

**The Association between Depression-related Disorders,
Chronic Physical Conditions and Leisure-time Physical
Activity among Canadians in Late Life: Results from the
Canadian Community Health Survey (Cycle 2.1)**

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

Introduction: The benefits of leisure-time physical activity on mental and physical health among older adults are well documented, but few studies have explored the association between depression and leisure-time physical activity within a theoretical framework.

Objective: The purpose of the present study was to identify the association between depression and leisure-time physical activity among community-dwelling, Canadian adults aged 65 and older, using a modified version of the International Classification of Functioning, Disability and Health (ICF) framework.

Method: The present study included a weighted sample of 3,785,145 community-dwelling, seniors aged 65 years or older who participated in the Canadian Community Health Survey (Cycle 2.1). Univariate and multiple logistic regressions were used to examine the cross-sectional association between depression-related disorders and leisure-time physical activity in the context of chronic physical conditions and psychosocial factors.

Results: Older adults reporting depression-related disorders were less likely to participate in leisure-time physical activity after adjusting for relevant psychosocial factors (odds ratios (ORs) ranged from 0.76 to 0.79, $p < 0.001$). This association was partially mediated by activity limitations associated with depression-related disorders. Similar results were observed between chronic physical conditions and participation in leisure-time physical activity.

Conclusion: Although the present study was unable to identify the temporal relationships among study variables, the results provide clinicians who care for older

adults with depression and/or chronic physical diseases with potentially useful information on the benefits of physical activity. They also provide evidence in support of community-based exercise or leisure-time physical activity program for seniors who are physically inactive to prevent chronic mental or physical illnesses and reduced quality of life

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1.0 INTRODUCTION

Since the proportion of seniors is increasing rapidly in Canada, it is essential to understand the determinants of healthy aging and quality of life in late life. As people age, they experience functional and cognitive decline and have an increased risk of having one or more chronic physical conditions (Brawley et al., 2003). Hence, researchers are increasingly emphasizing that modifiable risk factors may promote health, prevent disease and allow elderly to have longevity without poor health status (Shields et al., 2006).

Physical activity is a modifiable risk factor for all age groups. The health benefits of physical activity for older people are well documented (Fiatarone, 2002). Routine physical activity reduces both risk of cardiovascular disease, cancer, diabetes, obesity, high blood pressure, osteoporosis, symptoms of stress, anxiety and depression (Prohaska, 2006). Even though physical activity plays a key role in promoting health and preventing disability and premature death, approximately sixty per cent of seniors are inactive (Health Canada, 2003).

One health condition that compromises health in late life is depression. While the prevalence of depression in seniors is relatively low compared to younger population (Sjösten et al., 2006), the rate of depression has risen considerably over the past decade (i.e., 1.32% in 1991 to 5.54% in 2001) (Compton et al., 2006). Depression is highly associated with suicide in late life (Chapman et al., 2008) and has been shown to reduce functional abilities (e.g., activities of daily living and instrumental activities of daily living) and to be associated with risk factors for chronic disease (e.g., smoking, obesity).

Most recently, it has also been shown that the presence of depression tends to complicate the course and treatment of chronic physical conditions (Chapman et al, 2008; Moussavi et al., 2007; Ormel et al., 1998).

A limited number of studies have been conducted to determine the association between depression and physical activity among older adults (Strawbridge et al., 2002). Cross-sectional studies have shown an association between depression and physical activity in older adults, with high level of depression symptoms being associated with decreased participation in physical activity. In longitudinal studies, however, a relationship between depression and physical activity has not been observed consistently.

Using population-based data from the Canadian Community Health Survey (CCHS) (Cycle 2.1), the present study will examine the cross-sectional association between depression and engagement in leisure-time physical activity in the context of relevant chronic physical conditions and psychosocial factors. A modified version of the International Classification of Functioning, Disability and Health (ICF) theoretical framework will be used to describe the interplay between depression, chronic physical disease, physical activity and psychosocial factors.

In chapter 2 of this thesis a critical review of existing literature in the area of depression and physical activity in late life is presented. The ICF model will also be described and discussed in detail. In Chapters 3 and 4, the study objectives and methods will be presented, respectively. The main results are reported in Chapter 5. Finally, in chapter 6 the results will be discussed as well as strengths and limitations of this thesis.

2.0 LITERATURE REVIEW

There are a limited number of studies focusing on the relationship between depression and physical activity in late life (Strawbridge et al., 2002). In this literature review the following issues will be addressed: 1) the importance of physical activity in late life; 2) the prevalence of depression among older population; 3) empirical findings with respect to the association between depression and physical activity; 4) the application of the ICF framework to explain the relationship between depression and physical activity.

2.1 Physical Activity in Late Life

According to reports from the Center for Disease and Control Prevention (CDC) (CDC, 2008) and the American College of Sports Medicine (ACSM) (ACSM, 2007), the current recommendation for older persons aged 65 and older is participation in physical activity, especially of moderate intensity, for 30 minutes, 5 or more days per week. Physicians have also recommended that older persons participate in resistance training 2 to 3 days per week (Grodesky et al., 2006). However, relatively few older adults meet the current physical activity recommendation (Prohaska et al., 2006). According to the United States Department of Health and Human Services (USDHHS), only 10 to 30% of older adults in the U.S report participating in routine physical activity (Dergance et al., 2003). In Canada, it has been reported that 40% of older adults are sedentary. Another 40% of older adults exercise, however, their exercise levels in terms of frequency and intensity are too low to realize any substantial health benefits (Rhodes et al., 1999). More recently, Health Canada (2003) reported that 60% of seniors are inactive.

Epidemiological research indicates considerable variation in level of physical activity among subgroups of older adults. For instance, older (aged 70 years and older) adults are less likely to participate in physical activity than younger (aged 60 to 69), older men are more likely to be engaged in physical activity than older women, and White adults are more active than Black or Hispanic adults (CDC, 1997). Other socio-demographic factors including location of residence (urban versus rural), marital status, and the level of education and income are also associated with the variation in level of physical activity (King et al. 2000). Moreover, older adults with chronic physical diseases report more sedentary lifestyle than older adults without chronic conditions (Schwartz et al., 1999). Researchers mentioned that psychological factors among the elderly such as self-efficacy and attitudes toward physical activity also influence level of physical activity among older adults (Wilcox et al., 2002).

It has been reported that sufficient levels of daily physical activity could prevent about half of various physical declines (O'Brien Cousins, 2003; Fiatarone et al., 1994). Experimental evidence has revealed that participation in physical activity helps to reduce or prevent physical declines related to aging such as decreased endurance and functional capacity, sarcopenia, reduced bone density (Clark, 1999) and increased risk of falls (Barnett et al., 2003). Previous research focused on physiological benefits also showed that a physically active lifestyle plays an important role in prevention of chronic diseases such as coronary heart disease (Fraser et al., 1997), hypertension (Kokkinos et al., 2001), obesity (Jenkins et al., 2008), and diabetes (Ryan, 2000) in older age.

Routine physical activity also has positive effects on psychological aspects among the

elderly. Recent studies have shown that physical activity has beneficial effects on mental health such as reducing anxiety (Brosse et al., 2002) and sleeping disorders (King et al., 1997). Researchers also found that physical activity is positively associated with the improvement in psychological wellbeing (Fox et al., 2007) and enhanced self-efficacy (Orsega-Smith et al., 2007) in older age. In addition, several studies reported that older adults engaged in regular physical activity have shown the preventive effect of physical activity on cognitive decline. For instance, Boutcher et al. (2000) showed that older adults participating in physical exercise have faster reaction time, better memory, and better intelligence than their counterparts.

2.2 Depression and Anxiety Disorders among Older Population

It is noteworthy that depression among older populations became one of the priorities of public health in Canada (Patten, 2002; Patten et al., 2006). Prevalence estimates of depression among older adults aged 65 years or older range from 0.9% to 5.74% (Chapman et al., 2008; Klap et al., 2003). The rate of depression has risen considerably over the past decade, and depression will become the second leading cause of disease worldwide by 2020 (Chapman et al, 2008).

Depression in older adults is a strong predictor of suicide (Chapman et al., 2008, Bethell et al., 2007). This is noteworthy as older adults have a higher suicide rate than any other age group. Further, depression alone has been shown to reduce functional abilities (e.g., activities of daily living and instrumental activities of daily living) and to be associated with risk factors for chronic diseases (e.g., smoking and obesity) in older adults. More recently, it has also been shown that the presence of depression tends to complicate the

course and treatment of chronic physical conditions (Chapman, 2008; Moussavi, 2007). When depression symptoms are combined with chronic conditions in older adults, functioning may be more deteriorated than without chronic conditions (Ormel et al., 1998).

Although depression and anxiety are different mental disorders, many clinicians and researchers reported that those two chronic mental disorders frequently occur together and share common risk factors and similar symptoms. (Beekman et al., 1995, 2000; Hranov, 2007; Cerda et al., 2008; Martinsen, 2008). Also, seniors have both depression and anxiety disorders tend to have more severe symptoms than those who have pure depression (Beekman et al., 2000). On this basis, researchers have suggested that when researching depression, data on anxiety disorder also should be included (Beekman et al., 2000).

2.3 The Association between Depression and Physical Activity in Late Life

The nature of the relationship between physical activity and depression remains unclear. Researchers have reported the effects of physical activity on depression in clinically depressed and non-clinically depressed populations (Paluska et al., 2000). Netz et al. (1994) reported that psychogeriatric patients who were diagnosed as depressed showed the effect of exercise in reducing depressive symptoms. Timonen et al. (2002) also found that 26% of frail aged patients who were diagnosed with depression benefited from anaerobic exercise. However, several studies revealed that the observed effect may be only short-term (Weyerer, 1992; Kirtz-Silverstein et al. 2001; Lampinen et al., 2003; Wiles et al., 2007).

Findings of cross-sectional studies suggest that there is an association between physical activity and depression among older adults in a community-based population. Ruuskanen et al. (1995) found that depression was associated with lack of regular exercise and Cassidy et al. (2004) also reported that physically active women aged 70 years and older were half as likely to be depressed after adjusting for marital status and smoking habits. In older African American and White women in a rural area sample, Wilcox et al. (2003) also showed that the fewer depressive symptoms was significantly associated with higher level of physical activity. Sarkisian et al. (2005) reported that older adults who reporting under 30 minutes of moderate-vigorous physical activity in the previous week were more likely to have depressed mood than those reporting over 30 minutes of physical activity. Ormel et al. (1998) showed that older adults with depression and at least one medical condition reported the lowest level of physical activity compared with those without medical condition and/or depression.

Several studies have shown that the association between general distress and physical activity. Kaplan et al. (2001) found that the frequency of participation in physical activity is associated with psychological distress. Lim et al. (2005) also reported that adequate physical activity is related with lower level of psychological distress. Martin et al. (2000) showed that older adults reporting high level of physical activity had significantly lower levels of generalized distress.

Longitudinal studies have reported that little or no leisure-time physical activity is associated with an increased risk for depression among the elderly in a community sample. Strawbridge et al. (2002) found that after adjusting for confounding variables

such as age, sex, ethnicity and chronic physical conditions, high level of physical activity was protective for both prevalent depression and incident depression. In the Evergreen project, a prospective study on health and functional capacity among residents aged 65 and over of the city Jyväskylä in Central Finland, high level of physical activity at the baseline was indirectly associated with mental wellbeing including low levels of depressive symptoms at baseline and at follow-up (Lampinen et al., 2006). In an earlier study Lampinen et al. (2000) also reported that a low level of physical exercise increased the risk of depressive symptoms among older adults. Van Gool et al. (2006) found that physical inactivity was related to depressed mood longitudinally.

On the other hand, at least two longitudinal community-based studies did not report an association between depression and the level of physical activity. The Caerphilly Study, a cohort study of middle-aged men in Caerphilly, South Wales, United Kingdom, also showed that there was no association between physical activity and common mental disorders (Wiles et al., 2007). Indeed, the Rancho Bernardo Study revealed that while there was a cross-sectional association between exercise and depressed mood, there was no prospective effect of exercise at the baseline on depression at the follow-up (Kirtz-Silverstein et al., 2001).

2.4 Limitations of Current Studies

Several limitations of past studies have been noted in the literature. In terms of measurement of physical activity, a diverse range of instruments has been used to measure the level of physical activity. In addition, most studies did not assess duration,

intensity, and frequency of physical activity. For instance, Kirtz-Silverstein et al. (2001) used only two questions to measure participants' level of physical activity (Do you regularly engage in strenuous exercise or hard physical labor? Do you exercise or labor at least three times a week?); whereas, Strawbridge et al. (1996) developed a physical activity scale that included four questions about; 1) usual frequency of physical exercise; 2) participation in active sports; 3) taking long walks; and 4) swimming. For each question respondents were asked to rate frequency of participation on a three point scale (never, sometimes, or often). As noted earlier, for older adults the recommended physical activity level is participation in physical activity, especially of moderate intensity, for 30 minutes, 5 or more days per week.

Second, some researchers have drawn attention to the lack of an underlying theoretical framework. As Lampinen et al. (2006) acknowledged, sound theoretical framework could help to identify not only the multiple factors that influence the relationship between physical activity and depression but also help to specify the pathway(s) linking these two factors. The application of theoretical models would also help to address existing concerns about over-adjustment in past analyses of physical activity and depressive symptoms. It has been noted (Kaplan et al., 2001; Strawbridge et al., 2002) that some factors considered as confounders might be intervening variables or modifiers in the pathway between depression and physical activity. Specifically, while social networks have been usually considered as a confounding factor in most studies, some researchers have suggested that social networks might be a modifier between physical activity and depression (Kaplan et al., 2001; Strawbridge et al., 2002). Since older adults with depressive symptoms are less likely to interact with other people, they may

have less opportunity to be physically active than those without depression.

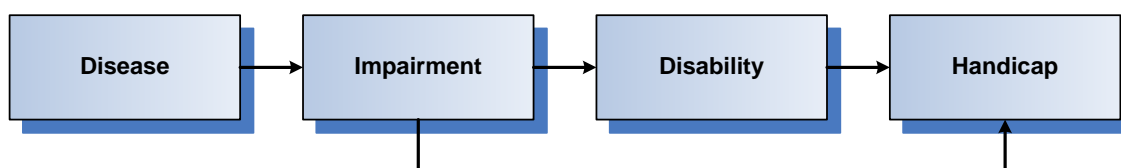
Moreover, several studies have not investigated the range of factors potentially associated with physical activity and depression. For example, Fukukwa et al. (2004) included only three variables, namely gender, annual income and the presence of chronic diseases. Lampinen et al. (2003) include only four covariates (i.e., gender, age, number of chronic illness and length of education), while Wilcox et al. (2003) included socio-demographic, psychological, and environmental factors but excluded number of chronic physical conditions. Sarkisain et al. (2005) excluded environmental factors such as social support (or social network) and marital status.

Limited number of studies have identified whether there exists the difference in health status, for instance depression and the level of physical activity participation between immigrant population and native-born population. The immigrant population in Canada represents more than 18.5% of the population, an increasing proportion of the Canadian population (Statistics Canada, 2004). Indeed, immigrants who entered Canada during the first wave of immigration are now old. Studies have suggested that older immigrants are more likely to experience declining health than the Canadian born-counterparts. Older immigrants may more experience health risks than Canadian-born counterparts due to cultural and language differences that further limit information and access to health services (Newbold et al, 2003, 2006; Newbold, 2006; Gee et al, 2004; McDonald et al., 2004; Dunn et al., 2000; Wu et al., 2002).

2.5 The International Classification of Functioning, Disability and Health (ICF)

In 2001, the World Health Organization (WHO) proposed the use of the ICF framework to study the consequences of chronic disease. The ICF model was derived from the International Classification of Impairment, Disability and Handicap (ICIDH) model published in 1980 by WHO (Dixon et al., 2008). In the ICIDH model, the consequences of a chronic disease are considered sequential, either moving from impairment to disability to handicap, or progressing directly from impairment to handicap (Johnston & Pollard, 2001) (See Figure 1).

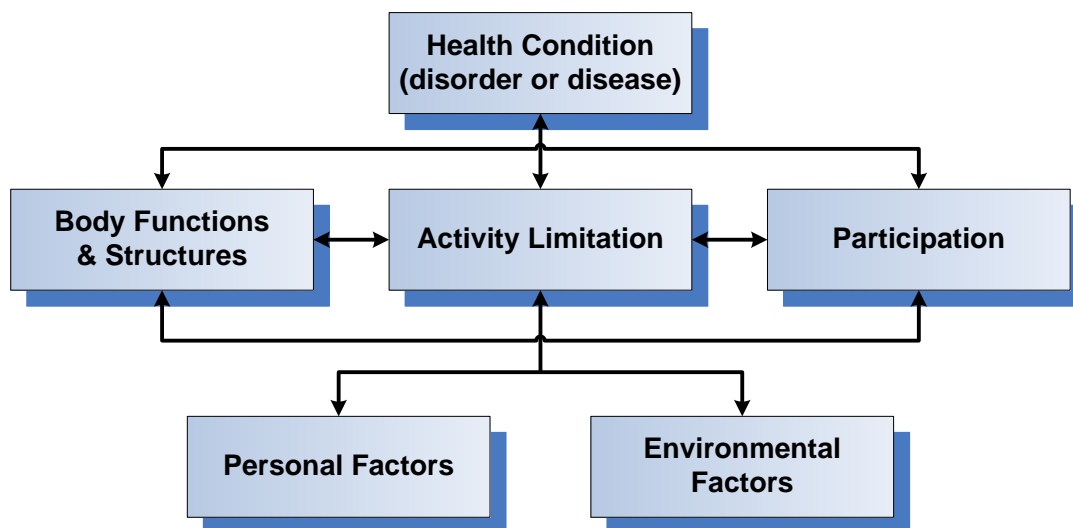
Figure 1 The International Classification of Impairment, Disability and Handicap (ICIDH) model (WHO, 1980)



According to the WHO definitions (1980), impairment in the ICIDH is ‘any loss or abnormality of psychological, physiological, or anatomical structure or function’ [p. 27]. Disability is ‘any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being’ [p. 28]. Handicap is ‘a disadvantage for a given individual, resulting from impairment or disability that limits or prevents the fulfillment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual’ [p.29].

However, there is evidence to suggest that impairment is not the only factor that affects disability, with factors such as psychological or contextual factors also leading to disability (Johnston & Pollard, 2001; Dixon et al., 2008). On this basis, the ICF model was developed to replace the original ICIDH model. In the ICF model (previously named ICIDH-2 model), disability or activity limitation at the individual level is viewed as the results of impairment, which in turn is the result of disease or disorder. The ICF model also proposed reverse causality, that is, lack of participation may cause activity limitations which may cause impairment. Within this framework, personal characteristics and environmental factors modify the transitions from impairment to participation (Johnston & Pollard, 2001) (see Figure 2).

Figure 2 The International Classification of Functioning, Disability and Health (ICF) model (WHO, 2001)

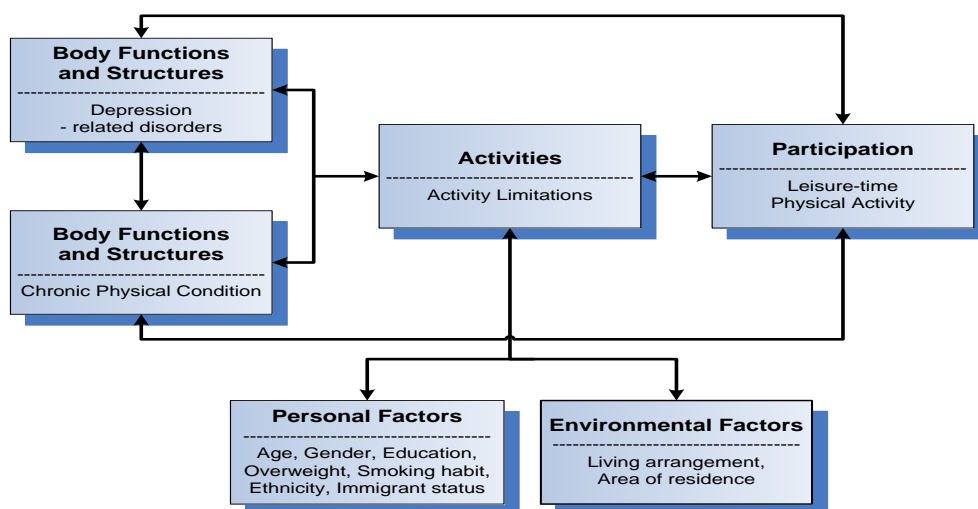


The main strength of the ICF model is its incorporation of both social and medical perspectives and thus its acknowledgement of both disease-related and psychosocial

factors. On the other hand, few empirical studies have been conducted to test relationship between ICF components and the strength of those relationships. One major constraint in the use of the ICF is that many researchers have had difficulties distinguishing between the activity and participation domains (Raghavendra et al., 2007).

A modified version of the ICF model was used as a guideline for the proposed thesis. It was assumed that impairments of body function, depression-related disorders and/or chronic physical conditions lead to impairments in general health status (i.e., activity limitations), and physical exercise (i.e., participation). The effect of depression may be influenced by the presence of other chronic physical disorders, personal factors (e.g., age, gender, weight, marital status, level of education, smoking habit, ethnicity, and immigrant status) and environmental factors (i.e., living arrangement and area of residence) (see Figure 3).

Figure 3 The modified International Classification of Functioning, Disability and Health (ICF) model



3.0 STUDY PURPOSE AND RESEARCH QUESTIONS

3.1 Study Purpose

The main goal of the present study was to identify the association between depression-related disorders and leisure-time physical activity among community-dwelling, Canadian elderly aged 65 and older.

3.2 Research Question & Hypotheses

3.2.1 Research Question 1

How are the depression-related disorders and chronic physical conditions related to activity limitations after adjusting for selected personal and environmental factors?

Hypothesis: Older adults having depression-related disorders alone or comorbid with one or more physical chronic conditions are more likely to report activity limitations than those who do not report a chronic mental or physical condition.

3.2.2 Research Question 2

How are activity limitations related to leisure-time physical activity after adjusting for personal and environmental factors?

Hypothesis: Seniors reporting limitations of activities are less likely to engage in leisure-time physical activity than those with no reported activity limitations.

3.2.3 Research Question 3

How are depression-related disorders and chronic physical conditions related to engagement in leisure-time physical activity after adjusting for personal and

environmental factors?

Hypothesis: Seniors having depression-related disorders alone or comorbid with one or more physical chronic diseases are less likely to participate in leisure-time physical activity than those who do not report a chronic mental or physical condition.

3.2.4 Research Question 4

How do the restrictions of activity mediate the association between chronic mental and physical condition and leisure-time physical activity after adjusting for personal and environmental factors?

Hypothesis: Older adults having chronic mental and/or physical illness as well as activity limitation are less likely to participate in leisure-time physical activity.

4.0 METHODS

This study examined data from the Canadian Community Health Survey (CCHS) (Cycle 2.1). The CCHS is a cross-sectional national population health survey conducted by Statistics Canada every two years. In this section we describe the data source, study measures, and data analysis. The source of information for the data source and measures used was the CCHS 2.1 user guide (Statistics Canada, 2005).

4.1 Data Source

The CCHS cycle 2.1 was collected between January 2003 and December 2003. Initial plans by the survey administrators were to allocate the sample uniformly across the 12 months, but due to unforeseen events the data collection was uneven across the four seasons of the year. This seasonal affect was accounted for by sample weighting (Statistics Canada, 2005).

The CCHS target population consisted of Canadians aged 12 years or older living in private dwellings. Residents of Native Reserves, Crown Lands, institutions, Canadian Forces Bases and some remote regions were excluded from this survey. This group represented approximately 2% of the Canadian population aged 12 or older (Statistics Canada, 2005).

The main goals of the CCHS were ‘to provide timely, reliable, cross-sectional estimates of health determinants, health status and health system utilization across Canada; to gather data at the sub-provincial levels of geography; to create a flexible survey instrument that: 1) meets specific health region data gaps; 2) develops focus survey

content for key data; and 3) deals with emerging health and health care issues as they arise' [p.4] (Statistics Canada, 2005).

The CCHS questionnaire was made up of three components: (1) common content, which was asked of all respondents, (2) sub-sample content where certain questionnaire modules were asked only of enough respondents to yield reliable estimates at the national and provincial level, and (3) optional content which allows health regions to focus on issues of local interest (Statistics Canada, 2005).

To obtain the population for this survey, total 126 health regions across ten provinces and three territories were targeted. A total sample size of 130,700 was required to get reliable estimates for each of these health regions. Using a three step process, the sample was allocated first to provinces, then health regions and then finally to the strata and clusters. At each stage, the allocation was generally proportional. In particular, for the provinces the sample was allocated according to both the population size and the number of health regions. For the health regions, allocation was proportional to the square root of the population. For the strata and clusters the allocation was proportional to the number of households (Statistics Canada, 2005).

To select the sample of household, the CCHS used three sampling frames. Forty-eights per cent of the sample came from an area frame designed for the Canadian Labour Force Survey and 50% came from a list frame of telephone numbers created from the Canadian phone directory and the corresponding postal codes. The remaining 2% came from a Random Digit Dialing (RDD) sampling frame that employed a 100s-bank-type sampling method (Statistics Canada, 2005).

The sampling technique for the area frame was a multistage stratified cluster approach. The area frame was stratified by geography, population density and median household income. For the area frame, the sampling was two-stage with selection of clusters within homogenous strata and then households within clusters. The list frame of telephone numbers was stratified by health regions. One telephone list frame was used for each health region and simple random sampling procedure was then used for selecting telephone numbers from each list frame stratum. The RDD frame was also approximately stratified by health region as possible and was used for just 5 of the 126 health regions. The RDD frame used the Elimination of Non-Working Banks (ENWB) method (Norris & Paton, 1991). The ENWB sampling method is to identify all working banks for an area and then to eliminate all telephone numbers within non-working banks. The banks after the elimination were grouped into stratum based on corresponding postal codes within its health regions (Statistics Canada, 2005).

4.1.1 Sampling Weight Construction

Since the sampling design is self-weighting at the household level within strata (Statistics Canada, 2008), the initial survey weight was roughly equal to the number of households in the stratum, divided by the number of households sampled in the stratum. In particular, for the area frame, the initial weight for each subject was given by the inverse of the product of the cluster and household selection probabilities. For the list frame, the selection probability was given by the ratio between the number of selected telephone numbers and the number of listed telephone numbers in the health region. For the RDD frame, the probability was calculated as the ratio between the number of selected telephone numbers and 100 times the number of banks in the stratum (Statistics

Canada, 2005).

After some adjustment of the weights to balance out higher-than-required sample sizes in some health regions and to remove households that were later found to be vacant, under construction, seasonal or secondary, the weights were adjusted to account for non-response. Using information available from all selected households, classes with significantly different response rates were defined. Households in the same class were assigned the same non-response adjustment factor, calculated as the ratio between the sum of initial weights among all selected households and the sum of weights among all responding households. A similar approach was used to adjust for individual non-response. Adjustment was applied only within the sampling frame (Statistics Canada, 2005).

Sampling weights for units obtained by telephone frames were further adjusted to account for coverage issues (e.g., unlisted numbers, households without a private residential land line and household with multiple lines). To reconcile the area and telephone frames through the survey weight, a technique referred to as integration (Skinner and Rao, 1996) was applied (Statistics Canada, 2005).

As stated previously, the data collection was not conducted uniformly over the years, as desired. Dividing the year up into four seasons, the adjustment factor for a given season was calculated as the sum of weights for the total sample divided by 4 times the sum of weights for the sample interviewed during the season under consideration (Statistics Canada, 2005).

These various adjustments increased weight variability. Any outliers identified among weights corresponding to the same health region, age, and sex were handled using a technique called Winsorization, where the outlying values were replaced by a percentile. The final stage in survey weight construction was calibration of the weights to correspond to health region, age group and sex specific population estimates obtained from recent census data (Statistics Canada, 2005).

4.1.2 Non-sampling Errors

Interview mode effects

A computer-assisted telephone interview (CATI) was conducted with respondents obtained from the telephone frames. Data from units selected from the area frame were collected using either computer assisted personal interviews (CAPI), CATI or a mix of both (Statistics Canada, 2005). As the first cycle of CCHS to collect a larger proportion of data via telephone, Statistics Canada carried out a study (St-Pierre and Béland, 2004) to test differences in some key health-related estimates caused by the mode of collection (CAPI versus CATI).

Findings of the study revealed mode effects in BMI and physical activity. Compared to data collected with CAPI, respondents tended to report lower BMI and higher scores on the Physical Activity Index (PAI) in the CATI. The authors suggested the difference in BMI was caused by social desirability response bias. As for the PAI, they suggested that the difference was likely due to interviewer variability. Interview times revealed that some CAPI interviewers may not have been running through the entire list of 20 activities with the respondents, and inadvertently under-estimated PAI (St-Pierre and

Béland, 2004).

The mode effects clearly required some consideration in the present study. Other work suggested that PAI may also be subject to social desirability bias. This form of bias may have been more likely to appear in CATI than CAPI (Gilmour, 2007; Motl et al, 2005).

Measurement method

As a result of the CAPI versus CATI study, Statistics Canada measured height and weight on subsample of CCHS respondents on the subsequent CCHS (Cycle 3.1). In comparing measured versus self-reported BMI, the data revealed that respondents tended to report BMI lower than the direct measurement (Roberts, 1995). Factors related to a tendency to report a difference between measured versus self-reported BMI were age greater than 65 years and among females, Physical Activity Index (PAI) (Shields et al., 2008).

Bias associated with self-reported diagnoses has also been studied by other groups. Depending on the chronic condition, older patients have been found to under-report an actual diagnosis (Martin et al., 2000).

Measurement errors may also be present in other variables such as Physical Activity Index even though it has been validated against a variety of other physical activity measures (Wister & Wanless, 2007). However, some authors suggested that PAI may be subject to bias through the reliance on the respondent's memory and the limitation to a set of specific leisure-time activities (Gilmour, 2007; Motl et al., 2005).

4.2 Study Measures

4.2.1 Outcome Variable

In this thesis, leisure-time physical activity was classified under the participation domain of the modified version of the ICF model. The CCHS assessed self-reported leisure-time physical activity with a checklist. Respondents were asked: “Have you done any of the following in the past 3 months and how many times in the last month?” The specific leisure-time activities were walking for exercise, gardening or yard work, swimming, bicycling, social dance, home exercise, ice hockey, in-line skating or rollerblading, jogging or running, golfing, exercise class or aerobic, downhill skiing or snowboarding, bowling, baseball or softball, tennis, fishing, volleyball, basketball and soccer.

The operational measure of leisure-time physical activity was average daily energy expended during leisure-time activities in the past three months. Energy expenditure (EE) was calculated using the frequency and duration per session of physical activity, as well as the metabolic equivalent (MET) of the activity. The MET was a value of metabolic energy cost expressed as a multiple of the resting metabolic rate. Namely, the formula to yield total daily EE = sum of (N×D×MET value)/365 where N = the number of times a respondent engaged in a specific activity over a 12 month period; D = the average duration in hours of the activity; and MET value = the energy cost of the activity expressed as kilocalories expended per kilogram of body weight per hour of activity (kcal/kg per hour)/365.

MET values tend to be expressed in three intensity levels that is, low, medium and

high. Since the CCHS questions did not ask the respondent to specify the intensity level of their activities, the MET values adopted correspond to the low intensity value of each activity. This approach was adopted from the Canadian Fitness and Lifestyle Research Institute because individuals tended to overestimate the intensity, frequency and duration of their activities (Stephens et al., 1990).

To classify a participant as physically active or not, the CCHS derived the PAI using the total daily EE values. If the total daily EE score was 3.0 or greater, the PAI categorized the respondent as being ‘active’, if the EE score was 1.5 or greater but less than 3.0, PAI categorized the respondent as being ‘moderately active’, and if the EE score was a less than 1.5, PAI categorized the respondent as being ‘inactive’. Since the purpose of the present study was to examine whether a participant was physically active or inactive, the active and moderately active were collapsed to form one category, herein referred to as ‘active’ (see Appendix A).

4.2.2 Main Explanatory Variables

Diagnosis of depression and anxiety

Many clinicians and researchers agree that depression and anxiety are related disorders (Beekman et al., 1995, 2000; Hranov, 2007; Cerda et al., 2008). On this basis, as well as concerns about relatively small number of respondents with a diagnosis of depression, the present study included respondents who reported a diagnosis of depression and/or anxiety disorder (see Appendix A).

The presence or absence of depression and anxiety was assessed on the basis of the following question: Which are expected to last or have already lasted six months or more

and that have been diagnosed by a health professional? For this study, participants who respond yes to the presence of a diagnosed mood disorder including depression, bipolar disorder and mania or dysthymia were considered to have depression. Similarly, participants who respond yes to the presence of a diagnosed anxiety disorder including phobia, obsessive compulsive disorder or panic disorder were considered to have anxiety.

Chronic physical conditions

The presence of a chronic physical disorder(s) was assessed using the same question to determine the presence or absence of depression and anxiety, that is, “Which are expected to last or have already lasted six months or more and that have been diagnosed by a health professional?” Food allergies, asthma, fibromyalgia, arthritis or rheumatism, back problems, high blood pressure, migraine headaches, chronic bronchitis, emphysema or chronic obstructive pulmonary disease, diabetes, epilepsy, heart disease, cancer, intestinal or stomach ulcers, the effects of a stroke, urinary incontinence, bowel disorder, Alzheimer’s disease or other dementia, cataracts, glaucoma, thyroid condition, chronic fatigue syndrome, multiple chemical sensitivities, schizophrenia, developmental disorders, eating disorder, and other long-term physical or mental health condition.

For this study, a comorbidity index was created. It was based on the Functional Comorbidity Index (Groll et al., 2005), developed to predict physical functioning. Other commonly used comorbidity indices such as the Charlson and Kaplan-Feinstein indices have been designed to predict mortality (Groll et al., 2005). Unfortunately, not all the comorbid illnesses of the Functional Comorbidity Index, namely osteoporosis, neurological disease (multiple sclerosis or Parkinson’s), peripheral vascular disease, and hearing problems were included in the CCHS question asking about a range of health conditions.

The chronic physical conditions included in this study's comorbidity index were: asthma, arthritis or rheumatism excluding fibromyalgia, back problems excluding fibromyalgia and arthritis, emphysema or chronic obstructive pulmonary disease, diabetes, heart disease, intestinal or stomach ulcers, the effects of stroke, cataracts, glaucoma, and other long-term physical or mental health conditions (a proxy for those conditions of the Functional Comorbidity Index not covered by the CCHS).

In addition, the Functional Comorbidity Index included not only chronic physical condition but also chronic mental illnesses such as depression and anxiety disorder. In the present study chronic mental and physical illnesses were distinguished and analyzed separately. While obesity was one of the illnesses in the Functional Comorbidity Index, the present study considered it as a personal factor. The number of chronic physical conditions that respondents reported was coded into three categories: none, one and two or more.

4.2.3 Main Intervening or Mediating Variable

Activity limitations

In the CCHS, participants were asked to report the frequency of activity limitations due to physical or mental health problems. Activity limitation was assessed with a derived variable (see Appendix A) that is based on the following three questions: 1) Do you have any difficulty hearing, seeing, communicating, walking, climbing stairs, bending, learning or doing any similar activities?; 2) Does a long-term physical condition, mental condition or health problem reduce the amount or the kind of activity you can do at home, school, or work?; 3) Does a long-term physical condition, mental condition, or health problem reduce the amount or the kind of activity you can do in other activities, for example, transportation or leisure? The scale of the derived activity limitation

variable was ordinal with three frequency levels: never, sometimes and often.

4.2.4 Modifying Variables

Personal and psychosocial factors

Personal factors included age, gender, marital status, education, weight, smoking habits, ethnicity, and immigrant status. Age was collapsed into two categories 65-74 years and 75 years and older. Gender was coded as a dichotomous variable with female as the reference category. Marital status was categorized into three groups (married, widowed/separated/divorced, and never married). Education was recoded into three categories (less than secondary, secondary and postsecondary). Based on the BMI, body weight was categorized into two groups (overweight or normal weight). Smoking habits were recoded into three categories (current smoker, former smoker and never-smoker). Ethnicity was categorized as White or Visible minority. Immigrant status was coded into two categories, not immigrant or immigrant. Psychosocial factors included living arrangement and area of residence. Living arrangement was recoded into two categories living alone or living with others. Area of residence was categorized as urban or rural. Lastly, the present study examined interview mode (in-person or telephone) to control for possible interview or social desirability bias.

4.3 Data Analysis

For all the analyses respondents were assigned to one of two groups (physically active versus inactive) based on the PAI (refer to page 28). The analysis for the present study followed two stages. In the first stage, descriptive analyses were conducted to identify frequencies and distribution of data and proportion of missing data. To obtain a rough gauge of dependence between a particular explanatory variable and the outcome variable or response while conditioning on the remaining covariates, correlation and partial correlation analysis was also conducted. In the second stage, the present study conducted univariate logistic regression analysis for each variable, followed by multiple logistic regression analyses to test the pathways of the modified ICF model.

All calculations were performed using SAS, version 9.1. All data were weighted using weights provided by Statistics Canada. Using BOOTVAR macros (SAS version) provided by Statistics Canada, the bootstrap resampling method was applied to univariate and multiple logistic regression analysis. Since Statistics Canada surveys including CCHS (Cycle 2.1) use complex sampling designs, variance estimation for these designs cannot be carried out by simple formulae. Thus, Statistics Canada has recommended that users perform resampling variance estimation with the bootstrap weights available in the CCHS (Cycle 2.1) master data file (Statistics Canada, 2005).

In the present study, the variance estimation for univariate and multiple logistic regression analyses was calculated using 500 bootstrap replicates. Since BOOTVAR macros (SAS version) did not support ordinal logistic regression analysis, however, we could not use bootstrap resampling method to test the pathway between variables,

depression-related disorders, chronic physical conditions and activity limitations.

The reference categories of each study variable were: inactive (leisure-time physical activity), never (depression-related disorders), never (chronic physical condition), never (activity limitations), living with others (living arrangement), rural area (area of residence), 65-74 (age), female (gender), never (obesity), nonsmoker (smoking habit), less than secondary (level of education), white (ethnicity), no (immigrant status), in-person (interview mode).

4.3.1 Descriptive Analysis

The descriptive statistics were calculated for all study variables from CCHS (Cycle 2.1). As Statistics Canada (Statistics Canada, 2005) recommended using survey weights (wtsc_m) frequencies and distribution of data and proportion of missing data were calculated for the total sample of CCHS seniors by level of engagement in leisure-time physical activity (inactive and active). In addition, frequency analysis of reported chronic physical illnesses was conducted to identify prevalence of those illnesses included in the Functional Comorbidity Index (Groll et al., 2005). To identify whether multicollinearity between a particular explanatory variable and PAI existed, the present study conducted not only simple correlation but also partial correlation analyses.

4.3.2 Univariate Logistic Regression Analysis

Univariate logistic regressions were run to identify the association between each explanatory variable and leisure-time physical activity, as measured by the PAI. This formulation modeled leisure-time physical activity as a binary outcome with “inactive”

(reference category) and “active” levels. In this case this gave a logistic regression model of the form

$$\text{logit}(\text{Pr}(PAI = \textit{inactive}|\mathbf{x})) = \alpha + \boldsymbol{\beta}^T \mathbf{x}$$

where \mathbf{x} is a covariate vector, α is an intercept parameter and $\boldsymbol{\beta}$ is a vector of coefficient parameters (SAS Institute Inc., 2007). Interpretation of parameter estimates $\hat{\boldsymbol{\beta}}$ can be carried out using the standard approach of examining the value of adjusted odds ratios $\exp(\hat{\boldsymbol{\beta}})$.

4.3.3 Testing Pathways of the modified ICF model

A five step multivariate logistic regression analysis procedure was used to testing pathways of the modified ICF model (see figure 4).

Step 1

The effect of interaction term between depression-related disorders and chronic physical condition in body function and structure domain was tested in this step. The two interaction terms (depression-related disorders*one chronic physical condition and depression-related disorders*two or more chronic physical conditions) were tested with P value ($p < .05$) (see Figure 4, pathway #1).

Step 2

The association between depression-related disorders and activity limitations was tested five ways: 1) without adjustment, 2) adjusted for personal factors, 3) adjusted for environmental factors, 4) adjusted for personal and environmental factors, and 5)

adjusted for personal and environmental factors and interview mode. Using sampling weights, ordinal logistic regression analysis was conducted since the activity limitation measured had three response categories (never, sometimes and often). As previously mentioned, BOOTVAR macros (SAS version) provided by Statistics Canada did not support the ordinal logistic regression. Similar analyses were done to examine the association between chronic physical conditions and activity limitations (see Figure 4, pathway #2).

Step 3

The relationship between activity limitation and leisure-time physical activity was tested five ways: 1) without adjustment, 2) adjusted for personal factors, 3) adjusted for environmental factors, 4) adjusted for personal and environmental factors, and 5) adjusted for personal and environmental factors and interview mode. Since the response variable, PAI, was binary, multiple logistic regression analysis was conducted using bootstrap weights (see Figure 4, pathway #3).

Step 4

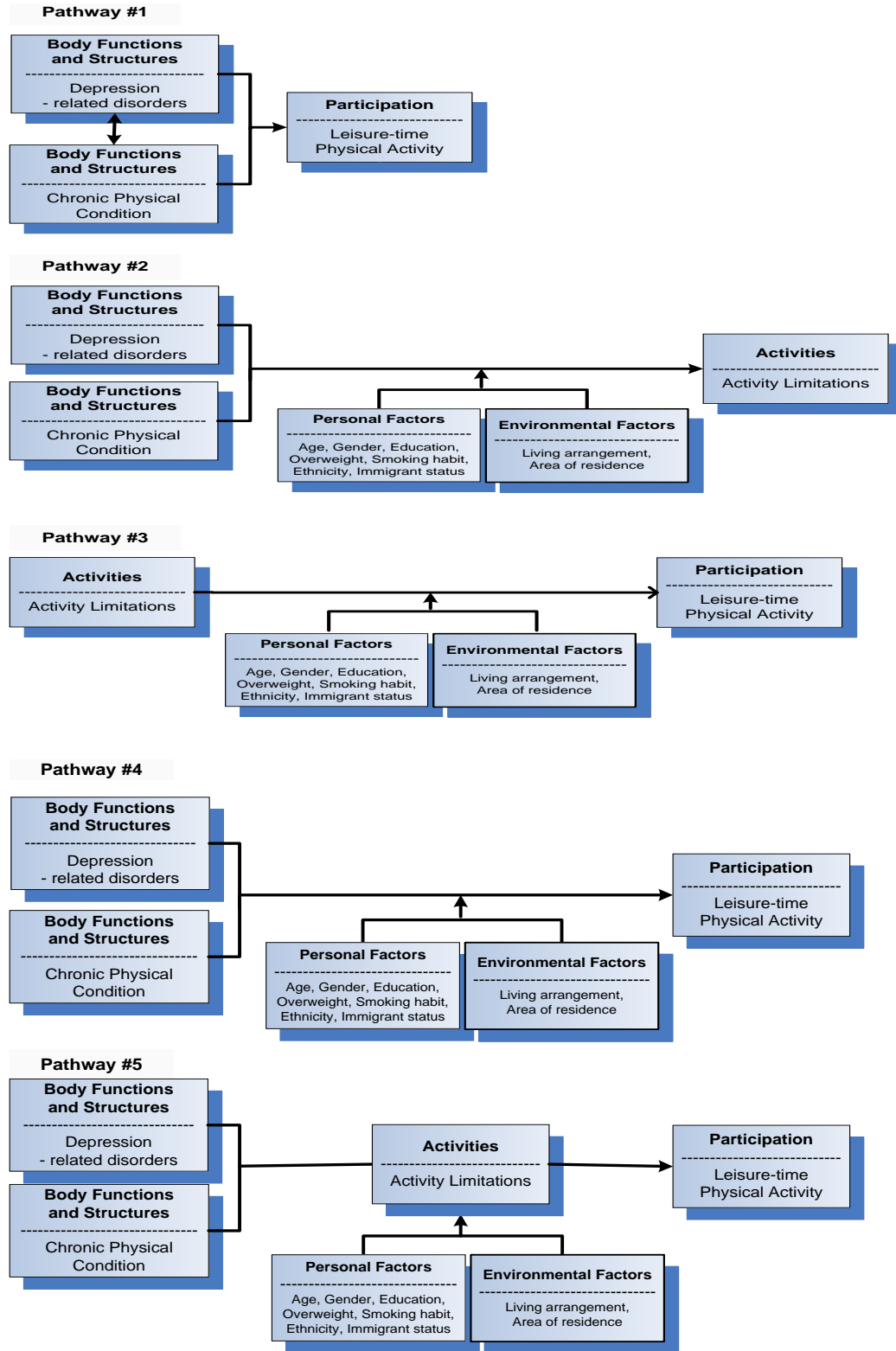
The relationship between two depression-related disorders and leisure-time physical activity was examined five ways: 1) without adjustment, 2) adjusted for personal factors, 3) adjusted for environmental factors, 4) adjusted for personal and environmental factors, and 5) adjusted for personal and environmental factors and interview mode. Using bootstrap weights, the estimation of variances for the multiple logistic regression analysis was conducted. Similar analyses were done to examine the association between chronic physical conditions and leisure-time physical activity (see Figure 4, pathway

#4).

Step 5

The effect of activity limitations on the relationship between both depression-related disorders and chronic physical health conditions and leisure-time physical activity was examined five ways: 1) without adjustment, 2) adjusted for activity limitations and personal factors, 3) adjusted for activity limitations and environmental factors, 4) adjusted for activity limitations, personal and environmental factors, and 5) adjusted for activity limitations, personal and environmental factors and interview mode. Using bootstrap weights, the estimation of variances for the multiple logistic regression analysis was conducted (see Figure 4, pathway #5).

Figure 4 Pathways of the modified International Classification of Functioning, Disability and Health (ICF) model



4.4 Access to Data

All data analysis was conducted at South Western Ontario Research Data Centre (SWORDC) located at University of Waterloo. I took an Oath of Office and was deemed an employee of Statistics Canada to access CCHS (Cycle 2.1). All output from the statistical analysis was reviewed by the SWORDC analyst to ensure confidentiality is maintained.

4.5 Ethics

Ethics clearance for the present study was granted by the Office of Research Ethics at University of Waterloo.

5.0 RESULTS

5.1 Study Sample

The total weighted sample of the Canadian Community Health Survey (Cycle 2.1) represented 26,578,128 individuals (unweighted n=135,573). Of these, 3,785,145 (unweighted n=28,672) 65 years or older were included in this study sample. Fifty-nine percent and 41 % of the sample were 65-74 years old and 75 years and older, respectively and 57% were females. Approximately 46% of the sample reported less than high school completion, while 38% reported completing some postsecondary education. The majority of the sample was married (61%), Canadian born (75%) and classified as white (93%). Approximately 35%, 54% and 11% of the sample were non-smokers, former smokers and current smokers, respectively and 55% reported being overweight. Sixty-nine percent of the sample was living with others and 80% resided in an urban area.

Fifty-nine percent of the sample reported being inactive. Approximately 6% of the sample reported a diagnosis of depression and/or anxiety (i.e., 3% reporting depression alone, 2% reporting anxiety alone and 1% reporting both depression and anxiety). Seventy-eight percent reported one or more chronic physical conditions, with 47%, 27% and 26% of the sample reported not having, sometimes or often activity limitations due to a long-term physical condition, mental condition or health problem, respectively.

5.2 Descriptive Analysis

5.2.1 Frequency Analysis of Major Study Variables by Leisure-time Physical Activity (LPA)

Table 1 describes the distributional properties of the major explanatory, intervening and modifying variables by level of participation in leisure-time physical activity, as measured by the PAI. Among respondents who reported being physically inactive, 6.34% reported being diagnosed with depression or anxiety; whereas 4.39% of those who reported being active experienced a similar diagnosis. In the physically inactive group, only 18.80% of the sample did not report a chronic physical condition, with 29.21% and 51.99% having one chronic physical condition or two or more chronic physical illnesses, respectively. By contrast, 26.16% of the active group reported no chronic physical illness, while 31.24% and 42.6% reported having one chronic physical condition or two or more chronic physical illnesses respectively.

The intervening or mediating variable in the modified ICF model was activity limitations due to a long-term physical condition, mental condition or health problem. Overall, 46.59%, 26.64% and 26.77% of the sample reported not having, sometimes or often having activity limitations, respectively. As shown in Table 1, the physically inactive group was less likely to report no activity limitations than the active group (39.26% versus 56.91%) and more likely to report often having limitations (32.76% and 18.35%).

The personal domain of the modified ICF model included eight factors: age, gender, level of education, marital status, smoking habit, overweight, immigrant status, and

ethnicity. The physically inactive group had a higher proportion of seniors who were 75 years or older (46.54%) and who were female (62.93%) compared with that in the active group (32.46% and 48.45%, respectively). In addition, respondents who were physically inactive reported less formal education, with 51.71% having not completed high school compared with 37.45% in the active group. They were also more likely to be single, widowed, divorced or separated (43%), current smokers (12.43%), and overweight (55.79%) than respondents in the active group (32.65%, 9.05%, and 52.92%, respectively). Further, the proportion of foreign born or immigrants was lower in the inactive group relative to the active group (23.70% versus 27.19%). There was no difference in ethnicity (white versus visible minority) between the two groups.

Environmental factors of the modified ICF model were living arrangement and area of residence. There was a higher proportion of respondents living alone in the inactive group than in the active group (33.32% versus 26.77%), and a higher proportion of respondents living in rural areas (20.13% versus 18.81%).

Finally, 33.2% and 66.8% of the total sample reported having an in-person interview and telephone interview, respectively. There was a difference in interview mode between the two activity groups, with the physically inactive group being more likely to undergo an in-person interview (36.16% versus 28.92%).

Table 1 Distribution of main explanatory, intervening and modifying variables by level of leisure-time physical activity (LPA)

Domain& [Type]	Variable	Response	LPA%(weighted n)			Total
			Inactive	Active	Missing	
Body function & Structure [Main explanatory variable]	Depression- related disorders	Never	93.66 (1916129)	95.61 (1385624)	7.66 (289929)	92.34 (3495216)
		Yes	6.34 (129791)	4.39 (63671)		
	Chronic physical condition	Never	18.80 (378833)	26.16 (375459)		
		Having 1	29.21 (588727)	31.24 (448350)	8.84 (334737)	91.16 (3450408)
		Having 2+	51.99 (1047610)	42.60 (611430)		
	Activity Limitation [Intervening variable]	Activity limitation	Never	39.26 (798010)	56.91 (821967)	
Sometimes			27.98 (568818)	24.74 (357277)	8.14 (308235)	91.86 (3476910)
Often			32.76 (665844)	18.35 (264994)		
Personal factors [Modifier]	Age	65-74	53.46 (1097769)	67.54 (980273)	7.41 (280396)	92.59 (3504749)
		75+	46.54 (955531)	32.46 (471176)		
	Gender	Female	62.93 (1292187)	48.45 (703154)	7.41 (280396)	92.59 (3504749)
		Male	37.07 (761113)	51.55 (748295)		
	Level of Education	< Secondary	51.71 (1028686)	37.45 (530468)		
		Secondary	16.09 (320102)	16.17 (229044)	10.02 (379369)	89.98 (3405776)
		> Secondary	32.19 (640404)	46.38 (657073)		
	Marital status	Single	4.73 (96873)	3.88 (56208)		
		Widow/ separated/ divorced	38.27 (784046)	28.76 (416492)	7.62 (288286)	92.38 (3496859)
		Married	57.01 (1168025)	67.35 (975215)		
	Smoking habit	Non smoker	36.40 (741214)	32.44 (469509)		
		Former smoker	51.16 (1041694)	58.51 (846930)	7.97 (301609)	92.03 (3483536)
		Current smoker	12.43 (253182)	9.05 (131006)		
	Overweight	No	44.21 (880995)	47.08 (674265)	9.52 (360298)	90.48 (3424847)
		Yes	55.79 (1111790)	52.92 (757797)		
Immigrant	Canada-born	76.30 (1498132)	72.81 (1022944)	11.01 (416725)	88.99 (3368420)	

	status	Immigrant	23.70 (465339)	27.19 (382005)		
	Ethnicity	White	93.24 (1829111)	92.91 (1303791)	11.10 (420301)	88.90 (3364843)
		Visible minority	6.76 (132513)	7.09 (99429)		
Environmental factors [Modifier]	Living arrangement	With others	66.68 (1367183)	73.23 (1061945)	7.52 (284693)	92.48 (3500452)
		Alone	33.32 (683044)	26.77 (388280)		
	Area of residence	Rural	20.13 (413350)	18.81 (273032)	7.41 (280396)	92.59 (3504749)
		Urban	79.87 (1639950)	81.19 (1178417)		
Mode effect	Interview mode	In person	36.16 (739697)	28.92 (418960)	7.69 (291174)	92.31 (3493971)
		Telephone	63.84 (1305726)	71.08 (1029589)		

5.2.2 Prevalence of Chronic Physical Conditions

As described previously (see section 4.2.2), a chronic physical illness index was derived for the present study, based on the Functional Comorbidity Index (Groll et al., 2005). The chronic conditions included in this index were: asthma, arthritis or rheumatism, back problem, emphysema, diabetes, heart disease, stomach or intestinal ulcers, the effects of stroke, cataracts, glaucoma and other long-term physical or mental health. Table 2 shows the frequency of selected chronic physical conditions included in the index. Arthritis or rheumatism was the most prevalent condition, reported by 47.14% of the sample. Back problems were the next most frequent condition, reported by 24.08% of the sample, followed by cataracts, heart disease, other long-term physical or mental health problem and diabetes (20.67%, 19.71%, 15.69% and 13.48%, respectively). Each of the remaining conditions was reported by less than 10% of the sample.

Table 2 Frequency of the specific chronic physical conditions included in the modified Functional Comorbidity Index (Groll et al, 2005)

Chronic physical condition	Response	Frequency	Percent
Asthma	Yes	286884.8	7.58
	No	3493424	92.29
	Missing	4835.87	0.13
Arthritis or rheumatism	Yes	1784472	47.14
	No	1991406	52.61
	Missing	9266.48	0.25
Back problem ¹	Yes	911393.8	24.08
	No	2866597	75.73
	Missing	7154.28	0.19
Emphysema ²	Yes	132998.7	3.51
	No	3641050	96.19
	Missing	11095.91	0.3
Diabetes	Yes	510420.2	13.48
	No	3270375	86.4
	Missing	4350.02	0.12
Heart disease	Yes	745914.1	19.71
	No	3029776	80.04
	Missing	9455.33	0.25
Stomach or intestinal ulcers	Yes	165278.1	4.37
	No	3610896	95.4
	Missing	8970.56	0.24
The effects of a stroke	Yes	170036.4	4.49
	No	3610001	95.37
	Missing	5107.45	0.14
Cataracts	Yes	782560	20.67
	No	2991166	79.02
	Missing	11419.06	0.31
Glaucoma	Yes	250323.1	6.61
	No	3514993	92.86
	Missing	19828.78	0.53
Other long-term physical/ mental health	Yes	593835.6	15.69
	No	3186619	84.19
	Missing	4690.49	0.13

¹ Back problems excluding fibromyalgia and arthritis

² Emphysema or chronic obstructive pulmonary disease

5.2.3 Correlation and Partial Correlation Analysis

Appendix B presents the results of correlation (lower triangle) and partial correlation (upper triangle) analyses. The correlation coefficient between marital status and living arrangement was high ($r=-.789$), indicating near collinearity. Therefore marital status was omitted from further analysis. The remaining variables, including the explanatory and response variables did not have strong association with each other.

5.3 Univariate Relationships between the Main Explanatory, Intervening and Modifying Variables and Engagement in Leisure-time Physical Activity

Table 3 presents the results of univariate logistic regression analysis examining the association between the individual explanatory, intervening and modifying variables and leisure-time physical activity. As shown, respondents that reported a diagnosis of depression and/or anxiety were less likely to be active than those who did not report those mental conditions (Odds ratio (OR) = 0.68; 95% Confidence Interval (CI) = 0.518-0.838). Seniors having one chronic physical condition were also less likely to participate in leisure-time physical activity than those who did not report a chronic illness (OR=0.77; 95% CI=0.663-0.873), as were those reporting two or more physical chronic illness (OR=0.59; 95% CI=0.493-0.685). Similarly, respondents who reported activity limitations either sometimes or often were less likely to be active than those who had no activity restrictions (OR=0.61; 95% CI=0.523-0.697 and OR=0.39; 95% CI=0.288-0.484, respectively). Respondents living alone were less likely to participate in leisure-time physical activity than those living with others (OR=0.73; 95% CI=0.665-0.799), while respondents living in urban areas were more likely to be active than those with living in rural areas (OR=1.09; 95% CI=1.001-1.175). Seniors aged 75 and over

were less likely to be physically active than their counterparts aged 65-74 years (OR=0.55; 95% CI=0.473-0.631), while males were more likely to be active than female (OR=1.81; 95% CI=1.733-1.881). Seniors who reported being overweight were less likely to be active than their normal weight counterparts (OR=0.89; 95% CI=0.817-0.965). Current smokers were less likely to participate in leisure-time physical activity than non-smokers (OR=0.82; 95% CI=0.688-0.946). Interestingly, former smokers were more likely to be physically active than their non-smoker counterparts (OR=1.28; 95% CI=1.205-1.363). Graduates of secondary and post-secondary education were more likely to engage in leisure-time physical activity (OR=1.39; 95% CI=1.283-1.493 and OR=1.99; 95% CI=1.908-2.072, respectively) compared with respondents who had not completed high school. While visible minority respondents were more likely to participate in leisure-time physical activity than white seniors (OR=1.05), this association was not statistically significant ($p>0.05$). Immigrants were more likely to be active than their Canadian-born counterparts (OR=1.20; 95% CI=1.105-1.299). Lastly, seniors who responded via a telephone interview were more likely to participate in leisure-time physical activity than those who had an in-person interview (OR=1.39; 95% CI=1.315-1.469).

Table 3 Results of the univariate logistic regression analysis that examines the relationship between the individual explanatory, intervening and modifying variables and leisure-time physical activity

Variable	Response	OR	95% CI	
			lower	upper
Depression-disorders	Never	1.00	-	-
	Yes	0.68	0.518	0.838
Chronic physical condition	Never	1.00	-	-
	Having 1	0.77	0.663	0.873
	Having 2+	0.59	0.493	0.685
Activity limitation	Never	1.00	-	-
	Sometimes	0.61	0.523	0.697
	Often	0.39	0.288	0.484
Age	65-74	1.00	-	-
	75+	0.55	0.473	0.631
Gender	Female	1.00	-	-
	Male	1.81	1.733	1.881
Level of education	Less than secondary	1.00	-	-
	Secondary	1.39	1.283	1.493
	Post secondary	1.99	1.908	2.072
Smoking habit	Non smoker	1.00	-	-
	Former smoker	1.28	1.205	1.363
	Current smoker	0.82	0.688	0.946
Overweight	No	1.00	-	-
	Yes	0.89	0.817	0.965
Immigrant status	No	1.00	-	-
	Yes	1.20	1.105	1.299
Ethnicity	White	1.00	-	-
	Visible minority	1.05	0.86	1.246
Living arrangement	With others	1.00	-	-
	Alone	0.73	0.665	0.799
Area of residence	Rural	1.00	-	-
	Urban	1.09	1.001	1.175
Interview mode	In-person	1.00	-	-
	Telephone	1.39	1.315	1.469

5.4 Testing Pathways of the modified ICF model: Multivariate Relationships among the Main Explanatory, Intervening and Modifying Variables and Engagement in Leisure-time Physical Activity

The results of the multivariate logistic regression analysis are presented in Table 4 to Table 8. To test the study's hypotheses and proposed pathways linking depression-related disorders, chronic physical conditions and leisure-time activity (refer to page 17, 18 and Figure 4) a five step logistic regression analysis was used.

Step 1: The interaction between depression-related disorders and chronic physical conditions

Table 4 shows that there was no evidence of statistical interaction between depression-related disorders and chronic physical conditions. Rather the measures of depression-related disorders and chronic physical conditions had a statistically significant, independent relationship with leisure-time physical activity ($p < .01$ and $p < .001$, respectively). Thus interaction terms between depression-related disorders and chronic physical conditions were excluded from further analyses.

Table 4 Results of the test for interaction between depression-related disorders and chronic physical conditions

Variable	Response	OR	95% CI
Depression-related disorders	Never	1.00	-
	Yes	0.63	0.467-0.789
Chronic physical condition	Never	1.00	-
	Having 1	0.78	0.670-0.882
	Having 2+	0.59	0.497-0.691
Interaction	Having depression-related disorders and one chronic physical condition	1.09	0.988-1.200

(interaction 1)		
Having depression-related disorders and two or more chronic physical Conditions (interaction2)	1.25	1.165-1.329

Step 2: Relationship between depression-related disorders, chronic physical conditions and activity limitations

Next, a series of ordinal logistic models that incorporated sampling weights was conducted to test the association between depression-related disorders, chronic physical conditions and activity limitations (Table 5). This association was examined: 1) without adjustment; 2) adjusted for personal factors only; 3) adjusted for environmental factors only; 4) adjusted for both personal and environmental factors; and 5) adjusted for personal, environmental, and interview mode.

Table 5 shows that the odds of reporting activity limitations among respondents having depression-related disorders relative to those with no depression-related disorders did not materially change after adjusting for the various personal and environmental factors, as well as interview mode (unadjusted and adjusted ORs=0.43). A similar pattern of results was observed for chronic physical conditions, as measured by the modified functional comorbidity index. That is, the values of the adjusted odds ratios for the presence of one chronic conditions (OR=0.39) and for the presence of two or more chronic (OR=0.14) were essentially the same as that for the unadjusted odds ratio.

Step 3: Relationship between activity limitations and engagement in leisure-time physical activity

Results of the logistic regression analysis that examined the association between activity

limitations and leisure-time physical activity are shown in Table 6. The unadjusted and adjusted analyses (similar to those in step 2) used bootstrap weights. The unadjusted odds ratio for seniors having activity limitations either sometimes or often was 0.61 (95% CI=0.533-0.697) and 0.39(95% CI=0.288-0.484), respectively. The magnitude of these odds ratios was somewhat weaker in the models that adjusted for personal factors (OR=0.64 and 0.42, respectively).

Step 4: Relationship between depression-related disorders, chronic physical conditions and engagement in leisure-time physical activity

In this step a logistic regression analysis that examined the association between depression-related disorders, chronic physical conditions and leisure-time physical activity was conducted. The unadjusted and adjusted analyses (similar to those in step 3) used bootstrap weights. The results are shown in Table 7 and indicated that the odds ratio for a diagnosis of depression-related disorders remained significant after adjusting for personal characteristics, environmental factors and interview mode, although the odds ratios were somewhat weaker in magnitude, ranging from 0.76 to 0.79, compared to the unadjusted odds ratio of 0.74. A similar pattern of results was observed for chronic physical conditions. That is, the magnitude of each of the adjusted odds ratio was weaker than the unadjusted odds ratio, but they remained significant. The observed changes in the odds ratios for both depression-related disorders and chronic physical conditions after the various adjustments were considered insufficient to warrant further investigation of the individual impact of either the individual personal and environmental factors or interview mode.

Step5: Relationship between depression-related disorders, chronic physical conditions and engagement in leisure-time physical activity, once adjusting for activity limitations

This final step repeated the logistic regression analysis conducted in step 4; however, the measure of activity limitations was also included in each of the adjusted models. This permitted the examination of the extent to which the observed associations between depression-related disorders, chronic physical conditions and leisure-time physical activity (Table 7) are mediated by activity limitations (see Figure 4, pathway #5 and hypothesis 4). As shown in Table 8, adjustment for activity limitations substantially reduced the associations between depression-related disorders and leisure-time physical activity that were observed in Table 7. The odds ratio for depression-related disorders in the model that adjusted for activity limitations and personal factors and in the model that adjusted for activity limitations, personal characteristics and environmental factor was 0.90 and 0.89, respectively and became statistically non-significant, suggesting that activity limitations mediated the relationship between depression-related disorders and leisure-time physical activities. Similarly, in the model that adjusted for activity limitations and environmental factors, the odds ratio for depression-related disorders was 0.86 and in the model that adjusted for all factors including interview mode, the odds ratios was 0.88. However, in both these models the association between depression-related disorders and leisure-time physical activity remained statistically significant.

In general, the same pattern of results was observed for the presence of either one chronic physical illness or two or more chronic physical conditions. The magnitude of

the odds ratios adjusted for activity limitations (as well as the other factors) ranged from 0.84 to 0.91, again weaker in magnitude than their counterparts in Table 7. It should be noted, however, that in all the models, the association between chronic physical conditions and leisure-time physical activity remained statistically significant. This was not the case for the association between depression-related disorders and leisure-time physical activity and suggested that the association between chronic physical condition and leisure-time physical activity was not entirely explained by the mediating influences of activity limitations.

Table 5 The association between depression-related disorders, chronic physical conditions and activity limitations

Variable	Response	Without adjustment		Adjusted for personal factors		Adjusted for Environmental factors		Adjusted for personal and environmental factors		Adjusted for personal, environmental and interview mode factor	
		OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Depression-related disorders	Never	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
	Yes	0.43	0.388 -0.471	0.43	0.387 -0.475	0.43	0.391 -0.475	0.43	0.388 -0.477	0.43	0.384 -0.472
Chronic physical condition	Never	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
	Having 1	0.39	0.361 -0.416	0.39	0.363 -0.422	0.39	0.359 -0.414	0.39	0.361 -0.420	0.39	0.361 -0.420
	Having 2+	0.14	0.131 -0.149	0.15	0.135 -0.155	0.14	0.131 -0.149	0.14	0.134 -0.155	0.14	0.135 -0.155

Table 6 The association between activity limitations and engagement in leisure-time physical activity

Variable	Response	Without adjustment		Adjusted for personal factors		Adjusted for Environmental factors		Adjusted for personal and environmental factors		Adjusted for personal, environmental and interview mode factor	
		OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
	Never	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Activity limitation	Sometimes	0.61	0.533 -0.697	0.64	0.545 -0.729	0.61	0.525 -0.699	0.64	0.544 -0.728	0.64	0.550 -0.736
	Often	0.39	0.288 -0.484	0.42	0.318 -0.520	0.39	0.295 -0.493	0.42	0.316 -0.518	0.43	0.325 -0.527

Table 7 The association between depression-related disorders, chronic physical condition and engagement in leisure-time physical activity

Variable	Response	Without adjustment		Adjusted for personal factors		Adjusted for Environmental factors		Adjusted for personal and environmental factors		Adjusted for personal, environmental and interview mode factor	
		OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Depression-related disorders	Never	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
	Yes	0.74	0.578 -0.902	0.79	0.624 -0.960	0.76	0.592 -0.918	0.79	0.622 -0.960	0.78	0.606 -0.950
Chronic physical condition	Never	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
	Having 1	0.78	0.673 -0.881	0.80	0.687 -0.915	0.78	0.671 -0.881	0.80	0.687 -0.915	0.81	0.692 -0.918
	Having 2+	0.60	0.501 -0.695	0.67	0.564 -0.772	0.61	0.511 -0.705	0.67	0.564 -0.772	0.68	0.573 -0.779

Table 8 The association between depression-related disorders, chronic physical condition and leisure-time physical activity, accounting for the intervening influence of activity limitations

Variable	Response	Without adjustment		Adjusted for activity limitation and personal factors		Adjusted for activity limitation and environmental factors		Adjusted for activity limitation, personal, environmental factors		Adjusted for activity limitation, personal, environmental and interview mode factor	
		OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Depression-related disorders	Never	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
	Yes	0.74	0.578 -0.902	0.90	0.725 -1.067	0.86	0.690 -1.022	0.89	0.722 -1.066	0.88	0.703 -1.053
Chronic physical condition	Never	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
	Having 1	0.78	0.673 -0.881	0.91	0.796 -1.024	0.90	0.792 -1.002	0.91	0.798 -1.024	0.91	0.799 -1.025
	Having 2+	0.60	0.501 -0.695	0.90	0.795 -1.011	0.84	0.743 -0.945	0.91	0.798 -1.012	0.91	0.799 -1.015

6.0 DISCUSSION

In the first section of the discussion the results pertaining to the univariate associations between the main explanatory, intervening and mediating variables and leisure-time physical activity were summarized and compared with those of past studies. The second section discussed the main results related to the study's four hypotheses. The third section provided the strengths and limitations of this study. The implications of this study were presented in the final section.

6.1 Univariate Findings

The study's univariate results were largely consistent with those of past studies. For example, the observation that depression-related disorders, chronic physical illnesses and activity limitation were negatively associated with engagement in leisure-time physical activity among seniors has been reported by others (Wolinsky et al, 1995; Jette et al, 1998; Kaplan et al., 2001; Strawbridge et al., 2002; Sawatzky et al., 2007). In addition, the finding that Canadian seniors living rural areas were less likely to participate in leisure-time physical activity than those in urban areas has been reported in the literature (CDC, 1998). Moreover, the findings that older-older adults (over 75 years) were less likely to be active than younger-older adults (65-74 years) and male seniors were more likely to be active than female seniors were consistent with past studies (Ruuskanen et al., 1995; Rhodes et al., 1999; Kaplan et al, 2001). Similarly, the findings related to the association between smoking habits and leisure-time physical activity is consistent with previous studies. Older adults who were current smokers were less likely to participate in leisure-time physical activity than those who were nonsmokers. The present study also found that former smokers were more likely to be

active than nonsmoker. This result supported that idea that smoking cessation increased engagement in leisure-time physical activity (French et al., 1996; Laaksonen et al., 2002). The results in terms of education, with higher levels of education being positively associated with engagement in leisure-time physical activity, replicated those of previous studies (King et al., 2000; Kaplan et al., 2001; Shaw et al., 2008). Finally, consistent with earlier findings (Motl et al., 2005; Gilmour, 2007), the present study observed an effect of interview mode. Seniors who participated via a telephone interview were more likely to participate in leisure-time physical activity than those who underwent an in-person interview.

Nevertheless, not all the univariate results were consistent with past reports. Several studies have shown that living alone did not limit seniors' participation in physical activity (Michael et al., 2001; Satariano et al., 2002). In this study, seniors living alone were less likely to be engaged in leisure-time physical activity compared with those living with others. Further, in contrast with other findings (Bryan et al., 2006; Crespo et al., 2000; Marshall et al., 2007), visible minority groups were more likely to participate in leisure-time physical activity than the white majority group, although this difference did not achieve statistical significance. This difference in results between the present study and other studies might be due to differences in the classification of ethnic groups. Previous studies categorized ethnicity into several groups (i.e., White, Aboriginal, Latin American, West and South Asian, East or Southeast Asian), whereas the present study classified according to two groups only (white versus visible minority). Also, this study found that seniors who were immigrants were more likely to engage in leisure-time physical activity than Canadian-born seniors. This finding is inconsistent with results

from other studies (Pérez, 2002; Tremblay et al., 2006) showing recent immigrants were less likely to be active compared to long-term immigrants who were less likely to be active than non-immigrants. The present study did not consider duration of residence within Canada (i.e., recent versus long-term immigrants), as there were a small number of elderly respondents who immigrated to Canada within the last 9 years. (i.e., the majority of elderly immigrants were long-term residents). Based on this study's findings, as well as others, duration in Canada may increase the probability of being active. Additionally, this result did not support previous studies that have reported that long-term immigrants have poorer health status and health behaviours due to cultural and language difference compared with recent immigrant and non-immigrants (Dunn et al., 2000; McDonald et al., 2004; Newbold et al., 2006).

6.2 Results Related to the Main Study Hypotheses

The first research hypothesis involved testing the pathway involving an interaction between depression-related disorders and chronic physical condition leading to activity limitations (see Figure 4, pathway #1). This pathway was explored because past studies have suggested that the joint effect of depression co-morbid with chronic physical illnesses such as arthritis, asthma, diabetes, musculoskeletal pain, coronary heart disease on health exceed that expected from the individual effects of depression alone and of chronic physical conditions alone (Mallen et al. 2008; Whooley et al., 2008; Moussavi et al., 2007). In the present study the interaction between depression-related disorders and chronic physical condition associated with leisure-time physical activity, while in the expected direction, was not statistically significant. Thus, the interaction term was excluded from further examination of pathways of the modified ICF model.

The association between depression-related disorders and activity limitation was therefore treated as constant across seniors having depression-related disorders alone and those who having depression-related disorders with comorbid chronic physical conditions. That is, seniors with depression-related disorders were more likely to report activity limitations than those who do not report a chronic mental or physical condition after adjusting for personal, environmental, and interview mode factors. This result was consistent with findings from previous studies which showing that depression may increase risk of physical disability (Beekman et al., 1995; Penninx et al., 1999). Similarly, the association between chronic physical conditions and activity limitations, also observed in previous studies (Guralnik et al., 1993; Ebrahim et al., 2000; Adamson et al., 2004), was treated as constant across respondents with and without depression (see Figure 4, pathway #2).

The second hypothesis involved testing the association between activity limitations and leisure-time physical activity (see Figure 4, pathway #3). The results showed that seniors who reported having activity limitations “sometimes” or “often” had reduced participation in leisure-time physical activity than those who without activity limitations. This was consistent with previous cross-sectional and longitudinal studies that have found that declining functional ability was associated with fewer opportunities to participate in or adhere to physical activity (Jette et al., 1998; Wolinsky et al., 1995; Kaplan et al., 2001). These findings, together with those showing depression-related disorders and chronic physical conditions related to activity limitations, support the notion that activity limitations was a potential intervening or mediating variable in the proposed ICF pathways (#5) linking chronic mental and physical conditions to leisure-

time activity (see Figure 4).

The third research hypothesis investigated the association between depression-related disorders, chronic physical conditions and leisure-time physical activity (see Figure 4, pathway #4). After adjusting for personal, environmental, and interview mode factor, seniors reporting depression-related disorders were less likely to engage in leisure-time physical activity. This results support past literature indicating that depression increases the likelihood of physical inactivity and/or physical inactivity worsens depression (Craft et al., 1998; Penninx et al., 1999; Kaplan et al., 2001; Harris et al., 2006; Strawbridge et al., 2002; Jiang et al., 2004). Similarly, respondents having chronic physical conditions reported lower level of leisure-time physical activity than those who without chronic physical condition. The recent study by Sawatzky et al. (2007) showed the same pattern using CCHS (Cycle 2.1). Kaplan et al. (2001) also found that increased number of chronic conditions was associated with reduced levels of physical activity.

The final research hypothesis examined the association between depression-related disorders, chronic physical conditions, and leisure-time physical activity after adjusting for activity limitations, personal characteristics, environmental factors, and interview mode (see Figure 4, pathway #5). These analyses provided some evidence suggesting that activity limitations mediated the association between depression-related disorders and leisure-time physical activity. In all the adjusted models the magnitude of the odds ratio for depression-related disorders was considerably weaker after adjustment for activity limitation compared to that in adjusted models without activity limitation. This was especially the case in the models that adjusted for both personal factors and activity

limitations, where the observed association between depression-related disorders and leisure-time physical activity was no longer significant. Similarly, after adjusting for activity limitations and other factors, the magnitude of the odds ratios for chronic physical condition was weaker, but all remained statistically significant. This suggested that activity limitations partially mediated the observed association between chronic physical conditions and leisure-time physical activity. While many studies have focused on the relationship between activity limitations and leisure-time physical activity (Jette et al., 1998; Wolinsky et al., 1995; Kaplan et al., 2001), to our knowledge this was the first study to provide evidence for the mediating influence of activity limitations in the association between depression-related disorders and leisure-time physical activity and between chronic physical conditions and leisure-time physical activity.

In summary, since this study was based on a cross-sectional design, it was impossible to identify the temporal sequence among depression-related disorders (or chronic physical condition), activity limitations, and leisure-time physical activity. However, the observed associations among these factors were consistent with predictions of the modified ICF model. Seniors having depression-related disorders or one or more chronic physical conditions experience activity restrictions leading to limited participation in leisure-time physical activity. Inversely, lack of physical activity (i.e., sedentary lifestyle) may lead to activity limitations that aggravate chronic mental or physical conditions.

Moreover, while few studies have identified the associations among these three factors simultaneously, the results for the present study were consistent with findings from

previous studies investigating the association between two of the factors. For example, Whooley et al. (2008) pointed out that a bidirectional association between depression and physical activity existed and several studies have showed that increased physical activity reduced the risk of chronic physical conditions (Wagner et al., 1992; Bijnen et al., 1998). Moreover, evidence has suggested a high correlation between depression and activity limitations (Beekman et al., 1995; Penninx et al., 1999) and between chronic physical conditions and activity limitations (Guralnik et al., 1993; Ebrahim et al., 2000; Adamson et al., 2004). Kaplan et al. (2001) also noted that it was not surprising that activity limitations were correlated with physical activity.

6.3 Strengths and Limitations of the Study

A major strength of the present study was the use of a large and representative sample of community-dwelling Canadians aged 65 years and older, with a relatively low proportion of missing data. This increased the generalizability of the findings. Also it was the first study to explore the association between depression-related disorders and leisure-time physical activity among Canadian elderly, using the theoretical model derived from the ICF model (WHO, 2001). This helped to improve our understanding of the structure of the pathways linking depression-related disorders and leisure-time physical activity.

On the other hand, the present study had several limitations. Although the modified ICF model was used as a theoretical framework to identify factors associated with physical activity, potentially important variables might have been excluded. For example, several studies have included social support in their examination of the relationship between

depression and physical activity. Unfortunately, the present study was unable to use the data from the social support scale in the CCHS (Cycle 2.1) since the data was obtained from Prince Edward Island and Newfoundland and Labrador only, resulting in small numbers.

The present study selected eleven chronic physical conditions among the list of chronic illnesses of CCHS (Cycle 2.1), based on the Functional Comorbid Index (Groll et al., 2005). Although the Functional Comorbidity Index has been shown to predict physical functioning, it did not include some potentially relevant diagnoses like cancer and chronic bronchitis. The prevalence of cancer and chronic bronchitis was 5.5% and 5.0% of the sample, respectively. However, it is hard to know how their inclusion would have changed the main findings materially, unless it increased the probability of interaction between depression-related disorders and chronic physical conditions.

In addition, since this study used cross-sectional data, the temporal or causal relationships among depression-related disorders, chronic physical conditions, leisure-time physical activity and the intervening and moderating variables could not be determined.

Moreover, the reliance on self-reported responses might be problematic. For example, several studies have argued that BMI based on self-reported height and weight and PAI based on self-reported engagement in physical activity may be unreliable (St-Pierre & Béland, 2004; Gilmour, 2007; Motl et al., 2005), particularly among older adults. In fact, compared to data collected via personal interview, respondents via a telephone interview tended to report higher level of participation in leisure-time physical activity in the

present study. Thus this study examined the association between depression-related disorders (or chronic physical condition) and leisure-time physical activity after adjusting for the mode effect.

Leisure-time physical activity items in the CCHS questionnaire may not have fully reflected Canada's cultural diversity. For instance, older adults with different cultural backgrounds (e.g., Asian) may have tended to participate in leisure-time physical activity not included in the CCHS questionnaire, such as Tai Chi. Thus, the level of leisure-time physical activity among subgroups of older people could be underestimated.

In addition, since physical activity was measured by leisure-time physical activity only, the present study was unable to assess respondents' total amount of physical activity. To do this, assessment of daily activities such as shopping, cleaning house, and any occupation-related physical activity would be required. The CCHS (Cycle 2.1) did not collect such data. This may have led to further underestimation of physical activity in this sample.

Finally, this study was unable to use the depression scale of the CCHS questionnaire, as it was administered to residents of Prince Edward Island and Newfoundland and Labrador only. This scale has been widely used in population health surveys to make a formal diagnosis of depression, and has the advantage of identifying both treated and untreated cases of depression (Eaton et al., 2008). There is considerable literature suggesting that approximately 50% of "true" cases of depression or anxiety never seek treatment (Wang et al., 2005). This thesis relied on self-reports of a diagnosis of depression and of anxiety to assess the presence (absence) of depression-related

disorders and therefore likely failed to detect all cases of depression and anxiety. It is difficult to know how this affected the results, but has the potential to underestimate the findings. One possible scenario is that a substantial proportion of those who reported no diagnosis of depression or anxiety were in fact experiencing depression and anxiety. If it was the case, these respondents would be more likely to be inactive or to report inactivity.

6.4 Implications

Although the benefits of leisure-time physical activity on physical and psychological well-being among older adults are well known, approximately sixty per cent of seniors are inactive (Health Canada, 2003). Numerous studies have revealed the benefits of physical activity on seniors' mental and physical health, but few studies have provided evidence in terms of the linkage between both chronic mental and physical health and leisure-time physical activity. A better understanding of these associations provides the basis and opportunity to design physical activity intervention tailored for community dwelling seniors who have chronic mental and physical conditions. This study's findings also provide evidence in support of community-based exercise or leisure-time physical activity program for seniors who are physically inactive to prevent chronic mental or physical illnesses and reduced quality of life. The results of the present study also provide clinicians who care for older adults with depression-related disorders and/or chronic physical diseases with potentially useful information on the benefits of physical activity.

6.5 Future Research

The results of this study suggest several directions for future research. First, some potentially important variables, namely social support and social networks were excluded from this analysis due to sample size and statistical power issues. Future studies should consider the inclusion of social support to better characterize the environmental domain.

Secondly, as previously mentioned, although using the modified Functional Comorbidity Index was useful to predict physical functioning, several chronic physical illnesses in the list of CCHS (Cycle 2.1) were excluded. For future studies, if any chronic physical illness frequently occurred in the elder population, even though these illnesses not included in the modified comorbidity index, it seems reasonable to include those illnesses to fully explain the relationship between chronic mental or physical conditions and leisure-time physical activity.

Thirdly, since physical activity was measured by leisure-time physical activity only, the present study was unable to assess respondents' total amount of physical activity. To estimate seniors' physical activity levels more precisely, not only leisure-time physical activity but also physical activity related to occupation and to daily activities (shopping, household duties) should be investigated in future studies.

Lastly, as described in the section of limitations of the study, the present study used only a single question to ask respondents about presence of depression and anxiety instead of the depression scale of the optional contents in the CCHS (Cycle 2.1). This measure

may have failed to detect all cases of depression and anxiety. Thus, better measurement of depression and anxiety would be necessary for future studies.

7.0 Conclusions

Using a representative sample of the Canadian population aged 65 years or older drawn from the CCHS (Cycle 2.1), the present study identified that depression and related disorders was significantly associated with leisure-time physical activity. Further, this association appeared to be mediated by daily activity limitations, after adjusting for a wide range of personal characteristics, environmental factors, and interview mode. Similar associations were observed between chronic physical conditions and leisure-time physical activity.

Since the present study was cross-sectional in design, it was impossible to identify the temporal relationships among the major study variables. However, this information will be useful to generate hypothesis about how chronic mental or physical conditions relate to seniors' engagement in leisure-time physical activity. The findings for the present study will also provide information that help clinicians who care for older adults with depression or chronic physical diseases to promote physical activity.

Appendix A Summary of Canadian Community Health Survey (Cycle 2.1) variables

Response variable			
Domain	Variables	Variable Name	Description
Participation	Physical Activities Index	PACCDPAI	This variable categorizes respondents as being active, moderate, or inactive based on total daily energy expenditure values calculated for PACCDPEE. If PAI=1, then Active. If PAI=2, then Moderate. If PAI=3, then Inactive
Explanatory variable			
Personal factors	Age	DHHC_AGE	Range from 12 to 104
	Sex	DHHC_SEX	1) male 2) female
	BMI	HWTGDGSIW (D)	1) underweight 2) normal weight 3) overweight 4) obese-1 5) obese-2 6) obese-3
	Marital Status	DHHC_MS	1) Married 2) Common-law 3) Widowed 4) separated 5) divorce 6) Single/never married
	Ethnicity	SDCC_7A	1) White 2) Visible minority
	Level of education	EDUCDR04 (D)	1) less than secondary school graduation 2) secondary school graduation 3) some post-secondary education 4) post-secondary degree/diploma
	Smoking habit	SMKCDSTY	1) daily smoker 2) occasional smoker (former daily smoker) 3) occasional smoker 4) former daily smoker 5) former occasional smoker 6) never smoker
	Immigration	SDCCFIMM (F)	1) immigrant 2) non-immigrant
Body functions and structures	Chronic physical conditions	CCCC_031, 051, 061, 91B, 101, 121, 141, 151, 191, 201, 901	Indicate whether the respondent has been diagnosed by a health professional as having one or more of the following chronic health conditions: asthma, arthritis or rheumatism, back problems, emphysema or chronic obstructive pulmonary disease, diabetes, heart disease, stomach or intestinal ulcers, the effects of stroke, cataracts, glaucoma, and any other long-term physical or mental health condition
	Chronic mental conditions	CCCC_280	Do you have a mood disorder such as depression, bipolar disorder, mania or dysthymia? 1) Yes 2) No
		CCCC_290	Do you have an anxiety disorder such as a phobia, obsessive-compulsive disorder or a panic disorder? 1) Yes 2) No
Activity limitation	Restriction of activity	RACCDPAL (D)	The variable classifies respondents according to the frequency with which they experience activity limitations imposed on them by a condition(s) or by long-term physical and/or mental health problems that has lasted or is expected to last 6 months or more. 1) sometimes 2) often 3) never

Environmental factor	Living arrangement	DHHCDLVG (D)	1) living alone 2) unattached individual living with others 3) living with spouse/partner 4) parent living with spouse/partner 5) single parent living with children 6) child living with single parent 7) child living with single parent 8) child living with two parents 9) child living with two parents 10) others
	Area of residence	GEOCDUR2	Grouped variable of GEOCDUR7 into 2 categories 1) urban 2) rural

Appendix B Results of correlation and partial correlation analysis for all study variables

	LPA	DEP	CC	AL	LIV	AREA	AGE	GEN	OW	MS	SMK	EDU	ETH	IMG	TI
LPA ₁	1	-.018	-.026	-.137	.017	.019	-.104	.107	-.050	.029	-.030	.112	-.007	.042	.061
DEP ₂	-.044***	1	.064	.096	.001	.006	-.049	-.056	-.002	-.007	.033	-.016	-.004	.015	.019
CC ₃	-.109***	.108***	1	.316	.007	.022	.057	-.084	.067	.009	.033	-.012	-.004	.008	-.003
AL ₄	-.198***	.128***	.372***	1	-.016	-.004	.146	.023	.051	-.018	.037	-.019	.001	-.029	-.048
LIV ₅	-.081***	.027***	.044***	.039***	1	.033	.075	-.091	-.002	-.789	.023	.013	-.057	.011	-.027
AREA ₆	.017**	.007	.028***	.004	.073***	1	.028	-.052	-.040	-.0003	.012	.080	.011	.107	-.053
AGE ₇	-.144***	-.024***	.109***	.180***	.197***	.050***	1	.021	-.121	-.041	-.132	-.082	-.046	.039	-.043
GEN ₈	.127***	-.060***	-.089***	-.015*	-.284***	-.070***	-.085***	1	.071	.095	.260	.036	.029	.032	-.019
OW ₉	-.043***	.007	.072***	.055***	-.060***	-.053***	-.110***	.078***	1	.013	-.045	-.063	-.023	.019	-.014
MS ₁₀	.089***	-.026***	-.036***	-.046***	-.781***	-.057***	-.172***	.258***	.064***	1	-.017	.035	-.051	.012	-.012
SMK ₁₁	.0001	.032***	.010	.035***	-.024***	-.013*	-.137***	.250***	-.019**	.022***	1	-.009	-.049	-.051	-.005
EDU ₁₂	.153***	-.019**	-.037***	-.058***	-.053***	.084***	-.094***	.052***	-.054***	.062***	.004	1	-.036	.088	.063
ETH ₁₃	.007	-.005	-.019**	-.015*	-.051***	.023***	-.036***	.029***	-.013*	.008	-.042***	-.017**	1	.204	-.014
IMG ₁₄	.056***	.001	-.007	-.030***	-.042***	.119***	.027***	.029***	.006	.038***	-.064***	.091***	.208***	1	-.022
TI ₁₅	.070***	.013*	-.030***	-.063***	-.039***	-.052***	-.049***	-.004	-.015*	.024***	-.004	.057***	-.014*	-.020**	1

* $p < .05$ ** $p < .01$ *** $p < .001$

¹Leisure-time physical activity, ²Depression-related disorder, ³Chronic physical condition, ⁴Activity limitations, ⁵Living arrangement, ⁶Area of residence, ⁷Age, ⁸Gender, ⁹Overweight, ¹⁰Marital status, ¹¹Smoking habit, ¹²Level of education, ¹³Ethnicity, ¹⁴Immigrant status, ¹⁵Interview mode

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