the *Number of Health Problems* variables. The total R^2 from these predictors for the urban stratum was 0.22.

In the rural sample testing, 19 predictor variables were identified with SAS and two variables (*Smoking Status, BMI*) were removed with the SUDAAN analysis. The 17 variables in the rural stratum model predicted only 18% of the variance. *BMI, Well Being Score* and *Smoking Status* were only found to be predictors in the urban stratum model and not in the rural stratum and *Painfree* ('Yes') was found to be a predictor only in the rural stratum (Table 5.10). The confidence limits around the beta coefficient include zero for *Household Type, Ethnic Group,* and *Number of Health Problems.*

Table 5.10

Comparison of Beta Coefficients in Urban and Rural Stratum

Variable	Level	Urban Stratum		Rural Stratum	
		Beta Coefficient	95% Confidence	Beta Coefficient	95% Confidence
Intercept		1.40	1.21 , 1.59	1.53	1.26 , 1.80
Social Variables					
Proportion of Friends Who Exercise	None of Them				
	All of them	0.54	0.46 , 0.62	0.64	0.51 , 0.77
	Most of them	0.39	0.35 , 0.43	0.49	0.42 , 0.56
	Half of them	0.26	0.22 , 0.30	0.30	0.24 , 0.36
	Few of them	0.14	0.11 , 0.17	0.20	0.15 , 0.25
Household Size		-0.011	-0.023 , 0.0014	-0.020	-0.038 , -0.0024
Household Type	Other				
	Head and Spouse/no children	-0.024	-0.061 , 0.013	-0.053	-0.12 , 0.014
	Head and Spouse/children	-0.055	-0.10 , -0.006	-0.014	-0.11 , 0.082
Marital Status	Separated or Divorced				
	Married or Widowed	-0.040	-0.10 , 0.017	-0.11	-0.22 , -0.0042
	Single	0.067	0.014 , 0.12	-0.0033	-0.11 , 0.10
Household Income		0.0070	0.0015 , 0.012	0.015	0.0068 , 0.023
Ethnic Group	Other				
	Canadian	0.059	0.034 , 0.084	-0.0067	-0.046 , 0.033
	Canadian and Other	0.046	0.017 , 0.075	-0.058	-0.11 , -0.0070
Physiological Variables					
Age		-0.0027	-0.0038 , -0.0016	-0.0029	-0.0046 , -0.0012
Gender	Males				
	Females	-0.11	-0.13 , -0.088	-0.059	-0.092 , -0.026
Body Mass Index		-0.0039	-0.0066 , -0.0012		

Table 5.10

Comparison of Beta Coefficients in Urban and Rural Stratum

Variable	Level	Urban Stratum		Rural Stratum	
		Beta Coefficient	95% Confidence	Beta Coefficient	95% Confidence
Other Personal Variables					
Occupational Status	Retired or keeping house				
	Working/ looking for work	-0.089	-0.12 , -0.060	-0.11	-0.15 , -0.069
	School	0.039	-0.018 , 0.10	0.042	-0.058 , 0.14
Work Type	Heavy work				
	Sitting around much of day	-0.038	-0.10 , 0.023	-0.019	-0.092 , 0.054
	Standing, lifting, carrying	0.041	-0.016 , 0.10	0.061	0.0022 , 0.12
Education Level	Post Secondary Education				
	Primary Education	-0.17	-0.22 , -0.12	-0.12	-0.19 , -0.053
	Some Secondary Education	-0.044	-0.073 , -0.015	0.0026	-0.039 , 0.044
	Completed Secondary Educatio	-0.00034	-0.028 , 0.027	-0.027	-0.066 , 0.012
Smoking Status	Current Smoker				
	Never Smoked/Former Smoker	0.051	0.026 , 0.076		
Drinking Status	Current Drinker				
	Never Drank	-0.14	-0.19 , -0.091	-0.11	-0.17 , -0.045
	Former drinker	-0.022	-0.065 , 0.021	-0.087	-0.14 , -0.030
Well Being Score		0.0036	0.0019 , 0.0053		
Number of Health Problems		0.0081	0.000064 , 0.016	0.011	-0.0019 , 0.024
Activity Accident	Yes				
	No	-0.20	-0.25 , -0.15	-0.22	-0.31 , -0.13
Mobility Limitations	None				
	Yes	-0.14	-0.21 , -0.071	-0.17	-0.28 , -0.058
Painfree	No				
	Yes			-0.046	-0.10 , 0.0050
Perceived Health Status	Fair or Poor Health				
	Excellent Health	0.19	0.14 , 0.24	0.13	0.059 , 0.20
	Very Good Health	0.095	0.052 , 0.14	0.070	0.0034 , 0.14
	Good Health	0.050	0.0069 , 0.093	0.054	-0.013 , 0.12

The beta coefficients of the included variables are described in Table 5.10. There are 16 common predictors in the two models; for 12 of these variables the same level is associated with higher levels of physical activity or the variable predicts in the same direction in the two stratum specific models. The twelve variables are: *Occupational Status* ('School'), *Perceived Health Status* ('Excellent Health'), *Proportion of Friends Who Exercise* ('All of them'), *Drinking Status* ('Current Drinker'), *Work Type* ('Standing, lifting, carrying'), *Activity Accident* ('Yes'), *Mobility Limitations* ('None'), *Age* (negative relationship), *Gender* ('Males'), *Household Type* ('Other'), *Household Size* (negative relationship), *Number of Health Problems* (positive relationship), and *Household Income* (positive relationship),

There are three variables that are common to both models, but the direction of the prediction is different. For the *Ethnic Group* variable, a higher level of physical activity is associated with 'Canadian' in the urban and 'Other' in the rural. The 'Single level of *Marital Status* is associated with a higher level of activity in the urban dwellers, but 'Separated or Divorced' is associated with the highest level of activity in rural residents. 'Post Secondary Education' for *Education Level* is associated with the highest level of activity in the urban stratum, but 'Some Secondary Education' predicts the highest level of activity in the rural stratum.

5.7 Summary

Overall, the results indicate that 20 to 30 percent of the variance of the *cube root (EE)* variable can be predicted. The predictors for the stratum specific models vary slightly; however, there is a significant amount of variation in the gender and the age group specific models. Much of the variation occurs in the direction of the prediction and the range of the confidence limits of the beta coefficients.

CHAPTER 6 DISCUSSION

This chapter will briefly review the findings of the analyses. The significant predictor variables will be discussed and explanations for the relationships found will be presented. Comparison of the findings of the thesis with the earlier work done on the same data set will be discussed. Strengths and limitations of the research in this thesis will be presented, along with recommendations for future research.

6.1 Summary of Key Findings

In the stepwise regression analysis with the entire available OHS sample, 19 of the 26 variables tested were found to be predictors of physical activity, all significant at the $p<0.05$ level. Three models were tested, including three, five and nineteen predictors. Variables that were included in each model depended on the partial R^2 found in the stepwise regression, and the 'clinical significance' of the particular variable. The variance predicted in the three models ranged from 16% with the three variable model to 21% for 19 variable model.

There were some differences noted in the subgroup analyses. Few new variables were added, but the variables that were significant in the 'whole group' model were not necessarily significant in the subgroups, particularly in the age group models. The R^2 in all the subgroup analyses varied between 0.16 and 0.29.

Only one variable, *Proportion of Friends Who Exercise* was significant in every subgroup analysis. The level, 'All of them' of this variable was associated with a higher level of physical activity in the main analysis and in every subgroup, and none of the beta coefficients for any of the levels of this variable included zero.

Two other variables, *Age* and *Gender,* were frequently identified as predictors in the analyses. *Gender* ('Males') was found in the age and stratum specific models; the only subgroup analysis that this variable was not identified as a predictor in was the one in which the gender variable could not be identified (i.e., Gender Subgroups). *Age* (negative relationship) was identified as a predictor in every subgroup except the four age groups. *Age* was included as a potential predictor in the age subgroups to assess if there was an effect of age within the range of each age group. There were only two variables, which were consistent predictors in the four age groups, six variables, which were consistent predictors in the gender groups, and 12 variables, which were consistent predictors in the stratum groups.

6.2 Interpretation of the Finding

Statistical significance in a regression model does not imply a causal relationship. This assertion of causation requires causal links and a theoretical justification. For this discussion, a positive relationship will refer to one where the beta coefficient of the regression slope is greater than zero (i.e., both the dependent and the independent variable change in the same direction), and a negative relationship will refer to a relationship where the beta coefficient of the regression slope is less than zero.

It is important to recognize that confounding is a possibility in this analysis. Confounding occurs when a third variable is associated with both the outcome and independent variables (98). Therefore, the estimated effect of the independent variables may be biased. There may be a relationship between physical activity level and variables that were not examined as part of the OHS. For example, self-efficacy has been shown to have a positive relationship with physical activity and may be related to other variables such as age (56). Self-efficacy and other variables will be discussed further in Section 6.3.

Proportion of Friends Who Exercise

According to this thesis, the proportion of friends who exercise has a positive relationship with the amount of physical activity an individual performs. There are different interpretations to the relationship between the proportion of friends who exercise and physical activity level. It is possible that people are influenced by their friends' behaviour and are more likely to be active if their friends are active. Peer pressure has been reported as an influence on 'unhealthy' behaviours, such as smoking (99). Peer pressure may also influence healthy behaviours such as physical activity. The relationship between the proportion of friends who exercise and physical activity could also be explained by the fact that people befriend those who are similar to them. Non-exercisers may be more likely to be friends with similar people who share interests and pastimes that do not involve any physical activity. Finally, it is possible that people choose to participate in sports and other physical activities for other reasons (e.g., to improve their fitness, to compete with others). Over time, the participation in such activities may lead to social contacts and friendships.

The proportion of friends who exercise was a predictor of physical activity in every age group, gender and stratum analysis. The pattern was consistent in all sub groups; the highest proportion of friends exercising was associated with the highest level of physical activity.

The literature reviewed for this thesis suggests that support from friends is a predictor of physical activity. Three of four studies that examined friend support and also found it to be a significant predictor of physical activity (50, 56, 66). Sallis et al (56) and Treiber et al (66) considered frequency of friends participating or offering to participate with the subjects as well as the frequency of encouragement provided by friends as part of a "friend's support" independent variable. Allison's study (50) of the 1990 OHS, found the proportion of friends who exercise was the strongest predictor of physical activity with an odds ratio of 7.4 in the multivariate analysis. Hovell et al (48) examined the support of friends as a potential predictor and did not find it to be significant; however, only walking was used as the outcome variable. From the description given in the walking study, it is difficult to determine if the friends support variable was not a significant univariate predictor or simply not included in the final model.

The proportion of friends who exercise is strongly related to physical activity as shown by the findings of this thesis and the previous literature. It is impossible to tell whether a high level of physical activity results in a high proportion of friends who exercise, or vice versa. Socialization may be a confounding variable in the relationship.

Household Type

The type of household was coded for this thesis as 'head and spouse', 'head and spouse with children' or 'other'. The results indicated that people in the 'other' category were more likely to be physically active. It is likely that single people comprise a high proportion of the 'other' category. Single people who live alone or with a roommate may be more likely to exercise. Single people may use activity as a social opportunity to meet potential partners, or to make other social contacts. Single people may be more likely to have more free time and less family obligations. However, the 'other' category would also include elderly single people, single parent families and blended families. It is unlikely that single parents have more time available than parents in two-parent families. It is possible that low-income single families are more active, in that they look for inexpensive family activities, which may include walking or other sports played in a park, involving all family members and the adults would be performing physical activity.

The 'other' category is associated with the highest level of physical activity in the 25-45 and 45-60 age groups, as well as in the urban stratum and in the subgroup of women. The relationship between physical activity and household type in the 25-45 and 45-60 age groups could be explained by child rearing, which would occupy the time of those people in the 'head and spouse with children' group. It is feasible that the adult's time is at a premium and physical activity becomes neglected. The presence of the same relationship in the women's subgroup may indicate that the different roles of men and women in a household affect the amount of physical activity an individual does. There appears to be a different effect of household type and physical activity in urban and in rural stratum, which is difficult to explain.

Two studies discussed in the literature review identified having children as negatively affecting the amount of physical activity that was done (52, 59). Bauman et al found that the number of children decreased the likelihood of participating in physical activity, once adjustments were made of gender, education and age(52). Parenthood has been documented as a negative predictor of women participating in physical activity (59). Allison's study found household type to be one of the main predictors of physical activity (50).

It is apparent that there is a relationship between the type of household and the amount of physical activity performed. Time availability may be the confounding variable in this relationship.

Household Size

According to this thesis, the number of members in the household was negatively associated with the amount of physical activity that an individual does. The larger the household, the more likely that there are certain obligations of the adult family members around child raising. The social activities may be different for individuals in large families, including less physical activity than for smaller families. This data suggests this is a possible explanation.

Household size was negatively associated with physical activity for males, rural households and individuals over the age of 60. It appears that the postulated effect of raising children on physical activity exists for males and for those in rural neighbourhoods. The effect of household size may be partially accounted for by the household type construct. According to this thesis, household size is a predictor of physical activity in people over the age of 60. This may be explained by type of residence for older people. Those people who live with other family members, may be more involved in family types of activities which are not necessarily associated with physical activity; those older people living on their own may be more likely to participate in social activities involving physical activity to maintain social contacts.

Allison also examined the relationship between household size and physical activity (50). The household size was not identified as a predictor of physical activity. From the analysis of this thesis, household size appears to be related to physical activity, but the relationship may be an indicator of time available to exercise.

Marital Status

Single people are more likely to be participating in physical activity than married, widowed, divorced or separated people. Single people tend to be younger, and are less likely to have children and family responsibilities. Single people are probably also less likely to own homes and have responsibilities, giving them more free time. Single people may be more likely to use physical activity as a means of socialization.

The subgroup analyses show different trends examining the relationship between marital status and physical activity. The trend noted in the youngest age group indicated that separated and divorced people under the age of 25 are the most active. This may be a reflection of trying out new lifestyles, or establishing new social contacts. It is possible that the people in young age groups who are divorced or separated have a desire to start anew, establishing new social contacts and they may be doing this through physical activity. It is also possible that frequent exercisers spent too much time exercising in the past and not enough time on their relationship, which may have lead to a separation or divorce. The older three age groups showed that there is no relationship between marital status and physical activity level. This suggests effect modification by age on the relationship between marital status and physical activity. The urban stratum and the male gender subgroup analyses both suggest that being single is associated with a higher level of physical activity. This could be explained by the single male would have less family responsibilities allowing more free time for exercise; however, it would seem that the same should be true for single females. Perhaps, males are more likely to use physical activity as a social activity.

Two out of four studies reviewed in the literature review suggest that marital status predicts the level of physical activity. Johnson et al (9) and Myers et al (68) found that being single was associated with a higher level of physical activity. Verhoef and Love (59) and Allison (50) both found that marital status was not associated with physical activity. Verhoef's study sample consisted of only women between the ages of 20 and 49 and 74% of the women were married. These demographic characteristics may have affected the ability to examine marital status in this study.

Marital status is likely a predictor of physical activity level. It is likely not causal, but both social activities and time availability are affected by marital status, and these two factors appear to impact on physical activity level.

Income

Household income had a positive relationship with physical activity in the whole sample analysis of this thesis. This may be an indicator of disposable income available for fitness club memberships, or an indication of free time (i.e., money can be used to purchase services such as house cleaning which would free up time for exercise). Income may be related to education as well. Higher income may be associated with living in a neighbourhood where facilities for physical activity may be more available; the higher socioeconomic status may also indicate a higher awareness of health benefits of physical activity; it is possible that this awareness could increase the amount of physical activity that is done, but this has not been well documented in the literature (48, 54, 56).

The subgroup analyses of income with physical activity were inconsistent. Income was positively associated with physical activity in males, but not in females. It is possible that males participate in activities that require money or are more likely to use disposable income on physical activity pursuits. Females may be more likely to participate in activities that require less money; or perhaps the females participate in physical activity regardless of income. The two youngest age groups did not show any relationship between physical activity and income; the two oldest age groups showed a positive relationship. This positive relationship in the older groups may indicate the social class structure, or availability of disposable income. Those people in the older groups with more income may live in buildings with better on site facilities for physical activity. Income was positively associated with physical activity in both urban and rural strata.

One out of the three studies reviewed that evaluated income as a potential predictor found income to be a significant predictor of physical activity; this finding was in the previous analysis of the OHS.(51). Desmond et al did not find income to be a predictor of physical activity in their study of factory employees (69). However, over 90% of the sample in the study by Desmond (69) had an income over $40,000. This distribution of income may have affected the ability to identify income as a predictor in the study. The large population based study by Bauman et al found no relationship between income and physical activity (52).

Physical activity level, as measured in the 1990 OHS, does not affect income, unless someone is a professional athlete. The effect of income on physical activity, which is not consistent across the subgroups, is likely one of association; physical activity does not require a large amount of disposable income. Time availability and resource availability may be the factors that directly affect the physical activity level.

Ethnicity

Those people who described their ethnic background as 'Canadian' were more likely to be physically active than the 'other' and the 'Canadian and other' groups. This effect is unlikely to be a direct causal one, but rather a reflection of the characteristics associated with ethnic identity. The differences noted in the ethnic group may be related to the acculturation of individuals who are from different cultures. They may be preoccupied adjusting their lifestyle to become integrated into Canadian lifestyle and therefore exercise is not a priority. Cultural differences of immigrants may not encourage physical activity (e.g., dress, how leisure time is spent). The awareness of physical activity benefits may not be as prevalent in other cultures as it is here. If the individual comes from a country where the incidence of ischaemic heart disease is low, then there may be a very low awareness on the part of the individual of the benefits of physical activity. The potentially low socioeconomic status of many immigrants may limit the time available to do physical activity.

According to the subgroup analyses in this thesis, this relationship between ethnic group and physical activity is found only in males, in urban residents and in subjects between the ages of 25 and 45. This may be a result of male immigrants being more involved with the cultural integration processes described above, or the processes may not affect the females in the same way (perhaps because the females are already doing less activity and this difference between the ethnic classifications of physical activity is not significant. The age group which shows this pattern may be related to beliefs and cultures as described above, but also might reflect a lack of time available for exercise for people in that age group.

The ethnic group classification that was used for this thesis was not used in other studies. Other studies have examined location of birth place (9). Johnson's study conducted in Australia, found that people born in Australia were more likely to be physically active. Race has also been examined in the literature and white people have been identified as performing the highest amount of physical activity (53, 62).

Age

There was a negative relationship between age and physical activity. In the past there may have been less focus on older people performing physical activity (100, 101) and it is possible that older individuals are less aware of the benefits of physical activity. It is also possible that older individuals were not made aware of the benefits of physical activity early on in their life and their established habits are hard to change. It is possible that older people have more health problems that make exercise more difficult to perform (e.g., arthritis, and heart disease). The other factor that may affect the older subject's ability to exercise may be the lack of availability of exercise facilities designed for the older person.

Both gender subgroups and stratum subgroups show the same relationship. Age and physical activity was assessed in all four age groups, but was only found to be significant, in a negative direction, in the over 60 age group.

The negative relationship between age and physical activity has been reported in nine of eleven studies reviewed. Two of the studies actually report a positive effect of age, if only a moderate level of activity was examined (48, 60). Perhaps, as people become older, they are more likely to perform moderate types of activity. Those individual who were exercising at high intensities at younger ages may be less likely to continue with the high intensity exercise as they get older and may be performing more moderate intense exercise. Those people who were always performing more moderate types of exercise earlier may be continuing to do so; the effect of any predicting variables on moderate exercise was not assessed in this thesis.

Age predicted physical activity and not the other way around. It is likely an association relationship and not a causal one. However, it appears to be a very strong relationship, as demonstrated by the literature and the sub-group analyses.

Gender

The results of this thesis indicate that males perform more physical activity than females. It is possible that there has been a stronger emphasis in the past on males performing physical activity and only recently have the benefits for physical activity in women been explored. The historical perspective may contribute to men doing more leisure time physical activity, particularly in the older population.

Five of eight studies found that being male was associated with a higher level of physical activity (9, 50, 52, 61, 62, 66). This finding held true in all four age groups and in both strata.

The association of gender with physical activity may also be related to socialization. Males might be more likely than females to use physical activity as a social activity.

Obesity

The relationship between BMI and physical activity was a negative one. Inactivity is a well known risk factor for obesity and physical activity is a commonly prescribed treatment to facilitate weight loss (7); this would suggest that the lower levels of activity likely result in an increased BMI. In addition, there may be a social component as some overweight people may be reluctant to become involved in physical activity because of a lack of self-confidence.

There was an inconsistent relationship between BMI and physical activity in the subgroup analyses. Both gender subgroups demonstrated a negative relationship. BMI was a negative predictor only in the urban stratum and only in the 25-45 and the 45-60 age groups; BMI was a non-significant predictor in the other groups. It is possible that the social aspects are stronger in these groups of adults where BMI was a predictor (social situations may lead to different effects, in the urban stratum). On the other hand, increased BMI may be due to a lack of physical activity more in these groups than in the others.

None of the other subgroups tested showed a significant relationship between physical activity and BMI.

Only three of eight studies reviewed which examined BMI or obesity and physical activity, found a negative relationship (9, 60, 61). The other four studies did not find BMI to be a significant predictor. Hovell may have not found BMI to be a predictor because walking was used as the outcome predictor, and it is possible that walking is not correlated with BMI in the same way as overall physical activity(48). It is difficult to explain the lack of relationship in the other four studies (50, 56, 65, 67). It is possible that the small sample sizes in Lochen's study limited the power to detect potential predictors.

Occupational Status

Those subjects who attended school or those who were retired were more likely to be active than those who did not. It is possible that many social activities are based on physical activity participation as well. Facilities are also convenient for students to use. There may also be more time available for students to do the activities, again give that the majority of them would not have family type of responsibilities.

The subgroup comparisons are fairly consistent. Students and retirees were found to be more active in the youngest age group and the oldest age group. This may suggest that physical activity is regarded as a higher priority in the younger individual, or that working or looking for work, requires more time in the older groups. Both genders and both strata examined note the same pattern of students and retirees being the most active.

Two studies examined occupational status and physical activity. Verhoef found no relationship, but the study was done with women between the ages of 20 and 49 (59). (The 25-45 age subgroup analysis in this thesis also showed no relationship between physical activity and occupational status.) The study by Desmond et al (69) found that office and clerical workers were more likely to be physically active than other workers were.

The relationship between occupational status and physical activity level may be attributed to either age or time availability. Students would normally be younger than others in the sample would, and age has been demonstrated to be a predictor of physical activity level. It is also conceivable that both students and retirees have more time available to follow an exercise programme. These two factors, age and time availability would likely account for much of the relationship between physical activity and occupational status.

Work Type

Subjects who report that they perform 'heavy work' exercise more than subjects who 'sit around much of the day' but less than subjects who 'stand, lift or carry light loads'. This may reflect that subjects who perform the heavy work feel that they are doing more than enough exercise at work and do not need any more activity. They may also be too fatigued after work to follow an exercise programme; those who sit at desks may not enjoy or may not be physically able to participate in physical work or exercise; thus the desk workers find a job and follow a lifestyle to match their ability and philosophy. The group who stand and carry light loads may enjoy activity and be less fatigued at the end of a shift than the workers doing the heavy jobs.

The subgroup analysis in males and in both strata demonstrated that the subjects who reported standing and carrying activities had the highest level of leisure time physical activity. For the female group, those who did heavy work performed the same amount of physical activity as those who lifted and carried. (There was only 1% of females who reported doing heavy work. In all four age groups, there was no difference in the level of physical activity between any of the three groups. The type of work was not analyzed in any of the studies included in the literature review for this thesis.

Education

Those individuals who are more highly educated are more likely to be physically active. Those with more education may be aware of the benefits of more regular exercise, which could be their rationale for following such a program. People who are more educated may be better off financially and can afford the time and the expense to follow regular exercise.

The subgroup analyses consistently show that post-secondary education is associated with a higher level of physical activity. There is some variation in the subgroups as to whether completing a secondary school education is more like some secondary school education, or more like post secondary education.

Five out of six studies reviewed indicate that education is a positive predictor of physical activity (48, 52, 53, 56, 62). The only study that did not find education to be a predictor of physical activity was a study by Desmond of employees at a factory. The range of responses to the education question may have been too small to detect an effect in the Desmond study (69).

Smoking Habits

Smokers are less likely to be exercisers than non-smokers are. This has been demonstrated in other research (9). Non smokers may be actually healthier and more able to follow a regular exercise programme. It is also possible that individuals tend to perform multiple healthy behaviours such as not smoking and physical activity.

The subgroup analysis indicated that this relationship did not hold true in the 25-45 year old age group, nor in either gender or in rural strata. The relationship between smoking and physical activity appears to be tenuous.

Only three out of eight of the reviewed studies which examined smoking status as a potential predictor found smoking to be a significant negative predictor (9, 56, 65). There does not seem to be an obvious pattern to the studies and their findings about this issue.

Drinking Status

Current drinkers are more likely to be exercisers than non-drinkers, according to our analysis of the OHS. This may be a reflection of the social aspects of adult physical activities, where alcohol may be associated with post exercise social gatherings as is commonly done after a hockey or a baseball game. The 'healthy habits' pattern described for smoking does not appear to exist in the same way for drinking.

Although the same relationship between physical activity and alcohol consumption was found in both urban and rural strata, it was not found in those people over the age of 65. The relationship was also found in males and not in females. The social aspects described above may apply only in males and not in females.

There was only one study reviewed that found any relationship between drinking and physical activity. Johnson reported that 'high risk' and 'non drinkers' were more likely to be inactive and 'low risk' drinkers were more likely to be active (9). Three studies that examined alcohol intake as a potential predictor did not find any relationship (48, 56, 61).

Wellness Score and Perceived Health

As would be expected, an indication of wellness is associated with higher level of physical activity. It is possible that the increased amount of exercise is associated with an increased sense of well being. It is also possible that those people who feel good about themselves are more likely to follow a regular exercise programme. Perceived health follows the same pattern and can be explained in the same way.

The wellness indicator is found in both gender subgroup analyses, but only in the urban stratum and only in the 25-45 and 45-60 age group. Perhaps physical activity is not associated with wellness in the two extreme age groups.

The variable measuring perceived health was a predictor of physical activity level in the whole sample analyzed in this thesis. This finding suggests that people who exercise either feel better, or they perceive their health as better if they exercise regularly. This finding also suggests that the perceived health status variable is a more valid indicator the construct of a person's judgement of their health status related to physical activity rather than the wellness score.

In all subgroups that were analyzed except for the two older age groups, perceived health was a positive predictor of physical activity. It would appear that there are other factors that affect perceived health in the older samples, other than the level of activity.

Three out of four studies reviewed also reported perceived health or health as a significant predicting variable (51, 59, 67). Allison and Verhoef measured perceived health the same way it was measured in this thesis; King reported on a 'health' variable thatconsidered weight, smoking status and physical health components. The only study which did not find 'health status' to be a predictor was Desmond (69); this lack of finding may be related to the small sample size in Desmond's study.

Although there is a strong relationship between perceived health and physical activity, it is impossible to tell which variable leads to the other.

Number of Health Problems

One of the more difficult relationships to explain was the number of reported health problems being positively associated with physical activity. This would seem contrary to the expected findings. However, because physical activity is recommended as an intervention for many of the conditions considered in framing this variable, this may be a true relationship. It is also possible that the variable does not measure impact or degree of impairment. The degree of impairment could be a better measure to compare to physical activity level.

Only the 25-45 age group and the female gender sub group demonstrated that the number of health problem was associated positively with physical activity. Perhaps, there are only a few individuals with multiple health problems in the younger age group and the impairment factor increases with the number of health problems in the older groups. In the gender subgroup analyses, the relationship is only noted in females. The relationship is not found in either stratum.

Number of health problems has not been examined in previous literature. However, Hofstetter reported that long tem illness had a positive relationship with moderate level physical activity and absence of illness had a positive relationship with vigourous type of physical activity (57).

The construct of number of health problems is not a useful one in this analysis, given the results. The severity and degree of limitation could be a better predictor of physical activity, than the actual number of problems.

Previous Accident Performing Physical Activity

According to this thesis, people who exercise regularly were more likely to have had an accident doing physical activity. It is reasonable to assume that the regular activity predicted the increased frequency of accidents, and not that the increased frequency of accidents was likely to make an individual pursue a physical activity.

This positive relationship between accident occurrence and physical activity was found in the three younger age groups. Advanced age would likely be associated with a greater likelihood of having had an accident, which may not be related to physical activity. There was no evidence of any findings of this in previous literature.

Mobility Limitations

Mobility limitations were associated with lower levels of physical activity. Those who have limitations have less physical activity resources available to do regular exercise. (If an individual has difficulty walking, they would require special equipment at home or the use of an accessible facility to do physical activity.) This relationship was consistent in both strata and both genders that were examined. The only subgroup which did not find mobility limitation to be a predictor was the youngest age group examined, but there were only nine subjects with mobility limitations in the sample of subjects under the age of 25. A similar construct of physical discomfort was found to have a negative association with physical activity (71). The direction suggests that the relationship is causal, the number of subjects with the problems is likely small.

Summary

In summary, there are explanations for all 19 variables that were found significant in the analysis for the first objective. However, this does not mean that the best model is the one containing 19 variables. This issue will be dealt with in Section 6.4.

It is difficult to identify which of the predicting variables would be causal, which would be mediators of physical activity and which variables would be a result of the physical activity level. Nonetheless, it appears that age, gender, education level, marital status and mobility limitations affect the physical activity level. They may not be causal, but it is not possible for physical activity to affect any of these five variables. In addition, there are reasonable explanations as to why these variables predict the physical activity level.

Health Status, either perceived or measured, and number of friends who exercise could be causal variables, or they could be caused by the level of physical activity, or both. It is impossible to assess based on the available data. Both directions are logical explanations for the strong relationships noted in this thesis analysis, and based on previous research. Proportion of friends who exercise also is closely related to physical activity level, but the direction of this association is difficult to establish, based on the available data.

The relationships assessed in this thesis are open to much interpretation. This is a limitation of the study, given the cross-sectional design and the variables available for the analysis.

Variables That Were Not Found To Be Predictors

Of the 26 potential predictors, seven were not significant in the analysis for the first objective. *Family Functioning Score* was the only social variable that was not a significant predictor. This variable has not been well examined in the literature, although family support has been shown to be a predictor. *Stratum* was the only environmental variable tested as a potential predictor and was not found to be a predictor.

The remaining five non-significant predicting variables all were in the 'Other Personal Variables' category: *MD Visits, Perceived Stress, Illness, Painfree* and *Pain Limitations*. Four variables *(MD Visits, Illness, Painfree, and Pain Limitations)* are directly related to health status. It is possible that different medical conditions, some of which activity is beneficial for, affect physical activity in different directions, resulting in no effect. Yet, *Number of Health Problems* had a positive effect on physical activity level.

6.3 Variables Not Examined In This Study

There are numerous predictors that have not been examined as part of this analysis. Predictors identified from psychological models and environmental factors will be briefly discussed.

Psychological Models

There are many psychological models that have been applied to physical activity participation. Two of these, self-efficacy theory and the transtheoretical model will be discussed below.

Specifically, many social-cognitive models have been studied to explain physical activity behaviour (102). One of the more successful theories in explaining exercise behaviour is the self-efficacy theory. According to self-efficacy theory, an individual should feel confident that they could adopt and maintain an exercise programme. The construct of self-efficacy was documented as a predictor in the literature reviewed (56). Self-efficacy can be affected by intervention, which could result in an increased level of physical activity (71

The Transtheoretical Model describes stages of change as a subject adopts a new behaviour [Prochaska, 1994 #264). This model describes a cycling pattern from precontemplation of behaviour change, contemplation, preparation for action, action. maintenance of a behaviour , and 'relapse' and back to the 'preparation for action' stage. This model can be applied to physical activity by identifying the current stage an individual is at and to apply interventions that are effective to move the individual to the next stage. This requires valid tools to identify the stage, effective interventions to apply, and a high level of individualized treatment, which may not be feasible (103).

Unfortunately, research to date has been less successful at determining successful interventions that will increase the physical activity level of individuals. Sallis and Hovell in a published review of determinants discussed the need to examine not only predictors of current level of activity, but also predictors of adoption of physical activity behaviour, maintenance of the behaviour, cessation of the behaviour and resumption of the behaviour (16). Examining the predictors of long term compliance to exercise and predictors of cessation and resumption of exercise programmes was beyond the scope of this thesis.

Environmental Predictors

There has been little research done evaluating environmental predictors of physical activity (71). Sallis found that a higher number of exercise facilities close to an individual's home was associated with a higher level of physical activity(58).

The majority of environmental influences are postulated, but have been minimally studied. An intervention, which was aimed at increasing employees' activity in returning to work was minimally effective, as only 7% of people in the study increased their exercise during their commute to work (104). Poor weather conditions were identified as a barrier to increasing the targeted activity by over 60% of the subjects. Physical activity would appear to be more related to seasonal variation than other health behaviours, particularly in variable climates. In a Finnish study, Uitenbrock reported that the proportion of respondents who were active fell from 32% in the summer to 23% in the winter, and the older people show a wider variation than the younger people (105). The older people may have had more concerns about safety in poor weather conditions. The seasonal affect is obviously attributed to weather conditions that make it more difficult to exercise outdoors, or to travel to an exercise facility; however, the seasonal variation could be explained by increased depressed moods in the winter months.

The 1990 OHS results indicated that whether the subject lived in an urban or a rural stratum was not a predictor of physical activity, although a difference was noted in the physical activity levels of the two groups. Data on the time of year a subject was surveyed was not available for the analysis of this thesis. Further research is required to evaluate the seasonal influences and other environmental influences of physical activity.

6.4 'Best' Model for Entire Sample

The best model for the prediction of physical activity in the OHS in my opinion is the model containing five variables; *Proportion of Friends Who Exercise, Perceived Health Status, Marital Status, Age* and *Gender.*

Parsimony has been recommended in choosing the best model (93). However, the partial F statistic suggests that the 19 variable model is significantly improved over the five variable model.

The three variables, *Proportion of Friends Who Exercise, Perceived Health Status* and *Marital Status* have three of the four highest r^2 when each potential predictor variable is regressed individually against the outcome variable. *Age* and *Gender* also had high r^2 when entered into individual regression equations.

The five variables in the endorsed model are credible choices as predictors. These variables account for and measure comparable constructs that many of the other 14 statistically significant variables measure. *Marital Status* will account for some of the effect that would be demonstrated by *Household Size* and *Household Type. Perceived Health Status* addresses some of the element of the 'health of the individual' construct, of with which at least three other variables *(Number of Health Problems, Well Being Score, Mobility Problems)* are associated. All five of the included variables in this favoured model have been previously identified as predictors.

6.5 Comparison to Previous Work Done On the Same Data Set;

An earlier analysis of the same data set for predictors of *energy expenditure (OHS)* was conducted by Allison (50, 51). As described earlier, there are major differences between Allison's work and this thesis. In Allison's analysis, many of the continuous variables, both independent and dependent, were categorized whereas in this thesis the continuous variables remained continuous variables. Allison's analysis was performed using a logistic regression, which has fewer assumptions than linear regression techniques (82). Allison also reported results as the predictors of inactivity, whereas in this thesis the focus was on determining the predictors of estimated level of physical activity.

The findings of the analysis by Allison are fairly similar to the analysis in this thesis. *The Proportion of Friends Who Exercise* was the strongest predictor in both analyses. This variable had the highest R^2 (0.11) in our analysis and had the greatest odds ratio, (7.4) in predicting inactivity in Allison's analysis. Allison reported that *Age, Gender, Proportion of Friends Who Exercise, Perceived Health Status, Future Health Problems, Household Type* and *Income* were significant predictors in the analysis of the entire sample, and that *Age, Gender, Proportion of Friends Who Exercise, Perceived Health Status* and *Future Health Problems* were significant in the subgroup analyses. *Marital Status* was a highly significant predictor in our analysis but is not listed as a strong predictor in Allison's study; however, *Household Type*, which may be measuring a similar construct, was not a strong predictor in the analysis for this thesis but is reported as a strong predictor in Allison's work.

As described earlier, Allison chose to include *Future Health Problems* (the likelihood that current level of activity will lead to) in the analysis. The decision was made here to exclude this variable because of the difficulty in understanding how the subject would interpret the question. Allison's study demonstrated that people who perceived their risk of future health problems as 'very likely' were more likely to be inactive.

The number of variables reported to be significant predictors varies greatly between the two analyses of the same data set. Allison reports seven variables out of 25 potential predictors as predictors in the multivariate analysis. In this linear regression analysis, 19 variables were found to be significant predictors; five out of the six that Allison found to be predictors (excluding Future Health Problems) and 14 additional variables. *Smoking Status* and *Number of Health Problems* were not found to be significant predictors in

Allison's analysis, although they were entered into the multivariate analysis; both variables were significant predictors in the main analysis of this thesis.

There are many reasons for the differences in the findings of the two analyses of the same data. First, Allison used the dichotomous outcome variable of physical activity index rather than energy expenditure. The logistic regression analysis of the dichotomous variable explains the odds of a subject with a specific characteristic having an activity level of 1.5 KKD or less compared to the odds of a subject without that particular characteristic having the same physical activity level, with an adjustment for all the other independent variables. The multiple regression examines whether that characteristic contributes to the determination of the amount of physical activity the person is doing and how much the characteristic contributes. Second, many of the variables in Allison's analysis were categorized, but all of the continuous variables in the analysis here were treated as continuous variables. Third, Allison chose to assess only 12 variables in his multivariate model; 29 variables were assessed here for inclusion into the linear regression models.

Finally, the analysis done by Allison did not fully consider the sampling design; he did use weighting, but did not use any specialized software to adjust for the sampling design. In our study, the sampling design was adjusted for here by using SUDAAN software. The effect of using SUDAAN would be to adjust the variance. If SUDAAN had not been used, the variances would likely be decreased and the variables would have been more likely to reach statistical significance.

The model, which was identified as the 'best' model, with five predicting variables, was very similar to Allison's final model of seven key variables. Allison included *Household Type* and the model in this thesis included *Marital Status*; as described above, these two variables are measuring a similar construct. The only other difference is the use of *Future Health Problems in* Allison's analysis. The similarity in findings suggests that Allison's findings are validated by this thesis.

6.6 Methodological Issues

6.6.1 Strengths

Energy Expenditure (NEW) was treated as a continuous variable for all regression analyses in this study. By keeping the outcome variable as a continuous variable, the value of the *energy expenditure (NEW)* was maintained. This increased the power of the study to detect a relationship between the independent variables and the dependent variable if one existed. However, there is an increased likelihood of detecting small differences with a large sample size.

Multiple linear regression is a logical choice of statistical method to analyze the predictors of physical activity in this data set. There is conflicting evidence about the minimal amount of exercise that an individual should do for health benefits (23, 26). It is also well documented that higher levels of activity are associated with greater health benefits (1). An individual who has an *energy expenditure (NEW)* score of 7.0 KKD will have more health benefits than an individual who has an *energy expenditure (NEW)* score of 3.0 KKD. It is important to identify factors which move people all the way along the continuum, as opposed to factors which differentiate the 'active' from the 'inactive'.

Linear regression assumes that the relationship between the independent variables and the dependent variable is linear (i.e., the relationship follows a straight line). This may not be the case for the analysis done in this thesis. Kleinbaum states that a linear regression should be attempted as the first step to analyzing a data set using multiple regression (93). The partial residual plots indicate that two out of six continuous variables have a linear relationship with the outcome variable, two of the variables appear to be affected by small numbers of subjects at extreme values and the remaining variables may not have a linear relationship. We are willing to accept this as a limitation of this analysis, especially since the two questionable variables are not included in the five variable model.

The assumptions associated with multiple regression could not be met if the outcome variable of *energy expenditure (NEW)* was used. Transforming the outcome variable to the cube root of energy expenditure enhanced the use of multiple regression techniques in this analysis. Our data suggest that the cube root of *energy expenditure (NEW)* was the best choice of outcome variable to meet the assumptions associated with multiple linear regression.

The models were chosen using a stepwise regression method. This method puts one independent variable into the model at a time, and tests the model for significance. An all-subsets regression is a recommended approach but was not used because the 26 potential independent variables would have made the all-subsets regression a very difficult task, with over 67,000,000 possible subsets (93).

Many subjects (10%) had an *energy expenditure (NEW)* score of 0 KKD. In terms of the data analysis for this study, the large proportion of subjects with the same score at an extreme value of *energy expenditure (NEW)* made it very difficult to run the analysis. This peak at the end of the distribution influenced the analyses that were done. However, the decision was made not to exclude subjects with scores of 0 KKD from the analysis because of the high proportion of them and because of the relevance of the findings to them from a public health perspective.

The OHS was a good data set for these analyses. First, there are enough subjects to perform multiple regressions with many predicting variables. Subjects were selected from over 40 different geographic regions of Ontario, improving the generalizability of the results. The size of the data set provided enough subjects to perform subgroup analyses. Second, the questionnaire included many activities to generate an estimate of total energy expenditure. In many studies, the physical activity assessment is based on one or a few questions. In the OHS, summing the energy expended for 20 different activities derived energy expenditure. The OHS method may result in a more complete score for leisure time energy expenditure. Third, there were numerous predicting variables available for the analysis. Many of the documented predictors of physical activity were available for this analysis.

The new variable, *energy expenditure (NEW)* was a better choice than the original variable *energy expenditure (OHS)*. This was due to the more stringent criteria for *energy expenditure (NEW)*. OHS documentation does not specifically describe how the missing data within the items comprising *energy expenditure (OHS)* was dealt with. The derivation of *energy expenditure (NEW)* included subjects who responded 'yes' or 'no' to all activities or responded 'yes' to some activities and left the remainder blank. There was some lenience for the 'other activity' question. This derivation ensured that, as many subjects as possible were included. Despite the decrease in sample size, the available sample size of 20,606 is larger than other studies examining predictors of physical activity (9, 52, 56).

Software that took the sampling design into account in the analysis was used for this thesis. Bauman (52) and Johnson (9), two studies described in the literature review as being similar to this analysis, also had samples chosen using multistage selection with either stratifying or clustering. Neither author reports using specialized software to deal with the sampling design. Allison also does not use specialized software, but he does incorporate weighting as recommended by the OHS (51).

6.6.2 Limitations

Linear regression is a technique that requires certain assumptions to be met (See Chapter 4). Even after the transformation, there is some concern that the assumptions are not met. The normal probability plot deviates from the perfect line and the homoscedasticity test suggests that the variance is not consistent across all levels of the independent variables. However, this was felt to be the best possible transformation for the available data.

There is likely some measurement error associated with the dependent variable. The duration of the activity was coded into one of four values, with the maximum length of any one activity performed being 60 minutes. This categorization of duration could potentially bias the energy expenditure score variable in either direction for those activities less than one hour in length but could result in a lower score for subjects who perform activities of very long duration (e.g., golf).

The MET level for activities included in the questionnaire were assigned by the OHS. MET levels were assigned, being approximately equal to the lower range of a MET level for a given activity. This approach simplifies the calculation and has been used in previous research (12). However, not all subjects perform activities at the same intensity. The MET level for walking varies depending on the speed, terrain, and the weather on a given day. Other activities, such as cross-country skiing have MET levels documented between 5 and 15 METS (45).

Walking was the most commonly reported activity in the OHS. It is possible that it was actually under-reported. The question in the OHS refers to 'walking for exercise'. If a respondent viewed their walking as a means of transportation, it is possible that they did not report it. None of the other activities refer to a 'for exercise' condition; however, it is unlikely that any of the activities (other than bicycling) would have been done for reasons other than exercise.

As discussed earlier, there has been little validity testing done of the measurement method used for the physical activity measurement. Documentation of the OHS claims that the questionnaire is similar to the MLTPA, which is a validated interviewer administered questionnaire (50). However, without an interviewer present, it is possible subjects reported their physical activity inaccurately. The tendency of subjects to over-report physical activity amounts has been discussed earlier in this thesis (40). Data is not available indicating whether this is a common problem across all physical activity levels or in population surveys.

There were 20 different items that made up the physical activity component of the 1990 OHS; it is possible that some common forms of exercise were not included in the list of items. There was a category for 'other' activities, but the MET level assigned to the other category was constant, regardless of what activity was specified by the respondent. Only leisure time physical activity was examined; this is commonly done in the physical activity literature (46, 71). Occupational physical activity is too difficult to measure to be included in analyses of physical activity. The societal trend appears to be that people are doing less physical activity at work, and therefore the activity that is done in leisure time becomes increasingly important for health benefits.

There is an underlying assumption that the method of measurement is valid for all ages of people in the survey, which may not be true. Other authors have identified the need for specialized data collection tools for physical activity measurement, particularly for the elderly population, where typical activities may differ from activities pursued by younger individuals (46). Further studies may benefit from age specific physical activity measurement tools.

It was not possible for the OHS to contain every single potential predictor of physical activity as part of the data collection. Many of the independent variables that have been evaluated in the literature can only be assessed by a lengthy interview, or by using specialized psychosocial tests. The OHS was not designed solely to evaluate physical activity predictors but to examine many aspects of the health status of Ontario residents. It is unreasonable to assume that all the known predictors of physical activity would be present in the data set.

The large amount of missing data may have biased the sample used for this analysis. The 20,606 subjects available for the analysis is only 46.8% of the initial sample 18 years of age or over. Those included in the analysis were seven years younger than those who were excluded, which may have contributed to age not being as strong a predictor of energy expenditure as previously described in the literature (14). Many older individuals were excluded from the analysis because they failed to complete the data collection properly. There were other significant differences between those included in the analysis and those not included. However, age was the variable with the largest absolute difference.

Data imputation was considered so that more subjects would be included in the analyses. Data imputation would have been performed for the outcome variable, either by a random assignment of *energy expenditure (NEW)* scores, or imputation of the mean value of *energy expenditure (NEW)* for those subjects who had missing values, or an 'educated guess' based on the values of the independent variables. Data imputation would have almost doubled the sample size. However, this procedure was not done. Data imputation is recommended when the observations appear to be missing at random, and that is not the case in this thesis (106).

Weights were assigned as part of the analysis of the OHS staff. The weights were assigned based on the number of Ontario residents that each subject represented. The missing data subsequently impacted on the weights. Given that the subjects who were excluded from the analysis were seven years older than those who were included, it is reasonable to assume that older people were not as well represented in our analysis and younger people may have been over represented. If older people perform less exercise, then it is feasible that there is an overestimation of the amount of physical activity that is being done by Ontario residents. Reassigning the weights to the smaller sample to adjust for the missing data was beyond the scope of this thesis.

6.7 Other Issues

It is possible that there are actually two or more different relationships between *energy expenditure (NEW)* and the independent variables. There may be one model that predicts low level energy expenditure and a second model that predicts higher levels of energy expenditure.

A specific model predicting low levels of energy expenditure would be very useful in addressing the problem of inactivity. In the inactive person, it is important to start them on a physical activity program. However, goals that are set too high are unlikely to be achieved. An exercise programme for the inactive person should include low level walking or other activities, with more emphasis on frequency and less emphasis on duration and intensity initially. This approach will decrease the risk of injury, and likely improve the odds of staying with the program. A low intensity programme is likely to be more enjoyable for the person who was previously inactive.

There may be different predictors, which need to be identified for an individual who is exercising but not doing enough exercise. The goals are different than for the inactive person. For the current exerciser who is not doing enough exercise, there needs to be education and increased awareness of the recommended amount of activity required for health benefits. The reasons why a person is not doing 'more' activity is likely not the same reasons why a person is not doing any activity. This should be a priority for future research.

6.8 Implications

There are 10% of the respondents to this survey who report doing no physical activity at all and 25% who are doing the equivalent amount of physical activity of walking four minutes per day or less. This demonstrates that inactivity is a major problem in Ontario. It is critical to intervene and encourage these people to become more active.

There appear to be numerous predictors of physical activity found in our analysis. Unfortunately, there are no definite key predictors, which can be used to target interventions. As discussed in Section 6.2, there are viable explanations for almost all of the predictors that were identified in the analyses. There are also a fair number of predictors that become non-significant or change direction in the sub-group analyses.

The total amount of variance that was predicted by the available independent variables is less than 30%. There are many predictors that were not tested in our analyses, and our results suggest that these 'unknown' predict a large amount of the variance.

An earlier publication from the Canadian Fitness and Lifestyle Research Institute describes physical activity as a behaviour that is influenced by the social norms (4). If more people are to become active, then being active has to be accepted as normal conduct, and it will be adopted and maintained by more people. As more people become active, then the *Proportion of Friends Who Exercise* will increase. Walking has been identified as the most prevalent form of physical activity and should continue to be encouraged(107). It would appear that walking is socially acceptable as exercise behaviour. One approach would be to further develop this acceptance, through the media, environmental strategies, legislative strategies and training of professionals (71).

Canada's Physical Activity Guide to Healthy Active Living has been recently released by Health Canada and the Canadian Society for Exercise Physiology (108). This guide is to help individuals initiate a physical activity programme and to ensure those who are active are doing enough activity. The amount of activity recommended depends on intensity of the activity, the more intense the activity, the less frequent. Endurance activities are recommended four to seven times per week, the frequency depends on the intensity of the activities. For light activities, the recommended frequency is daily. Stretching and strength building activities are also advocated.

The guide uses case histories to provide examples of adopting and maintaining exercise programmes. In five of the seven case histories presented, there is an element of exercising with other people. Group activities are frequently mentioned in the suggestions for increasing activity. This concurs with our finding of *Proportion of Friends Who Exercise* being a strong predictor. Suggestions for moderate levels of activity are recommended especially for those individuals that are inactive initially. The guide is also directed towards different 'segments' of the population, indicating that the problem of inactivity exists in many different people.

6.9 Future Research

The results of this thesis suggest that there is still much work to be done in evaluating the predictors of physical activity. Some suggestions for future research are described below.

There is a need to further evaluate the predictors identified in this thesis. For example, it is impossible to determine if health perception and number of friends who exercise influence the activity or if physical activity influences these variables. It would be useful to design a study to examine this, such as a qualitative study to interpret the relationship between physical activity and these two variables. Heath perception would be especially important, because it is a variable that could be targeted intervention if it was found to be causal. BMI, which could also be causal (secondary to social stigmas) or influenced by physical activity is another variable for which the relationship with physical activity could be further examined. Distinguishing between friends' participation and friends support needs to be further studied.

Time availability is a potential predictor of physical activity that needs to be evaluated in future research. Many of the predictors found in this thesis can be explained by time availability. The use of physical activity as a social behaviour might also provide some information on the links between predictors such as gender and physical activity.

The development of a simple, validated and reliable tool to measure physical activity would be very valuable in this type of research. Although this might not be feasible, such a tool would enable studies to be comparable, across regions and across samples. The issue of generalizability is a concern in physical activity research, and a common measurement tool would improve the generalizability. In this study a simpler tool may not have provided as much information, but a simpler measurement of physical activity may have decreased the amount of missing data.

A study specifically designed to assess predictors of physical activity would contribute to the field. A validated measurement tool to assess the outcome variable and collection of data on independent variables previously identified as predictors of physical activity would strengthen this study. A longitudinal study design would have the added benefit of assessing adherence, and possibly adoption, dropout and resumption of exercise. The study should be done considering a free-living sample, not participants in a supervised programme to improve the generalizability. A large sample would have the added benefit of being able to perform further subgroup analysis.

Studies need to continue to assess all levels of physical activity and not just vigourous activity. This was done in the OHS, and is recognized in the literature as a requirement for future studies (16). There is also a need to assess determinants of moderate activity and compare it to vigourous activity. Ideally, a common list of independent variables should be used in studies of physical activity. This would improve the comparability across groups. Independent variables studied should include personal variables, environmental variables and psychological variables. The variance predicted in this study was less than 25%; other predictors need to be included and tested in prediction models.

Finally, research is needed to establish effective interventions to increase the physical activity of individuals. Unfortunately, there are many predictors that are not amenable to change through intervention (e.g., age). Identifying the predictors alone will not increase the physical activity level of people. There is little information available about effective interventions to increase physical activity and this should definitely be a direction for future research.

REFERENCES

1. U.S. Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General.Atlanta, Georgia: Department of Health and Human Services, Centers for Disease Control and Prevention, National Centre for Chronic Disease Prevention and Health Promotion, 1996

2. NIH Consensus Development Panel on Physical Activity and Cardiovascular Health. Physical Activity and Cardiovascular Health. Journal of the American Medical Association 1996;276(3):241-246.

3. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273(5):402-7.

4. Craig CL, Russell SJ, Cameron C, Beaulieu A. 1997 Physical Activity Benchmarks Report.Ottawa: Canadian Fitness and Lifestyle Research Institute, 1998:58.

5. Anonymous. Exercise for health. WHO/FIMS Committee on Physical Activity for Health. Bulletin of the World Health Organization 1995;73(2):135-6.

6. Astrand PO. J.B. Wolffe Memorial Lecture. Why exercise? Medicine and Science in Sports and Exercise 1992;24(2):153-62.

7. Blair SN, Kohl HW, Gordon NF, Paffenbarger RSJ. How much physical activity is good for health? Annual Review of Public Health 1992;13:99-126.

8. Bouchard C, Shephard RJ. Physical Activity, Fitness and Health: The Model and Key Concepts. In: Bouchard C, Shephard, R.J., and Stephens, T., ed. Physical Activity, Fitness and Health: International Proceedings and Consensus Statement. Champaign: Human Kinetics Publishers, 1994: 9 - 76.

9. Johnson NA, Boyle CA, Heller RF. Leisure-time physcial activity and other health behaviours: are they related? Australian Journal of Public Health 1995;19(69-75).

10. U.S. Department of Health and Human Services. Public Health Focus: Physical Activity and the Prevention of Coronary Heart Disease. MMWR 1993;42:669-672.

11. Stephens T. Leisure-Time Physical Activity. In: Canads's Health Promotion Survey 1990 Technical Report. Ottawa: Health and Welfare Canada, 1990: 120.

12. Stephens T, Craig CL. The Well- Being of Canadians: Highlights of the 1988 Campbell's Survey.Ottawa: Canadian Fitness and Lifestyle Research Institute, 1990:120.

13. Dishman RK. Determinants of participation in physical activity. In: Bouchard C, Shephard, R.J., and Stephens, T. et al., ed. Exercise, Fitness and Health: A Consensus of Current Knowledge. Champaign, Illinois: Human Kinetics Publishers, 1990: 75-102.

14. Dishman RK, Sallis JF. Determinants and Interventions for Physical Activity and Exercise. In: Bouchard C, Shephard, R.J., and Stephens, T., ed. Physical Activity,

Fitness and Health: International Proceedings and Consensus Statement. Champaign: Human Kinetics Publishers, 1994: 214-238.

15. Dishman RK. Introduction: Consensus, Problems and Prospects. In: Dishman RK, ed. Advances in Exercise Adherence. Champaign, Illinois: Human Kinetics Publishers, 1994: 1-28.

16. Sallis JF, Hovell MF. Determinants of Exercise Behaviour. Exercise and Sport Sciences Reviews 1990;18:307-330.

17. Blair SN, Kannel WB, Kohl HW, Goodyear N, Wilson PW. Surrogate measures of physical activity and physical fitness. Evidence for sedentary traits of resting tachycardia, obesity, and low vital capacity. American Journal of Epidemiology 1989;129(6):1145-56.

18. Perusse L, Tremblay A, Leblanc C, Bouchard C. Genetic and Environmental Influences on Level of Habitual Physical Activity and Exercise Participation. American Journal of Epidemiology 1989;129(5):1012-1022.

19. Montoye HJ, Kemper HCG, Saris WHM, Washburn RA. Measuring Physical Activity and Energy Expenditure.Champaign: Human Kinetics, 1996:191.

20. Eaton CB. Relation of physical activity and cardiovascular fitness to coronary heart disease, Part II: Cardiovascular fitness and the safety and efficacy of physical activity prescription. Journal of the American Board of Family Practice 1992;5(2):157-65.

21. American College of Sports Medicine K, W. L.,, al. e. Guidelines for Exercise Testing and Prescription. (Fifth ed.) Media, Pa.: Williams and Wikins, 1995:372.

22. Hein HO, Suadicani P, Gyntelberg F. Physical fitness or physical activity as a predictor of ischemaic heart disease? A 17 year follow-up in the Copenhagen Male Study. Journal of Internal Medicine 1992;232:471-479.

23. Haskell WL. Health consequences of physical activity: understanding and challenges regarding dose-response. Medicine and Science in Sports and Exercise 1994;26(6):649-60.

24. American College of Sports Medicine. The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults. Medicine and Science in Sports and Exercise 1998;30(6):975-991.

25. Paffenbarger RJ, Hyde RT, Wing AL, Hsieh C-C. Physical Activity, All-Cause Mortality, and Longevity of College Alumni. New England Journal of Medicine 1986;314:605-613.

26. Barinaga M. How Much Pain for Cardiac Gain. Science 1997;276:1324-1327.

27. Logan W, MD G. Mortaliy and coronary and myocardial disease in different social classes. Lancet 1952;I:758-759.

28. Morris J, Kagan, A, Pattison, et al. Incidence and prediction of ischemic heart disease in London busmen. Lancet 1966;II:554-559.

29. Paffenbarger RJ, Laughlin M, Gima A, Black R. Work activity of longshoremen as related to death from coronary heart disease and stroke. New England Journalof Medicine 1970;282:1112-1113.

30. Paffenbarger RJ, Brand RJ, Sholtz RI, Jung DL. Energy expenditure, cigarette smoking, and blood pressure level as related to death from specific diseases. American Journal of Epidemiology 1978;108(1):12-8.

31. Hennekens CH, Rosner B, Jesse MJ, Drolette ME, Speizer FE. A Retrospective Study of Physical Activity and Coronary Deaths. International Journal of Epidemiology 1977;6(3):243-246.

32. Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M. Characteristics of Leisure Time Physical Activity Associated with Decreased Risk of Premature All-Cause and Cardiovascular Disease Mortality in Middle Aged men. American Journal of Epidemiology 1996;143(9):870-880.

33. Paffenbarger RJ, Wing AL, Hyde RT, Jung DL. Physical activity and incidence of hypertension in college alumni. American Journal of Epidemiology 1983;117(3):245-57.

34. Paffenbarger RJ, Wing AL, Hyde RT. Physical activity as an index of heart attack risk in college alumni. American Journal of Epidemiology 1978;108(3):161-75.

35. Arraiz GA, Wigle DT, Mao Y. Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Mortality Follow-up Study. Journal of Clinical Epidemiology 1992;45(4):419-428.

36. Berlin JA, Colditz GA. A meta-analysis of physical activity in the prevention of coronary heart disease . American Journal of Epidemiology 1990;132(4):612-28.

37. Powell KE, Thompsoon PD, Casperson CJ, al e. Physical activity and the incidence of coronary heart disease. Annual Review of Public Health 1987;8:253-287.

38. Montano L. Ischemic heart disease mortality attrigutable to Physical Inactivity in Ontario. Public Health and Epidemiology Report Ontario 1994;5(6):135-138.

39. Pomrehn PR, Wallace RB, Burmeister LF. Ischemic Heart Disease Mortality in Iowa Farmers: The Influence of Lifestyle. JAMA 1982;248(9):1073-1076.

40. Klesges RC, Eck LH, Mellon MW, Fulliton W, Somes GW, Hanson CL. The accuracy of self-reports of physical activity. Medicine and Science in Sports and Exercise 1990;22(5):690-7.

41. Washburn RA, Goldfield SR, Smith KW, McKinlay JB. The validity of self-reported exercise-induced sweating as a measure of physical activity. American Journal of Epidemiology 1990;132(1):107-13.

42. Taylor CB, Coffey T, Berra K, Iaffaldano R, Casey K, Haskell WL. Seven-day activity and self-report compared to a direct measure of physical activity. American Journal of Epidemiology 1984;120(6):818-24.

43. Blair SN, Haskell WL, Ho P, et al. Assessment of habitual physical activity by a seven-day recall in a community survey and controlled experiments. American Journal of Epidemiology 1985;122(5):794-804.

44. Jakicic JM, Polley BA, Wing RR. Accuracy of self reported exercise and the relatioship with weight loss in overweigh women. Medicine and Science in Sports and Exercise 1998;30(4):634-638.

45. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. Medicine and Science in Sports and Exercise 1993;25(1):71-80.

46. Kriska AM, Caspersen CJ. Introduction to a Collection of Physical Activity Questionnaires. Medicine and Science in Sports and Exercise 1997;29(6):S5-S9.

47. Dishman RK, Sallis JF, Orenstein DR. The determinants of physical activity and exercise. [Review]. Public Health Reports 1985;100(2):158-71.

48. Hovell MF, Sallis JF, Hofstetter CR, Spry VM, Faucher P, Caspersen CJ. Identifying correlates of walking for exercise: an epidemiologic prerequisite for physical activity promotion. Preventive Medicine 1989;18(6):856-66.

49. Hawkes JM, Holm K. Gender differences in exercise determinants. Nursing Research 1993;42(3):166-72.

50. Allison KR. Predictors of Inactivity: An Analysis of the Ontario Health Survey. Canadian Journal of Public Health 1996;87(5):354-358.

51. Allison KR. Physical Activity in Ontario: A Report on the Ontario Health Survey. In: Ontario Ministry of Health and Premier's Council on Health, Well-Being and Social Justice, Ontario Health Survey 1990 Working Paper No. 9, 1995, 1995:

52. Bauman A, Owen N, Rushworth RL. Recent trends and socio-demographic determinants of exercise participation in Australia. Community Health Studies 1990;14(1):19-26.

53. Shea S, Stein AD, Basch CE, et al. Independant Associations of Educational Attainment and Ethnicity with Behavioural Risk Factors for Cardiovascular Disease. American Journal of Epidemiology 1991;134(6):567-582.

54. Macera CA, Croft JB, Brown DR, et al. Predictors of adopting leisure-time physical activity among a biracial community cohort. American Journal of Epidemiology 1995;142(6):629-35.

55. Fogelholm M, Mannisto S, Vartiainen E, Pietinen P. Determinants of energy balance and overweight in Finland 1982 and 1992. International Journal of Obesity 1996;20:1097-1104.

56. Sallis JF, Hovell MF, Hofsteter CR, et al. A Multivariate Study of Determinants of Vigorous Exercise in a Community Sample. Preventive Medicine 1989;18:20-34.

57. Hofstetter CR, Hovell MF, Macera C, et al. Illness, Injury and Correlates of Aerobic Exercise and Walking: A Community Study. Research Quarterly for Exercise and Sport 1991;62(1):1-9.

58. Sallis JF, Hovell MF, Hofstetter CR, et al. Distance between homes and exercise facilities related to frequency of exercise among San Diego residents. Public Health Reports 1990;105(2):179-85.

59. Verhoef MJ, Love EJ. Women's Exercise Participation: The Relevance of Social Roles Compared to Non-role-related Determinants. Canadian Journal of Public Health 1992;83(5):367-370.

60. McPhillips JB, Pelletera KM, Barrett-Connor E, et al. Exercise Patterns in a Population of Older Adults. American Journal of Preventive Medicine 1989;5(2):65-72.

61. Cauley JA, Donfield SM, LaPorte RE, Warhaftig NE. Physical Activity by socioeconomic class in two population based cohorts. Medicine and Science in Sports and Exercise 1991;23(3):343-352.

62. Folsom AR, Cook TC, Sprafka JM, et al. Differences in Leisure-Time Physical Activity Levels Between Blacks and Whites in Population-Based Samples: The Minnesota Heart Survey. Journal of Behavioural Medicine 1991;14(1):1-9.

63. Bild DE, Jacobs DJ, Sidney S, Haskell WL, Anderssen N, Oberman A. Physical activity in young black and white women. The CARDIA Study. Annals of Epidemiology 1993;3(6):636-44.

64. Horne TE. Predictors of physical activity intentions and behaviour for rural homemakers. Canadian Journal of Public Health. Revue Canadienne de Sante Publique 1994;85(2):132-5.

65. Lochen M-L, Rasmussen K. The Tromso Study; physcial fitness, self reported physical activity, and theri relationship to ithe coronary risk factors. Journal of Epidemiology and Community Health 1992;26:103-107.

66. Treiber FA, Baranowski T, Braden DS, et al. Social support for exercise: relationship to physical activity in young adults. Preventive Medicine 1991;20(6):737-50.

67. King AC, Taylor CB, Haskell WL, DeBusk RF. Identifying strategies for increasing employee physical activity levels: findings from the Stanford/Lockheed Exercise Survey. Health Education Quarterly 1990;17(3):269-85.

68. Myers AM, Weigel C, Holliday PJ. Sex- and age-linked determinants of physical activity in adulthood. Canadian Journal of Public Health. Revue Canadienne de Sante Publique 1989;80(4):256-60.

69. Desmond AW, Conrad KM, Montgomery A, Simon KA. Factors Associated with Male Workers Engagement in Physical Activity, White Collar vs. Blue Collar Workers. AAOHN Journal 1993;41(2):73-82.

70. Baecke JAH, Burema J, Fritters ER. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. American Journal of Clinical Nutrition 1982;36:936-942.

71. King AC, Blair SN, Bild DE, et al. Determinants of physical activity and interventions in adults. Medicine and Science in Sports and Exercise 1992;.

72. Stephens T, Jacobs DJ, White CC. A descriptive epidemiology of leisure-time physical activity. Public Health Reports 1985;100(2):147-58.

73. Pampalon R. Health Discrepancies in Rural Areas in Quebec. Soc Sci Med 1991;33:335-360.

74. Reeder BA, Chen Y, MacDonald SM, et al. Regional and rural-urban differences in obesity in Canada. Can Med Assoc J 1997;157(1 (suppl)):S10-S16.

75. Ontario Ministry of Health. Ontario Health Survey 1990: Users Guide Vol 1 Documentation and Volume 2 Microdata Manual.1992

76. Taylor HJ, Jacobs DRJ, Schucker B, et al. A questionnaire for the assessment of leisure time physcial activities. J Chron Dis 1978;31:741-755.

77. Hennekens CH, Buring JE. Epidemiology in Medicine.Toronto: Little, Brown and Company, 1987:383.

78. Colton T. Statistics in Medicine.Boston: Little, Brown and Company, 1974:372.

79. Payton OD. Research: The Validation of Clinical Practice. (2 ed.) Philadelphia: F. A. Davis Company, 1988:311.

80. Hulley SB, Cummings SR. Planning the Measurement: Precision and Accuracy. In: Hulley SB, Cummings SR, ed. Designing Clinical Research. Baltimore: Williams and Wilkins, 1988: 31-41.

81. Roscoe JT. Fundamental Research Statistics for the Behavioural Sciences.New York: Holt, Rhinehart and Winston, Inc., 1969:336.

82. Tabachnick BG, Fidell LS. Using Multivariate Statistics. (Third ed.) New York: HarperCollins College Publishers, 1996:850.

83. Jacobs DR. Minnesota Leisure-Time Physical Activity Questionnaire. Medicine and Science in Sports and Exercise 1997;29(6):S62-S72.

84. Stephens T, Craig CL, Ferris BF. Adult Physical Activity in Canada: Findings from The Canada Fitness Survey I. Canadian Journal of Public Health 1986;77:285-290.

85. Haskell WL, Montoye HJ, Orenstein D. Physical activity and exercise to achieve health-related physical fitness components. Public Health Reports 1985;100(2):202-12.

86. Moser CA, Kalton G. Survey Methods in Social Investigation.New York: Basic Books, Inc., 1972:488.

87. Henry GT. Practical Sampling.Newbury Park: Sage Publications, 1990:139. (Bickman L, ed. Applied Social Research Methods Series; vol 21).

88. Breithaupt K. Issues related to the analysis of data from complex survey designs. Perspectives 1998;6(4).

89. Shah BV, Barnwell BG, Bieler GS. SUDAAN User's Manual: Software for Analysis of Correlated Data, Release 6.40.Research Triangle Park, NC: Research Triangle Institute, 1995

90. Kirk-Gardner R, Steven D. An Analysis of the Ontario Health Survey from a Cardiovascular Perspective. Canadian Journal of Cardiovascular Nursing 1994;5(3):7 - 13.

91. Statistics Canada. Profile of census divisions and subdivisions in Ontario, Part B.Ottawa: Industry, Science and Technology Canada, 1994. 1991 Census of Canada. Catalogue number 95-338.,

92. Michels KB, Greenland S, Rosner BA. Does Body Mass Index Adequately Capture the Relation of Body Composition and Body Size to Health Outcomes? American Journal of Epidemiology 1998;147:167-172.

93. Kleinbaum DG, Kupper LL, Muller KE, Nizam A. Applied Regression Analysis and Other Multivariate Methods. (Third Edition. ed.) Toronto: Druxbury Press, 1997

94. Neter J, Wasserman W, Kutner MH. Applied Linear Statistical Models. (Third ed.) Boston: Irwin, 1990:1181.

95. Hardy MA. Regression with Dummy Variables.Newbury Park: Sage Publications, 1993:88. (Lewis-Beck MS, ed. Quantitative Applications in the Social Sciences; vol 93).

96. Fox J. Regression Diagnostics.Newbury Park: Sage Publications, 1991:88. (Lewis-Beck MS, ed. Quantitative Applications in the Social Sciences; vol 79).

97. Atkinson AC. Plots, Transformations and Regressions. An Introduction to Graphical Methods of Diagnostic Regression Analysis.Oxford: Oxford University Press, 1988:271. Oxford Statistical Science Series

98. Abramson JH. Making Sense of Data; A Self Instruction Manual on the Interpretation of Epdemiologic Data. (Second Edition ed.) New York: Oxford University Press, 1994:389.

99. Winett RA, King AC, ALtman DA. Health Psychology and Public Health.Elmsford, NY.: Pergamon Press Inc., 1989:378.

100. Lovett SB. Processes of Aging: Enhancement of the Later Years. In: Winett RA, King AC, ALtman DA, ed. Health Psychology and Public Health. Elmsford, NY.: Pergamon Press Inc., 1989: 378.

101. Holloszy JO. Exercise, health and aging: a need for more information. Medicine and Science in Sports and Exercise 1993;25(5):538-542.

102. Godin G. Theories of reasoned action and planned behaviour: usefulness for exercise promotion. Medicine and Science in Sports and Exercise 1994;26(11):1391-1394.

103. Marcus BH, Simkin LR. The transtheoretical model: applications to exercise behavior. [Review]. Medicine and Science in Sports and Exercise 1994;26(11):1400-4.

104. Vuori IM, Oja P, Paronene O. Physically active commuting to work - testing its potential for exercise promotion. Medicine and Science in Sports and Exercise 1994;26(7):844-850.

105. Uitenbroek DG. Seasonal variation in leisure time physical activity. Medicine and Science in Sports and Exercise 1993;25(6):755-760.

106. Stevens J. Applied multivariate statistics for the social sciences.Mawah, NJ.: Lawrence Erlbaum Associates., 1996

107. Siegel PZ, Brackbill RM, Heath GW. The Epidemiology of Walking for Exercise: Implications for Promoting Activity among Sedentary Groups. American Journal of Public Health 1995;85(706-710).

108. Health Canada and Canadian Society for Exercise Physiology. Handbook for Canada's Physical Activity Guide for Healthy Living.Ottawa: Health Canada, 1998:27.

APPENDICES

Appendix 1

Questions Comprising the Physical Activity Item

Have you participated in the following physical activities during the last month?

	Yes/No	Number of Times	How Much Time Per Occasion
Walking for Exercise			
Bicycling			
Running or Jogging			
Exercises at Home			
Exercise Class, Aerobics			
Ice Skating			
Cross-Country Skiing			
Ice Hockey			
Swimming			
Squash or Racquetball			
Tennis			
Softball, Baseball			
Downhill Skiing			
Curling			
Bowling			
Golf			
Weight Training			
Basketball, Soccer, Volleyball			
Dancing - Popular, Ballet, Modern			
'Other' (Specify)			

* Actual Time	Time Recorded
1 – 15 minutes	7 minutes
16 – 30 minutes	21 minutes
31 – 60 minutes	45 minutes
> 60 minutes	60 minutes

Appendix 2

Assigned MET Levels For Activities Included in the 1990 Ontario Health Survey

Activity	**Assigned MET level (kcal/kg/hour)**
Walking for Exercise	2
Bicycling	4
Running or Jogging	8
Exercises at Home	3
Exercise Class, Aerobics	4
Ice Skating	4
Cross-Country Skiing	5
Ice Hockey	6
Swimming	3
Squash or Racquetball	6
Tennis	4
Softball, Baseball	3
Downhill Skiing	4
Curling	4
Bowling	2
Golf	4
Weight Training	3
Basketball, Soccer, Volleyball	5
Dancing - Popular, Ballet, Modern	3
'Other' Activities	4

Appendix 3

Sample Calculation Used to Derive *Energy Expenditure (NEW)*

Subject reports:

Activity	Number of Times per Month	Minutes per Session*	MET Level (Kcal/kilogram/hour)
Walking	28	45	2
Swimming	4	60	3

Calculations

Activity Specific Energy Expenditure = (sessions/month) X [(Minutes/session) / (60 minutes/hour)] X [MET Level (Kcal /kg/hour) / (30 days/month)]

Walking = 28 times/month X (45minutes/session)/(60 minutes/hour) X 2/30
= 1.4 KKD

Swimming = 4 times/month X (60 minutes/session)/(60 minutes/hour) X 4/30
= 0.53 KKD

Energy Expenditure (NEW) = 1.9 KKD

* Time Recorded (See Appendix 1)

Appendix 4

A Comparison of Energy Expenditure (NEW) and Energy Expenditure (OHS)

	Energy Expenditure (OHS)	Energy Expenditure (NEW)
Number of Subjects with Valid Scores	35,333	30,955
Mean Score (kcal/kg/day)	1.25	1.27
Standard Deviation	1.93	2.47
Skewness	3.7	10.13
Kurtosis	19.7	242.4
Range	0 – 19.9	0 – 115

Appendix 5

Medical Conditions Included in
'*Number of Health Problems*' Variable

Skin allergies or other skin diseases
Hay fever or other allergies
Back Pain
Arthritis or rheumatism
Serious Problems with joints or bones
Paralysis or speech problem due to stroke
Asthma
Emphysema, bronchitis or chronic cough
Epilepsy
High blood pressure or hypertension
Circulatory problems
Heart disease
Diabetes
Urinary problems or kidney disease
Stomach ulcers
Other digestive problem
Goitre or thyroid problem
Eye problem such as glaucoma or cataract
Cancer
Other longterm health problem

Appendix 6

Derivation of Final Sample Size

Sample	Number of Subjects
All subjects in the 1990 Ontario Health Survey 18 years of age or older.	43,954
Subjects meeting above criteria and having valid Energy Expenditure (NEW) scores	31,030
Subjects meeting above criteria and having valid Energy Expenditure (NEW) $\leq$ 20 KKD.	30,955
Subjects meeting above criteria and having valid scores for all independent variables	20,606

Appendix 7

Ethics Approval

Université d'Ottawa • University of Ottawa

Faculté de médecine
Cabinet du doyen

Faculty of Medicine
Office of the Dean

June 20, 1996

Alan Mayhew
Department of Epidemiology & Community Medicine
University of Ottawa

Dear Mr Mayhew

Thank you for your letter of June 17th, regarding your thesis proposal for an MSc in Epidemiology to examine the Ontario Health Survey for predictors of physical activity and for any regional differences therein.

I reviewed your letter, the thesis proposal which had been approved by the Graduate Education Committee of the Department and the relevant part of the questionnaire of the Ontario Health Survey.

As the data obtained through the OHS is now in the public domain, and as personal identifers have been removed from it, and there is no element of risk, benefit or intrusiveness to the original participants of the survey, and lastly that the original participants' consent to such re-examination of the data would not be obtainable, it is my opinion that full review by the Human Research Ethics Committee of the Faculty of Medicine is neither warranted nor required.

Accordingly, on behalf of the Faculty of Medicine, the University and the Research Ethics Committee, I acknowledge that you have requested approval for your project. It is my pleasure to advise you that the re-examination of the data in the 1990 Ontario Health Survey, as proposed in your thesis proposal, is approved.

If there are any deviations from the thesis proposal as approved by the Graduate Education Committee of your Department, please advise the Faculty's Human Research Committee as soon as possible.

With best wishes for successful completion of the project and your thesis.

Yours sincerely

George P. Biro, MD, PhD
Associate Dean, Medical Research and Graduate Studies

cc Dr N. Birkett
Dr R. Nair
Dr I. McDowell
Dr J. Farrall

451, ch. Smyth
Ottawa (Ontario) K1H 8M5 Canada

451 Smyth Rd.
Ottawa, Ontario K1H 8M5 Canada

(613) 562-5800 poste/ext 8113 • Télec Fax (613) 562-5457