Diet, Nutritional Status, Inflammation and Functional Outcomes in Older Adults Residing in Long Term Care Homes

A Thesis Submitted to the College of

Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Doctor of Philosophy

In the College of Pharmacy and Nutrition,

Division of Nutrition and Dietetics

University of Saskatchewan

Saskatoon

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Abstract

Many older adults residing in long term care (LTC) homes have underlying health conditions and limited functionality. The objective of this research was to address the issues which might affect the health status and functionality of older adults (age ≥ 60y) living in LTC homes. To achieve this objective, the research was carried out as four studies. In the first study, supplement and medication use was examined, specifically exploring the impact of dementia, and to assess pill burden in older adults residing in LTC home. In the second study, menu served in this LTC was assessed for recommendations of Canada's Food Guide servings, macro, micro nutrients, and diet quality score. This menu analysis was compared to a similar analysis conducted a decade ago to find out what changes had occurred over time. In the third study, LTC residents were assessed for blood inflammatory markers, 25-hydroxyvitamin D (25(OH)D), metabolic syndrome, physical functioning, cognition, pain, and associations between inflammation and markers of functionality. Similar analyses on healthy community dwelling older and younger adults was conducted to draw differences amongst all three groups, i.e., older frail (LTC residents), older healthy, and younger healthy (community dwelling). In the fourth study the option of adding an anti-inflammatory diet was explored to address the issues of inflammation and compromised menus in LTC.

Major findings suggested that there was inappropriate overuse of supplements, yet vitamin D supplements were consumed by only one-third residents of the LTC home. The LTC menu did not meet the recommendations for Canada's Food Guide servings except for Fruits & Vegetables. Diet quality of the LTC menu was low and indicated the need of improvement, however, the comparison of current menu to a decade old menu showed some improvements. Inflammatory markers in LTC older adults were high, and the majority of subjects had

insufficient 25(OH)D. Metabolic syndrome was seen in about more than one-third of subjects. Significant correlations between C-reactive protein, cognition and activities of daily living were detected. The anti-inflammatory diet was validated from research, and strategies of incorporating it into the diets of LTC residents were addressed.

Acknowledgments

With a deep sense of feelings, I would like to express my gratitude and appreciation to my supervisor, Dr. Susan Whiting for accepting me as her student and for her advice, vision, kindness, and support throughout the course of my project and much beyond that. You have challenged me to think in different directions and your guidance helped me successfully reach my goals. You are the best! I would also like to acknowledge the assistance and guidance of my committee members: Dr. Jane Alcorn, Dr. Lilian Thorpe, Dr. Larry Brawley, and Dr. Brian Bandy. Dr. Bandy, I greatly appreciated your help and support particularly during the beginning stages of my graduate program I would like to also thank Dr. Shanthi Johnson for your feedback and constructive suggestions during the thesis defense and serving as an external examiner.

I am thankful to Saskatchewan Health Research Foundation and University of Saskatchewan for the financial support for this project. Special thanks to Dr. Jennifer Billinsky, for her help with experiments, and Dr. Hassan Vatanparast for his help with the statistical analysis. I would also like to acknowledge the support and help of my fellow graduate students who I have had the pleasure of interacting with over the past few years. I have also been very fortunate to be surrounded by great friends out of school and the Punjabi Cultural Association of Saskatchewan, who have helped me in adjusting in a new environment and really made Saskatoon feel like my second home.

Lastly, I cannot forget the support of my family, Shivdeep Viveky, Dhiraj Viveky, Mahesh Attri, Savita Attri, Dr. Omvir Singh, Mrs. Laxmi Devi, Gagandeep and my Mama ji. Thank you for supporting my academic pursuits and for always encouraging me to achieve my goals. I am eternally grateful for the spoken and unspoken wishes of Gurfee, Trijal, Jaimal, Fateh and Rubaiyat. Last but not least, Aman, I can never thank you enough for your support, encouragement, understanding and love which made this project not only successful but enjoyable.

Dedication

This thesis is dedicated to the promise I made to my father, Dr. T.L. Viveky, and to his faith in me! To my mother, Urmil Viveky, you have always believed in me more than I have believed in myself.

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List of Abbreviations

25(OH)D	25-hydroxyvitamin D
AGE	Advanced glycation end product
AI	Adequate intake
BMI	Body mass index
BP	Blood pressure
c	Cup
CCHS	Canadian Community Health Survey
CNF	Canadian nutrient file
CRP	C-reactive protein
CSDD	Cornell Scale for Depression in Dementia
d	Day
DRI	Dietary reference intake
EAR	Estimated average requirement
F	Female
FFQ	Food frequency questionnaire
g	Gram
gl	Glass
Hb	Hemoglobin
HDL	High density lipoproteins
HEI	Healthy eating index
IL-6	Interleukin-6
IU	International units
kcal	Kilocalorie
LDL	Low density lipoproteins
LTC	Long term care
M	Male
MetS	Metabolic syndrome
mg	Milligram
mL	Milliliter
MUFA	Monounsaturated fatty acid
NCEP	National Cholesterol Education Program
NPH	Natural health products
O	Older adults
oz	Ounce
PADL	Physical activities of daily living
Pain CAS	Pain colored analogue scale
PUFA	Polyunsaturated fatty acid
RAVLT ST	RAVLT sum of trials
RDA	Recommended dietary allowance
SCPOR	Saskatoon Centre for Patient-Oriented Research
SHR	Saskatoon Health Region
SOD	Single oral dose
SPMSQ	Short Portable Mental Status Questionnaire

TG	Triglyceride
TNF-α	Tumor necrosis factor-α
tsp	Teaspoon
tbsp	Tablespoon
UL	Tolerable upper intake level
USDA	United States Department of Agriculture
WAID	Weil's anti-inflammatory diet
WHO	World Health Organization
WMSR-ISR TS	WMSR-ISR Thematic Score
WMSR-DB	WMS-R Digit backward score
wk	Week
y	Year
Y	Young

Chapter 1

Introduction

1.1. Rationale

A long term care (LTC) home provides a living environment for individuals with chronic and often acute health conditions or significant functional impairments who require a higher level of care than can be provided in the community. The ideal goal of LTC placement is to optimize residents' health and overall quality of life for as long as is reasonably possible, taking into account the eventual need to provide holistic, end of life care. Good nutrition is one of the important routes towards fulfilling these goals (Dorner, 2010). Nutrition plays a crucial role in improving the quality of life and health during aging (Denny, 2008). Malnutrition is highly prevalent in older adults which might be attributable to the decline in physical activity levels. This is turn may cause a decrease in basal metabolic rate. At the same time aging also changes the sense of taste, smell, digestion, absorption, and metabolism of nutrients due to presence of several chronic diseases (Gillette et al, 2007). Because of these changes and to compensate for the metabolic transitions, the need for specific nutrients increases.

Chronic inflammation may promote the development of age related conditions such as Alzheimer's Disease, osteoporosis, pain and frailty (Visser et al., 2002a; Galland et al., 2010) especially in LTC residing older adults (Fox et al., 1999). Age is an important determining factor in an elevated state of inflammation (Ferrucci et al., 2005). Evidence from the literature suggests that inter-relationships exist between chronic inflammation, age and functional abilities (Yaffe et al., 2003; Tall & Raja, 2004; Ferrucci et al., 2005; Graham et al., 2006).

1.2. Overview of studies

This project focuses on determining nutritional status, inflammatory markers and functional parameters in older adults residing in LTC homes in Saskatoon Health Region. Because of the paucity of data from Saskatchewan, the current study was planned with the following hypotheses and objectives and carried out in four studies:

Study 1 focused on dietary supplement usage in LTC homes. Consumption of dietary supplements in older adults residing in LTC home was analyzed. The objective was to compare the usage among residents with and without a dementia diagnosis. As a secondary objective, the pill burden in residents with a dementia diagnosis was assessed.

Study 2 was the analysis of LTC homes weekly menus and comparison with a ten year old menu analysis. The one week menu of a LTC home was analyzed to assess whether it met the recommendations of Canada's Food Guide servings and nutrients. Canadian adaptation of Healthy Eating Index was used assess the nature and quality of 2011 menu. This menu analysis was compared to a similar menu analysis from 2000 to determine changes over time.

Study 3 addressed nutritional status and inflammation in older adults (≥60y). In this study, nutritional status, anthropometric measurements, inflammatory markers, physical functioning, cognition and pain measures were assessed on older adults residing in LTC home. Older adults who had lived in LTC for more than four weeks were enrolled in the study. The main objective of this study was to find out the associations between inflammation and functional markers in older adults.

The secondary objective of this study was to carry out similar assessments in community dwelling older adults (60-80 y) and young adults (18-45y) and to further compare the inflammatory status of old frail, old healthy and young adults. Markers of inflammation, dietary

intake, and activity score were assessed in community dwelling young and older adults. Individual differences in inflammatory states were explored, as were age-related differences. A food frequency questionnaire of usual dietary intake was analyzed for diet quality, macronutrients, micronutrients and number of Canada's Food Guide servings. The Godin Leisure-Time Exercise Questionnaire was analyzed to categorize the subjects into "activity groups" according to their weekly physical activity.

Study 4 concerned anti-inflammatory diets in LTC homes. In this part of the research, a literature review was performed to determine an appropriate anti-inflammatory diet which might be used in older adults residing in LTC. Weil's anti-inflammatory diet was speculated as a possible option to incorporate the anti-inflammatory diet which could be added in to the diet of LTC residing older adults. Further investigation of diet components and the feasibility of adding the anti-inflammatory foods was explored to address the issues of inflammation and inadequate diet in the LTC homes.

1.3. Objectives

The overall purpose of this research was to explore factors affecting the health and quality of life of older adults living in LTC homes in Saskatoon, Saskatchewan. Supplement use, optimality of menus, inflammatory markers, and physical, cognitive and pain indices of older adults were assessed individually and in correlation between each other. The specific objectives of each study were:

Study 1

1. To determine the quantity and quality of supplement use in long term care residents, to compare the usage in residents with and without a diagnosis of dementia.

2. To determine the use of vitamin D supplementation and other supplements related to inflammation and oxidative stress in LTC homes in Saskatoon Health Region.
3. To determine whether overuse of supplements contributes to "pill burden" in long-term care in Saskatoon Health Region.

Study 2

1. To assess whether the weekly menu of LTC residents meets the guidelines of Canada's Food Guide.
2. To assess nature of the menu in terms of pro-inflammatory and anti-inflammatory foods according to Weil's Anti-Inflammatory Diet.
3. To evaluate the menus used in LTC for their optimality in terms of quantity and quality of protein, carbohydrate and fat intakes.

As a secondary objective, the current menu was compared with a similar analysis done in 2000. The goal was to explore improvements, challenges and overall changes over the past ten years.

Study 3

1. To find clinically relevant relationships between nutritional status and outcomes that might be influenced by inflammatory status, including anthropometric measurements, cognition, pain and musculoskeletal functions.
2. To determine whether inflammatory markers differ between frail and healthy older subjects, and between younger and older subjects.

Study 4

1. To search evidence for benefits of the anti-inflammatory diet, and then to consider the feasibility of adding specific components to the diets of LTC residents.

1.4. Purpose/ Hypothesis

The overall hypothesis for this research was that there is a positive association between poor nutritional status and measures of inflammation in the LTC residing older adults. The specific purpose/ hypothesis of each study were:

Study 1

1. Older adults residing in LTC homes with dementia have higher supplement usage compared to residents without dementia.

It was hypothesized that older adults living in LTC homes with dementia will consume more supplements such as vitamin D (provided alone in a supplement), B vitamins (any single supplement), Vitamin A (cod liver oil), Vitamin B complex and/ or C (including stress products), multivitamins, and calcium (formulations may also include vitamin D). It was also anticipated that residents with a dementia diagnosis may consume overall more medications, further contributing to pill burden.

Study 2

1. The menu of a long term care institution meets the recommendations of Canada's Food Guide and as a result is adequate in anti-inflammatory foods.

It was hypothesized that the weekly menu served to LTC residents meets the recommendations for older adults. The menu served was compared to food guide servings for all the food groups according to Canada's Food Guide and recent RDAs. The diet quality of the menu was also assessed to determine what kind of foods the residents were being offered.

Study 3

1. To determine relationships between poor nutritional status and measures of inflammation and metabolic syndrome in older adults residing in long-term care.

The purpose of this study was to assess if there is an association between nutritional status and inflammatory status of young adults, older community dwelling adults, and older adults residing in long-term care. Prevalence of metabolic syndrome in LTC residents was determined.

Study 4

1. An anti-inflammatory diet in LTC is needed and feasible, and may lead to improvements in the health and wellbeing of the residents.

All of the components of this research were focused on different aspects of overall quality of life in older adults residing in LTC homes. The main objective was to address age-related conditions caused by chronic inflammation, which could be addressed through optimal nutrition. Consideration was given to adjusting LTC menus to incorporate foods with health benefiting properties (anti-inflammatory) to reflect the changing needs of aging.

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Chapter 2

Review of literature

2.1. Nutrition and aging

Healthy aging is described as "a lifelong process of optimizing opportunities for improving and preserving health and physical, social and mental wellness, independence, quality of life and enhancing successful life-course transitions" (Health Canada, 2002). Nutrition is one of the most important determining factors of successful aging, as it helps the body maintain its mental and physical function, to enable it to continue an active engagement of life (Rowe, 1998). The effect of nutrition on aging is discussed in the sections 2.1.1-2.1.4.

2.1.1. Aging

Aging is accompanied by a number of physiological, psychological and social changes. Reduction in bone mass, size of body organs, skeletal muscle and body water, along with variations in body fat, may singly or in combination be responsible for the decrease in total lean and fat mass seen in older adults (Shatenstein, 2001). Decline in body fat and energy consumption are associated with other risk factors like nutrient deficiencies and frailty, which lead to hospital admissions and longer recovery time. Swallowing problems are also very common, frequently worsening overall food intake (Feldblum et al., 2007). Older adults often live alone and have difficulty in shopping and preparing their own meals. An overall decreased intake due to the above factors frequently results in decreased intake of individual nutrients and a higher risk of nutritional deficiencies (Harris, 2005).

A long term care (LTC) facility provides the living environment for individuals having chronic conditions, limited functional abilities, and who require care or assistance. Older adults may need care or supervision for an array of different health reasons including frailty, physically

debilitating diseases or even terminal illness. The Canadian Community Health Survey (CCHS) found that some chronic conditions and disorders are highly prevalent in older adults requiring care. About 47% older adults reported arthritis/rheumatism, 25% had back problems and cataracts or glaucoma, and 20% reported diagnosis of heart disease (CCHS, 2003). Urinary incontinence and diabetes each affects at least one out of 10 older adults (Gilmour and Park, 2007). Older adults having cognitive problems also require 24-hour care. According to the 2003 CCHS, two percent of both men and women aged 65 y or old who reported having either Alzheimer's disease or dementia were living in private households. Statistics Canada's General Social Survey (GSS) respondents reported that the reason an older adult is most likely to receive primary care (defined as needing a caregiver for most of the time for the past year due to long-term health or physical limitation) is due to a "physical problem only" (Gilmour and Park, 2007).

The GSS revealed that seven out of 10 older adults receiving the primary care were women, likely due to their higher life expectancy. Men were found to be more likely to remarry when their spouse died. Approximately half of the primary care receivers were adults 75 to 84 y, and about one-quarter of men and one-third of women were 85 y or older.

2.1.2. Malnutrition

Malnutrition is a very common characteristic of high prevalence in older individuals (Harris, 2005). Malnutrition is a multi-factorial condition; it can happen because of altered nutritional status due to physiological changes of aging which leads to changes in food intake, body composition, and weight (Dorner et al., 2010). The most important factors contributing to the malnutrition in older adults living in LTCs are dietary intake, appetite, dysphagia, nutrition support, end-stage disease, weight status, and fluid intake (Bocock et al., 2008). The decline in body mass and physical activity levels may cause a decrease in basal metabolic rate affecting

appetite. At the same time older adults also experience changes in the sense of taste, smell, digestion, absorption, and metabolism of nutrients due to presence of several chronic conditions (Gillette et al., 2007). Occurrence of various eating disorders and difficulty in chewing and swallowing of food, lack of motivation to eat, or lack of personal assistance during dining can also lead to difficulty in meeting the nutritional needs of residents. Eventually there is progression to poor consumption which compromises the ability to meet nutrient requirements (Feldblum et al., 2007). This further leads to preclinical symptoms and signs of malnutrition, which can be measured, and to clinical symptoms, which can be visibly observed at later stages. Nutrient deficiencies may lead to falls and fractures which might result in a high rate of morbidity and mortality among older adults. The other consequences include sarcopenia (age related muscle loss), problems in oral cavity, and loss of functionality (Kamp, 2010). The high prevalence of malnutrition is a challenge to health professionals working in LTC facilities (Womack and Breeding, 1998).

Nutrient needs for protein, some vitamins and minerals increase, and calories decrease, in older adults as compared to younger adults. Table 2.1 shows the different Estimated Average Requirements (EARs) of major nutrients of older adults vs. younger adults. EAR, is the "average daily nutrient intake level that is estimated to meet the requirements of half of the healthy individuals in a particular life stage and gender group" and Recommended Dietary Allowance (RDA) is "the average daily nutrient intake level that is sufficient to meet the nutrient requirements of nearly all (97-98 percent) healthy individuals in a particular life stage

Table 2.1. Nutrient Estimated Average Requirements of older adult (> 50y) compared to younger adults (19-50 y)

Vitamins	Minerals
Vitamin A ↔	Calcium ↑
Vitamin D*↔	Phosphorus ↔
Vitamin E ↔	Magnesium ↔
Vitamin K ↔	Iron ↓ (women)
Vitamin C ↔	Zinc ↔
Vitamin B1 ↔	Manganese ↔
Vitamin B2 ↔	Copper ↔
Niacin ↔	Selenium ↔
Folic acid ↔	Molybdenum ↔
Vitamin B6 ↑	Iodine ↔
Vitamin B12 ↔	Chromium ↓
Pantothenic acid ↔	Potassium↔
Biotin ↔	Sodium ↓

*The Recommended Dietary Allowance increases for older adults ≥70 y.
↑ increase with age, ↓decrease with age, ↔ no change
(Otten et al., 2006)

Table. 2 .2. Dietary Reference Intakes for minerals for older adults (> 50y) compared to younger adults (19-50 y)

Nutrient	EAR	RDA/AI	UL (<50y)	UL (>50y)
Calcium (mg)	800	1000 M[#], 1200 F	2500	2000
Chloride (mg)	ND	2300 (<50), 2000 (>50)[#]	3600	3600
Chromium (µg)	ND	35(<50), 30 (>50) M 25(<50), 20(>50) F	ND	ND
Copper (µg)	700	900	10000	10000
Fluoride (mg)	ND	4 M, 3 F	10	10
Iodine (µg)	95	150	1100	1100
Iron (mg)	6	8, 18 F (<50)	45	45
Magnesium (mg)	350	420 M, 320 F	350	350
Manganese (mg)	ND	2.3 M, 1.8 F	11	11
Molybdenum (µg)	34	45	2000	2000
Phosphorus (mg)	580	700	4000	4000[#]
Potassium (mg)	ND	4700	ND	ND
Selenium (µg)	45	55	400	400
Sodium (mg)	ND	1500 < 50, 1300 > 50[#]	2300	2300
Zinc (mg)	9.4 M, 6.8 F	11 M, 8 F	40	40

Estimated Average Requirements (EAR), Recommended Dietary Allowances (RDA), Adequate Intakes (AI),Tolerable Upper Intake Levels (UL). ND (Not Determinable): Due to lack of suitable data, UL could not be established. This does not mean that there is no potential for adverse effects resulting from high intakes.
[#] Calcium RDA/AIs for ≥70 y adults is 1200mg; [#] Chloride RDA/AIs for ≥70 y adults is 1800mg; [#] Phosphorus ULs for ≥70 y adults is 3000mg; [#] Sodium RDA/AIs for ≥70 y adults is 1200mg.

and gender group" (Otten et al., 2006). Dietary Reference Intakes (DRIs) are nutrient reference standards developed for use in planning and assessing diets of apparently healthy Canadians and Americans (Barr, 2006). DRIs define older adults as <50 y, >50 y, but >50 y are further divided into 51-70 y and >70 y. Table 2.1 and 2.2 show that the EARs and RDAs are mostly similar between age groups except for few nutrients.

2.1.3. Changes in food consumption and appetite with age

A survey by the British Columbia Ministry of Health, reported that older adults did not eat enough from each food group of the Canada's Food Guide. As a result, 80% of the older adults did not get enough fiber and had low calcium intake. Older women in the age of 75-84 y had a high risk for inadequate consumption of essential vitamins and minerals (Levy-Milne, 2005). Older adults eat less food calories because of poor appetite, leading to fewer nutrients and more risk of deficiencies (Feldblum et al., 2007). Researchers have shown that poor appetite prevails at a very high rate in the LTC and according to one study more than 33% of the residents reported poor or variable appetite (Keller, 1993), which depletes the body's nutrients because of decreased intake of protein, energy and micronutrients (Womack & Breeding, 1998).

Prevalence of inadequacy of nutrients was found to be 5-85% (overall average 30%) in older adults residing in LTC homes in Saskatoon in the late 1990s (Lengyel et al., 2008). Pauly (2007) found the malnutrition prevalence rate measured by Mini-Nutritional Assessment (MNA) to be 2% to 38% in institutionalized older adults, and a larger percentage, 37% to 62%, were at risk of developing malnutrition. MNA is used to identify the older adults for malnutrition; it is accepted worldwide and is effective in determining the degree of malnutrition in varied settings. Components of MNA include changes in food intake over the past three months, weight loss during last three months, mobility, and occurrence of any psychological stress or acute disease in

past three months, neuropsychological problems, body mass index (BMI) or calf circumference. The MNA is specifically recommended for assessing nutritional status of older adults (Kaiser et al., 2010).

2.1.4. Supplements

Achieving optimum nutrition status may help in ameliorating symptoms of various chronic diseases associated with poor dietary status (Volkert et al., 2010). In prevailing nutritional inadequacy, it becomes important to enhance the quality of diet of older adults as caloric intake is also limited at this age (Kamphuis et al., 2010). Strategies for the optimization of health should therefore consider appropriate dietary enhancements, including supplementation of specific nutrients in accordance with evidence based guidelines (Wendland et al., 2003; Kamphuis 2010). For example, vitamin D supplementation is recommended for all adults (Hanley, 2010). It has been found that despite the presence of fortified foods in North America, deficiencies of some nutrients like calcium, vitamin D, and vitamin B12 occur in older adults (Johnson, 2004). Dietary supplements might be a feasible way to improve nutritional status of older adults.

Supplement use is common in older adults to prevent deficiencies as well as due to the perceived health promoting and disease fighting benefits of the nutrients (Satia-Abouta et al., 2003; Buhr and Bales, 2009). Reports suggest that the majority of the North American adults consume at least one nutritional supplement (Rock, 2007; Timbo et al., 2006; Vatanparast et al., 2010a). The most commonly consumed supplement reported was multivitamin-mineral, along with range of single and combination supplements. Evidence indicates that older adults, especially women, use more nutritional supplements as compared to the other age groups (Timbo et al., 2006; Vatanparast et al., 2010a). Results of National Health and Nutrition Examination

Survey III, revealed that use of dietary supplement in adults ≥ 60 years is high (Radimer et al., 2004).

The evidence regarding effects of supplementation on older adults demonstrates mixed results (Park et al., 2008; Buhr and Bales, 2009; 2010). The dietary intake of supplemental vitamins, trace minerals, lipids and antioxidants may be linked to the decreased incidence of cognitive decline and improved mental functions (Gillette et al., 2007). Nutrients singly or in combination may act on neurological pathways and functions which effect mental health and cognition. Dietary fats, fatty acids, omega-3 fatty acids, eicosapentaenoic acid, docosahexaenoic acid, B vitamins (including thiamine, riboflavin, niacin, pantothenic acid, vitamin B6, biotin, folic acid, vitamin B12), vitamin C, vitamin D, vitamin E, zinc, magnesium and manganese have been implicated to have some affect in the prevention of Alzheimer's Disease (George et al., 2009). Some studies suggest that the risk of developing Alzheimer's Disease was low in people who consumed vitamin E, vitamin C and omega-3 fatty acids, whereas, low vitamin B, C and homocysteine blood levels were related to increased incidence of disease occurrence (Scheltens, 2009). Cell culture and animal studies stated that cognition can be enhanced by antioxidant properties of nutrient supplements derived from specific nutrients and foods (Chan et al., 2010). However, the results of the preclinical studies emphasize the benefit of a combined supplementation, where mixture of various nutrients was used over a single nutrient in improving cognition related functions (de Wilde et al., 2008).

2.1.5. Concerns of excess intakes of nutrients

Tolerable Upper Levels (ULs) are established for many vitamins and minerals, and intakes exceeding the ULs have potential for risk of adverse health effects. The UL for a nutrient accounts for the overall consumption of a specific nutrient from all dietary, water and

supplemental sources as specified in each instance (Otten et al., 2006). The term “excessive” can also imply intakes of nutrients in multiple pills that create a burden on the patient having to swallow these and on the institution delivering the medications (Loya et al., 2009). Polypharmacy (high use of concurrent medications and supplements) and excess nutritional intake can increase the risk of adverse drug effects in patients (Maggiore et al., 2010).

Excessive intake of some nutrients is especially of concern in older adults, who tend take more medications overall because of multiple underlying health conditions, and sometimes inappropriate prescribing, excessive self-medication and/or lack of co-ordination among practitioners (Queneau, 2006). Adding to the risks imposed by polypharmacy are age-related declines of various organ functions, which may increase adverse drug effects and interactions (Patel, 2003). More co-ordination between practitioners, dietitians and care givers is required to make sure that older adults are not exposing themselves to the risk of overconsumption of nutrients.

A study conducted on unaffected first degree relatives of people who already had Alzheimer's Disease and assessed their genetic risk for developing Alzheimer's Disease revealed that people started consuming supplements after their risk assessment. Sixteen percent of individuals started taking dietary supplements which comprised mainly vitamin and botanical supplements. The most common changes were found in the intake of vitamin E (47%), vitamin C (29%), botanicals (including gingko biloba, curcumin, and green tea; 22%), multivitamins (18%), vitamin B (16%), and fish oil/omega (16%) (Vernarelli et al., 2010). The reasons and motivation behind the consumption of supplements were not undertaken in the study. It is important to understand people’s perception, motivation and expectations to better understand the changed behavior.

2.1.6. Health associations website recommendations for supplements

In this section recommendations made by nutrition authoritative bodies' for supplement use are compiled. Heart and Stroke Foundation in Canada and its provinces does not recommend any vitamin and mineral supplement except vitamin D as per recommended by CFG (http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.2796497/k.BF8B/Home.htm). There is no special reference to recommendations of older adults. Whereas, American Heart Association in their Position Statement on vitamins and minerals highlights that vitamin and mineral supplementation is not a substitute for a nutritious diet that limits excess calories, saturated fat, trans fats, sodium, and dietary cholesterol (http://www.heart.org/HEARTORG/). The Canadian Diabetes Association makes no recommendations for vitamins and minerals supplements for any age group (http://www.diabetes.ca/). Osteoporosis Society of Canada recommends 1200 mg calcium and, 800 IU vitamin D per day for adults over 50 y (http://www.osteoporosis.ca/). Canadian Cancer Association recommends that adults should consume 1000 IU vitamin D during the fall and winter months, as the evidence from studies report beneficial effects of this amount in the incidence of cancer with least chances of causing any harm (http://www.cancer.ca/).

2.2. Oxidative stress, inflammation and metabolic syndrome

Oxidative stress, inflammation and metabolic syndrome are highly prevalent conditions in older adults. They are related and associated with the occurrence of chronic diseases which ultimately affect functional status of the older adults. Inflammation and oxidative stress are related to a variety of different chronic conditions and diseases prevalent in older adults (Stephens et al., 2009). Occurrence of muscle wasting and osteoporosis is stimulated by pro-inflammatory cytokines, for example, IL-6 and TNF-α (Steeve et al., 2004; Roubenoff, 2003). Also, vascular dementia and Alzheimer's Disease development is often associated with the high

blood pressure and inflammation of blood vessels (Dziedzic, 2006; Skoog et al., 2006). Furthermore, high prevalence of oxidative stress indicates the early instigation of metabolic syndrome (Furukawa et al., 2004).

2.2.1. Oxidative stress

Oxidative stress refers to the condition caused by the imbalance between antioxidant defense system, reactive oxygen species (ROS) and reactive nitrogen species (RNS). Superoxide (O_2^-), hydrogen peroxide (H_2O_2) and hydroxyl radical ($^{\bullet}OH$) adversely affect various bodily functions by destroying macro-molecular structures. Oxidative stress might be one of the underlying factors in the development of chronic diseases which are associated with muscle wasting (Moylan, 2007). The progressive aggregation of tissues with oxidative deterioration has been studied in many species as a result of aging (Head, 2009). The normal, balanced and ongoing degradation and re-synthesis of skeletal muscle protein is interrupted during the process of aging leading to the increased oxidative stress (Koopman, 2009). Oxidative stress affects several bodily organs and functions, but brain is especially prone, due to relatively low levels of antioxidants, high levels of polyunsaturated fatty acids (PUFA), and high demand of oxygen (Sultana et al., 2008).

Oxidative stress may stimulate the age-related diseases through activation of inflammatory pathways. Aging is associated with increased inflammation caused by the release of "cytokines" (hormone-like compounds) which are associated with muscle protein degradation (Roubenoff, 2003). Increased levels of oxidative stress induce chronic low-grade inflammation which is reported to be damaging to the skeletal muscle (Siu et al., 2008). The development of sarcopenia is complex and is ascribed to oxidative stress, inflammation, lack of physical activity

and poor nutritional status (Meng, 2010; Nicklas & Brinkley, 2009). Therefore, reducing the oxidative stress and inflammation may help in ameliorating many of the age related conditions.

2.2.2. Inflammation

Inflammation is an automatic response of the body to remove the initial cause of cell injury caused by internal and external damaging agents (García -Lafuente et al., 2009; Hubbard &Woodhouse, 2010). Classic symptoms of inflammation are redness, pain, swelling, and heat of affected organ or tissue accompanied with rise in inflammatory markers. Inflammation of the internal organs can occur with or without these classic signs. Inflammatory responses are very important as they provide protection against various infectious agents (Marcason, 2010). The immune response is stimulated as a result of inflammation and initializes the synthesis of both pro-inflammatory and anti-inflammatory cytokines. To remove the pro-inflammatory cytokines, the body releases its nutrient stores to produce positive acute phase proteins and lymphocytes. Acute phase proteins are classified as positive or negative. Positive acute phase proteins are those which rise rapidly at the expense of negative acute phase proteins which have reduced synthesis during the inflammatory response (Litchford, 2010).

Inflammation can be of two types, acute (or innate) and chronic. Acute inflammation is a self limiting process where inflammatory mediators have short half life spans. It results in a prompt degradation of inflammatory mediators due to presence of negative feedback mechanisms. Acute inflammation occurs following surgery, trauma or an injury. Hence, controlled inflammatory responses are important for maintaining homeostasis and health. In contrast, chronic inflammation results when the immune response to injury is not eliminated, leading to the continued stimulation of the synthesis of proinflammatory cytokines, which contribute to risk of developing diseases (Litchford, 2010). Damage caused by chronic

inflammation usually accumulates slowly, sometimes asymptomatically for many years and can lead to severe tissue impairment (Mitchell & Cotran, 2003).

Chronic-low grade inflammation promotes the development of several age related diseases (Galland et al., 2010), such as atherosclerosis (Libby, 2006), type 2 diabetes (Festa, 2002), Alzheimer's disease (Griffin, 2006), and osteoporosis (Kimble, 1995). Inflammation is also related to the occurrence of depression and frailty, which are common in older adults (Raison, 2006). Inflammation contributes to the loss of muscle mass and functionality causing onset of disability (Morley, 2001; Pennix et al., 2004). The major outcome of the chronic, low-grade inflammation is the age-associated morbidity, and mortality (Franceschi, 2007). Inflammation is influenced by many positive and negative factors such as genetic reactions, stress, exposure to environmental toxins, diet (Palmer, 2009), exercise (Volkmann et al., 2010) and age (Ferruci et al., 2005).

2.2.2.1. Markers of inflammation

Chronic inflammation leads to increased levels of inflammatory markers that can be attributed to development of chronic diseases. With a rising recognition of the role of inflammatory factor in atherogenesis, the use of inflammatory markers as indicators of disease development came into limelight (Pearson et al., 2003). Measurement of the markers of inflammation has emerged as an important strategic tool for screening patients needing primary care for management of cardiovascular diseases (Grundy et al., 2000). The important biomarkers of inflammation predominantly cytokines and their nature and role are described in Table 2.3(a), and all other markers excluding cytokines are described in Table 2.3(b). Evidence from some studies has highlighted interest in the potential use of inflammatory biomarkers and cytokines in mediating inflammation and related diseases.

Inflammatory and non-inflammatory cells secrete cytokines which act as signals to regulate the innate and acquired immune response (Petersen & Felker, 2006). Cytokines are complex cascade of signaling proteins, produced by the cells which interact with the immune system in response to disease and infection. Cytokines mediate normal cellular processes in the body such as growth and development, production of blood cells and immune responses. When an immune response is activated in inflammation, this starts the release of both proinflammatory and anti-inflammatory cytokines (Table 2.3(b)). The body then must circulate the nutrients needed for production of T and B lymphocytes and acute phase proteins, for combating the proinflammatory cytokines (Litchford, 2010).

2.2.2.2. Age differences in inflammation

Age is an important determining factor in elevated state of inflammation. The markers of inflammation increase with age (Ferrucci et al., 2005). Tables 2.3(a) and 2.3(b) show the pattern of changes in the markers of inflammation with age, for instance, increase or decrease with age. Levels of cytokines and acute phase reactants are several fold higher in older adults as compared to younger older adults (Franceschi et al., 2000; Giuliani et al., 2001). IL-6 levels are higher in the older adults $\geq$ 70 y of age and the rise in markers continues with age (Giuliani et al., 2001). IL-6 soluble receptor, CRP, TNF-alpha, IL-18, 1L-1 receptor antagonist show a similar trend of elevation with age in older individuals (Ferrucci et al., 2005). Reasons attributed to the age related increase in chronic inflammation are increase in fat mass, presence of infections, chronic health conditions and less secretion of sex steroid hormones.

Table 2.3(a). Important predominant cytokines as markers of inflammation

Markers of inflammation	Nature	Effect of aging	Function/Production
IL-6	Anti-inflammatory cytokine	Increase	Produced by variety of cells: mononuclear phagocytes, T cells & fibroblasts. Stimulation of acute phase proteins by liver.
IL-1alpha,1L-1 beta	Pro-inflammatory cytokines	Increase	Trigger fever by enhancing prostaglandin E_2. Synthesized by the vascular endothelium of hypothalamus.
TNF- alpha	Pro-inflammatory cytokine	Increase	Produced by several types of cells especially macrophages.
IL-18	Pro-inflammatory cytokine	Increase	Stimulates synthesis of IFN-g by T lymphocytes.
1L-1 receptor antagonist	Anti-inflammatory cytokine	Increase	Specific inhibitor of IL-1a- and IL-1b-mediated cellular activation at the IL-1 cellular receptor level. Produced by monocyte/macrophage dendritic cells.
IL-4	Anti-inflammatory cytokine	Increase	Promotes Th2 lymphocyte development; inhibition of LPS induced proinflammatory cytokine synthesis. Produced by T cells (Th2), mast cells, B cells, stromal cells
IL-11	Anti-inflammatory cytokine	-	Restricts proinflammatory cytokine response by monocyte/macrophages and promotes Th2 lymphocyte response. Produced by stromal cells and fibroblasts.
IL-13	Anti-inflammatory cytokine	-	Shares homology with IL-4 and shares IL-4 receptor attenuation of monocyte/macrophage function. Produced by T cells.
IL-8	Pro-inflammatory cytokine	Increase	Neutrophil activation and chemotaxis, basophil and T cell attractant, angiogenesis. Is produced by astrocytes and microglia, monocytes, fibroblasts, epithelial cells
IL-10	Anti-inflammatory cytokine	Decrease	Inhibits interferon-γ and macrophages. Produced by astrocytes, microglia, T cells, monocytes.
IL-12	Pro-inflammatory cytokine	Increase	Induces production of interferon-γ, TNF-α and IL-2 via T cells and natural killer cells and lysosomal discharge. Produced by astrocytes, microglia, dendritic cells, macrophages and B cells

IL = Interleukin, TNF= Tumor necrosis factor
(Dinarello, 2000; Opal & DePalo, 2000; Ballantyne & Nambi, 2005; Litchford, 2010).

Table 2.3(b). Important markers of inflammation (excluding cytokines)

Markers of inflammation	Nature	Effect of aging	Function/Production
C-reactive protein	Positive acute phase protein Pro-inflammatory	Increase	Synthesis is initiated by response to acute injury, infection or other inflammatory stimuli & trauma
Alpha-1-acid glycoprotein	Acute phase protein	Increase	Systemic tissue injury, inflammation or infection. Expression is controlled by glucocorticoids, cytokines mainly IL-1 beta, TNF alpha, IL-6.
8-isoprostane	Biomarker of oxidative stress and anti-oxidant defense	Increase	Is one of the family of eicosanoids of non-enzymatic origin produced by the random oxidation of tissue phospholipids by oxygen radicals.
Adiponectin	244–amino acid protein	-	Synthesized and secreted by adipocytes
Monocyte chemoattarctant protein 1 (MCP1)	CC chemokine	-	Produced by endothelial and smooth muscle cells
CD40ligand (CD40L)	Transmembrane protein related to tumor necrosis factor	-	A variety of cells involved atherosclerosis, such as endothelial cells, smooth muscle cells, macrophages, T lymphocytes and platelets, express CD40L

Dinarello, 2000; Opal & DePalo, 2000; Ballantyne & Nambi, 2005; Litchford, 2010)

2.2.2.3. Physical activity and inflammation

Physical activity is one of the well recognized strategies for reducing the risk of disease development and improvement of the chronic inflammatory markers (Beavers et al., 2010). Chronic inflammation is a contributor to age-related muscle loss and limited functionality. In the midst of anti-inflammatory drugs and medical treatments, physical exercise is emerging as a promising option to improve functional outcomes and decrease of biomarkers of inflammation in frail older adults (Nicklas and Brinkley, 2009). Studies show that these older individuals who engage in more and intense physical activity and showed lower inflammatory state (Nicklas & Brinkley, 2009). Evidence from large population studies such as NHANES III supports an inverse relationship between C-reactive protein (CRP) and physical activity. Number of hours spent per year in moderate and intense physical activity is negatively related to IL-6 and CRP concentration in older men irrespective of BMI (Taaffe et al., 2000). As well, the highest level of recreational activities is related to lower level of CRP and IL-6 in older adults (Reuben et al., 2003).

2.2.2.4. Anthropometric measurements and inflammation

Levels of inflammation in the body as measured by circulating inflammatory cytokines are related to the body mass index (BMI) and body fat, especially abdominal fat (Forouhi et al., 2001). Cytokines may increase the rate of adverse changes in the body composition which are particularly related to the aging process (Ferrucci et al., 1999). The amount of abdominal fat mass puts the older adults at the risk associated to obesity which further increases inflammation (Fain et al., 2004). Higher levels of total and abdominal adiposity are associated with elevated CRP, IL-1ra, and IL-6 levels in older adults. Waist circumference is also a clinically relevant tool for measuring inflammation in older adults (Brinkley et al., 2012). Waist circumference also has

strong associations with the insulin and is positively related to the intake of total carbohydrate, sugars, and foods with high glycemic load (Ackermann et al., 2011).

2.2.2.5. Pro and anti-inflammatory potential of food

Dietary components may have a potential role in modulating chronic inflammatory conditions. For example, foods including long chain omega-3 fatty acids, antioxidant vitamins, plant flavonoids, prebiotics and probiotics are believed to have the anti-inflammatory properties (Kris-Etherton et al., 2004). High intake of fruit, vegetables, healthy fats and whole grains are inversely associated with development of inflammatory diseases. Several human interventional studies (Baer et al., 2004; Basu et al., 2006) suggest an anti-inflammatory potential of some plant foods (Jacobs Jr et al., 2009; Basu et al., 2006; Mitrou et al., 2007). The unique properties of plant-based diet (Jacobs Jr et al., 2009) are believed to decrease the inflammatory diseases such as cardiovascular diseases (Basu et al., 2006), and cancer (Mitrou et al., 2007). In the sections 2.2.2.6.1 – 2.2.2.6.5, different pro-inflammatory and anti-inflammatory foods and nutrients are discussed.

2.2.2.5.1. Saturated fats and trans fat

A positive correlation between diets high in saturated and trans fats with markers of inflammation is reported by several observational studies (Lopez-Garcia et al., 2005; King et al., 2003). Inflammation and risk of chronic disease development is believed to increase with a diet high in pro-inflammatory foods such as junk foods (foods which are usually low in nutritional value and are often processed or ready to eat) and high-fat meats. The reason attributed is use of unhealthy fats especially trans fats and saturated fats in the preparation and processing of these foods that are common to modern diets (Fung et al., 2001). Other sources of saturated fats are

meats, dairy products and eggs, but these foods also contain essential vitamins, minerals, and the n-6 fatty acid, arachidonic acid. Some amount of arachidonic acid is important for optimal health, but high amounts in the diet may worsen inflammation. The solution could be choosing low-fat milk and cheese and lean cuts of meat, which will not promote inflammation. A decrease in levels of CRP compared to baseline has been demonstrated with the intake of low cholesterol/ low saturated fats diet (also low in trans fats) in hypercholesterolemia subjects (Pirro et al., 2004).

2.2.2.5.2. Refined sugars

Sugar-rich diets are linked with inflammation, obesity and development of chronic diseases. High carbohydrate consumption occurs with intake of processed and high-glycemic foods in Western diets such as pop (sodas), pastries, pre-sweetened cereals (Johnson et al., 2009; Tappy & Le, 2010). High sugar intake causes repeated spikes in the blood sugar and eventually leads to insulin resistance. Dyslipidemia, inflammation and increased oxidative stress are the underlying mechanisms linking sugar intake with disease development (Grimble, 2002). Furthermore, evidence from epidemiological and interventional studies suggest a relationship between glycemic load and inflammation, in particular the intake of sugar sweetened beverages which promote inflammation, obesity, type 2 diabetes mellitus or cardiovascular risk in healthy adults (Mucci et al., 2011; Aeberli et al., 2011). Increased consumption of rapidly digested and absorbed carbohydrates positively related to CRP concentrations and waist circumference (Liu et al., 2002; Ackermann et al., 2011).

Formation of pro-inflammatory compounds known as AGEs (advanced glycation end products) by the chemical reactions of sugars and protein (Uribarri et al., 2010) are known to contribute towards oxidative stress and inflammation. The modern diet is a very rich source of

AGEs because of excessive cooking or processing to enhance flavor, maintain quality, appearance, color and acceptability (Goldberg, 2004). It is found that even single AGEs rich meal fed to humans is well absorbed and contributes towards the total AGEs pool of the body (Koschinsky et al., 1997). AGEs might lead to propagation of inflammation and development of diseases such as CVD and diabetes (Basta et al., 2004)

2.2.2.5.3. n-3 and n-6 fatty acids

Polyunsaturated fatty acids (PUFA) are essential nutrients and components of neuronal and glial cells (which protect neurons from various infections and produce inflammatory cytokines which act particularly through receptors expressed by the brain). Diets rich in n-3 fatty acids decrease the production of pro-inflammatory cytokines, possibly by inhibiting production of lipids involved in cytokine synthesis (Caughey et al., 1996). PUFA in the diet are essential to regulate prostaglandin and proinflammatory cytokine production. n-3 fatty acids are anti-inflammatory while n-6 fatty acids are precursors of prostaglandins. It is very important to attain an optimal ratio of n-6 and n-3 fatty acids in the diet as there is a beneficial role of n-3 fatty acids in neurodegenerative diseases associated to aging (Carrie et al., 2009; Layé, 2010).

PUFA in the diet may have favourable effects on cardiovascular diseases (Hu, Manson & Willett, 2001) and inflammation (Calder, 2001). The n-3 and n-6 fatty acids are substrates for the production of eicosanoids and require the same enzymes for synthesis of prostaglandins and leukotrienes. The eicosanoids that develop from n-6 fatty acids have less pronounced anti-inflammatory properties as compared to the ones that come from n-3 fatty acids. Therefore, in several inflammatory processes the proportion of n-3 to n-6 fatty acid intake is very crucial (Pischon et al., 2003). Because of the anti-inflammatory properties, n-3 fatty acids are often used in clinics to treat the symptoms of various inflammatory diseases, like as rheumatoid arthritis or

Crohn's disease (Connor, 2000). A cross sectional study of healthy women reported that the intake of dietary n-3 fatty acids was associated with biomarkers of inflammation (Lopez García et al., 2004). n-3 fatty acids, having anti-inflammatory properties are richly available in fish, walnuts, flax, hemp, and to a lesser extent in canola, soy and sea vegetables. In typical Western diets, n-6 fatty acid intake far exceeds that of n-3 fatty acids (Browning & Jebb, 2006). The n-6 fatty acids are found mainly in oil-rich seeds and oil used in snack foods and fast foods, consumption of which is on rise.

2.2.2.5.4. Phytochemicals and antioxidants

Foods with some "medicinal" properties have been in demand among consumers, as prevention or cure for various chronic diseases (Institute of Food Technologists, 2005). "A *functional food* is similar in appearance to, or may be, a conventional food that is consumed as part of a usual diet, and is demonstrated to have physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions, i.e. they contain bioactive compound" (Health Canada, 1998). The popularity of the functional foods is increasing because of their safety, natural taste and easy sourcing for the attenuation of certain diet related chronic diseases. Fruits and vegetables are excellent sources of essential vitamins, minerals, fiber, phytochemicals and antioxidants, all of which help in reducing inflammation (Guo et al., 2009). The natural compounds found in fruits and vegetables, for instance flavonoids and proanthocyanidins, are known to have a protective mechanism against various diseases such as CVD (Mirmiran et al., 2009) and cancer (Pacheco- Fiqueiredo et al., 2011).

Evidence from literature supports high intake of fruits and vegetables as a preventive measure against low grade inflammation (Basu et al., 2006). Consumption of vegetables, fruits, and whole grains as suggested by nutrition authoritative bodies provides a wide range of

bioactive compounds at a level beneficial for promoting health (Watzl, 2008). Fruits, vegetables and beverages derived from plants are rich source of flavonoids, naturally occurring compounds, reported to have anti-inflammatory properties which may help in preventing several diseases. It has been demonstrated that flavonoids are able to modulate the enzymes such as cytochrome P450 enzymes as well as other inflammatory process such as cytokines, chemokines or adhesion molecules. There are the many studies published with *in vitro* approaches that allow identifying molecular mechanisms of flavonoid effects on inflammatory processes (Rathee et al., 2009; Tuñón et al., 2009).

The beneficial effects of fruits and vegetable consumption are demonstrated in several human studies. Wannamethee et al. (2006) found a strong association between dietary and plasma vitamin C concentrations, fruit and vegetable intakes with the markers of inflammation and hemostasis, a cross-sectional study comprising 3258 men age 60–79 y. The subjects had no physician diagnosis of myocardial infarction, stroke, or diabetes at baseline. Plasma vitamin C, fruit intake, and dietary vitamin C intake were inversely and significantly associated with CRP, fibrinogen, tissue plasminogen activator (t-PA) antigen. Vegetable intake was related inversely only with t-PA. Plasma (but not dietary) vitamin C was inversely related to fibrinogen concentrations and blood viscosity. Consistent with these findings, Holt et al. (2009) reported an inverse association between intake of fruit and vegetables, antioxidants, folate, and total flavonoids in relation to the markers of inflammation and oxidative stress in adolescent boys and girls. The intake of fruit and vegetables was related to the markers of inflammation and oxidative stress even after the adjustment of confounding factors. This suggests that increased intake of fruits and vegetables are related to lower systemic oxidative stress and inflammation markers in adolescents and adults. The Women's Health Initiative dietary modification trial determined the

effect of dietary carbohydrate modification with a low fat and high fruits, vegetables and grains diet in post-menopausal women. It was found that there were no adverse effects on lipids and lipoprotein compositions by replacing seven to eight percent of fat intake with complex carbohydrates for over six years (Howard et al., 2010).

2.2.2.5.5. Vitamin D

Vitamin D is known for its potential role in muscle function, cardiovascular health, diabetes, and cancer prevention. Vitamin D also has various extra skeletal functions including neuroprotective properties possibly via anti-oxidative mechanisms, neuronal calcium regulation, immune-modulation, increased nerve conduction, detoxification properties, development and functioning of adult brain. These findings underscore the potential role of vitamin D in cognitive function. An increasing number of epidemiological and clinical findings support this principle (Buell et al., 2008; McCann, 2008; Barnard & Colón-Emeric, 2010).

Vitamin D in human body comes from several sources like sunlight, diet, and dietary supplements. Vitamin D is present naturally in foods or added to foods (fortified). Vitamin D from dietary sources as well as synthesized from skin undergoes metabolism in the liver to 25-hydroxyvitamin D (25(OH)D), which is used as a measure to examine vitamin D status. 25 (OH)D is metabolized into the active form, 1,25 dihroxyvitamin D by enzyme 25 hydroxyvitamin D-1α-hydroxylase in kidneys as well as other tissues. Levels of plasma parathyroid hormone, serum calcium and phosphorus levels regulate the renal production of 1,25 dihroxyvitamin D (Holick , 2008). Serum levels of 25(OH)D are reported to be directly associated to bone mineral density in many ethnic groups in both men and women, with an optimal 25(OH)D level at 100 nmol/L (Bischoff-Ferrari et al., 2006). Vitamin D deficiency was found in about 93% of people with diagnoses of fibromyalgia, chronic fatigue, muscle aches and

bone pain admitted to the emergency ward in hospital in the age range of 10-65 y (Plotnikoff and Quigley, 2003).

Many cross-sectional studies have reported decreased muscle strength, high body sway, more falls, and disability in older men and women with low 1,25-dihydroxyvitamin D and low 25- hydroxyvitamin levels (Bischoff et al., 1999; Dhesi et al., 2002; Zamboni et al., 2002). Positive results on physical function and isometric knee extensor strength have been found with vitamin D supplementation in the older adults (Verhaar, 2000). Significant reduction in falls has been demonstrated with 1000 IU per day consumption of vitamin D for three months, an amount sufficient to correct vitamin D insufficiency (Bischoff-Ferrari et al., 2005-06). Higher levels of 25(OH)D were associated with longer 6-minute walk distance in older adults whereas shorter walk distances were correlated with increased levels of cortisol, CRP, IL6, and intact parathyroid hormone (PTH). Overall, increased frailty was associated with increased CRP, higher IL-6, and lower 25(OH)D (Boxer et al., 2008).

The active metabolite 1,25 dihydroxyvitamin D plays a role in modulating inflammation, enhancing immunity (while suppressing autoimmune injury) and exerting control over cell differentiation. The active metabolite of vitamin D activates receptors on neurons which help in regulation of behavior, activate neurotrophin release, and also has an important role in protecting the brain by buffering antioxidant and anti-inflammatory defences (Cherniack, 2009). Vitamin D activity is mediated by vitamin D receptors (VDR) that are found in tissues including neurons and glial cells. VDR are present in the human cortex and hippocampus, important region for cognitive functioning. Their absence may be related to neurodegenerative diseases such as Alzheimer's Disease (Annweiler et al., 2009, 2010). Also, adequate levels of 25(OH)D may be associated with better glycemic control (Buell et al., 2008; McCann, 2008).

Vitamin D deficiency is highly prevalent in geriatric patients (30–90%) and independent, community-dwelling older adults (2–60%) in Canada (Visser, 2003). Many reasons contribute to the deficiency including a lower capacity of the older skin to synthesize vitamin D3 (Visser, 2003). In Canada the prevalence of vitamin D deficiency is high among older adults in LTC due to reduced sun exposure and low dietary and supplemental intake of vitamin D (Schwalfenberg and Genuis 2010). Vitamin D is a nutrient which is lacking in the diet of most Canadians (Vatanparast et al., 2010b), especially in comparison to newly released Dietary Reference Intakes (Ross et al., 2011), where the RDA for those over 70 y is 800 IU, and 600 IU for adults 70 y and younger. Deficiency of vitamin D is very common in older adults living in institutions, so the recommendation to use supplements is made to ensure good quality of life (Holick et al., 2011). Osteoporosis Canada recommends at least 800 IU for all adults over 50 years of age (Hanley et al., 2010).

2.2.3. Metabolic syndrome

The term "Metabolic Syndrome" (MetS) refers to the cluster of a number of risk factors viz obesity, hypertension, dyslipidemia and hyperglycemia. The original definition of MetS as per described by the Adult Treatment Panel III criteria requires three or more of the following features i.e., abdominal obesity (waist circumference > 102 cm for men and > 88 cm for women), increased triglyceride level (1.7 mmol/L), reduced high-density lipoprotein (HDL) cholesterol level (< 1.03 mmol/L for men and < 1.30 mmol/L for women), elevated blood pressure (130/85 mm Hg); or elevated fasting blood glucose (6.1 mmol/L) (National Cholesterol Education Program (NCEP), 2002). The most operational definition of Metabolic Syndrome was proposed by World Health Organization (WHO) with hyperglycemia and/ or insulin resistance as a central feature, associated with two or more related metabolic abnormalities i.e. elevated blood

pressure, dyslipidemia, central obesity or microalbumineria (WHO, 1999). Several metabolic abnormalities emerge as key players in the pathogenesis of the syndrome, including insulin resistance, obesity, and inflammation. Mancia et al. (2007) determined that, although Metabolic Syndrome is a significant predictor of early death, the two components that apparently explain the association between MetS and mortality are hyperglycemia and high blood pressure. Important causative factors leading to this syndrome are identified as increasing physical inactivity and poor diet; and a prominent clinical feature is abdominal obesity (Mozaffarian et al., 2008).

The prevalence of each of these risk factors as well as MetS is increasing worldwide (Borch-Johnsen, 2007). The last decade witnessed a heightened interest in the metabolic syndrome, as it has become a health issue of epidemic proportions (Grundy et al., 2005). Metabolic syndrome is associated with a seven fold elevated risk of type 2 diabetes and two to three fold higher risk of cardiovascular disease mortality (Geiss et al., 1995) in older adults (McNeill et al., 2006). The prevalence of underlying conditions which cause MetS is a matter of concern, as with age the incidence of cardiovascular disease increases.

Report from national representative sample from the Canadian Health Measures Survey (2007–2009) indicated that one out of five adults had MetS. The prevalence of MetS was age-related, as 18.31% participants in the age group of 12–79 y reported MetS and lowest prevalence (3.50%) was found in adolescents (Setayeshgar et al., 2012). Another Canadian study also reported similar age related increase in prevalence of MetS, with highest incidence in very old 70-79 y (39.0%) (Riediger & Clara, 2011). Both studies reported abdominal obesity as the most prevalent condition (Setayeshgar et al., 2012; Riediger & Clara, 2011). Similar findings have been reported by MetS prevalence in United States from NHANES III (Ford et al., 2002). In a

review from major studies on the prevalence of MetS in older adults, MetS ranges from 11% to 43% (according to WHO definition), and from 23% to 55% according to NCEP definition (Denys et al., 2009). Diabetes, CVD and further frailty are occurring at alarming rates in patients with metabolic syndrome which leads to poor functional outcomes including mortality (Mozaffarian et al., 2008).

2.3. Functional status in long term care homes

Functional and health outcomes are negatively affected in the residents of LTCs because of high prevalence of malnutrition (Grieger et al., 2009). Malnutrition may develop because of many underlying factors such as loss of appetite, cognitive impairment or depression. Some nutrient deficiencies are related to incidence of falls, fractures, dementia and pain. The impact of nutrition on functional status is discussed in sections 2.3.1-2.3.3.

2.3.1. Cognition

Cognition refers to a person's mental ability to understand the processes involved in perception, understanding and knowledge. It involves logical thinking, learning, evaluating and problem-solving comprising the upper degree functions of the brain and encompass decision making, judgment, language and planning required for everyday life. Executive functioning refers to the cognitive process that controls and collects other cognitive activities, for example episodic memory. Executive functions include a range of other cognitive behaviors such as critical thinking, finding potential solutions to the problems, behaving socially in appropriate ways and selecting strategies (Mueller, 2012). With aging, most people have fairly stable cognitive abilities accompanied by only a gradual decrease in short term memory and processing. On the other hand, some people have more severe cognitive impairment arising from several forms of neurodegenerative diseases. The cognitive impairment causes increased interference in

normal life activities as the severity rises (Daviglus et al., 2010). Aging causes neuronal loss in many areas of brain especially in the frontal cortex affecting the synaptic losses which further has a great impact on cognitive decline.

Nutrition is required for normal functioning of brain, attaining nutritional status is crucial in older adults as malnutrition can cause various disruptions in the blood supply to brain, leading to neurological impairment (Denny, 2008). Brain functioning is particularly sensitive to dietary factors, such as, diet low in folate, vitamin B12, and vitamin B6 which are related to cognitive impairment (Selhub et al., 2010). Malnutrition, oxidative stress and vitamins related to homocysteine metabolism may play a role in development of neurodegenerative diseases like Alzheimer's Disease (von Arnim et al., 2010). Epidemiological studies suggest that antioxidants or polyunsaturated fatty acids in the diet aid in the reduction of dementia incidence (Middleton, 2009). Decreased incidence of cognitive decline has been associated with the consumption of supplemental vitamins, minerals, lipids and antioxidants alone or in combination (Remington et al., 2009; Chan et al., 2010). Smith et al. (2009) emphasized that older generation should be encouraged to maintain a good, rather than just an adequate, vitamin B12 status by dietary means to attain a better cognitive health. However, cognitive impairment, especially when adequate supports are unavailable, may make appropriate food access and preparation difficult, and in the later stages of dementia, agitation and resistance to care may limit compliance to adequate dietary management (Gillette et al., 2007). Effect of supplementation of some vitamins and nutrients on cognition is discussed in sections 2.3.1.1-2.3.1.3.

2.3.1.1. B Vitamins and cognition

Vitamin B12 deficiency is very common in certain demographic groups especially older adults in some countries. One of the various complications arising due to the deficiency is neurological complications affecting sensory and motor function (Green, 2009). Vitamin B6 is important for regulating the mental performance and mood. It also plays an important role in homocysteine catabolism thus increases in blood homocysteine levels can be found as a result of B6 deficiency. Homocysteine is a risk factor for development of several diseases of central nervous system by having the direct toxic effects on neurons. Several observational studies revealed that prevalence of poor vitamin B6 status is high especially amongst older people. Supplementation of the diet with B vitamins including vitamin B6 may help in reducing the hyperhomocysteinaemia which might play a role in the development of Alzheimer's Disease and dementia (Malouf, 2008).

Limited studies demonstrated the effect of folic acid, with or without vitamin B12 on the cognitive performance in older adults. Vitamin B12 supplementation given to moderate dementia patients who had B12 deficiency did not affect cognitive performance and behavior, whereas delirium which is related to dementia was decreased significantly. Evidence does not support the benefit of vitamin supplements for delaying dementia progression, even at high doses, when disease is progressed to an advanced stage, and B vitamins show negligible effects in preventing cognitive impairment (Kwok et al. 2008; Aisen et al., 2008).

2.3.1.2. Vitamin C and E, and cognition

Oxidative stress might affect cognitive ability and could be a risk factor for dementia. There seems to be a tremendous interest in identifying any relationship between the antioxidants use for protection of cognitive impairment. Accumulating evidence suggests that vitamins C and

E may scavenge free radicals, transforming them to less reactive state and may delay the possible impact of high oxidative stress on cognitive and functional abilities (Fillenbaum et al., 2005). Low levels of plasma vitamin E could be a causative factor for dementia, and high dietary intake of vitamin E may be associated with better cognitive performance (Morris et al., 2002). The beneficial effects of vitamin E are presented in various reviews and studies but the results are fairly inconclusive (Morris et al., 2002; Kang et al., 2006). Lloret et al. (2009) tested the effect of vitamin E supplementation on suppressing the oxidative stress and therefore loss of cognition in Alzheimer's Disease. It was found that cognition scores decreased acutely to levels even lower as compared to placebo. Therefore it was suggested that vitamin E supplementation might only benefit cognition if it decreases oxidative stress in Alzheimer's Disease patients. Vitamin E is speculated to work as pro-oxidant in some cases (Abudu et al., 2004). Therefore, vitamin E supplementation cannot be recommended to Alzheimer's Disease patients without knowing its antioxidant effect.

Studies on animals and humans targeted the retardation of the cognitive decline through enrichment and antioxidants. Some reports are in agreement with the fact that consumption of vitamin E as a supplemental form and physical activity may be beneficial together in preventing the age related cognitive decline if it is started in early middle age (Devi, 2009). Others report (Cetin et al., 2010) that vitamin E supplementation and exercise may act synergistically on the aging brain to decrease free radicals and oxidative stress (Devi, 2009).

2.3.1.3. Combination supplementation and cognition

Better cognitive performance can be obtained with nutrient supplements containing the optimal amount of the dietary components which are proven to be efficacious (Chan et al., 2010). Combination supplementation of some nutrients (folic acid, B12, vitamin E, S-

adenosylmethionine, N-acetyl cysteine and acetyl-L-carnitine) indicated improvements in the cognition and daily life activities in moderate to later stage Alzheimer's Disease institutionalized patients and community dwelling people with early stage Alzheimer's Disease (Remingon et al., 2009; Chan et al., 2009). The improved performance was consistent for further 16 months as reported by the caretakers. The authors suggest that the combination supplementation was effective in preventing cognitive decline, when provided early in disease progression. Similarly, daily dosage of a combination of nutrients (phosphatide precursors along with cofactors, B vitamins, vitamins C and E, selenium, and phospholipids, these nutrients implicated in synaptic membrane formation and function) to drug-naive mild Alzheimer's Disease patients was found to improve cognition functions, ultimately enhancing the memory in patients with early Alzheimer's Disease. This supports the efficacy of combined nutrient over single nutrient supplementation, as these specific nutrients may aid in raising the brain levels of synaptic membranes (Wurtman et al., 2006) which could help in improving the cognitive ability (Holguin, 2008) in early stages of cognitive impairment.

2.3.2. Musculoskeletal functions

Older adults become less independent with age which can be measured by the diminished abilities in activities of daily living (Ervin, 2006). Sarcopenia is the state of reduced muscle strength and muscle mass as a result of aging (Roubenoff, 2000). This in turn increases the functional limitations, and mortality in people aged 65 y and older (Visser, 2002). Aging predisposes skeletal muscle to increased levels of oxidative stress, which might have a role in causing sarcopenia-associated muscle loss (Siu, 2008). As sarcopenia leads to declined physical capacity with aging, it is the most important risk factor for functional status (Stuck et al., 1999).

Preserving physical capacity is crucial to maintaining autonomy, health and quality of life in older adults (Ávila-Funes et al., 2008).

Fractures and falls are frequent which may lead to considerable morbidity and mortality in older adults residing in nursing care facilities and hospitals (Bischoff-Ferrari et al., 2009). Incidence of falls and fractures is three fold higher in nursing care facilities as compared to community living older adults, which equals the rates of 1.5 falls per bed or 1.4 falls per person per year (Nurmi and Lüthje, 2002). Falls may have multi-factorial consequences including bone fractures and injuries. Reports from several nursing care facilities revealed that amongst the prevalence of all fractures of 70 per 1000 person in a year, about 35 per 1000 person in a year occur in long bone and, incidence of hip fractures is 10 times higher than that in the community (Cameron et al., 2010). Moreover, approximately 20% of older adults residing in nursing care facilities might have suffered from any kind of head injury from a fall in any given year (Cameron et al., 2010). Vitamin D supplementation seems to be efficient in reduction of falls in nursing care facilities (Parikh et al., 2009).

2.3.3. Pain

Aging is associated with the decline in majority of sensory systems such as vision, hearing, taste, smell, and tactile acuity. With age musculoskeletal pain rises both in the frequency and severity (Jimenez, 2012). Hypovitaminosis D in the older adults causes osteomalacia which includes bone pain as a major symptom; a relationship exists between severe hypovitaminosis D with persistent, non-specific musculoskeletal pain (Mascarenhas, 2004).

Reportedly, there is some association with nutrient status and pain. Different dietary treatments such as soy, omega-3 fatty acids, fruits and vegetables rich in anthocyanins may be effective in pain management (Tall & Raja, 2004). Supplementation of omega-3 fatty acids in an

intervention trial was found to be effective not only in reduction of pain but also decreased use of inflammatory drugs (Goldberg & Katz et al., 2007). Evidence also exists for amino acids such as phenylalanine and tryptophan on pain reduction (Seltzer et al., 1981).

2.4. Diets in LTC

Nutrition plays a crucial role in good quality of life and healthy living during aging (Denny, 2008). The importance of nutritional well-being is emphasized by the American Dietetic Association (ADA) for better health and quality of life of the older adults (ADA, 2005). The role of food is crucial not only because it is important for physiological well-being but it holds importance in social, cultural, psychological and overall quality of life.

Food is an integral part of quality of life for the residents of LTC homes, because an unacceptable diet may lead to reduction in food intake and overall poor nutritional status (ADA, 2005). There is a possibility of residents getting admitted to LTC in a malnourished state, the overall nutritional status might get worse after their admittance. Other reasons for malnutrition may be an inability to attain the unique nutritional needs of each resident, due to inadequate menu (Lengyel et al., 2008), problems in swallowing and functional restrictions, or lack of sufficient personal assistance in dining (Leydon & Dahl, 2008).

Lengyel et al. (2008) assessed food service delivery, dietary intakes, menu and resident food satisfaction from 18 different LTCs from Saskatoon Health Region. Their results demonstrated that LTC menus did not meet the recommendations for most of the vitamins and minerals. Energy intake was 88% of the recommended and failed to meet all the recommended servings of Vegetable & Fruits and Grain Products. It was found that nutrient dense snacks were provided in some facilities but were not consistently offered to all the residents. It was reported that overall residents were satisfied with the food offered by LTCs but dissatisfaction was shown

for variety, quality of food, awareness of menu, taste and appearance. Schematic diet planning and efficient team work is required for ensuring that dietary intakes of LTC residents do not pose a risk of malnutrition (Sitter et al., 2011).

2.4.1. Planning according to DRIs and Canada's Food Guide

Menu planning for LTC homes, in the recent trend of "resident-centered care", involves consideration of many factors such as DRIs in accordance with Canada's Food Guide (CFG), residents' preferences, as well as management issues such as food acquisition, preparation and the method of production (Ducak & Keller, 2011). Generally, nutrition managers, registered dietitians and cooks are involved in the planning process of the LTC menu, which is then evaluated by residents for overall acceptability (Ducak & Keller, 2011). Further, involvement of residents in making diet related decisions helps in meeting their nutrient needs while allowing the dietitians to alter it according to the medical conditions (ADA, 2005).

Planning of LTC menus should be done in accordance with Canada's Food Guide to meet the overall nutritional requirements of the older adults. Since Canada's Food Guide is based upon DRIs (Barr, 2006; Murphy, 2008), the consumption of a variety foods from all food groups gives the best possibility to meet nutritional recommendations (Health Canada, 2007). Although planning of menus should be done in accordance with Canada's Food Guide to meet the overall nutritional requirements of the older adults. Research highlights the need of using more than one standard guidelines to plan menus, because DRIs are meant for healthy people and residents in LTCs may have comorbidities and conditions in which requirement for certain nutrients is more than what is typically designed for healthy older adults (Ducack and Keller, 2011). The planning of menus and meals should be done in a way that the target levels of DRIs are achieved and menus are planned using foods in food groups of Canada's Food Guide (Ducak & Keller, 2011).

Canada's Food Guide however is not considered "health promoting or illness preventing" either. Some experts think that CFG is obesogenic and the total calories if eaten as recommended will lead to weight gain in average healthy individual (Kondro, 2006). Foods are not appropriately categorized and the development of CFG seems more from industry benefiting perspective rather health promoting by Government. For example, consideration of juices in Fruit & Vegetables food group where it might have as much as calories and sugar as a cup of pop. Experts are also disappointed with recommendation of having only half of the Grain Products consumption from whole grains. The fortification of folic acid in white flour is not considered the best substitute. Foods which comprise almost 25% of the total caloric intake i.e., sugars and oils are not part of any food group.

2.4.2. How well LTCs meet standards

Residents have reported difficulty in consuming the large size or volume of foods and fluids recommended by Canada's Food Guide (Ducak & Keller, 2011). It has been documented that even if residents consume the entire typical diet of 2000 kcal/d that is planned for them, there is still the possibility of residents being micronutrient deficient (Wendland et al., 2003). These authors (Ducak &Keller, 2011; Wendland et al., 2003) reported that the menu cycle offered in a typical accredited institution, that was developed using food guidelines, is not sufficient in meeting the recommended adequate levels of vitamins and minerals. Indeed, Wendland et al., (2003) refute the fundamental assumption that by planning the menus according to public health guidelines, nutritional requirements of the institutionalized older adults will be met. Carrier, Ouellet, and West (2007) highlight the need to change some aspects of food service that may contribute towards the increasing risk of malnutrition among residents of nursing homes.

2.4.3. Dietary assessment

The process of nutrition care involves assessment of nutritional status of the LTC residents by considering the different needs of individuals (American Dietetic Association, 2005). Assessment of the diet allows health care professionals to get an idea about the overall nutritional status of the residents (Lengyel et al., 2008). Several methods are used to assess the dietary intake of individuals and are mainly divided into two categories. The prospective measures, in which the quantitative daily consumption is assessed as food is consumed, are performed by measuring the quantity of individual foods consumed over one or more periods of 24 hours (Gibson, 2005). Several prospective measures include estimated or weighed records, and observed intake of individuals. These methods can be repeated several times or on different days to obtain the "usual", i.e., habitual intake of individuals or groups. Those methods which are retrospective include diet history and food frequency questionnaire (FFQs) (Gibson, 2005). These measure the pattern of food intake reported, often over a longer and less precisely defined period of time. These methods also can provide information on usual intake of food and food groups, and with certain modifications, individual nutrients can also be assessed. The main difference between prospective and retrospective methods is that the former do not rely on memory yet the reported intake may be modified if the respondent feels the researcher may desire a certain type of intake. A second difference is that prospective measures tend to be quantitative while retrospective are semi-quantitative at best. Depending upon the type of study and assessment purpose, any of the methods can be used (Gibson, 2005).

In FFQs, the respondents are asked to report their usual frequency of consumption of different food items and groups over a specified period, such as six months, for each food in a list (Gibson, 2005). FFQs provide information on foods consumed, serving sizes, supplement and beverage intake. The Block FFQ includes the full list of 110 food items. This questionnaire can

help in determining the estimate of usual and customary intake from a broad range of food groups. It usually takes about 30-40 minutes to respond to all the questions which can either be self/ or interviewer administered. Extensive food list in this questionnaire was adapted from the data of National Health and Nutrition Examination Survey (NHANES) III dietary recall. For standard referencing, nutrient database for the questionnaire was established from the United States Dietary Assessment nutrient database. Several choices of portion sizes are designated for each food item to determine the portion sizes. FFQs provide reasonable estimates of an individual's overall food intake (www.nutritionquest.com).

2.4.3.1. Challenges in conducting nutrition studies

Self-report bias often occurs in nutrition studies as participants would respond in a certain way that makes them and their records look at their best. Therefore, participants tend to distort the information and often under-report or over report certain behaviors according to the study question. Confounders often influence nutrition studies as a researcher may find a correlation between two variables where there is no actual association (Chiu and Taylor, 2007). Inaccurate methodologies lead to recall bias. It is a challenge to obtain accurate and valid data from subjects and models used in nutrition study analysis for parameters like dietary intake. Longitudinal data is important for analysis of any relationship like diet and health; however it is hard to obtain in nutrition studies. For example, asking respondent to recall what they ate in the last month or week may lead to bias as it is hard to remember and people tend to under-report (Livingstone, 2011). There are many other challenges in conducting nutrition studies such as ethics, i.e., to compare two nutrients you cannot deprive one group from nutrients necessary for healthy living, measures of quality of life, food access, security and affordability (Nayga, 2008). Also, research

methodology in nutrition studies poses challenges to draw associations and correlations between the two factors.

Hill's criterion is considered the gold standard in nutrition and epidemiology studies to determine whether or not a causal relationship exists between two things for example vitamin D and breast cancer (Mohr et al., 2012). Hill's criteria has seven main points: a temporal relationship which suggests that exposure must precede the disease; a strength of association which implies the magnitude of the association in relationship in two factors; a dose-response relationship implies increasing or decreasing exposure to one factor leads to corresponding increase or decrease in other factor; a consistency, that results from different studies determining an association between two factors are consistent in most or all studies; biological plausibility explains the correlation in two factors and coinciding of the results with biological mechanisms of that association; an alternate hypothesis is ruling out disease before making any inferences about the casual relationship among two factors for example, vitamin D and incidence of osteoporosis (Hill, 1965).

2.4.3.2. Dietary assessment in LTCs

There are many limitations while doing nutrition assessments of older adults residing in institutions (Lasheras et al., 1999). The analysis of foods offered to LTC residents can be done because the actual intake of residents living in institutions is difficult to assess (Lengyel et al., 2008). Nutritional assessment may hinder the routine work of employees working there, moreover the residents with some health conditions may find it difficult to report their intakes accurately (Traughber et al., 1983; Sahyoun et al., 1988). The observation method is often used in the field situations to determine the food intake of individuals. Observation of the foods consumed emerged as an important method in determining the food intake because it did not

depend upon the individual's capability to remember and recall the dietary consumption. In this method the observer often the trained professional can visualize and estimate the foods consumed by individuals (Gittelsohn et al., 1994). On the basis of observed actual food intakes of the institutionalized older adults, it was calculated that they tend to eat 18% less than the total food offered to them (Lengyel et al., 2008). Therefore, assessing the foods offered in LTCs can give an estimate of what the residents might eat.

2.4.4. Strategies to improve diet

Food service and foods offered to the residents need to be monitored and modified accordingly to enhance the nutritional intake of individuals. These changes include offering ready to eat foods, providing porcelain dishes, allowing freedom to choose food and eating place, increased access to food, choice to season food according to own taste, adding more variety to menu to break monotony, making foods appealing and appetizing, familiar food choices and consideration of cultural preferences (Carrier, Ouellet, and West, 2007).

Energy-dense foods in the menu could be replaced with nutrient-dense foods to improve diet quality (MyPlate, 2012). This also means that nutrient-dense snacks, supplying foods and beverages rich in nutrients and in fluids (Whiting et al., 2004), or vitamin fortified puréed foods, (Adolphe et al., 2009); or oral nutritional supplements (Johnson et al., 2009), should be provided to ensure that LTC menus meet the DRIs. This increased need of nutrient-dense foods with aging requires LTCs to consider other diet solutions than the Food Guide or DRIs to cope with the changing nutrient demands of aging.

2.5. The anti-inflammatory diet

Diets with anti-inflammatory properties are described by many authors (Bullo´ et al., 2006; Sears, 2009; Szarc vel Szic et al., 2010). There appears to be some common features in

these anti-inflammatory diets such as low-glycemic load foods, low in n-6 fatty acids and rich in n-3 fatty acids (Sears, 2009). Foods with low-glycemic load are beneficial as they cause only a gentle rise in blood sugar and insulin levels attributing to slow digestion and absorption of food in body. Low insulin level is desirable as prolonged elevation in insulin levels is one of the major risk factor in development of chronic inflammatory diseases (Barclay et al., 2008; Reddy & Bhatia, 2011). The most common foods in the anti-inflammatory diets are fruits and vegetables, n-3 fatty acids such as fish or fish oil supplements, whole grains, lean protein sources such as chicken, less red meat and full-fat dairy foods, low saturated and trans fats, limited refined foods and processed foods, alcohol in moderation; and spices (Basu et al., 2006; Giugliano et al., 2006; Nedrow et al., 2009; Sears, 2009; Walker et al., 2009). Some of the features are similar to a typical Mediterranean diet, often considered as a prudent form of an anti-inflammatory diet (Trichopoulou et al., 2003; Esposito, 2004).

Nedrow et al. (2009) have determined the feasibility and impact of administering an anti-inflammatory diet in type 2 diabetes and pre-diabetes on inflammatory outcomes in 30 individuals with mean age of 56 years. In a randomized control trial (RCT) of six weeks duration an anti-inflammatory diet was compared to a control diet. In this study, the anti-inflammatory diet was based on fish, nuts, flaxseed, vegetables, and fruits. As well, foods these authors considered antigenic were omitted. American Diabetes Association (ADA) guidelines for

Table 2.4. Weil's Anti-inflammatory diet (WAID) components

Food Group	WAID	Serving size equivalent
Vegetables (both raw and cooked, from all parts of the color spectrum, organic when possible)	4-5/d min.	2 c salad greens, ½ c vegetables (cooked, raw or juiced)
Fruits (fresh in season or frozen, organic when possible)	3-4/d	1 medium sized piece of fruit, ½ c chopped fruit, ¼ c dried fruit
Whole & cracked grain	3-5/d	½ c cooked grains
Pasta (al dante)	2-3/wk	½ c cooked pasta
Beans & Legumes	1-2/d	½ c cooked beans or legumes
Healthy fats (extra virgin olive oil, expeller-pressed canola oil, nuts-walnuts, avocados, seeds-hemp and freshly ground flaxseeds)	5-7/d	1 tsp oil, 2 walnuts, 1 tbsp flaxseed, 1 oz avocado
Fish & Seafood (wild Alaskan salmon, alaskon black cord, sardines)	2-6 /wk	4 oz fish or sea food
Whole soy foods (edamame, soy nuts, soymilk, tofu, tempeh)	1-2/d	½ c tofu or tempeh, 1 c soymilk, ½ c cooked edamame, 1 oz soynuts
Cooked Asian mushroom	Unlimited	
Other sources of protein (high quality natural cheeses and yogurt, omega-3 enriched eggs, skinless poultry, lean meats)	1-2/ wk	1 oz cheese, 8 oz serving of dairy, 1 egg, 3 oz cooked poultry, 3 oz skinless meat
Healthy Herbs & Spices (garlic, ginger, turmeric, cinnamon)	Unlimited	
Tea (white, green, oolong)	2-4 c/d	
Supplements	Daily	High quality multivitamin/multimineral that includes key antioxidants (vitamin C, E, carotenoids, selenium); coenzyme Q10, 2-3 grams of molecularly distilled fish oil, 2000 IU vitamin D3
Red wine	1-2 gl/d	
Healthy sweets (plain dark chocolate)	Sparingly	

Oz= ounce, c=cup, gl=glass, tsp= teaspoon, tbsp= tablespoon, d= day, wk= week

Table 2.5(a). Similar components of Weil's anti-inflammatory diet and Canada's food guide.

Food Group	Weil's Anti-Inflammatory Diet	Canada's Food Guide Serving/day
Vegetables and Fruits	4-5/ d (vegetables)minimum 3-4/ d (fruits)	7/d
Grain Products	3-5/d (whole & cracked grains) 2-3/ wk (pasta)	6,7 (female, male)
Milk & Alternatives	1-2/wk (soy beverage, tofu)	3
Meat & Meat Alternatives	1-2 /d (beans & legumes) 2-6/ wk (fish & seafood) 1-2/wk (other sources of protein eggs, tofu, cheese, yogurt, skinless poultry, lean meats)	2,3 (female, male)
Oils & fats	5-7/d Healthy fats (extra virgin olive oil, expeller-pressed canola oil, nuts-walnuts, avocados, seeds-hemp and freshly ground flaxseeds)	2-3 tbsp (canola, olive and soybean)

c=cup, tbsp= tablespoon, d= day, wk= week

Table 2.5(b). Additional components of Weil's anti-inflammatory diet

Food Group	Weil's Anti-Inflammatory Diet	Canada's Food Guide Serving/day
Cooked Asian mushrooms	Unlimited amounts	-
Herbs & Spices (garlic, ginger, turmeric, cinnamon)	Unlimited amounts	-
Tea (white, green, oolong)	2-4 c/ d	-
Supplements	Daily	Vitamin D (400 IU)
Red wine	1-2 gl/d	-
Healthy sweets (plain dark chocolate)	Sparingly	-

c=cup, gl=glass, d= day.

nutrition therapy were used as basis for control diet. It was found that fasting glucose, lipids, cytokines and weight were reduced in both the diet groups with more weight loss in group having anti-inflammatory diet.

2.5.1. Weil's anti-inflammatory diet (WAID)

Weil's Anti-inflammatory Diet is a prudent form of a food guide based on anti-inflammatory foods (Palmer, 2009). WAID provides specific guidelines regarding keeping blood sugar low, and by preventing inflammatory processes due to formation of AGEs (Table 2.4). It emphasizes consuming whole grains, beans, sweet potatoes, winter squashes and other vegetables and fruits like berries, cherries, apples, and pears instead of bananas, pineapple, mango and papaya. It recommends having less meat and poultry, as they contain pro-inflammatory fats, and having more vegetable protein (soy foods, beans, lentils and other legumes), whole grains, seeds, and nuts. Fish is recommended, but only oily varieties containing n-3 fatty acids are encouraged (wild Alaska salmon, sardines, herring, and black cod). Overall, it limits bread, white potatoes, crackers, chips, snack foods, pastries, sweetened drinks, less refined and processed foods, and eliminates fast foods and products made with high fructose corn syrup.

The food groups of Weil's Anti-inflammatory Diet (Table 2.4) are comprised of vegetables, fruits, whole & cracked grain, pasta, beans & legumes, healthy fats, fish & seafood, whole soy foods, cooked Asian mushrooms, other sources of protein, healthy herbs and spices, tea, supplements, red wine, healthy sweets. All the food items are recommended with serving size and ranges. There are many foods and items which are similar and are part of Canada's Food Guide (Table 2.5(a)). WAID also comprises additional foods (Table 2.5(b)) which are not part of Canada's Food Guide are anti-inflammatory in nature.

2.6. Summary

The literature suggests that there is high rate of supplement consumption in older adults and dementia diagnosis, but only few studies address the supplement use in LTC homes with respect to dementia diagnosis. Future study is needed to determine the prevalence of supplement use in LTC with focus on dementia diagnosis. Diet in LTC homes are matter of current research but little data is available on diet quality in LTC.

Menu analysis of LTC menu in Saskatoon Health Region was done a decade ago. To evaluate the on-going initiatives related to menu planning and food service management in the Saskatoon Health Region and changes in menu over the past years, a study is required to assess the changes in LTC menu with respect to macro and micronutrients and servings of Canada's Food Guide over time and diet quality.

Chronic inflammation is speculated to play an underlying role in occurrence of age related conditions such as dementia, sarcopenia etc. Literature points in the direction of positive associations between inflammation and incidence of some diseases and health conditions. Evidence also suggests that inflammatory markers rise with age and furthermore with frailty. It is evident from the accumulating body of research that older adults residing in LTC homes might have multiple health conditions, are frail, and have limited mobility which is one of the many reasons of their admittance to LTC home. On the other hand, older adults living in the community are mostly independent and may have better muscle strength. Long term care homes and living in community each has different characteristics and environments. However, there is lack of studies comparing the LTC residing older adults with their community dwelling counterparts for assessing relationship of inflammation and functionality. A study is needed to draw these associations in LTC population and have the inflammatory status, functional outcomes and dietary intakes status compared with healthy community dwelling older adults.

Finally, some foods are believed to have anti-inflammatory properties which might help in managing the chronic inflammation. It is documented that these foods have beneficial effects in ameliorating certain diseases such as cardiovascular diseases, hypertension and dementia. But none of the studies addressed the feasibility of adding an anti-inflammatory diet into the menus of LTC homes. Research is warranted to evaluate the need and feasibility of incorporating an anti-inflammatory diet in LTC to address the underlying inflammation and related health conditions.

Chapter 3

STUDY 1. Use of vitamin and mineral supplements in long-term care home residents

Supplement usage in LTC was the first study performed in the series of four studies included in this thesis because the data generated from this study was related to the subsequent studies. In this study, supplement and medication usage by the LTC residents was explored. Then the differences, supplement and medication use of the residents with and without the diagnosis of dementia was assessed. The main results indicate a high consumption of vitamin/mineral supplements by some residents and low consumption of vitamin D by the residents. The major highlights of the study were provided to the LTC home in the form of brochure, which was made available to caregivers and families.

A concise version of chapter was published in the *Applied Physiology, Metabolism and Nutrition.*

Viveky, N., Toffelmire, L., Thorpe, L., Billinsky, J., Alcorn, J., Hadjistavropoulos, T., & Whiting, S. J. (2012). Use of vitamin and mineral supplements in long term care home residents. *Applied Physiology, Nutrition and Metabolism, 37*(1), 100-105.

3.1. Introduction

Nutrition is very important for healthy living and better quality of life during aging (Denny, 2008). Unfortunately, malnutrition is very common in elderly people admitted to hospitals for a variety of reasons (Heersink et al., 2010). A decrease of energy intake occurs in older adults, partially as a response to the decline in basal metabolic rate and physical activity levels over time. Swallowing problems are also very common in hospitalized older adults, frequently worsening overall food intake (Feldblum et al., 2007). Cognitive impairment, especially accompanied with lack of adequate support, may cause difficulty in accessing and preparing food (Reed et al., 2005). Therefore consideration of appropriate dietary enhancements for the optimization of health, which may include use of supplements of specific nutrients according to the evidence based guidelines (Kamphuis, 2010; Wendland et al., 2003), for example, vitamin D supplementation, should be encouraged for all adults (Hanley, 2010).

Brain functioning is particularly sensitive to dietary factors. For example, high fat and low fibre diets have been associated with the development of cerebrovascular diseases (Denny, 2008), and diets deficient in certain B vitamins have been associated with cognitive impairment (Selhub et al., 2010). Recent reviews have noted that nutritional status may influence various other measures of mental health and cognitive performance (Dauncey, 2009). The intake of supplemental vitamins, trace minerals, lipids and antioxidants alone or in combination has been linked to the decreased incidence of cognitive decline and improved mental functions by some authors (Chan et al., 2010; Remington et al., 2009). von Arnim et al. (2010) reported that malnutrition, oxidative stress and vitamins related to homocysteine metabolism may play a role in development of neurodegenerative diseases like Alzheimer's disease. Daviglus et al. (2010) argued that the essential role of nutritional and dietary factors for the prevention of Alzheimer's

disease is not conclusive. The authors report lack of supporting evidence from the recent literature for the beneficial role of the nutrition and diet in the prevention of disease except for intake of omega-3 fatty acids which is shown to be beneficial in the reduction of cognitive decline. The National Institute of Health (Daviglus et al., 2010) documents that data from only a few studies support the role of vitamin B, vitamin E, vitamin C, folate, and beta-carotene. There is some evidence in favor of low saturated fat and high vegetable dietary intake. Several other groups (Chan et al., 2009; Kamphuis, 2010; Remington et al., 2009; Scheltens et al., 2009) support the use of multi nutritional interventions to target the various aspects of the neurodegenerative process to avoid the progression of disease, as long as supplementation occurs at an early stage. However, excessive intake of most nutrients can be detrimental, thus the establishment of Tolerable Upper Intake Level for intakes was essential (Otten et al., 2006).

The excessive use of vitamin and mineral supplementation without good clinical evidence for use has been discouraged, as it may add to the burden of adverse effects in frail elderly (Nahin et al., 2009). The term "excessive" can also refer to the intake of nutrients in pill form that create a burden on the patient and on the institution delivering the medications (Loya et al., 2009). Excessive use of concurrent medications and supplements (called polypharmacy) is known to increase the risk of adverse drug effects (Maggiore et al., 2010), and is a major issue of concern (Nahin et al., 2009).

There might be a detrimental effect of polypharmacy and excessive nutrient intake in LTC residents (especially in older adults with dementia). Unfortunately, the use of supplements in this population has not been adequately studied as medications are administered routinely by staff, compared to community, where intake is more sporadic.

Objective

In this descriptive cross-sectional study, pharmacy records from the year 2009 were used to investigate the prevalence of vitamin/mineral supplement usage in the adults (≥65 years of age) living in a long-term care home. As a secondary objective, to illustrate use in a common chronic disease state in LTC, use of supplements by those with a diagnosis of dementia was compared to those with no dementia diagnosis. Finally, in a subsample, the total number of medications consumed, i.e., potential for pill burden was assessed.

3.2. Methods

Subjects

This study is based on the analysis of 2009 records from a pharmacy database of all nutritional supplements provided for residents of a non-profit long-term care home with 270 beds. The study was approved by the LTC home. Researchers used de-identified data provided by the home regarding diagnosis, supplement and medication use. As the study was particularly focussed to find out the impact of supplementation on older individuals in LTC, only the records for those 65 years or older (n=189) were examined. Residents were further subdivided into those diagnosed with dementia (n=87) and without dementia (n=102); the diagnosis of dementia was based on charted diagnosis of dementia. Both groups consisted 59% females and 41% males.

Data collection

Nutritional supplements prescribed to the study population were recorded for each resident. Use was defined as a treatment for at least three consecutive months in order to eliminate inconsistent or acute use. Potassium and sodium supplements were not included as these were given as treatments for specific electrolyte disorders. Analysis was based on the type and quantity of supplement use by residents in the home, and then subdivided into those with

(n=87) and without (n=102) a diagnosis of dementia. Supplements were divided into 5 categories: vitamin D (provided alone in a supplement), vitamin A (as cod liver oil), vitamin B complex and/or C (including stress products), multivitamins, and calcium (formulations may also include vitamin D). From an initial list of 189 residents, 114 residents were using supplements, and 22 were removed as they consumed only electrolyte products or used supplements for less than 3 months consecutively. The total pharmaceutical usage from prescriptions was determined in a subsample of 56 residents with a diagnosis of dementia.

Analyses

Supplement consumption profiles for the total population (≥ 65yrs) residing in the LTC home was determined and then compared to those consuming supplements. Significance of the differences in the number of supplements taken between those with and without a chart diagnosis of dementia were assessed using the non parametric Kruskal Wallis test. Frequencies were assessed according to gender, supplement type, supplement user status (taking supplement or not) and cognitive status using the chi-square test. Statistical tests were performed by using the Statistics Online Computational Resource (Dinov, 2006) statistical online analyses tool (http://www.socr.ucla.edu/).

3.3. Results

Frequency of supplement use in the long-term care home

Table 3.1 provides supplement use profile for the whole LTC home and for users of supplements. Close to half of the residents were taking supplements, with 64% of supplement users taking more than one supplement per day. Table 3.1 show that two percent of subjects in

Table 3.1 Supplement users and use profile in the total long term care home* and the use profile of the user group.

Supplement usage	%	%
	Supplement users in the LTC home (n=189)	Consumption among supplement users (n=92)
Users taking 6	0.1	1.0
Users taking 5	1.5	3.3
Users taking 4	2.6	5.4
Users taking 3	8.9	18.4
Users taking 2	17.4	35.8
Users taking 1	17.4	35.8
Users taking 0	51.3	0
Mean intake	1.0	2.1
Vitamin D	35.4	72.8
Vitamin A	0.1	1.0
Vitamin B and/ or C	19.0	39.0
Calcium	25.9	53.2
Multivitamin	19.5	40.2

* Residents ≥ 65 yrs

the LTC home consumed five or more supplements per day, representing four percent of the user group. Use of three to four supplements comprised over 10% of LTC home residents and close to 25% of supplement users. The percentage of consumption of one to two supplements was the most frequent, at 35% of residents in the whole LTC and 71% of the supplement user group. Overall, 49% residents in LTC were taking at least one supplement. The mean intake was 1.01 supplement/day for the LTC (n=189) and 2.07 supplement/day in the user group (n=92).

The supplement with the highest use, at 73% amongst the supplement user group, was vitamin D, but this represented only 35% for the whole LTC (Table 3.1). The remaining supplements, in descending order of consumption, were calcium, multivitamins, vitamins B and/or C, and vitamin A.

Frequency among supplement users diagnosed with dementia

Supplement usage did not vary within the supplement user groups as a function of dementia diagnosis (Table 3.2). In both the groups four percent were taking five or more supplements each day. The percentage of people taking three to four supplements was 21% and 26% in the dementia and non-dementia group, respectively. The most common level of consumption within the non dementia group was two supplements (39%) whereas for the dementia group the most common use was one supplement per day (41%). The mean daily consumption did not significantly differ ($p \geq .05$) between the dementia group (2.0) and the non-dementia group (2.2). The percentage of females consuming supplements in both the groups was 59%.

The type of supplements consumed by both the groups was similar ($p \geq .05$). Most people in both groups i.e., 74% and 72%, were taking vitamin D. The consumption of vitamin A supplement (as cod liver oil) was very low. Use of vitamin B and/or C was significantly higher

Table 3.2 Supplement usage in the residents* in long term care with and without a dementia diagnosis.

Supplement usage	% Dementia diagnosis n=46	% No dementia diagnosis n=46
Users taking 6	2.2	0
Users taking 5	2.1	4.3
Users taking 4	4.3	6.5
Users taking 3	17.4	19.5
Users taking 2	32.6	39.1
Users taking 1	41.3	30.4
Mean intake	2.0	2.2
Users taking Vitamin D	73.9	71.7
Users taking Vitamin A	2.1	0
Users taking Vitamin B and/ or C	43.4	34.7
Users taking Calcium	43.4	63.0
Users taking multivitamin	36.9	43.4
Percentage of females	58.6	58.6

* Residents ≥ 65 yrs

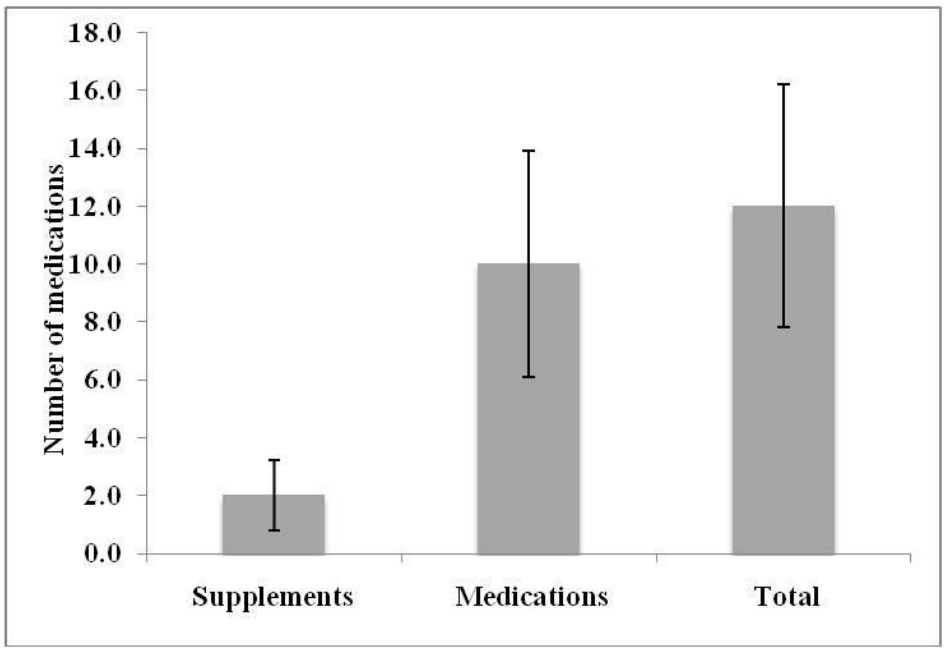

Figure 3.1. Average use by residents diagnosed with dementia showing the contribution of supplements to the total medication use. Data shown as mean ± standard deviation.

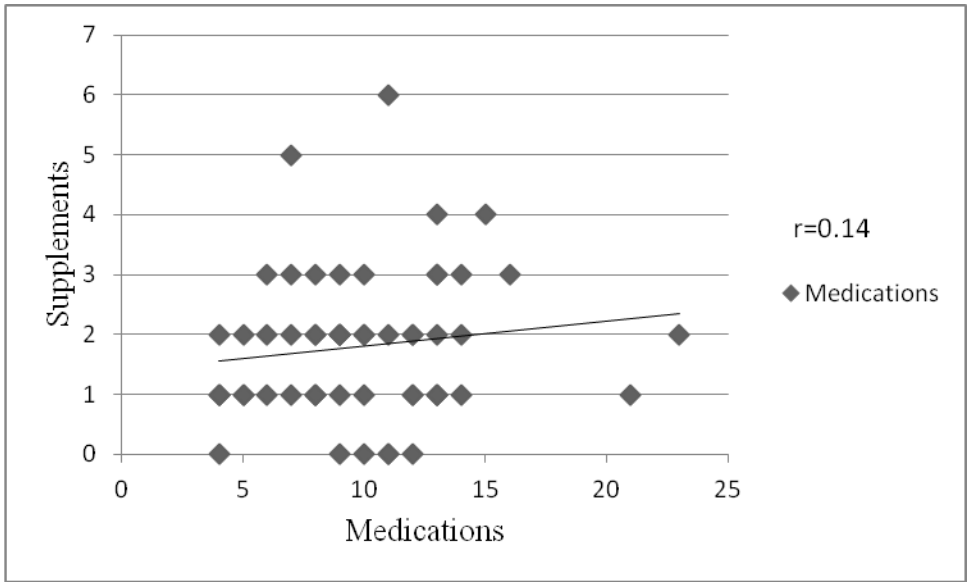

Figure 3.2. Correlation between supplement use and medication use in LTC residents.

Table 3.3 Examples of long term care residents who were taking large numbers of supplements.

		Supplement Type				
Subjects	Dementia*	Vitamin D	Vitamin B/C	Calcium	Multivitamin	Others
User taking 6 Subject A Female	Yes	1000 IU tablet	Folic Acid 1mg Vitamin B6 50 mg Thiamine 100mg tablet	Apo-calcium 500/1250 mg tablet	Centrum Select 50+#	
User taking 6 Subject B Female	No	400 IU tablet	Folic acid 5mg Vitamin B-50 complex	Apo calcium 500/1250 mg	Centrum #	Slow K-8 MEQ/ 600mg
User taking 5 Subject C Female	Yes	1000 IU tablet	Vitamin B6 100mg Folic acid 1mg	Apo calcium 500/1250 mg	Centrum select 50+#	
User taking 5 Subject D Female	No	1000 IU tablet	Vitamin B6 25 mg Folic acid 5mg	Calcium & magnesium 333/167mg	Centrum select 50+#	
User taking 4 Subject E Female	No	1000 IU tablet		Caltrate select 600mg/400 IU	Vitalux multivitamin Multisure women 50+#	Slow K-8 MEQ/ 600mg

*Diagnosis of dementia

Contains vitamin D

($p \leq .05$) in the dementia group (43%) compared to the non-dementia group (35%). In contrast, the consumption of calcium was higher (63%) ($p \leq .05$) in the non-dementia group compared to 43% in the dementia group. The prevalence of multivitamin use was 37% and 43% in the dementia and the non-dementia group, respectively, with no significant difference ($p \geq .05$) between the groups.

Supplement use in those residents who took the highest number of supplements was examined. Table 3.3 identifies five residents who took four to six supplements per day. All these residents took vitamin D in tablet form in addition to vitamin D from multivitamins and calcium supplements. Subject E was taking vitamin D in most of the supplements used.

Medications and supplements

The overall pill burden from medications including supplements for residents with a diagnosis of dementia consuming supplements were then determined. As shown in Figure 3.1, the average prescription medication use was 10 (range 4 to 23); average supplement use was 2 (range 0 to 6); with a combined average burden of 12 (range 4 to 25). Of the two people taking the most medications, one who took 23 medications per day was diagnosed with dementia and Parkinson's disease and the one consuming 21 had memory loss, cerebral aneurysm and hypertension. There was no significant correlation ($p \geq .05$) between the supplement use and medication use ($r=0.14$) (Figure 3.2).

3.4. Discussion

This study showed much variation in the consumption frequency and pattern of supplement use in a LTC home. Many different types of supplements were taken by the

residents**.** These findings are similar to Nahin et al. (2009), as both demonstrate frequent concomitant use of supplements and medications in older adults in different settings.

There were no significant differences in the supplement use between the groups with and without diagnosis of dementia, other than the highest supplement consumption rate of 1 supplement/day in dementia vs. 2 supplements/day in the non-dementia group. Results of other studies do not support the benefits of vitamins for slowing down dementia progression, even at high doses, when disease is progressed to an advanced stage, and B vitamins or antioxidants show negligible effects in preventing cognitive impairment (Aisen et al., 2008; Kang et al., 2006; Kwok et al., 2008; Mgekn et al., 2008; Morris et al., 2002; Nelson et al., 2009). Some studies (Chan et al., 2009; Remington et al., 2009; Scheltens et al., 2009) support the beneficial effects of multi-nutrition supplementation if intervention is given at an early stage. However, these supplements used by residents with dementia may be imposing an extra burden without benefit to residents who are at advanced stages of dementia and frequently resist care, medications. A review of the total intake from all the dietary and supplemental sources should be conducted, as overconsumption may lead to adverse effects (Otten et al., 2006).

Only 35% of all residents took vitamin D as a separate supplement, although close to 50% had some vitamin D from all supplement sources. This is a concern, considering that authoritative agencies such as Osteoporosis Canada, recommend that all adults should use vitamin D supplements, and in sufficient amounts. Vitamin D is a nutrient which is lacking in the diet of most Canadians (Vatanparast et al., 2010a), especially in comparison to newly released Dietary Reference Intakes (Ross et al., 2011). Osteoporosis Canada recommends at least 800 IU for all adults over 50 years of age (Hanley et al., 2010). Canadian studies showed that the prevalence of vitamin D deficiency is high among older adults in LTC due to reduced sun

exposure and low dietary and supplemental intake of vitamin D (Schwalfenberg and Genuis, 2010). The findings of epidemiologic studies and small-scale clinical trials suggest a relationship between 25(OH)D concentrations on many diseases like systolic blood pressure, CVD, depression, cognitive impairment and mortality (Barnard and Emeric, 2010). Deficiency of vitamin D is very common in older adults living in institutions, so the recommendation to use supplements is made to ensure good quality of life.

It was found that use of multiple supplements frequently resulted in duplicated intake of the same nutrient. For users taking two or more supplements, there should be a review of the necessity of the supplements (other than vitamin D). For example, for daily calcium intake recommendations have been reduced from 1500 mg to 1200 mg and this might reduce the need for extra calcium supplement use (Hanley et al., 2010). Several consequences of over-medication may include the adverse drug reactions because of drug-drug interactions, mistakes in taking medicines, and increased financial burden. As shown in Figure 3.1, supplements add to overall burden of medication use. While supplement use may be lower than prescription medication use, both contribute to this burden which can reduce quality of life of residents having to swallow these (often in pill form). They sometimes need to be crushed and taken with food such as applesauce which causes increased nursing effort. Some are also available in liquid form but this may be more expensive and may be unpalatable. Residents may have extra medical coverage for medications but not usually for vitamins, which can result in considerable cost for some residents.

Providing better information to residents' families is a possible strategy to reduce the unnecessary use of supplements, as many residents and their families are the drivers of this use, believing that vitamin/mineral protocol is very important to a resident's well being (Vernarelli et

al., 2010). Both risks and benefits of supplements should be explained to residents and their families, and a dietitian should ideally review their usage, taking into consideration the nutrients provided by food and nutritional supplements. Safety for patients in an outpatient setting (when access to a dietitian is less readily available) might be increased by designating nutrients such as vitamin A, E, D, folic acid and niacin as over-the-counter medications and providing information regarding concurrent use with other products, toxicities, dosage and recommended upper intake levels on labels or product inserts to limit their overuse (Rogovik et al., 2010).

3.5. Strengths and limitations

A main limitation of this study was that supplement use was examined in only one long term care home, which may not be fully representative of all long term care homes in local region. Therefore replication of this study is needed. For the total number of medications, a pill count was conducted, however, for some medications; more than one pill is required to meet the dosage needs for the patients. The important strength of this study is that it is the only study conducted in Saskatchewan LTC to evaluate use of dietary supplement consumption in residents with and without a diagnosis of dementia. Also, the informational brochure regarding the supplement use was provided back to LTC home.

3.6. Conclusion

A significant proportion of older adults in a LTC took many supplements. Yet, there was a low rate of vitamin D use in the long term care residents, whereas this nutrient should ideally be taken by 100% of residents. Supplement use was comparable in the group with and without a diagnosis of dementia, and an examination of use in residents who took more than 4 supplements per day revealed duplication in vitamins and minerals obtained through supplementation. Use of vitamin/mineral supplements should be reviewed by the dietitian or pharmacist in consultation

with the physician to determine the appropriateness of each supplement being ordered. While the dietary intake of supplemental vitamins and minerals has been found by some researchers (Remington et al., 2009; Chan et al., 2010) to decrease the incidence of cognitive decline, disease progression does not slow down when intervention is given at the advanced stage of dementia, so supplement use in this situation needs particular scrutiny. Supplements may add to the burden of medication use. Therefore, some guidelines/recommendations should be developed regarding use of nutritional supplements in LTC homes (Johnson et al., 2009).

In summary, the information obtained may be very helpful to other LTC homes in helping to optimizing the care of residents. Knowing supplement use profiles may help decrease the overall burden of additional adverse effects of polypharmacy (including vitamin and mineral supplementation).

Chapter 4

STUDY 2. Continued challenges in meeting dietary recommendations for long term care menu

Results from Study 1 indicated that supplement use was high and not all LTC residents were taking vitamin D supplements as recommended. In Study 2, a one-week menu analysis of the same large LTC home was conducted to determine whether the menus meet the recommendations of Canada's Food Guide servings and DRIs for older adults. As a secondary objective the current analysis was compared to a similar analysis conducted almost 10 y ago to identify potential menu changes over the decade.

The condensed version of this chapter is published in Canadian Journal of Dietetic Practice and Research.

Viveky, N., Billinsky, J., Thorpe, L., Alcorn, J., Hadjistavropoulos, T., Whiting, S. (2013). Challenges in planning long-term care menus that meet dietary recommendations. *Canadian Journal of Dietetic Practice & Research,74*, 84-87.

4.1. Introduction

Food is integral to the quality of life for the residents of LTC homes. An unacceptable diet may lead to a reduction in food intake and overall poor nutritional status (ADA, 2005). Although newly admitted residents in LTC may already be malnourished, poor LTC menus may further exacerbate this state and contribute to a worsening medical condition. Concerted diet planning with efficient team work is required to ensure that dietary intakes of LTC residents do not pose a risk of malnutrition (Sitter & Lengyel, 2011). Furthermore, the recent trend of "resident-centred care" obliges menu planning in LTC homes to consider factors such as Dietary Reference Intakes (DRIs) that are the basis of Canada's Food Guide, resident preferences and individual needs, and management issues such as food acquisition, preparation, production time and cost (Carrier et al., 2007; Lengyel et al., 2008; Ducak & Keller, 2011).

Planning of LTC menus should be in accordance with Canada's Food Guide with the aim of meeting the overall nutritional requirements of older adults. DRIs are the base of evidence used to develop Canada's Food Guide (Barr, 2006; Murphy, 2008); the consumption of a variety of foods from all food groups provides the best opportunity to meet nutrient recommendations and to reduce the risk and exacerbation of chronic health conditions (Health Canada, 2007). Current dietary recommendations meet the nutrition requirements for healthy people, yet many or most LTC residents have co-morbidities and conditions in which the requirement for certain nutrients is greater than those for healthy older adults. Consequently, more than one standard guideline to plan menus should be employed (Ducak & Keller, 2011) and suggests a need for nutrient-dense snacks and beverages (Whiting et al., 2004), or vitamin fortified puréed foods as appropriate for dysphagia (Adolphe et al., 2009), to assure that LTC menus meet the nutritional needs of older adults suffering from health-related problems.

The Healthy Eating Index (HEI), developed by the United States Department of Agriculture (USDA) using its Dietary Guidelines (Bowman et al.,1998; Guenther et al., 2007), determines diet quality and was modified for use in Canada in 2005 (Garriguet, 2009). The index analyses the diet on the basis of four components: adequacy, moderation, variety and balance. The index provides a score based on the dietary recommendations of the Canada's Food Guide, with categories specifying food components and nutrient groups. Using data from a 2004 Canadian Community Health Survey an average HEI score of older adults ≥71 y was 60 out of 100 (Garriguet, 2009). However, a paucity of data exists regarding the diet quality of older adults residing in LTCs.

A nutrient analysis of foods offered in several LTC menus in a mid-size Canadian city in 2000 using the 1992 Canada's Food Guide to Healthy Eating to determine the adequacy of food guide servings found that the LTC menus did not meet recommendations for major nutrients such as vitamin E, vitamin C, niacin, vitamin B6, folate, magnesium, zinc, calcium and vitamin D and failed to provide the recommended servings of Grain Products or Vegetables and Fruit, and were low in dietary fiber (Lengyel et al., 2003, 2008). Residents consumed only 82% of food offered in the menu, which may explain, in part, why nutrient intake was below recommended levels. Studies to date (Ducak & Keller, 2011; Lengyel et al., 2008; Lasheras et al., 1999; Wright-Thompson & Piché, 2011; Wendland et al., 2003) have reported that LTC menus do not provide sufficient nutrients and food servings as recommended for older adults.

Objective

The objective of this study was to analyze a 7-day menu offered in a large metropolitan LTC home to determine whether it met the current nutrient recommendations and 2007 Canada's Food Guide servings for older adults. Diet quality was further assessed using the Canadian

adaptation of the Healthy Eating Index. As a secondary objective, these results were compared to a similar analysis conducted in 2000 (Lengyel et al., 2003, 2008) to determine menu changes over the past ten years.

4.2. Methods

Data collection

A full week menu used in a large LTC home in a mid-size Canadian city for November 2011 was analyzed. As the menu provided choices to residents, foods that were most likely to be chosen by residents based on the judgement and experience of the LTC home's dietitian were selected. It was also attempted to include as many different food choices as possible in order to maximize variation in the foods eaten by the majority of residents. The menu that was examined provided approximately 1800 kcal/day excluding snacks, which residents may consume within or outside the LTC home.

The menu was evaluated against servings of the four food groups in the Canada's Food Guide (i.e. Vegetables and Fruit, Grain Products, Milk and Alternatives, and Meat and Alternatives) and Recommended Dietary Allowances (RDA) values for ages ≥70 y. Both food group and nutrient analysis was performed using Food Processor SLQ software (Version 10.2.0, ESHA Research, Salem, OR, 2009). Within the software, Canadian foods were chosen when possible to account for differences in food fortification between Canada and the United States of America. When a food was not present in the database, food with similar nutritional composition was entered for analysis. Missing nutrient values were imputed using the Canadian Nutrient File, Health Canada (http://webprod3.hc-sc.gc.ca/cnf-fce/search-rechercher.do?lang=eng).

For serving sizes in each food group, the standard portion sizes of Canada's Food Guide were used. For example, one serving of Vegetables and Fruit was ½ cup or 125 mL or equivalent

of fruits, vegetables or fruit juices; one serving of Grain Products was 1 bread slice, ½ pita (35 g or equivalent) or ½ cup (125 mL) cooked rice and pasta, one serving of Milk and Alternatives was 1 cup (250 mL) equivalent or 50 g cheese, and for Meat and Alternatives it was 75 g cooked meat or 2 tbsp (60 mL) peanut butter or 2 eggs.

The LTC menu was assessed for diet quality using the Canadian adaptation of Healthy Eating Index. In addition to the four food groups, this index has six additional groupings – whole fruit, dark green and orange vegetables, whole grains, unsaturated fat, saturated fat, sodium and "other foods" (i.e., foods high in fat, sugar and/or salt such as butter, margarine, cooking oils, lard, desserts, deep-fried foods and fried snack foods). Each group was assessed and scored from zero to ten for total vegetables and fruit, milk and alternatives, meat and alternatives, unsaturated fats, saturated fats, sodium level. A score of zero to 20 was assigned for decreasing calories from "other foods" as described in the previous 1992 version of Canada's Food Guide. The score of zero to five was assigned for whole fruit, dark green and orange vegetables, total grain products and whole grains. A calculation of intermediate values was done proportionally. The maximum score obtained from the sum of components was 100. The components related to food groups were based on the foods and preparations described in 2007 Canada's Food Guide. The scores are assigned as low (under 51), average (between 51 and 80), and high (over 80).

Analyses

The mean and standard deviation (SD) as well as median of number of food servings and macro and micronutrients provided by the diet was calculated using Microsoft Excel (Version 2007, Redmond, WA). Independent t-tests were used for comparing the 2011 menu values to those described somewhere else (Lengyel et al., 2003; 2008).

4.3. Results

Canada's Food Guide servings

The menu offered in 2011 provided on average 7.2 servings of Vegetables and Fruit (as compared to the recommended 7 servings), 3.1 servings of Grain Products (as compared to the recommended 6-7 servings), 1.2 of Milk and Alternatives (as compared to the recommended 3 servings) and 1.6 for Meat and Alternatives (as compared to the recommended 2-3 servings). Comparison of the 2000 to the 2011 menu analyses revealed an improvement (Figure. 4.1) in the number of servings of Vegetables and Fruit from 4.6 to 7.2 ($p \leq 0.05$) and servings of Grain Products, from 4.9 to 3.6, while servings of Meat and Alternatives, from 2.4 to 1.6 remained the same ($P > 0.05$). A significant decrease was observed in Milk and Alternatives, from 2.4 to 1.2 servings.

Nutrient content of LTC menu

Protein, fat and carbohydrate levels (the macronutrients), expressed as a percentage of total energy intake, provided by the 2011 LTC menu, were in the Acceptable Macronutrient Distribution Range (AMDR), which is a pre-defined percentage range of energy intake of the important macronutrients (Table 4.1). Carbohydrates comprised 55%, fat 30%, and protein 15% of total energy intake. Distribution of total carbohydrates (Figure 4.2) showed that sugar intake was below the maximum limit. Dietary fiber did not meet the recommendation. The fat distribution profile (Figure 4.3) revealed a high level of saturated fats, which exceeded the recommendations, but cholesterol was within the recommended range. Monounsaturated fatty acids (MUFA) in the menu met the recommended level, but polyunsaturated fatty acids (PUFA) offered were below the recommended level. The protein quality analyses showed that mean score of all the amino acids was below the ideal score (data not shown). Comparison of macronutrients

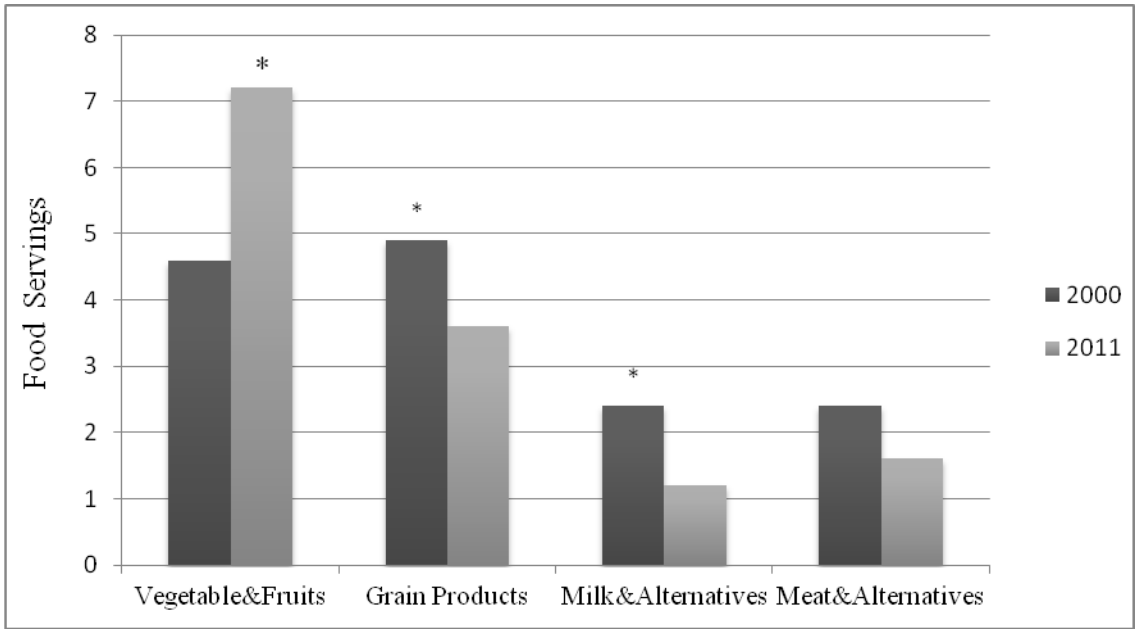

Figure 4.1. Comparison of mean food servings providing approximately 1800 kcal according to Canada's Food Guide for weekly long term care menus in 2000 and 2011.

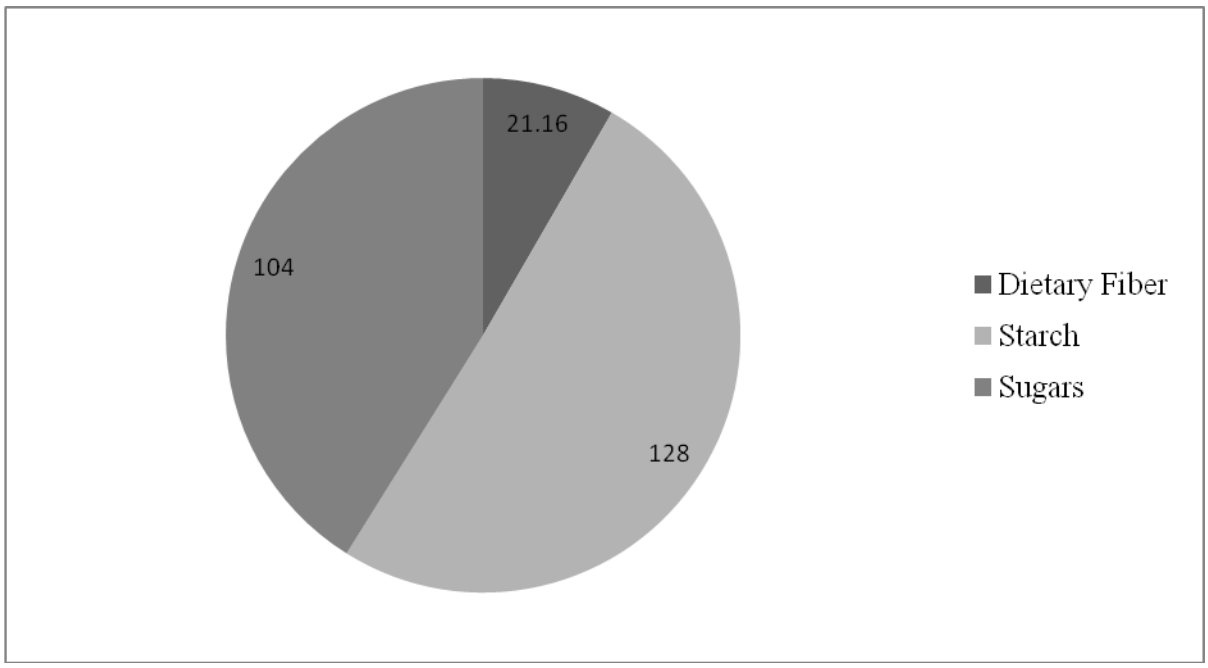

Figure 4.2. Average carbohydrate distribution profile of a weekly LTC menu

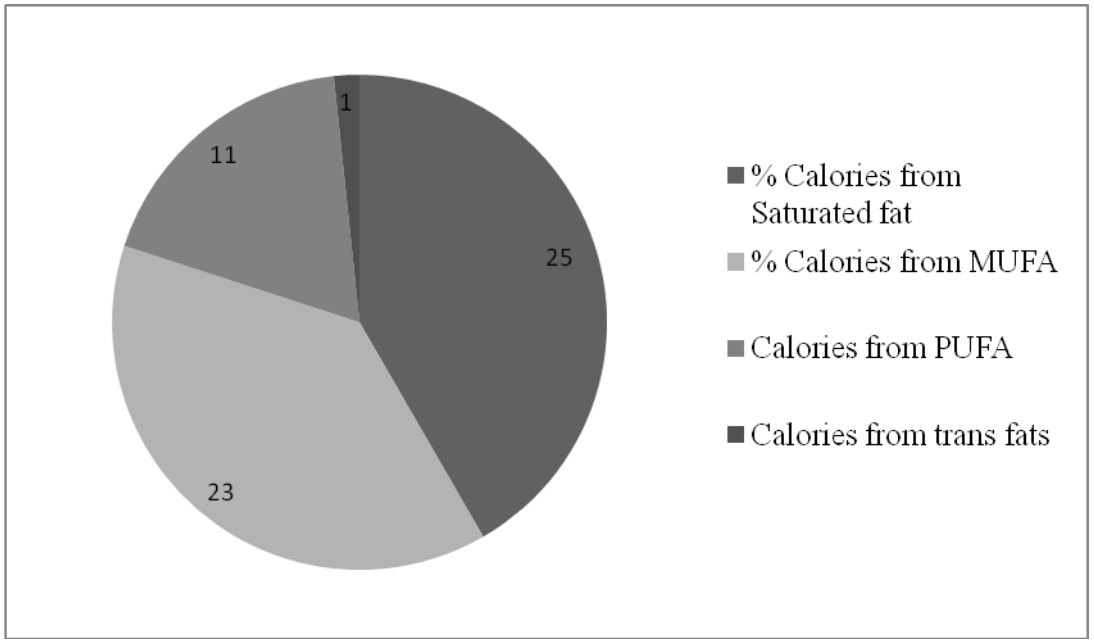

Figure 4.3. Average fatty acid distribution profile of weekly LTC menu

Table 4.1 Average macronutrient content of weekly LTC menus in 2011 and comparison to recommendations.

Nutrient	Mean ± SD	Median	Recommended
Calories (kcal)	1804 ± 6	1804	1834
Carbohydrates (g)	253 ± 17	253	203-293[*]
Fat (g)	61 ± 4	61	40-70[*]
Protein (g)	70 ± 14	77	45-157[*]
Saturated fat (g)	25 ± 6	22	18[#]
Monounsaturated fatty acid (g)	23 ± 3	23	20[#]
Polyunsaturated fatty acid (g)	11 ± 1	11	18[#]
Trans fatty acid (g)	1.0 ± 1.1	0.5	-
Cholesterol (mg)	280 ± 145	335	300
Dietary fiber (g)	21 ± 8	19	26
Soluble fiber (g)	2 ± 1	2	-
Total sugars (g)	104 ± 17	101	113[**]

[*] Calculated using 1800 kcal, Carbohydrates (recommendation is 45-65% energy), Fat (recommendation is 20-35% energy), Protein (recommendation is 10-35% energy).
[#] Calculated as percent recommended for older adults.
[**] Calculated as 25% of the energy.

Table 4.2 Comparison of average macronutrient content of weekly LTC menus in 2000 and 2011.

Nutrient	Mean ± SD (2000[≠])	Mean ± SD (2011)	P-value
Calories (kcal)	1841 ± 129	1804 ± 6	0.46
Carbohydrates (g)	241 ± 17	253 ±17	0.22
Fat (g)	68 ± 8	61 ± 4	0.07
Protein (g)	71 ± 8	70 ±14	0.86
Dietary fiber (g)	14 ± 3	21 ± 8	0.05

[≠] Data from Lengyel et al., 2003, 2008.

Table 4.3 Comparison of average vitamin and mineral content of weekly LTC menus in 2000 and 2011.

Nutrient	Mean ± SD (2000)	Mean ± SD (2011)	P-value	Recommended
Vitamin A (IU)	1644 ± 663	3746 ± 446	0.001	900 M/700 F
Thiamin (mg)	1.4 ± 0.1	1.8 ± 0.4	0.05	1.2 M/1.1 F
Riboflavin (mg)	2.0 ± 0.1	2.1 ± 0.4	0.56	1.3 M/1.1F
Niacin (NE)	15.7 ± 1.7	28 ± 5	0.0002	16 M/14 F
Vitamin B6 (mg)	1.3 ± 0.2	2.0 ± 0.5	0.008	1.7 M/1.5 F
Vitamin B12 (mcg)	7.9 ± 4.8	4.0 ± 1.9	0.07	2.4
Vitamin C (mg)	78 ± 11	107 ± 54	0.22	90M/75F
Vitamin D (mcg)	6.9 ± 1.3	4.9 ± 1.5	0.02	10
Vitamin E (mg)	10.3 ± 1.6	5.1 ± 1.4	0.001	15
Folate (mcg DFE)	188 ± 29	357 ± 102	0.003	400
Calcium (mg)	1002 ± 151	979 ± 283	0.85	1200
Iron (mg)	13.0 ± 1.7	14.2 ± 3.5	0.45	8
Magnesium (mg)	263 ± 27	238 ± 50	0.25	420 M/320 F
Zinc (mg)	8.8 ± .95	10.0 ± 1.6	0.11	8
Sodium (mg)	2516 ± 239[≠]	2643 ± 468	0.53	1200

[≠]Upper Level for older adults 2300 mg
M – Male, F - female.

offered in 2011 to the 2000 menu analysis showed that total carbohydrate and protein offered remained the same (Table 4.2). However, a lower fat and a higher dietary fiber content were found in the new menu.

Vitamin and mineral content

Analysis of the 2011 LTC menu demonstrated that average vitamin and mineral content was close to recommendations (Table 4.3). Vitamin C, thiamin, riboflavin, niacin, vitamin B6, and vitamin B12 met the Recommended Dietary Allowances. Folate, vitamin E, vitamin D and vitamin K were below recommendations. For minerals, iron, phosphorus and zinc met Recommended Dietary Allowances while calcium, magnesium and potassium were lower than recommendations. Sodium (2643 mg/day) exceeded the Upper Level. Comparison of vitamin and mineral content of the 2000 to 2011 LTC menus showed mixed results (Table 4.3). Vitamin A, thiamin, niacin equivalents, vitamin B6 and folate significantly increased in the 2011 menu. No significant differences were found for riboflavin, vitamin B12, vitamin C, calcium, iron, magnesium, zinc and sodium. On the other hand, vitamin D and vitamin E levels were decreased in the 2011 menu.

Healthy Eating index (HEI)

The LTC menu was assessed for diet quality using the Canadian adaptation of Healthy Eating Index. The mean score of 2011 LTC menu was 53 which put it in the category of "average diet quality" (Table 4.4). Healthy Eating Index had not been applied to the 2000 menu.

Table 4.4 LTC Menu according to the components of Canadian adaptation of Healthy Eating Index, range of scores and scoring criteria.

Component	Range of scores (points)	LTC diet score	Scoring criteria
Adequacy	0 to 60		
Total vegetables and fruit	0 to 10	7.2	Minimum: 0 Maximum: 4 to 10 servings
Whole fruit	0 to 5	2.7	Minimum: 0 Maximum: 0.8 to 2.1 servings (21% of recommendation for total vegetables and fruit)
Dark green and orange vegetables	0 to 5	4.0	Minimum: 0 Maximum: 0.8 to 2.1 servings (21% of recommendation for total vegetables and fruit)
Total grain products	0 to 5	2.2	Minimum: 0 Maximum: 3 to 8 servings
Whole grains	0 to 5	2.8	Minimum: 0 Maximum: 1.5 to 4 servings (50% of recommendation for total grain products)
Milk and alternatives	0 to 10	4.1	Minimum: 0 Maximum: 2 to 4 servings
Meat and alternatives	0 to 10	5.0	Minimum: 0 Maximum: 1 to 3 servings (75 to 225 grams)
Unsaturated fats	0 to 10	10.0	Minimum: 0 Maximum: 30 to 45 grams
Moderation	0 to 40		
Saturated fats	8 to 10 0 to 8	4.0	Minimum 7% to 10% of total energy intake 10% to maximum 15% of total energy intake
Sodium	8 to 10 0 to 8	1.0	Adequate intake to tolerable upper intake level Tolerable upper intake level to twice tolerable upper intake level
"Other food"	0 to 20	10.0	Minimum: 5% or less of total energy intake Maximum: 40% or more of total energy intake
Total Score	0-100	53.0	

4.4. Discussion

The 2011 LTC menu did not meet the recommendations for all Canada's Food Guide food groups. These results displayed a similar pattern of food group servings as observed in a study conducted recently in Ontario LTC homes (Wright-Thompson & Piché, 2011) that reported servings of Vegetables and Fruit were the highest followed by Grain Products, Meat and Alternatives and lastly Milk and Alternatives. It also reported an increase in servings of Vegetables and Fruit servings and decrease in Milk and Alternatives and Grain Products when a fall-winter 2006-2007 menu was compared to fall-winter 2007-2008 menu after an increase in the Ontario raw food cost allowance. Residents often report difficulty in consuming the large size or volume of foods and fluids recommended for their age group by Canada's Food Guide (Ducak & Keller, 2011). Further, complete consumption of a 2000 kcal/d menu does not preclude the possibility of micronutrient deficiencies in LTC residents (Wendland et al., 2003). An analysis of menu cycles of typical accredited institutions that used Canada's Food Guide guidelines showed that these menus failed to meet recommended levels of vitamins and minerals (Ducak & Keller, 2011; Lengyel et al., 2008; Wendland et al., 2003). Indeed these authors refuted the fundamental assumption that menus planned according to public health guidelines will guarantee the nutritional requirements of the institutionalized older adults (Wendland et al., 2003).

The average calories (1800 kcal/day) provided in the LTC diet indicated that the foods offered were mostly calorie-dense. It was found that the percentage energy from saturated fat exceeded the Acceptable Macronutrient Distribution Range. Saturated fats were found in foods such as muffins and tarts, suggesting that these should be limited and reformulated to increase the intake of essential nutrients. Furthermore, n-6 and n-3 fatty acids were low in the diet. It is

important to incorporate foods rich in PUFA as these fats have anti-inflammatory properties, which may be effective in prevention of many age-related chronic diseases including Alzheimer's disease (Basu et al., 2006).

Dietary fiber offered by the 2011 menu (21 g/day) was below recommended levels, but did exceed the average dietary fiber intake of older Canadians as determined by Canadian Community Health Survey, which was 19 and 16.6 g/day in food secure 51-70 y males and females, respectively (Kirkpatrick & Tarasuk, 2008). Low fiber intake is associated with risk of many chronic conditions such as gastrointestinal diseases, cancer, hyperlipidemia, cardiovascular disease, diabetes, and dietary fiber plays a very important role in the management of many health conditions like type-2 diabetes (Meyer et al., 2000). Thus, it is important to ensure that optimum dietary fiber is present in the diet of older adults (Dharamrajan et al., 2003). An additional serving of whole grains by replacing refined grains would be appropriate to reach the target level of dietary fiber.

The mean level of most minerals, including calcium, copper, iron, and zinc, was close to the recommended levels, but potassium and magnesium were significantly lower ($p \geq 0.05$). Certain other factors such as perceived lactose intolerance in older adults might influence the choices they make for milk products (Elbon et al., 1998). Increased cost of foods especially cheese in dairy may affect the consumption of Milk and Alternatives. Milk product consumption may also vary with ethnicity (Sebastian et al., 2010). Recommended calcium levels could be achieved by incorporating an additional low fat serving of Milk and Alternatives per day, which would additionally replace some fat and sugar sources. Calcium is an important nutrient of older adults as a high incidence of osteoporosis, fractures and decreased bone density is reported in older adults having inadequate intake of calcium (Mangano et al., 2011; Garriguet, 2011).

Sodium offered in the LTC menu was higher than the tolerable upper level for older adults. The LTC menu could reduce sodium levels by reducing the use of processed foods. Evidence from animal and human studies suggests that a high sodium intake is linked with increased blood pressure and cardiovascular disease (Cook et al., 2007; Morrison & Ness, 2011). On the basis of strong evidence, several national and international organizations such as World Health Organization (WHO) promote reductions of sodium intake in order to lower the incidence of cardiovascular disease (Institute of Medicine, 2010; WHO, 2007).

The mean vitamin content of the diet was close to recommendations. However, low vitamin D in diet emphasizes the need to provide foods rich in vitamin D and/or consume dietary supplements. Low consumption rates of vitamin D dietary supplements in a LTC were previously found (Chapter 3). It is recommended that all Canadian adults take vitamin D supplements in optimum amounts (Hanley et al., 2010).

The Healthy Eating Index score of the 2011 LTC diet showed a score at the low end of the "average" range. The low diet quality score implies that LTC diet requires improvement. Key reasons for low score were attributed to low nutrient-dense foods, high sodium and saturated fats followed by low Milk and Alternatives and Meat and Alternatives in the LTC menu. In comparison, community-dwelling Canadians (≥ 71 y) scored 60 when assessed in 2004 Canadian Community Health Survey (Garriguet, 2009).

The 2011 menu improvements could be attributed to the on-going initiatives related to menu planning and food service management in the local health region. As of this writing, many LTC homes within the same region have their menus planned according to recommendations (Director, Food and Nutrition Services, Local Health Region, personal communication February 23rd 2012). Furthermore, since 2000 LTC homes have used software programs for analyzing and

planning menus to determine ingredients and costs. In 2005, a regional LTC advisory committee was established to increase the involvement of dietitians in the planning of menus. Also, resident and caregiver requests are now taken into consideration; if any specific food is requested, it is usually added to the menu. Several food service training opportunities such as Meal Time Assistance and Food Education and Standard Training, with the motive of making "every day a celebration, every meal a feast", are offered to staff to improve their understanding of and how to meet the needs of LTC residents especially related to their dining experiences (Leydon & Dahl, 2008).

The cost of labour and raw food also places a challenge in providing LTC residents with nutrient rich meals (Ducak & Keller, 2011). A recent report suggested that hospital food, which seems similar to LTC food, is unappetizing and lacks appeal. The majority of patients admitted to hospitals miss their meals, which increases risk of malnutrition and possibly also worsens their response to the critical medical condition. In Canada the food allowance for LTC homes is about $7 per person/day (Wright-Thompson & Piché, 2011). Although the raw food allowance was increased in Ontario, it is still considered inadequate in meeting the resident's nutritional needs due to increasing cost of food as well as culturally and therapeutically diverse choices (Ducak & Keller, 2011, Ontario Association of non-profit homes and services for seniors, 2009). Despite these ongoing initiatives and improvements, several challenges remain in meeting the recommendations. These include the provision of energy-dense food, the cost of raw food, deficiency of important nutrients in the menu, and lack of provincial regulations regarding the need for dietitian services in LTC homes. This analysis indicates that standards on "food and nutrition", "quality of food" and healthy eating are required to improve the LTC menu and overcome the challenges to meet all nutrient and food group recommendations for older adults.

4.5. Strengths and limitations

The main limitation of this study was that the LTC menu analysis did not measure actual resident food intake. This is an important limitation as one study reported intakes in LTC to be 18% lower than what was offered (Lengyel et al., 2008). Pureed, therapeutic diets were not analyzed. This analysis did not include snacks, which residents may consume within or outside the LTC home. The comparison of 2000 menu to 2011 was not done on the same LTC homes; the 2011 menu analysis was conducted on one large LTC home accounting for approximately 20% of the total beds analyzed in 2000. Lastly, this analysis involved only one large LTC home. Since considerable differences exist between different LTC homes even in one city, results may not generalize to other homes. Strengths of this study include assessment of diet quality and protein quality of the LTC menu. The results of software analysis were verified and all the missing values were imputed using the Canadian nutrient file leading to more accurate results.

4.6. Conclusion

Overall improvement in accordance with recommendations for food groups and nutrients offered occurred in 2011 implying that greater attention has been placed on menu formulation. The LTC menu analyzed in 2011 showed more servings of Fruits and Vegetables, and increased dietary fiber compared to 2000. However, many challenges must be overcome to help LTC residents meet their nutritional recommendations. For instance, calcium, vitamin D, fiber and sodium are important nutrients that require continued consideration to ensure recommendations are met, as these nutrients are known to play an essential role in the quality of life of older adults. The 2011 menu needs the addition of milk and other dairy foods to provide the recommended servings of Milk and Alternatives. The Canadian adaptation of Healthy Eating Index indicated the 2011 LTC menu provided an “average” diet quality. This suggests that foods used in the LTC

menu are high in fats and sugars and low in essential vitamins, minerals and fiber. Energy-dense foods in the menu should be replaced with nutrient-dense foods to improve diet quality (MyPlate for older adults, 2011). The on-going work of food service management in the local health region needs focussed efforts and measures to make menus more compatible to the nutritional needs of residents.

Chapter 5

STUDY 3. Association of inflammatory markers with cognitive, pain and functionality assessment measures in long term care and community dwelling older adults

This study includes analysis of the baseline results from two clinical trials: “Flax supplementation clinical trial” and “Single Oral Dose (SOD) of BeneFlax to Healthy Young and Older Adults”. In the “Flax supplementation clinical trial” older adults living in LTCs were enrolled. The blood measures for inflammatory markers, cognition, pain, functionality, supplement and medication use were done at baseline before any intervention was started. In the SOD study healthy young and older adults were enrolled. This study was a pharmacokinetic trial but for this thesis only baseline data on serum inflammatory markers, physical activity, and questionnaires regarding food intake, medication, and supplement use were used. The purpose was to assess relationship between nutritional status and markers of inflammation and determine metabolic syndrome in residents of long-term care. Inflammatory markers, dietary intake and associations between inflammation and functional parameters were conducted, in all three groups to compare the young healthy adults, the old healthy adults, and the old frail adults.

5.1. Introduction

Chronic-low grade inflammation may have an impact on the health of older adults, by promoting the development of several age related conditions such as Alzheimer's Disease, osteoporosis, pain and frailty. Some studies reported relationships between the markers of inflammation and measures of functionality in older adults (Visser et al., 2002b). Inflammation contributes to the loss of muscle mass and functionality which could lead to onset of disability in older adults (Visser et al., 2002a). Markers of inflammation continue to increase with advancing age and frailty (Ferrucci et al., 2005; Hubbard &Woodhouse, 2010). Increased levels of inflammatory markers may lead to limited functionality and increased dependence (Taaffe et al., 2000; Ervin, 2006).

Cognitive functions decline with age. Although several factors impact cognition such as nutrition and oxidative stress, chronic inflammation is speculated to play a significant role in cognitive impairment (Teunissen et al., 2003). High levels of inflammatory markers viz. IL-6 and CRP may coincide with a drop in cognitive abilities in older adults (Weaver et al., 2003; Yaffe et al., 2003).

Pain is related to health and functionality status in adults (Schein al., 2008). Although other sensory processes diminish with age, pain severity and frequency is reported to rise with age (Jimenez, 2010). Elevated levels of CRP, an inflammation marker in older adults were found to be significantly correlate to pain (Graham et al., 2006). Increased pain severity in older adults might have some association with the cognitive impairment (Karp et al., 2006). The prevalence of pain is reported to be high in LTC residents (Fox et al., 1999).

Diet is related to inflammation in adults and some foods are believed to mitigate the deleterious effects of inflammation (Tall & Raja, 2004; Sears et al., 2009). Study 2 highlighted

the poor diet quality of LTC menus. Diet quality of community dwelling older adults is reported to be better than in young adults (Garriguet, 2009). Yet there is no such comparison of diet quality and nutrients, to the best of my knowledge, between the diet of LTC and community dwelling older adults.

Evidence from the literature suggests that markers of inflammation increase with age which may lead to decreased physical functioning, cognitive impairment and increased incidence of pain. These functional measures are also correlated with each other in older adults (Karp et al., 2006). This study was based on the above rationale, with the aim to determine associations between inflammatory markers, i.e., interleukin-1α (IL-1 α), interleukin-1β (IL-1 β), interleukin-6 (IL-6), and tumour necrosis factor-α (TNF- α), hs-CRP, 25(OH)D, and measures of functionality measured as grip strength, Berg Balance Scale, cognition (neurocognitive assessment battery), and pain (Colored Analogue Scale, Verbal Rating Scale, BOX 21) in older adults (≥60 y) residing in LTC homes and the community in Saskatoon, Saskatchewan, Canada. The purpose of this study was to determine whether a positive relationship exists between poor nutritional status and measures of inflammation. The study was designed with the specific objective to find clinically relevant relationships between nutritional status and outcomes that might be influenced by inflammatory status, including anthropometric measurements, cognition, pain and musculoskeletal functions. The second objective was to determine whether inflammatory markers were different in older frail compared to older healthy adults and if there was an age difference between younger and older adults. Another aim of the study was to compare dietary intake and diet quality of community-dwelling healthy vs. long term care residing older adults.

5.2. Methods

5.2.1. Objective 1

Data were obtained from the baseline of "Flax supplementation clinical trial". The details of the design and methods of the clinical trial are in Appendix 1. The clinical trial had a two-group design in which participants within each long term care site were randomly allocated to active treatment or placebo. Researchers involved in data collection and analysis did not have access to this list until the study was completed and all data had been analyzed. In this chapter, baseline data from both the treatment and placebo groups were used (no intervention had occurred at that time point).

Subjects

Subjects were 60 to 80 year old males and females who had lived in the LTC home for a minimum of four weeks prior to screening and were able to satisfactorily comply with the protocol requirements. There was an extensive exclusion list (see Appendix 2) but conditions such as mild hypertension, arthritis, moderate dementia, and type 2 diabetes were not excluded. During the recruitment process the researchers gauged the ability of residents to follow instructions. Subjects (or their appropriate substitute decision-makers) were informed about the study and consent was obtained in the manner approved by the University ethics protocol. Blood collection was performed by Gamma-Dynacare Medical Laboratories (Saskatoon, SK); vital signs, chart review, and individual assessments were performed at baseline by trained study personnel.

Blood Collection

Blood was drawn and collected into K_2EDTA or lithium heparin tubes. 2 x 10mL K_2EDTA tubes were spun at 1500 g for 10 minutes to obtain plasma at 4°C and then aliquotted into 500uL volumes for inflammatory markers (Cayman Kits). All other blood samples were processed by Saskatoon Health Region as per protocol. Blood was collected (generally in the morning), by a registered phlebotomist and was coordinated with any collections done as part of each resident's routine clinical care. Blood was analyzed for inflammatory cytokines IL-1 α, IL-1 β, IL-6, TNF- α using kits. For measure of inflammatory cytokines in LTC residents, the blood was transferred to study location next day and might not be in the best condition to perform these tests. Homocysteine, hs-CRP, 25(OH)D, total cholesterol, triglycerides, HDL, fasting blood glucose and prealbumin were measured by Gamma-Dynacare Medical Laboratories (Saskatoon, SK).

Physical and functional measures

Many tests to assess physical, cognitive and pain measures were conducted, and the ones which were valid and reliable in older adults based on literature were included in the analysis in this chapter. Results were then used to test purpose statement and determine associations.

Musculoskeletal function

Musculoskeletal functions were assessed with Berg Balance Scale. Berg Balance scoring pattern was 0-20: wheelchair bound, 21-40: walking with assistance, 41-56: independent. Grip strength was measured with Baseline Hydraulic Hand Dynamomter (Fabrication Enterprises Incorporated, White Plains, NY) for both hands three times. The mean reading from the

dominant hand is included in the analysis. Some subjects had limited functionality in one hand due to stroke or other condition, so the higher value was always used. The Physiotherapist fall risk assessment was conducted and was scored as, 1-10 (negligible fall risk- highest fall risk). All the components of the Senior Fitness Test were administered by staff trained and supervised by licensed physical therapists, however, these are not included in this analysis.

Cognitive Function Tests

The neurocognitive assessment battery consisting of nine measures was selected to assess memory and executive function. WMS-R Digit Forward Score (number of digits recalled forward), WMS-R Digit Backward Score (number of digits recalled backward), WMS-R Digit Total Score (total of forward and backward score), WMS-R ISR Recall Score (assessment of verbal immediate memory, score reflects the each story unit recalled), WMS-R ISR Thematic Score (ability to recall story theme), RAVLT Sum of Trials (measure of verbal immediate memory), COWAT Sum of Trials (access to semantic memory, score reflects the number of words recalled), Category Animals Score (semantic memory, score reflected the number of animals recalled in one minute), WMS-R DSR Recall Score (verbal delayed memory assessment), WMS-R DSR Thematic Score (verbal delayed memory test), RAVLT Net Recall Score (verbal delayed recall memory measure), RAVLT Net Recognition Score (verbal delayed recognition memory test) and RAVLT Sum of Recall Recognition (sum of net recall and recognition) were included in the analysis. For all tests, higher scores indicated better cognitive performance.

All tests were administered by study personnel who had been trained by study investigators. All testing was done in a quiet and well lit room, mostly in the morning to optimize participants' attentiveness.

Pain Assessment

Pain was measured using three assessments of pain. The Coloured Analogue Scale (CAS) score measured the rate of pain on a scale of 0-10 (0=no pain and 10=most pain) subject was experiencing on the test day. In Pain Verbal Rating Scale subjects rated their pain they were experiencing at the time of testing on a score of 0-6. The 21-Point BOX Scale measured the severity of pain in the last seven days. These were one-page assessments that the participant or caregiver filled in. The testing was done in a location where the subject was rested and comfortable.

Additional chart information and interview of care aides

Charts were reviewed by study personnel for any changes in function, diet and medications in the previous year as well as during the study. The number of falls for each subject was obtained from nursing charts, as recorded during the previous year and throughout the study. In addition, study personnel interviewed care aides for an assessment of Activities of Daily Living (ADLs) for any change in function. The care aides were asked the following by a research assistant:

- OARS Physical Activities of Daily Living (PADL) Sub-Scale (Fillenbaum 1988), a brief, valid, and reliable instrument that was used as a clinical assessment of functional status.
- Cornell Scale for Depression in Dementia (CSDD) (Alexopoulos et al., 1988) was used to assess mood. It is a well-validated scale designed for the assessment of depression in individuals with dementia and individuals residing in long-term care. Scores range from 0 to 38, with scores of 6 and higher indicating likely depression (Barca et al., 2010).

- Short portable mental status questionnaire (SPMSQ) (Pfeiffer, 1975) was based on asking 10 general questions such as date of birth, today's date etc. It was scored on the basis of errors a subject made.

5.2.2. Objective 2

Baseline blood from the "Single Oral Dose of BeneFlax to Healthy Young and Older Adults" was collected from two groups of healthy adults between the ages of either 18-45 or 60-80 years. The objective of this study was to determine any age differences in the way the body metabolizes lignans found in flax seed, administered as 300 mg SDG-enhanced flax lignin. Details of SOD clinical trial are found in Appendix III. Participants also had blood haemoglobin tested at Saskatoon Centre for Patient-Oriented Research (SCPOR) immediately prior to study commencement to ensure they were not at risk for anemia. For this thesis research, baseline blood data were used to determine age differences in metabolic markers of inflammation.

Institutional ethics approval was granted for both "Flax supplementation clinical trial" and SOD trial.

Subjects

A total of 22 subjects were enrolled in the study; 6 male and 6 female participants in the young group and 8 females and 2 males in the old age group. Participants had abstained from consuming any alcohol 48 hours prior to dosing and during the trial. Subjects fasted overnight. At the first time point, 20 mL of blood was drawn to provide blood for all baseline analyses; at each subsequent time points, 10 mL of blood was drawn. Blood was collected into K_2EDTA vacuum tubes. The blood was drawn by a nurse at SCPOR and a physician was on call for the duration of the study. The blood was immediately put on ice and subsequently centrifuged to

obtain plasma. Plasma samples were frozen immediately and were subsequently stored at -80ºC until analysis.

Height, weight and waist measurement

For pre-screening, participants had weight and height measures taken to obtain BMI. To measure waist circumference, top of the right hip bone (iliac crest) was located and a measuring tape was placed in horizontal plane around the abdomen at the level of the iliac crest. Before reading the tape measure, it was ensured that the tape was snug, did not compress the skin and was parallel to the floor. The measurement was made after the subject exhaled (National Institutes of Health, 2000). Waist measurement was done in older adults only.

Food and activity measurement

University of Saskatchewan version of the Block Food Frequency Questionnaire taking approximately 40 minutes to complete was administered the first day that the participants were at the SCPOR, as was the Godin Leisure-Time Exercise Questionnaire. Scoring in Godin Leisure-Time Exercise Questionnaire was based on a cut point at 24 units, the cumulative score of two intensities, strenuous and/or moderate except the mild intensity. A score of 24 units or more is categorized as active with substantial benefits and, 14-23 units are moderately active with some benefits, < 14 units indicate insufficiently active with less substantial/low benefits (Godin & Shephard, 1985).

Blood Analysis

Fasting blood was collected just prior to dosing. Blood was immediately spun to obtain plasma, then frozen plasma was analyzed for IL-1 α, IL-1 β, IL-6, TNF- α using standardized kits (Cayman Chemicals, Ann Arbor, Michigan).

5.2.3. Objective 3

Comparison of diet quality: LTC and community dwelling older adults

The dietary intake of community dwelling (n=10) adults was determined with food frequency questionnaires while for long term care dietary intake, a week's menu (food offered) of a large LTC home was analyzed (Chapter 4). To obtain an estimate of intake, the data of Lengyel et al. (2008) were used. They had reported differences between offered and eaten intakes of nutrients of 18%. Thus using the analysis of the menu served to LTC residents (Chapter 4), intakes were assumed to be 18% less of what was offered. Dietary intake, medication and supplement use were compared.

Statistical Analyses

The mean, standard deviation (SD) and median of general characteristics, inflammatory markers and functional parameters (cognition tests, grip strength, CSDD, SPMSQ) and number of food servings, macro and micronutrients provided by the diet were found (Microsoft excel 2007). Independent t-test was used for comparing the LTC menu calculated intake to the community dwelling older adults, and to compare inflammatory, dietary and activity measures. Pearson correlations were obtained (SPSS version 16). Bonferroni adjustment was done to avoid p-value inflation. Tukey's test was applied to detect the outliers (Tukey, 1977).

Table 5.1 General characteristics, vitals and medication use of long term care residents (n=26).

Items	Mean ± SD	Median	Normal range[#]
Age (y)	70.7 ± 6.3	71.1	
Sex	8F, 18M		
BMI	26.2 ± 6.4	25.4	
Triglyceride (mmol/L)	1.5 ± 0.8	1.4	0.60-2.30
HDL cholesterol (mmol/L)	1.2 ± 0.4	1.2	0.9-2.00
BP/systolic (mm Hg)	120.6 ± 23.3	118.5	120
BP/diastolic (mm Hg)	74.7 ± 13.1	75.5	80
Glucose fasting (mmol/L)	5.2 ± 1.7	4.8	3.6-6.0
Waist (cm)	102.4 ± 14.7	98	
No. of medications	13.3 ± 6.2	11	
No. of supplements + NHPs	2.2 ± 1.7	2.0	
Total pills (medicines+ supplements +NPH)	21.7 ± 10.4	22	

[#]Normal range, Saskatoon Health Region standards
BMI=Body mass index, HDL=High density lipoproteins, BP=Blood pressure, NHP= Natural health products

Table 5.2 Components of metabolic syndrome (MetS) in long term care residents (n=26).

Sex	Triglyceride (mmol/L)	HDL cholesterol (mmol/L)	BP (mm Hg)	Blood glucose (mmol/L)	Waist (cm)	MetS*
F	0.49	2.32	122/71	4.3	88.0	-
M	0.75	1.04	102/57	4.5	90.6	-
F	1.13	1.40	116/76	3.7	-	-
M	0.98	1.09	145/89	5.1	98.0	-
F	1.96	0.99	74/42	4.3	108.0	√
M	1.18	0.84	82/59	6.0	96.0	-
M	1.38	1.34	119/72	10.2	100.0	-
M	0.44	2.00	126/75	6.3	90.0	-
M	2.84	1.07	143/95	9.0	99.5	√
M	1.73	1.16	123/86	4.5	104	-
M	2.12	1.09	147/84	4.4	86.0	-
F	2.37	1.17	111/78	5.3	98.0	√
M	1.52	1.36	109/63	4.5	86.0	-
M	1.23	1.14	161/68	9.0	115.0	√
F	1.25	1.16	160/80	4.3	132.5	-
F	3.04	1.40	116/81	5.3	126.0	√
M	0.70	1.22	118/77	4.4	91.0	-
M	1.41	0.8	99/63	4.8	92.0	-
F	1.02	2.05	105/71	4.7	90.0	-
M	1.50	0.6	137/84	3.8	114.0	√
F	0.66	1.88	154/92	3.8	81.5	-
M	3.10	0.82	121/73	4.9	109.0	√
M	1.75	1.18	131/97	5.7	124.0	√
M	2.60	1.17	99/71	5.1	113.0	√
M	1.35	0.83	119/66	2.9	97.0	-
M	1.45	1.21	148/95	5.3	131.0	-
Normal range[#]	0.6-2.30	0.9-2.00	120/80	3.6-6.0		

*Three or more of the following features i.e., abdominal obesity (waist circumference > 102 cm for men and > 88 cm for women), increased triglyceride level (1.7 mmol/L), reduced high-density lipoprotein (HDL) cholesterol level (< 1.03 mmol/L for men and < 1.30 mmol/L for women), elevated blood pressure (130/85 mm Hg); or elevated fasting blood glucose (6.1 mmol/L) (National Cholesterol Education Program, 2002).
[#]Normal range: Saskatoon Health Region standards
Shading indicates over specified cut-off indicative of MetS, underline indicates residents taking anti-hypertensive drugs.

Table 5.3 Inflammatory markers of long term care residents (n=26).

Marker	Mean ± SD	Median	Normal range[#]
Homocysteine (umol/L)	25.5 ± 34.6	25.5	3.00-15.00
CRP (mg/L)	5.7 ± 6.6	4.0	0.0-0.7 CRP: Cardiac risk low: <1 Mean:1.0-3.0, high:>3.0
Total 25(OH)D (nmol/L)	68.7 ± 30.2	62.0	Deficient: <30 insufficient:30-75, Optimal:75-150, Toxic:>250
Magnesium (mmol/L)	0.9 ± 0.1	0.9	0.70-1.10
Prealbumin (mg/L)	227.7 ± 59.4	235.0	180-450

CRP=C-reactive protein; 25(OH)D=25-hydroxyvitamin D
[#]Normal range, Saskatoon Health Region standards
Total 25 (OH)D: IOM and Endocrine Society.

5.3. Results

General characteristics of long term care residents

A total of 26 subjects were recruited (8 female, 18 male) (mean age 70.7 y) (Table 5.1). Mean BMI of the older adults was 26.2 ± 6.4. Hemoglobin, triglyceride levels, HDL cholesterol, BP/Systolic, fasting blood glucose were all within the normal range; BP Diastolic was not. Mean waist measurement was 102.4 ± 14.7 cm. Total pills consumed per day by LTC residents were on average 22 (range of 5-43) per person. Dietary supplements and NPH consumption was approximately 2 per day. In this group of LTC residents 62% were taking vitamin D supplements.

Metabolic syndrome (MetS) in long term care residents

Metabolic syndrome and components were assessed in LTC residents according to National Cholesterol Education Program criteria. Three or more of the following features i.e., abdominal obesity (waist circumference > 102 cm for men and > 88 cm for women), increased triglyceride level (1.7 mmol/L), reduced high-density lipoprotein (HDL) cholesterol level (< 1.03 mmol/L for men and < 1.30 mmol/L for women), elevated blood pressure (130/85 mm Hg); or elevated fasting blood glucose (6.1 mmol/L) (NCEP, 2002). Those taking antihypertensive drugs were also considered as having high blood pressure (Setayeshgar et al., 2012). MetS was observed in 34.6% of the all older adults (three or more of the symptoms) (Table 5.2). The most common component was high BP (73%), followed by high waist circumference (50%), elevated TG levels (34.6%), reduced HDL levels (23 %) and elevated blood glucose (15%).

Inflammatory markers of long term care residents

Average homocysteine levels of LTC residents were very high. Only one person accounting for 3% of all the residents, was below the lowest cut-off (3mg/L), and all the residents were above that level with 31% above the highest mark of 15 mg/L. For CRP 54% had CRP above the highest cut-off, putting them in the highest risk category for cardiovascular disease, 19% were between medium and high. Mean 25(OH)D was 68.7 ± 30.2 nmol/L. The majority (62%) of residents had insufficient and 38% had optimal 25(OH)D levels (Table 5.3). However residents consuming vitamin D supplement every day had significantly higher 25(OH)D levels ($p \leq 0.05$). Other markers of inflammation TNF-α, IL-1α, IL-1β and IL-6 were also conducted however no detectable values were found as majority of the subjects fell below the quantification limit of the kits. These values were suspect due to poor handling of blood brought to test location, and therefore not used.

Physical functioning assessments of long term care residents

Mean grip strength was 22 ± 10.9 kg (Table 5.4). A score of ≤21 kg on grip strength indicates limited mobility in females, and 6 female LTC residents out of total 8 were below the cut-off. Similarly, cut-off for males was ≤37 kg and only one male out of 18 was above that mark which indicated the widespread limited mobility in this group of LTC residents. The Berg Balance Scale total score is out of 56, and LTC older adults had mean score of 16.2, and range of 0-55 in subjects; 70% of subjects were wheelchair bound, 7% needed assistance in walking and 23% were independent according to score interpretation. Mean physiotherapist fall risk assessment score was 3, which shows that subjects had approximately 30% risk of falls.

Table 5.4 Physical function assessments of long term care residents (n=26).

Scale	Old adults (LTC) Mean ±SD	Median	Range	Results/Interpretation
Grip strength dominant hand (kg)	22 ± 10.9	18.8	3-53	Cut-off ≤37 kg for men and ≤21 kg for women increased likelihood for mobility limitation*
Berg balance scale Total score	16.2 ±21.8	4.0	0-55	0-20: wheelchair bound 21-40: walking with assistance 41-56: independent
Physiotherapist fall risk assessment score	3.0 ± 2.4	2.5	1-9	1-10 (negligible fall risk- highest fall risk)

*Sallinen et al., 2010

Table 5.5 Neurocognitive assessment of long term care older residents (n=26).

Scale	Mean ± SD	Median	Optimal score[#]
WMS-R digit forward score	7.7 ± 2.6	8.0	16
WMS-R digit backward score	3.7 ± 1.9	4.0	14
WMS-R digit total score	11.4 ± 4.2	11.5	30
WMS-R ISR recall score	5.4 ± 4.1	4.5	25
WMS-R ISR thematic score	2.9 ± 1.9	3.0	7
RAVLT sum of trials	26.0 ± 13.5	27.0	
COWAT sum of trials	15.0 ± 9.4	13.0	
Category animal score	7.1 ± 4.6	7.0	
WMS-R DSR recall score	7.3 ± 20.9	1.0	25
WMS-R DSR thematic score	1.6 ± 2.1	0.5	7
RAVLT net recall score	-1.6 ± 7.3	0.0	15
RAVLT net recognition score	6.7 ± 4.5	7.0	15
RAVLT sum of recall recognition	7.0 ± 8.5	7.0	30

[#]highest score shows best performance

Table 5.6 Pain, memory, behavior, mood assessments in long term care residents (n=26).

Scale	Mean ± SD	Median	Results/Interpretation
Box 21 score	19.6 ± 25.4	10.0	0 = no pain,100 = pain as bad as it could be
Pain CAS score	2.2 ± 3.0	1.0	1 -10 (least-most pain)
Pain verbal rating scale score	1.3 ± 1.5	1.0	0 = no pain, 1 = slight pain, 2 = mild pain, 3 = moderate pain, 4 = severe pain, 5 = extreme pain, 6 = pain as bad as it could be
PADL total score	6.7 ± 4.5	5.5	0-15 (Severe-good)
CSDD total score	3.1 ± 2.8	2.5	0-38 (Scores of 6 and higher indicate likely depression).
SPMSQ total score	6.3 ± 2.5	6.5	0-2 errors: normal, 3-4 errors: mild cognitive impairment, 5-7 errors: moderate cognitive impairment, 8 or more errors: severe cognitive impairment [#]

CAS = Colored analogue scale, PADL = OARS Physical activities of daily living, CSDD = Cornell Scale for Depression in Dementia, SPMSQ = Short Portable Mental Status Questionnaire

[#]One more error is allowed in the scoring if a patient has had a grade school education or less. One less error is allowed if the patient has had education beyond the high school level.

Table 5.7 General characteristic and vitals of community dwelling young and older adults (n=22).

Item	Young adults (n=12)		Older adults (n=10)	
	Mean ±SD	Median	Mean ±SD	Median
Age	28.7 ± 5.4	27.0	72.0 ± 8.1	75.5
Gender	6 F, 6M		8 F, 2M	
Race	3 white/5 Asian/4 Black		All white	
Height (m)	1.7 ± 0.1	1.6	1.6 ± 0.1	1.6
Weight (kg)	65.5 ± 11.7	66.4	72.7 ± 19.4	76.1
BMI	23.3 ± 2.1	24.0	26.9 ± 6.2	27.1
Waist (cm)			85.1 ± 16.4	87.0
Hb (g/L) males	156.6 ± 8.8	156	148 ± 15.5	148
Hb (g/L) females	131 ± 10	129	136.1 ± 8.1	133
BP(Lying) systolic	118.8 ± 13.0	115.0	125.7 ± 13.4	123.0
BP(Lying) diastolic	73.8 ± 7.0	72.0	72.1 ± 6.0	71.0
BP(Stand) systolic	120.2 ± 18.9	113.0	127.9 ± 10.5	128.5
BP(Stand) diastolic	80.0 ± 9.5	76.0	78.9 ± 9.2	81.5

BMI= Body mass index, Hb= hemoglobin, BP= Blood pressure,

Table 5.8 Number of food group servings according to Canada's Food Guide and HEI score in community dwelling young and older adults (n=22).

Food Group	Young adults (n=12)		Older adults (n=10)		P-value
	Mean ± SD	Median	Mean ± SD	Median	
Vegetable & Fruits	5.1 ± 3.3	4.4	5.9 ± 2.1	5.9	0.49
Grain Products	5.0 ± 4.0	4.5	3.3 ± 1.3	3.0	0.18
Meat & Alternatives	2.2 ± 1.3	2.0	1.3 ± 0.5	1.3	0.04
Milk & Alternatives	1.0 ± 0.9	0.7	1.7 ± 1.1	1.6	0.12
HEI score	66 ± 14	66	73 ± 9	73	0.14

HEI=Healthy Eating Index , adjusted $p<0.01$* (Bonferroni adjustment)

Neurocognitive assessment of long term care residents

Many cognitive tests were performed on older adults (Table 5.5). On WMS-R Digit Forward Score, LTC residents got 50% of the maximum; WMS-R Digit Backward Score was 26.4%; WMS-R Digit Total Score was 38%; WMS-R ISR Recall Score was 21.6%; WMS-R DSR Recall Score was 29.2%; WMS-R DSR Thematic Score was 22.8%; RAVLT Net Recall Score was -10%; RAVLT Net Recognition Score was 44.6%; and RAVLT Sum of Recall Recognition was 23%. For all tests, higher scores reflected a better cognitive performance.

Pain, memory, behavior, mood assessments in long term care older adults

Mean score of BOX 21 was 19.6, reflecting that most subjects had some pain (Table 5.6). Mean Pain CAS score was 2.2, indicating that mild pain was experienced by the subjects. Verbal rating mean score in LTC older adults was 1.3, indicating slight to mild pain. Physical activities of daily living was based on descriptive questions on the daily life such as if a person can eat, undress, take care of their own appearance, walk, get in and out of bed, take a bath/ shower, have trouble getting to the bath room on time etc. The total PADL score was 6.7 indicating intermediate level of functioning. CSDD ratings were based on signs and symptoms which occurred during the week prior to interview. 15% residents had score of 6 or more indicating depression (Barca et al., 2010). According to the SPMSQ cut-off criteria in the LTC residents, only 4% were normal, 23% had mild cognitive impairment, 31% had moderate cognitive impairment, and highest proportion of 35% residents reported severe cognitive impairment.

Table 5.9 Mean Macronutrient content of the diet and percent energy source in community dwelling young and older adults (n=22).

	Young adults (n=12)			Older adults (n=10)			P-
Nutrient	Mean ± SD	Median	AMDR	Mean ± SD	Median	AMDR	Value
Calories (kcal)	1584 ± 668	1520		1412 ± 334	1413		0.45
Protein(g)	66.8 ± 31.6	64.7	16%	54.1 ± 12.2	56.9	15%	0.23
Total fat (g)	59.3 ± 24.2	59.4	33%	52.9 ± 17.1	53.6	34%	0.47
Carbohydrate (g)	201.0 ± 95.4	186.9	51%	179.8 ± 43.3	170.3	51%	0.50
% kcal from fat	34.4 ± 6.2	33.7		33.7 ± 8.2	36.1		0.83
% kcal from protein	17.5 ± 2.2	18.0		15.5 ± 2.4	15.6		0.06
% kcal from carbohydrate	49.9 ± 8.7	47.8		51.5 ± 8.1	50.2		0.65
% kcal from sweets	7.1 ± 5.1	5.9		9.6 ± 2.4	10.0		0.15
% kcal from alcohol beverages	0.5 ± 0.2	0.2		2.9 ± 5.0	0.8		0.16
Saturated fat (g)	16.5 ± 7.5	15.9		15.8 ± 4.7	15.1		0.79
Monounsaturated fat (g)	25.4 ± 11.1	25.9		19.8 ± 7.7	19.0		0.17
Polyunsaturated fat (g)	12.5 ± 5.7	11.8		13.0 ± 5.1	12.2		0.82
Cholesterol (mg)	231 ± 120	190		150 ± 55	147		0.05
Fiber (g)	19.6 ± 15.8	17.9		17.5 ± 6.0	17.1		0.68
Trans fatty acids (g)	3.1 ± 1.1	3.2		4.2 ± 1.6	3.6		0.07
Omega 3 fatty acids (g)	1.2 ± 0.4	1.1		1.4 ± 0.5	1.5		0.32

adjusted $p<0.003$* (Bonferroni adjustment)
Acceptable macronutrient distribution range=AMDR. Carbohydrates (recommendation is 45-65% energy), Fat (recommendation is 20-35% energy), Protein (recommendation is 10-35% energy).

Table 5.10 Mean vitamin content of the diet obtained from food frequency questionnaire in community dwelling young and older adults (n=22).

	Young adults (n=12)		Older adults (n=10)		RDA	P-value
Nutrient	Mean ± SD	Median	Mean ± SD	Median		
Vitamin A (RAE)	**5263 ± 4844**	**2573**	**3723+2337**	**2856**	900 M 700 F	0.3
Thiamin (mg)	**1.5 ± 0.8**	**1.3**	**1.2 ± 0.4**	1.2	1.2 M 1.1 F	0.28
Riboflavin (mg)	**1.6 ± 0.7**	**1.6**	**1.6 ± 0.5**	**1.6**	1.3 M 1.1F	-
Niacin (mg)	**21.0 ± 11.5**	16.8	15.6 ± 4.9	15.6	16 M 14 F	0.15
Vitamin C (mg)	**97.2 ± 62.9**	**79.0**	**114.8 ± 53.9**	**113.6**	90M 75F	0.48
Folate, DFE (mcg)	**496 ± 316**	441	339 ± 87	328	400	0.12
Vitamin E (mg)	7.5 ± 3.3	6.6	7.7 ± 1.8	7.6	15	0.85
Vitamin B6 (mg)	**1.9 ± 1.0**	1.6	1.6 ± 0.4	1.6	1.3 Y 1.7 M 1.5 F	0.35
Vitamin D (IU)	152 ± 102	125	128 ± 87	97	15 Y 20 O	0.55
Vitamin B12 (mcg)	**3.7 ± 1.5**	**4.2**	**2.6 ± 1.0**	2.6	2.4	0.05

Y= Recommendations for young adults, O= Recommendations for older adults, M=males, F=females
Recommended Dietary Allowance=RDA, Adequate intake= AI
Bold means mean of group ≥ RDA
adjusted $p<0.005$* (Bonferroni adjustment)

Table 5.11 Mean mineral content of the diet obtained from food frequency questionnaire in young and older adults (n=22).

Nutrient	Young adults (n=12)		Older adults (n=12)		RDA/AI	P-value
	Mean ± SD	Median	Mean ± SD	Median		
Calcium (mg)	628 ± 305	563	799 ± 256	674	1000 Y 1200 O	0.16
Phosphorus (mg)	**1092 ± 461**	**1112**	**1017 ± 226**	**1024**	700	0.63
Iron (mg)	**15.5 ± 8.1**	**15.5**	**11.7 ± 3.6**	10.9	18 Y F 8	0.16
Sodium (mg)	**2308 ± 1128**	**2198**	**1985 ± 441**	**2118**	1500 Y 1200 O	0.39
Potassium (mg)	2466 ± 1094	2383	2620 ± 621	2391	4700	0.68
Zinc (mg)	**11.3 ± 6.2**	**8.9**	**8.4 ± 3.2**	7.8	11 M 8 F	0.17
Magnesium (mg)	270.6 ± 160.6	221.5	258.5 ± 73.4	235.7	420 M 320 F	0.81

Y= Recommendations for young adults, O= Recommendations for older adults, M=males, F=females
Recommended Dietary Allowance=RDA, Adequate intake= AI
Bold means mean of group ≥ RDA
adjusted p<0.007* (Bonferroni adjustment)

Table 5.12 Leisure activity score measured by Godin leisure-time exercise questionnaire in young and older adults (n=22).

Activity	Young Adults (n=12)		Older Adults (n=12)		P-value
	Mean ± SD	Median	Mean ± SD	Median	
Strenuous exercise	9.0 ± 10.9	4.5	10.8 ± 11.8	9.0	0.72
Moderate exercise	12.5 ± 6.9	10.0	8.5 ± 8.5	7.5	0.23
Mild exercise	10.0 ± 8.7	10.5	13.5 ± 7.4	13.5	0.31
Total leisure score (strenuous + moderate)	21.5 ± 15.2	19.5	19.3 ±15.1	26.5	0.73

adjusted p<0.01* (Bonferroni adjustment)

General characteristics of young and old community dwelling adults

Subjects from the SOD trial who were healthy and community dwelling were in two categories: young (18-45 y) and old adults (60-80 y). Average BMI was normal (23.3) in young and overweight (26.9) in old adults. Older adults' mean waist circumference was 85.1 (Females: 82.0 ± 16.7 cm; Males: 97.25 ± 9.5 cm). BP standing systolic and diastolic was in normal range for both young and older adults (Table 5.7).

Food guide servings, macronutrient and micronutrient content of the diet in young and older adults

Food frequency questionnaires were analyzed for servings of Canada's Food Guide, Healthy Eating Index (HEI) score (Table 5.8), macronutrients (Table 5.9), micronutrients (Table 5.10, 5.11). Mean consumption of Vegetable & Fruits in young adults was around 5 servings (recommended 7-10) and older adults was 6 servings approximately (recommended 7); Grain products consumption was 5.0 servings (recommended 6-8) in young and 3.3 servings (recommended 6,7) in older adults; Milk & Alternatives consumption was 1 serving (recommended 2) in young adults and 1.7 servings in older adults (recommended 3); Meat & Alternatives servings were 2.2 (recommended 2,3) in young and 1.3 in older adults (recommended 2,3). In either age group, mean levels did not meet the recommendations for any of the food group servings.

Macronutrients

Energy intake in young and old group was 1584 kcal and 1412, respectively (Table 5.9). Carbohydrate, protein, fat consumption were within the AMDR in both young and old adults,

however fat was toward the upper end (34% approximately) and protein intake was towards the lower end (15-17%) in both the groups. The amounts of saturated fat, polyunsaturated fatty acids, dietary cholesterol and dietary fiber were lower than recommendations. Monounsaturated fat recommendations were met by both the groups. The Healthy Eating Index score was 65.8 in young and 73.1 in old adults.

Vitamins and minerals

Vitamin, flavonoids and mineral content obtained from food frequency questionnaires is in Tables 5.10 and 5.11. As mean intakes, young and old group met the recommendations for vitamin A (RE), thiamin, riboflavin, vitamin C, vitamin B12, phosphorus, iron, zinc. Niacin and folate were met by young group only. In terms of mean intakes, neither of the groups was able to meet recommendations for vitamin D, vitamin E, pantothenic acid, calcium, potassium and magnesium.

Activity score in young and older adults

The activity score was measured by Godin Leisure-Time Exercise Questionnaire in young and older adults (Table 5.12). Strenuous exercise score was 9 units in young and 10.8 units in old adults, implying 15 minutes and 18 minutes per week spent on strenuous activity respectively. Moderate exercise was 12.5 units, 8.5 units in young and old adults respectively. Moderate activity time in younger adults was approximately 38 minutes and 26 minutes per week in old adults. Mild exercise score was 10.0 units in young and 13.5 units in old adults. Young adults were spending 50 minutes and older adults were spending 68 minutes per week on mild activity. The total leisure activity score (strenuous + moderate) was 20.5 in young and 19.3 in old adults. It indicates that both groups were moderately active according to scoring criteria.

Table 5.13 Correlation of inflammatory markers with cognitive, pain and functionality assessment measures (long term care residents) (n=26).

Marker	WMSR –DB	WMSR- TS	Grip strength	PADL total	BOX 21
CRP	-0.54*	-0.37[#]	-0.14	-0.41[*]	-0.10
25(OH)D	0.01	-0.31	0.43[*]	0.10	0.10
Prealbumin	0.27	0.37[#]	0.17	0.27	0.35[#]

WMS-R Digit Backward Score= WMSR-DB; WMS-R ISR Thematic Score =WMSR TS; OARS: Physical activities of daily living=PADL
* Correlation is significant at the 0.05 level (2-tailed).
[#]Correlation is significant at the 0.1 level (2-tailed).

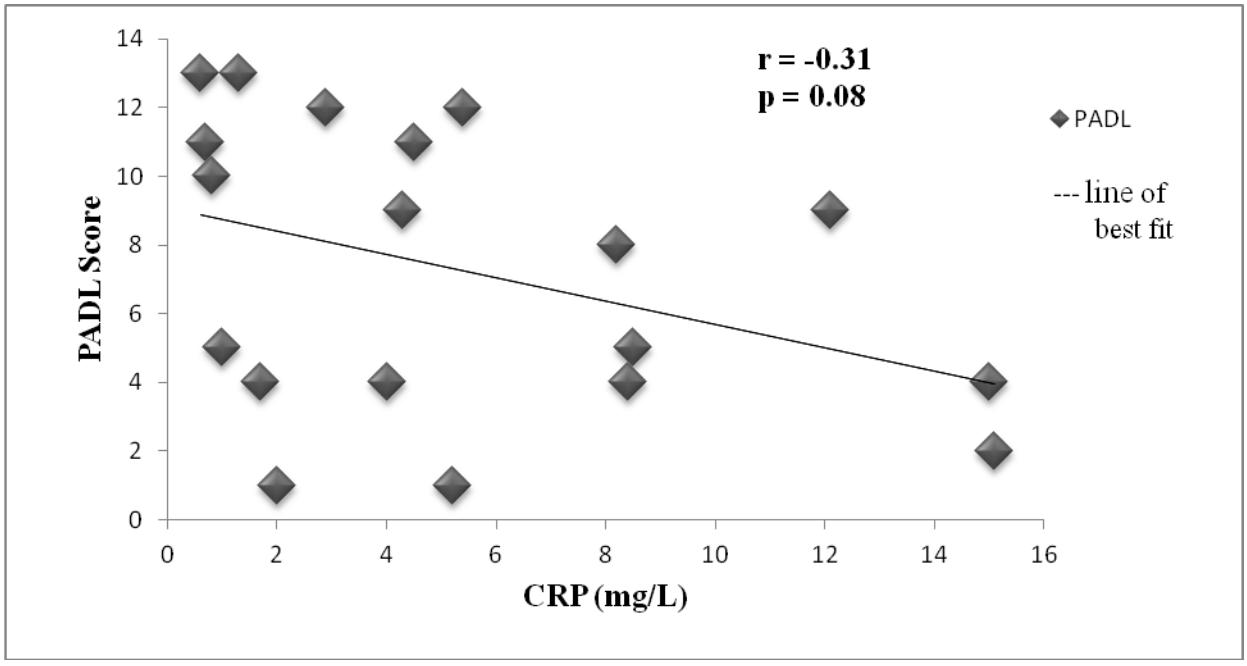

Figure. 5.1. Relationship of CRP with physical activities of daily living in LTC residents

Whereas, young adults were spending total 103 minutes and older adults were spending 112 minutes per week on all kinds of leisure activities. For only moderate activity time spent was 38 minutes in younger adults and 26 minutes in older adults per week as compared to the 150 minutes per week of moderate activity recommendations for adults according to Canada's physical activity guide (Public Health Agency of Canada, 2013).

Medication and supplement use in young and older adults

The medication use was 1.4 pills/day in older adults, while young adults did not consume any medications. Dietary supplement and Natural Health Product (NHP) consumption was not common in younger adults, older adults consumed average 3 supplements per day. Total consumption from all forms of pills was 4 in older adults.

Association of inflammatory markers with cognitive, pain and functionality assessment measures in long term care residents

Associations of inflammation marker with measures of functionality are in Table 5.13. Vitamin D was positively correlated with grip strength ($p \leq 0.05$), but significantly negatively correlated to age ($r = -0.41$) in LTC residents. After controlling age, the association between grip strength and 25(OH)D was not significant ($r = 0.36$). CRP was inversely correlated to cognitive tests i.e. WMS-R digit backward score ($p \leq 0.05$), WMSR-ISR thematic score ($p \leq 0.1$). CRP was negatively associated to the PADL score ($p \leq 0.05$) (Figure 5.1). One outlier had been removed, resulting in changes to r from -0.41 to -0.36 and the p value from 0.04 to 0.08. CRP and prealbumin were negatively correlated to each other ($p = 0.06$). Prealbumin was positively associated with WMSR-ISR thematic score ($p \leq 0.1$). Pain measures showed no significant correlations, except positive association of BOX 21 with prealbumin. RAVLT sum of trials was

Table 5.14 Association of blood measurements with medications, supplement use and inflammatory markers, functional and pain assessment measures (long term care residents) (n=26).

Marker	Waist	No. of medications	No. of supplements	No. of NPH	Total pills
Grip strength#	0.04	-0.14	0.19	0.18	-0.13
Berg balance	-0.16	-0.44*	-0.29	0.01	-0.47*
Physiotherapist fall risk	0.06	-0.08	0.26	0.15	-0.10
BOX21	0.29	0.16	-0.19	0.29	0.31
Pain CAS score	0.15	0.13	-0.24	0.19	0.29
Verbal rating	0.28	0.09	-0.25	0.22	0.26
PADL total	-0.11	-0.40*	-0.19	0.00	-0.39

#Grip Strength
B.P., Fating blood glucose, TNF-α, IL-1α, IL-1β: no values were obtained
IL=Interleukin, Pain CAS=Colored analogue scale, PADL= OARS: Physical activities of daily living
* Correlation is significant at the 0.05 level (2-tailed).

Table 5.15 Comparison of medication use in LTC residents (n=26) and Community dwelling older adults (n=10).

Marker	LTC residents Mean ± SD	Older adults Mean ± SD	P-value
No. of medications	13.3 ± 6.2	1.4 ± 0.5	0.001*
No. of supplements + NPHs	2.2 ± 1.7	2.9 ± 1.8	0.30
Total pills (medicine + supplements +NPHs)	21.7 ± 10.4	3.9 ± 2.4	0.001*

adjusted p<0.01* (Bonferroni adjustment)
NPH=Natural Health Products

positively correlated to BOX 21 and Pain CAS score in LTC older adults. CRP was positively correlated to number of supplements, and dietary vitamin D was correlated to both number of supplements and natural health products consumed. Waist circumference was positively associated with the use of natural health products and total pills (data not shown).

Functionality assessment measures such as Berg Balance and physiotherapist fall risk, physical activities of daily living demonstrated significant positive correlations with grip strength (data not shown). Berg Balance was also significantly positively correlated to activities of daily living and negatively correlated to verbal rating score of pain. BOX 21 and Pain CAS score were positively significantly related to each other, verbal rating score and CSDD total score. Number of medications and total pills were negatively correlated with Berg Balance Score and Activities of Daily Living in LTC residents (Table 5.14).

Associations of diet and activity in community dwelling young and old adults

Dietary vitamin D was positively correlated to calories, protein and fat in the older adults. Significant positive correlations were found between HEI score and fibre, BMI and diastolic BP in community dwelling adults (data not shown).

Differences in young, old and LTC residents

Dietary intakes

Medication use was highest in the LTC residents, as in SOD only those subjects who were not taking a prescription drug (that could be stopped for the period of study) were included. Supplement and NPH use was similar in both the LTC and community dwelling older adults (Table 5.15). Total pill consumption from all sources was significantly high in LTC residents.

Table 5.16 Comparison of diet quality of long term care residing older adults vs. community dwelling older adults (n=10)

Nutrient	Mean (adjusted[#] dietary intake LTC)	Mean intake (CD older adults)	Recommendation	P-value
Calories (kcal)	1443	1412		0.81
Carbohydrate (g)	230.0	179.8	203-293[##]	0.007
Fat (g)	48.8	52.9	40-70[##]	0.49
Protein (g)	47.6	56.9	45-157[##]	0.18
Saturated Fat (g)	20	15.8	18	0.15
Monounsaturated fatty acid (g)	18.4	19.8	20	0.62
Polyunsaturated fatty acid (g)	8.8	13	18	0.03
Trans fatty acid (g)	0.8	4.2		0.001*
Cholesterol (mg)	224.0	150	300	0.15
Dietary fiber (g)	14.9	17.5	25.7	0.50
Vitamin A – RE	1046	1559	900 M 700 F	0.11
Thiamin (mg)	1.4	1.2	1.2 M 1.1 F	0.51
Riboflavin (mg)	1.7	1.6	1.3 M 1.1F	0.72
Niacin equivalents (mg)	23.0	25	16 M 14 F	0.43
Vitamin B6 (mg)	1.8	1.6	1.7 M 1.5 F	0.40
Vitamin B12 (mcg)	3.2	2.6	2.4	0.48
Vitamin C (mg)	107.0	114.8	90M 75F	0.77
Vitamin D (mcg)	3.3	3.2	10	0.91
Vitamin E (mg)	4.7	7.7	15	0.002

Folate, DFE (mcg)	332.0	338.7	400	0.89
Calcium (mg)	675.5	798.7	1200	0.38
Iron (mg)	11.1	11.7	8	0.73
Magnesium (mg)	183.3	258.5	420 M 320 F	0.024
Phosphorus (mg)	954.5	1017	700	0.52
Potassium (mg)	2312	2620	4700	0.31
Sodium (mg)	2273	1985	1300	0.23
Zinc (mg)	7.0	8.4	8	0.25
Healthy Eating Index score	52.9	73.1	61•	0.001*

adjusted p<0.001* (Bonferroni adjustment), CD=Community dwelling, •HEI (Garriguet, 2009)
adjusted intakes were obtained from the difference in observed vs. actual intake LTC diets from a week's menu. (Lengyel et al., 2008).
##Calculated using 1800 kcal, Carbohydrate (recommendation is 45-65% energy), Fat (recommendation is 20-35% energy), Protein (recommendation is 10-35% energy). Calculated as percent recommended for older adults.

Dietary intakes for both young and old community dwelling adults were obtained from food frequency questionnaires. There were no significant differences between the macro and micronutrient intakes (Table 5.8, 5.9, 5.10).

Diet quality of long term care residents vs. community dwelling older adults was compared. Both groups of older adults had similar dietary intake except higher trans fat in community dwelling older adults (Table 5.16). In terms of mean intakes, neither group met the recommendations for dietary vitamin D, vitamin E, folate, calcium and potassium. Community dwelling older adults had a significantly higher HEI score.

5.4. Discussion

Metabolic syndrome in LTC residents

In the present study, 35% of LTC residents were found to have MetS. A national Canadian study of non-institutionalized subjects reported a high prevalence of MetS in older adults of 39% (Riediger & Clara, 2011); the most common feature was reported as abdominal obesity in those respondents (Setayeshgar et al., 2012; Riediger & Clara, 2011). About half of the LTC resident subjects were found to have increased waist circumference but most common feature in the present study was elevated blood pressure. LTC residents in this study were healthier than others, because that was the criteria to be a part of the clinical trial and may represent only a small percentage of LTC population.

Inflammatory markers and physical functioning in LTC residents

Inflammatory marker CRP was high, and 54% of the residents had values above the normal range which also indicated high risk of cardiovascular diseases. The prevalence of MetS in this population was low (35%) as compared to the cardiovascular risk (54%) assessed by CRP.

The relative low incidence of MetS in this group of subjects could be due management of triglycerides and blood sugars with medications, although we accounted for consumption of blood pressure lowering medications as being diagnosed with hypertension (Setayeshgar et al., 2012). Or MetS is a tool to assess cardiovascular disease at preliminary stages rather than in people who are already diagnosed with CVD. Majority of residents (62%) had insufficient levels of 25(OH)D. Hyperhomocysteinemia was highly prevalent in this population as almost all the residents were above the lower cut-off and 31% were above the highest level of normal range. Inflammatory cytokines were not appropriate in this study to draw any inferences of inflammatory status of LTC residents due to compromised blood handling and storage procedures. However other measures of inflammation such as CRP demonstrate the presence of inflammation in LTC residents.

The physical measures of functionality i.e. Berg Balance showed that most of the subjects were wheelchair bound; however the range of score was wide. Low 25(OH)D and wheel chair dependence was seen in the older adults in several other studies as well (Bischoff et al.,1999; Dhesi et al.,2002; Zamboni et al.,2002) demonstrating low 25(OH)D and loss of muscle strength resulting in disability. 25(OH)D was not related to grip strength. Age plays a detrimental role in diminishing muscle strength in older adults. Visser et al. (2003) reported from a prospective population based study in older men and women that low 25(OH)D and high parathyroid hormone levels indicated increased risk of developing sarcopenia measured as grip strength. The likelihood of experiencing sarcopenia was almost three times higher in adults with 25(OH)D levels <25 nmol/L, which further increased at follow-up after three years. Hand grip is emerging as a very useful tool for assessment of mobility in older adults. Most (89%) of the LTC residents in this study were below the cut-offs specified by Sallinen et al. (2010) respectively for older

males and females, which means the residents had less muscle strength. This could impact activities such as walking.

LTC residents had an average score of 50% on the activities of daily living, indicating that they required assistance to carry out the daily living activities. The literature demonstrates that dependence on others increases with age which is reflected by the diminished capacity to conduct daily living activities (Ervin, 2006). Increased inflammation measured with inflammatory cytokines and CRP was found related to decreased physical activity in older adults (Taaffe et al., 2000). The association of CRP and PADL is speculated to have a potential significance with such a small sample size. Our results are in agreement with Boxer et al. (2008) who reported increased frailty with elevated CRP, and lower 25(OH)D and increased cytokine concentration reflects decreased muscle strength (Visser et al., 2002b). However, results from this study are only modestly indicative of associations between these measures, and points to more research with larger sample size to develop conclusive findings.

Inflammatory markers and cognition in LTC residents

Majority of the LTC residents (35%) were found to have severe cognitive impairment followed by moderate and mild impairment as measured by SPMSQ, but this was a selected group from LTC chosen to be able to follow instructions. The score of LTC residents on other tests of cognition was either 50% or less than that of maximum score, reflecting issues with cognition. Results from the present study highlight that CRP was inversely correlated to some tests of cognition. A study on a large sample of older adults reported similar findings of increased inflammation measured by CRP and diminished cognitive abilities (Yaffe et al., 2003). A longitudinal study on older adults reported that the prevalence of metabolic syndrome especially hyperglycemia and raised CRP levels contribute to poor cognitive performance (Dik et

al., 2007). LTC residents from present study demonstrated a qualitative correlation between cognition and measures of pain. Pain severity was found related to mental functions in community dwelling older adults as well (Karp et al., 2006; Westoby et al., 2009). There is evidence that plant-based foods with anti-inflammatory potential such as fruits and vegetables have an effect on the cognitive abilities of older adults (Kang et al., 2005). Findings from a cross sectional study on older adults (70-74y) consuming a diet rich in fruits, vegetables, grain products and mushrooms showed the highest score on cognition tests as compared to those with very low or no intake (Nurk et al., 2010).

Inflammatory markers and pain in LTC residents

Pain assessment measures demonstrated that LTC residents had some pain. However no significant correlations were found between pain measures and 25(OH)D in this sample of subjects. Pain was found positively correlated to prealbumin. Pain is associated with low 25(OH)D in the older adults with symptoms such as bone pain and persistent, non-specific musculoskeletal pain (Mascarenhas, 2004). High prevalence of pain is reported in older adults residing in LTCs (Fox et al., 1999) and raised inflammation measured as CRP levels was significantly correlated to pain in older adults (Graham et al., 2006). Pain is also reportedly related to intake of foods having anti-inflammatory properties (Tall & Raja, 2004) which are not commonly served in LTCs. Previous findings from Study 2 also demonstrated that LTC diet is low in quality as measured by HEI, and is high in sugar, saturated fats etc.(Chapter 4). Foods which are usually served may be cooked or processed and thus rich in AGE's. Also, diets are high in saturated fats (25g, which exceeded the recommended levels). Both of these are pro-inflammatory in nature (Uribarri et al., 2010). Diet high in saturated fats may cause elevation in

inflammatory markers which could further cause the onset of inflammation related diseases (Lopez-Garcia et al., 2005; King et al., 2003).

Dietary and activity differences in young, older adults and LTC residents

There was a little difference in the overall macro and micronutrient intake in young and old community dwelling adults; similar findings were reported by Howarth et al. (2007). HEI score of community dwelling older adults was higher than community dwelling young healthy adults. This was attributable to consumption of more servings of fruits, milk and lesser servings of Grain Products in community dwelling old adults as compared to the young adults. However, our younger adults group consisted mostly of graduate students of different ethnicities, so their food choices could be different and varied as compared to older adults who were all Caucasian. High diet quality in older adults as compared to younger adults has been reported in a Canadian nationally representative sample (Garriguet, 2009). It was also found that activity score was higher in the community dwelling healthy young adults compared to old adults. The decline in physical activity has been reported with age by others as well (McAuley et al., 2009). However, the community dwelling older adults were moderately active, as compared to LTC residents who had limited mobility and functionality as indicated by low grip strength, low score on PADL and low Berg Balance Score.

Diet quality from the actual food intake was higher in community dwelling older adults compared to that calculated for LTC older adults. It suggests improvements should be done to meet the recommendations of nutrients especially in LTCs to enhance the diet quality. Diet quality in LTC was found to be low (53 out of a maximum score of 100), needing improvement (Chapter 4) as compared to diet of household population of older adults (≥ 71y) who had a higher score of 60 (Garriguet, 2009).

Older adults are recommended to have vitamin D supplements every day. In this study, LTC residing and community dwelling older adults had a very low dietary vitamin D as compared to the recommendations for older adults. Furthermore, majority (62%) of LTC residents had insufficient 25(OH)D levels. LTC residents who were consuming vitamin D supplements had optimal 25(OH)D levels, which was significantly higher ($p \leq 0.05$) than non consumers. Vitamin D supplementation of 800 IU by all adults over 50 y is recommended by Osteoporosis Canada (Hanley et al., 2010; Holick et al., 2011). Saskatoon Health Region supports recently issued Osteoporosis Canada's recommendation of 800-2000 IU daily of Vitamin D supplement for all year to the < 50y home dwelling adults. However, doses up to 4000 IU vitamin D per day for LTC residing adults with advice of health-care professional are recommended by Saskatoon Health Region (September, 2012) (Saskatoon Health Region, 2012).

5.5. Strengths and limitations

Limitations of this study include the small sample size of LTC residents due to exclusion and inclusion criteria. SOD study was also small and subjects may not be representative of community dwelling younger and older adults. This prevented the ability to draw representative correlations in this age group, because "healthy" community dwelling young and old adults were enrolled. The sample size in this study was a typical Phase I pharmacokinetic study which is usually up to 24 adults.The dietary comparisons between community dwelling and LTC residing older adults were not based on the same nutritional assessment methods. The measures used in Flax and SOD trial were similar but not the same, which limited the capacity to compare the same markers. Values for energy in community dwelling older and younger adults were low, which could be attributable to the use of food frequency questionnaires, which underestimate the calories. Strengths include the evaluation of several associations of inflammation with activities

of daily living, physical functionality, cognition and pain measures. The markers were measured by a licensed laboratory for accuracy and different types of measures were done by trained professionals.

5.6. Conclusion

Overall, results from present study indicated an association of inflammatory markers with functionality tests, particularly grip strength, cognition, and activities of daily living in the older adults residing in LTC. The inflammatory markers in community dwelling young and older adults were similar, indicating little or no inflammation. Number of medications, supplements and total pill consumption was highest in LTC residents followed by community dwelling older adults and young adults. Diet quality of community dwelling older adults was higher than LTC residents. It suggests that improvements should be made to meet the recommendations of nutrients especially in LTCs to enhance the diet quality. LTC residents consuming vitamin D supplements had optimal 25(OH)D levels. Therefore older adults are also encouraged to have vitamin D supplements every day.

CRP was negatively associated to the Physical Activities of Daily Living, along with a low grip strength further pointing at loss of muscle strength and limited mobility in LTC home residents. Diminishing muscle strength and ability to carry out activities of daily living increases the dependence on others which may lead to compromised quality of life, and adds to the burden of staff and LTC homes. Many of the functional tests such as pain and cognition were correlated to each other. Cognitive ability was inversely associated to CRP in the LTC residents. It is speculated that increased incidence of pain, impaired cognition and compromised functionality occur with inflammation.

Chapter 6

STUDY 4. Should the anti-inflammatory diet be used in long term care homes?

Study 1, 2 and 3 highlighted the supplement, menu, inflammatory and functional conditions of the LTC residents. LTC residents were found to be consuming inappropriate vitamin/mineral supplements and not taking enough vitamin D. The menu analysis demonstrated that LTC menu was not meeting the recommendations for Canada's Food Guide servings, except for Fruits & Vegetables. The menu did meet RDAs/AIs for most of the vitamins and minerals, however the diet quality was low and indicated the need of improvement. Results from Study 3 reflected an elevation of some inflammatory markers in LTC residents with compromised functional abilities and lower cognition scores and having pain. Chronic inflammation seems to be the connecting link to the functional outcomes. The inclusion of Weil's anti-inflammatory diet in LTC menus may be a possible option to prevent some of the outlined conditions especially if anti-inflammatory foods replace pro-inflammatory foods. In this chapter new dialogue to address the issues of LTC residents with a prudent diet is opened.

This chapter is published in *Healthy Aging Research*.

Viveky, N., Dahl, W.J., Whiting, S.J. (2013). Should the anti-inflammatory diet be used in long term care homes? *Healthy Aging Research.* 2:1. doi:10.12715/har.2013.2.1

6.1. Introduction

Older adults may need care or supervision for an array of different health reasons. As frailty increases with age, some of them may have a physically debilitating disease or may be terminally ill. The Canadian Community Health Survey found that chronic conditions such as arthritis/rheumatism, back problems, cataracts or glaucoma, heart disease, urinary incontinence, diabetes and cognitive diseases such as Alzheimer's disease or dementia are very common in residents of LTC homes (Statistics Canada, 2003; Gilmour et al., 2006). Most of these conditions are associated with chronic inflammation.

Nutrition is an important determining factor for successful aging, as it helps the body maintain its mental and physical functioning, to continue an active engagement in life (Rowe, 1998). An overall decreased food intake with age results in decreased intake of individual nutrients and a higher risk of nutritional deficiencies (Harris & Haboubi, 2005). Although there is possibility of residents being admitted to a LTC home in a malnourished state, they may also become malnourished after their admission, resulting in a worsening overall health condition. Other reasons for malnutrition may be inability to meet the unique nutritional needs of residents, due to inadequate menu, problems in swallowing and functional restrictions, or lack of sufficient personal assistance in dining (Leydon & Dahl, 2008).

In Canada, menu planning for LTC homes, in the recent trend of "resident-centred care", involves consideration of many factors such as Dietary Reference Intakes (DRIs) in accordance with Canada's Food Guide, residents' preferences, as well as management issues such as food acquisition, preparation and the method of production (Ducak & Keller, 2011). Residents of LTC homes often report difficulty in consuming the large size or volume and foods and fluids recommended by Canada's Food Guide (Ducak & Keller, 2011). Studies also reported that the menu cycle of a typical accredited institution in Canada, developed using food guidelines, is not

sufficient in meeting the recommended adequate levels of vitamins and minerals (Ducak & Keller, 2011; Wendland et al., 2003). Indeed, the fundamental assumption that planning the menus according to public health guidelines can achieve the nutritional requirements of the institutionalized older adults was recently refuted (Wendland et al., 2003). The need to use more than one standard guideline to plan menus was highlighted, because DRIs are meant for healthy people and residents in LTCs may have comorbidities and conditions in which requirement for certain nutrients is more than what is typically designed for healthy older adults (Ducak & Keller, 2011).

Relationship of diet and inflammation

Development of several age-related diseases commonly present in the older adults such as atherosclerosis (Libby, 2006), type 2 diabetes (Festa et al., 2002), Alzheimer's disease (Griffin, 2006), and osteoporosis (Kimble et al., 1995) may be related to chronic, low-grade inflammation (Galland, 2010). Inflammation is an automatic response of the body to get rid of the initial cause of cell injury caused from the original insult (García-Lafuente et al., 2009), and can be either acute or chronic. Acute inflammation is a self-limiting process where inflammatory mediators have short half life spans, due to prompt degradation in the presence of negative feedback mechanisms. This type of inflammation occurs following surgery, trauma or an injury, and shows that controlled inflammatory responses are important for maintaining normal homeostasis and health. Chronic inflammation results when the immune response to injury is not eliminated, leading to continued stimulation of the synthesis of proinflammatory cytokines, which contribute to risk of many chronic diseases (Litchford, 2010). Damage caused by chronic inflammation accumulates slowly, sometimes asymptomatically for many years and can lead to

severe tissue impairment (Mitchell & Cotran, 2003). Markers of inflammation are also reported to increase with age indicating greater risk for older adults (Ferrucci et al., 2005).

Factors affecting chronic inflammation

Persistence of chronic inflammation is influenced by many factors such as genetics, stress, exposure to environmental toxins and diet (Palmer, 2009) as well as exercise (Volkmann et al., 2010). Some factors are positive, others negative. There is the potential for reversal of the inflammatory condition by using foods which are anti-inflammatory in nature (Lomangino, 2009; Giugliano et al., 2006; Sears, 2009). To this end, various dietary components including long chain n-3 fatty acids, antioxidant vitamins, plant flavonoids, prebiotics and probiotics, have been identified as having the ability to modulate predisposition to chronic inflammatory conditions and thus may have a role in their therapy (Kris-Etherton et al., 2004). Inverse associations are found with high intake of fruit, vegetables, healthy fats and whole grains to risk of inflammatory diseases leading to chronic diseases such as cognitive impairment (Baer et al., 2004; Basu et al., 2006; Nurk et al., 2010). This suggests an anti-inflammatory potential of some plant foods (Jacobs Jr et al., 2009; Mitrou et al., 2007).

6.2. Methods

Purpose

The prevalence of chronic diseases and compromised nutritional intake in LTC residents leads to the question of whether LTC homes need to consider menu solutions beyond basic food guides and DRIs to cope with the changing nutrient demands of aging. Older adults residing in LTC homes are reported to have some health conditions for which the underlying cause might be inflammation. Evidence for the anti-inflammatory diet was searched, and then feasibility

(defined as need of the added components considering factors like health benefits, cost etc.), of adding specific components to the diets of LTC residents was considered.

What is an anti-inflammatory diet?

Many authors have described an anti-inflammatory diet (Sears, 2009; Bulló et al., 2007; Szarc vel et al., 2010). There appears to be common features such as a low glycemic load, low in n-6 fatty acids and rich in n-3 fatty acids (Sears, 2009). Though some specific details are different in each anti-inflammatory diet, there are some common foods, such as fruits and vegetables, n-3 fatty acids such as fish or fish oil supplements, whole grains, lean protein sources such as chicken, less red meat and full-fat dairy foods, low saturated and *trans* fats, limited refined foods and processed foods, alcohol in moderation; and spices (Giugliano et al., 2006; Sears, 2009; Basu et al., 2006; Nedrow et al., 2009; Walker & Reamy, 2009). Some of these features are similar to the Mediterranean diet, which is sometimes considered as a prudent form of an anti-inflammatory diet (Trichopoulou et al., 2003; Esposito et al., 2004).

Foods with a low glycemic load are beneficial as they lead to only gentle rises in blood glucose and insulin levels. A prolonged elevation in insulin levels is one of the major risk factors for development of chronic inflammatory diseases (Barclay et al., 2008; Reddy & Bhatia, 2011). Also, the formation of pro-inflammatory compounds known as AGEs (advanced glycation end products) by the chemical reactions of sugars and protein (Uribarri et al., 2010) are known to contribute towards oxidative stress and inflammation. The modern diet is a very rich source of AGEs because of excessive cooking or processing to enhance flavor, keeping quality, appearance, color and acceptability (Goldberg et al., 2004). Even a single AGE rich meal fed to

humans is well absorbed and contributes towards the total AGE pool of the body (Koschinsky et al., 1997).

6.3. Results

Weil's Anti-inflammatory Diet

Andrew Thomas Weil is a well known physician and author of many best-selling books who writes about nutrition and healthy aging (Wikipedia, 2013). Weil has developed an anti-inflammatory diet by putting together a combination of many foods in a pyramid format. Weil's Anti-inflammatory Diet (WAID) has suggested serving sizes and foods from all the major food groups. This diet is primarily formulated to decrease the risk of age-related diseases and to attain the overall health (Palmer, 2009). The main characteristics of WAID include regulating blood glucose with low-glycemic load foods, using lean protein sources, including healthy fats, drinking more water, and consuming high amounts of fibre from fresh fruits and vegetables which also provide anti-inflammatory factors (Palmer, 2009). Further, this diet plan claims to have an appropriate balance of n-3 to n-6 fatty acids.

WAID provides specific guidelines regarding keeping blood glucose regulated, and by preventing inflammatory processes due to formation of AGEs. It emphasizes consuming whole grains, beans, sweet potatoes, winter squashes and other vegetables, and fruits like berries, cherries, apples, and pears instead of bananas, pineapple, mango and papaya. It recommends using less meat and poultry, as they contain pro-inflammatory fats, and including more vegetable protein (e.g. soy, beans and lentils), whole grains, seeds, and nuts. Fish is recommended, but primarily as oily varieties containing n-3 fatty acids (e.g., wild Alaska salmon, sardines, herring, and black cod). Overall, WAID limits bread, white potatoes, crackers, chips, snack foods, pastries, sweetened drinks, refined and processed foods, and eliminates fast foods and foods

Table 6.1 Comparison of Weil's anti-inflammatory diet to Canada's Food Guide.

Food group	Weil's anti-inflammatory diet	Canada's Food Guide serving/day*
Vegetables and Fruit	4-5/d (vegetables) minimum 3-4/d (fruits)	7 (1 dark green,1 orange vegetables)
Grain Products	3-5/d (whole & cracked grains) 2-3/wk (pasta)	6,7 (female, male) (50% whole grains, variety of whole grains)
Milk & Alternatives	1-2/wk (soy beverage, tofu, cheese, yogurt)	3 (Select lower fat milk alternatives, fortified soy beverages)
Meat & Meat Alternatives	1-2 /d (beans & legumes) 2-6/wk (fish & seafood) 1-2/wk(other sources of protein eggs, tofu, skinless poultry, lean meats) nuts- walnuts, avocados, seeds- hemp and freshly ground flaxseeds)	2,3 (female, male) (beans, lentils and tofu, at least two Food Guide Servings of fish each week, select lean meat and alternatives
Oils and Fats	5-7/d healthy fats (extra virgin olive oil, expeller-pressed canola oil	2-3 tbsp (canola, olive and soybean) low in saturated and trans fats, limit butter, hard margarine, lard and shortening.
Herbs & Spices (garlic, ginger, turmeric, cinnamon)	Unlimited amounts	-
Tea (white, green, oolong)	2-4 c/d	-
Supplements	Daily	Vitamin D (400 IU)
Red Wine	1-2 gl/d	-
Healthy Sweets (plain dark chocolate)	Sparingly	-
Cooked Asian Mushrooms	Unlimited amounts	-

Oz=ounce, c=cup, gl=glass, tsp=teaspoon, tbsp=tablespoon, d=day, wk=week
* Canada's Food Guide serving recommended for <51+ y adults

made with high fructose corn syrup. The food groups comprising the WAID diet are shown in Table 6.1. Food items have recommended serving sizes and ranges (Weil's anti-inflammatory diet & pyramid, 2013).

How does Canada's Food Guide compare to Weils's Anti-Inflammatory Diet?

Canada's Food Guide (CFG), as released in 2007, provides recommendations for planning menus based on foods found in four predefined food groups i.e. Vegetables & Fruits, Grain Products, Milk & Alternatives, Meat & Meat Alternatives (Katamay et al., 2007). This version of CFG was developed with a unique approach, which included a simulation of varied food choices among each food group and its impact on nutrient intakes. Dietary guidelines and food guides based on the DRIs provide the appropriate nutrient intake for people (Barr, 2006). However, it is assumed that individuals following the food guidelines will make choices from diverse foods within each food group. Thus, individuals making poor food choices with significant deviation from food groups may not meet the nutritional goals (Murphy, 2008). Though CFG provides good nutritional advice, its critics argue that even with the revisions in 2007, it may not minimize the risk of chronic diseases (Andresen, 2007).

Both CFG and WAID are educational tools encouraging people to make better food choices to attain optimum nutritional status and health (Palmer 2009, Katamay et al., 2007). Table 6.1 illustrates that there are food items in WAID common to as well as additional to the CFG. The food items which are common to both include: fruits and vegetables, particularly green and orange vegetables; low fat milk and alternatives (e.g. soy); meat alternatives such as lentils, beans, tofu; and weekly servings of fish, specifically those rich in n-3 fats; use of unsaturated fats; and promoting water as the main beverage. CFG recommends making half of

grain consumption whole grain where WAID emphasizes exclusively whole and cracked grains. Common components in both the diets vary somewhat in number of servings and food groupings. For example, cheese and yogurt are under Milk and Alternatives in the CFG but in the WAID they are in the category of "Other sources of protein". WAID is very specific with recommendations of Asian mushrooms, herbs and spices, tea, supplements, red wine and healthy sweets. CFG is developed for already healthy people to maintain their health, while WAID targets the inflammatory conditions arising with age.

Evidence for anti-inflammatory potential of components of both WAID and CFG

There are studies to support the high intake of fruits and vegetables as a preventive measure against low grade inflammation (Basu et al., 2006). Fruits and vegetables are excellent sources of essential vitamins, minerals, fiber, phytochemicals and antioxidants, all of which reduce inflammation (Guo et al., 2009). Flavonoids and proanthocyanidins, found in fruits and vegetables, for instance, are known to have a protective mechanism against various inflammatory diseases (Watzl, 2008) such as cardiovascular diseases (CVD) (Mirmiran et al., 2009) and cancer (Pacheco-Figueiredo et al., 2011). It has been demonstrated that flavonoids are able to modulate the enzymes as well as other inflammatory process such as cytokines, chemokines or adhesion molecules. There are the many studies published with *in vitro* approaches that allow identifying molecular mechanisms of flavonoid effects on inflammatory processes (Rathee et al., 2009; Tuñón et al., 2009). There is a strong association between dietary vitamin C from fruits and vegetables with plasma vitamin C concentrations, both being linked to a fall in markers of inflammation (Wannamethee et al., 2006). Inverse associations were reported between fruit and

vegetable intake, antioxidants, folate, and total flavonoids in relation to the markers of inflammation and oxidative stress (Holt et al., 2009).

There is significant evidence for the anti-inflammatory properties of the additional foods and supplements included in the WAID that are not specifically recommended in CFG. Nuts, categorized as healthy fats in WAID, have the potential of modulating inflammation as they contain n-3 fatty acids, which possess anti-inflammatory properties (Salas-Salvadó et al., 2008). Evidence from large epidemiological studies suggest that frequent nut consumption (more than four times per week) reduces the CVD risk by 37% (Kelly & Sabaté, 2006) and type 2 diabetes in some prospective studies (Jiang et al., 2002) and randomized control trials (Garg et al., 2007). Improved insulin sensitivity and reduction in inflammatory markers such as IL-6 was reported with the 30 g nut consumption per day in clinical trial on subjects with metabolic syndrome (Casas-Agustench et al., 2011). Flax, also categorized as "healthy fats" in WAID**,** has been shown to impart protection in CVD. Flax supplementation in multiple clinical trials reported to result in modest reduction in the plasma levels of total cholesterol, low-density lipoprotein cholesterol, in both normal and hypercholesterolemic patients. Lignan and dietary fibre found in the flaxseed also have the hypocholesterolemic action. n-3 fatty acids present in the flaxseed oil have the anti-proliferative mechanisms along with anti-atherogenic and anti-inflammatory potential (Bassett et al., 2009).

Soy supplementation along with lifestyle changes, can lead to an improvement in endothelial function, some markers of inflammation and blood pressure in postmenopausal women with hypertension (Nasca et al., 2008; Azadbakht et al., 2007). Asian mushrooms**,** when supplemented as an extract, showed mild antidiabetic effects and improvement of dyslipidemia associated with diabetes in humans (Chu et al., 2012). Herbs and spices such as turmeric and its

active compound curcumin are believed to have disease-modifying properties. Evidence from *in vitro, in vivo* and human clinical studies suggests that it has anti-inflammatory, antioxidant and anti-cancer properties (Epstein et al., 2010). Cinnamon and ginger may have positive effects on insulin resistance, hyperglycemia, hyperlipidemia, and other symptoms linked to obesity (Aggarwal, 2010). Garlic possesses some anti-inflammatory and anti-arthritic properties which may have a role in the treatment of inflammatory and arthritic diseases (Ban et al., 2009).

Green tea, when supplemented in a randomized, double-blinded and placebo-controlled phase trial, demonstrated protective effects along with diminished oxidative DNA damage (Luo et al., 2006). Oolong tea extract (8 g/d) supplementation for 6 weeks in obese/overweight women reduced the body fat content and body weight along with improved lipid metabolism (He et al., 2009). The extracts from green, oolong and black tea have some polysaccharides which might help in reducing diabetes (Chen et al., 2009). Dietary supplement consumption demonstrates mixed results (Aisen et al., 20081; Jae et al., 2006) with the exception of vitamin D. Higher levels of 25(OH)D were associated with longer 6-minute walk distance in older adults whereas shorter walk distances were correlated with increased levels of cortisol, high-sensitivity C-reactive protein, interleukin-6 (IL-6), and parathyroid hormone (PTH). Overall, increased frailty was associated with increased high-sensitivity CRP, higher IL-6, and lower 25(OH)D (Boxer et al., 2008).

Red wine intake improved antioxidant defense mechanisms along with platelet responsiveness via modulating the inflammatory cytokines and cell adhesion molecules in an intervention trial (Tozzi et al., 2011). The active polyphenol of red wine, resveratrol, inhibits enzymes involved in the production of pro-inflammatory prostaglandins (Frémont, 2000; Gusman et al., 2001). Finally, dark chocolate is associated with increased plasma total

antioxidant capacity (Serafini et al., 2003). Cocoa flavonoids demonstrated beneficial effects on adult population with elevated serum cholesterol levels in a clinical intervention trial, as these flavonoids lower lipid oxidation and decrease the platelet aggregation (Allen et al., 2008).

6.4. Discussion

Can LTC menus be anti-inflammatory?

A recent menu analysis of a large LTC home was carried out and compared with CFG serving recommendations (Chapter 4). The menu did not meet the CFG recommendations for food groups except for Fruit & Vegetables. The menu was higher than recommended in saturated fats, sodium and high in pro-inflammatory foods such as sugar. The diet quality of the LTC menu had a score of only 53 out of 100 using the Healthy Eating Index (Garriguet, 2009), which suggested improvement is needed. As LTC residents tend to consume only 80% of the foods offered to them (Lengyel et al., 2008), menu planning following minimum servings of CFG will result in inadequate nutrient intake. There is a need to incorporate healthier options and nutrient-dense foods (Dunne & Dahl, 2007).

Although it is expected that many LTC homes have successfully implemented healthful menu changes and may have evaluated the outcomes of these changes, few LTC menu interventions have been published. Incorporation of nutrient-dense foods into LTC menus has been successful in improving nutrient intakes of LTC residents (Germain et al., 2006) and should be the first step in menu revision to ensure the provision of all nutrients including those considered to be anti-inflammatory. This could be achieved by judicious selection of naturally nutrient dense foods or by providing foods specifically fortified at levels appropriate for older adults in care. For example, as energy requirements are lower for older adults, it is reasonable to suggest that menus may not need to achieve the recommendations for Grain

Table 6.2 Recommendations to incorporate additional components of WAID along with CFG

Food Group	Recommendations
Cooked Asian mushrooms	Topping and filling in sandwich, salads
Herbs & Spices (garlic, ginger, turmeric, cinnamon)	Salad dressing, recipes
Tea (white, green, oolong)	Adding to choice of hot/cold beverages without sugar
Supplements	Vitamin D everyday*
Red Wine	Occasional
Healthy Sweets (plain dark chocolate)	Choice in deserts
Nuts	Breakfast cereal, salads, smoothies; consider nut butters
Flax	Breakfast cereal, salads, smoothies

*Vitamin D supplementation already started in some health regions (Fraser Health Canada, 2013).

Products. For example, as energy requirements are lower for older adults, it is reasonable to suggest that menus may not need to achieve the recommendations for Grain Products, especially as only half of the servings are wholegrain. White bread which is served commonly in LTC home (Chapter 4) has found to be related to low scores on cognitive tests as compared to high fibre bread in older adults (Nurk et al., 2010). Foods made with white flour could be eliminated allowing room to achieve recommended intakes of Milk & Milk Products and Meat & Alternates. However, menus planners would need to ensure adequate intakes of the vitamins and minerals added to grains by fortification.

Next, pro-inflammatory foods could be replaced with anti-inflammatory foods and some examples are given in Table 6.2. For instance, replacing foods such as cakes and cookies with healthy dark chocolate desserts would be a way of improving anti-inflammatory food intake yet ensure menu acceptance. Novel recipes could be developed to incorporate nuts, flax and soy, as well as the recommended herbs and spices. It is easier to incorporate herbs and spices considering the cost and added flavor. In addition, guidelines could be developed for vitamin-mineral supplementation of LTC residents, as currently, many residents may not even be provided with vitamin D supplements (Chapter 3). Alternatively, vitamin and mineral requirements may be achieved through food fortification (Adolphe et al., 2009) or oral supplements (Silver, 2009).

6.5. Strengths and limitations

A limitation for the adoption of WAID into LTC is that studies were not conducted on frail elderly, nor was therapy the outcome. Although pro-inflammatory foods could be replaced with anti-inflammatory food options, cost, familiarity, personal and cultural preferences and eating /chewing difficulties must be considered. Also, additional staff effort would be required to

follow-up if these additions/changes are made. In agreement with Walker and Reamy (2009), the additional components could be added to existing diets of older adults using a stepwise approach to have maximum benefit of interventions. Another study on nursing home residents suggested incorporation of several enhanced foods in more than one meal to help in achieving the optimal nutritional status (Castellanos et al., 2009). Strength of this study includes addressing the important issue of inflammation in LTC homes via diet rich in health benefitting properties. Other strength is the extensive search of literature regarding evidence of additional items of WAID, and ways of incorporating them into the existing menu.

6.6. Conclusions

The implementation of the anti-inflammatory diet of Weil, the WAID, over and above CFG, has the potential for improving the health and wellness of LTC residents through ameliorating inflammation, further study is needed. If implemented, it is suggested to add anti-inflammatory components with a stepwise approach along with meeting the recommendations of a food guide, e.g., CFG with close regard to personal and cultural preferences, taste, and chewing and swallowing difficulties. LTC intervention trials involving recipe development, sensory evaluation and food substitution should be carried out. Those who have successfully undertaken LTC menu change are challenged to evaluate and publish their outcomes.

Chapter 7

Discussion

7.1. Overview of studies

In summary the studies conducted in this thesis were designed to evaluate the relationship of diet to inflammation in LTC residing older adults. The overall objective was to address different components such as use of dietary supplements in LTC homes and whether supplements were adding to patient pill burden, menus for optimality, and inflammation and its relationship to functional outcomes in older adults residing in LTC homes. The overall purpose was to assess the associations between dietary and inflammatory status is older adults residing in LTC homes.

The main results of the study included several important findings which were not available in the literature and some findings add to the existing body of evidence. The most important findings are as below:

Study 1

1. The use of vitamin-mineral supplements was high in some residents of a LTC home. Some residents took as much as six different supplements every day. Only one-third of the residents in the large LTC home took vitamin D followed by calcium and multivitamins.
2. Study 1 also showed a similar supplement use in residents with and without the dementia, leading to rejection of hypothesis that residents with dementia would have higher supplement use.

3. The mean consumption of 2 supplements per day and average medication use per day was 10 (4-23), with a mean total of 12 pills per day. Supplements add to the overall pill burden of residents who have to consume high number of medications and of the LTC home who has to make these pills available to the residents.

Study 2

1. There was an improvement in the servings of Fruits and Vegetables in LTC menu since 2000, servings of Meat and Alternatives, total carbohydrate, and protein were not significantly different. While Grain products and Milk and Alternatives decreased significantly in 2011 menu.
2. Five micronutrients, i.e., Vitamin A, thiamin, niacin equivalents, vitamin B6 and folate increased, and vitamin D and vitamin E intakes decreased significantly, while others remained same.
3. The diet quality of LTC menu was poor.

Study 3

1. Evidence exists for the inverse association of inflammatory marker such as CRP with PADL score and some measures of cognition.
2. No significant correlations and differences were found between older frail, older healthy and healthy younger adults for inflammatory markers except for medication and supplement use which was highest in LTC residents.
3. Majority of LTC residents (62%) had insufficient 25(OH)D levels, and residents consuming vitamin D supplements had significantly higher 25(OH)D levels.

4. More than one-third of the residents of LTC in this study had MetS with highest proportion of hypertension followed by increased waist circumference.
5. The diet quality was highest in the community dwelling older adults as compared to younger adults.

Study 4

1. Study 2 indicated the poor diet quality of LTC menu. To improve the diet quality of menus, it is important to incorporate additional nutrient-dense and anti-inflammatory food items to the existing menu and reduce pro-inflammatory foods containing fats and sugars. This is in agreement with others who argue the need of considering value foods up and above Canada's Food Guide to meet the additional needs of older adults who are not healthy and may need more than what is recommended in Canada's Food Guide.
2. Health benefits of additional food items which are part of WAID and are additional to CFG were established from the literature. Ways of introducing new foods from Weil's anti-inflammatory diet were explored.

Adequate nutritional status is a very important component of successful aging, which might help in delaying the onset of age-related health conditions and diseases (Sánchez et al., 2012). Where it is the top priority to meet the nutrition goals of older adults, it becomes crucial to evaluate the overuse or excessive intake of nutrients especially through dietary supplements. Older adults tend to take at least one dietary supplement in North America (Rock, 2007; Timbo et al., 2006; Vatanparast et al., 2010a). Highest supplement consumption is reported in older adults out of all the age groups (Radimer et al., 2004). Results from Study 1 reported similar findings, as some LTC residents were consuming many supplements. Nahin et al. (2009)

discourages the use of dietary supplements in older adults living in nursing homes without good clinical evidence. It is recommended that in LTC homes, evidence-based guidelines should be developed and implemented for monitoring of oral nutritional supplements (Johnson et al., 2009). Only one-third residents in the large LTC home were taking the vitamin D supplement which is recommended by Osteoporosis Canada (Hanley et al., 2010) and supported by the Saskatoon Health Region.

Nutrition-related problems in older subjects have not been the utmost priority; good nutritional status is essential to optimize health of older adults especially for long term care home residing older adults. They have unique needs which are hard to meet in a LTC setting. Although the focus on the menu planning is shifting towards resident-centred needs (Ducak & Keller, 2011), it is still very difficult to meet the recommendations of nutrients and food servings of Canada's Food Guide in long term care menu (Wright-Thompson & Piché, 2011). Study 2 documented that LTC menu offered to LTC residents is not efficient in meeting the recommendations for older adults, because the menu could not meet the recommendations for most of the food servings and nutrients. However, the comparison of recent menu to a similar menu analysis conducted a decade ago showed some positive improvements in the servings of Fruits & Vegetables along with higher fibre and lower fat which was in agreement with Wright-Thompson & Piché (2011). The diet and protein quality of menu offered to LTC was poor and, Germain et al. (2006) suggested revising the menus of LTC homes to ensure the provision of all nutrients with inclusion of nutrient-dense foods which are considered to be anti-inflammatory. The poor diet quality and high prevalence of chronic health conditions among LTC adults (Statistics Canada, 2003; Gilmour et al., 2006) makes it necessary to improve the diet served to them. The need to make LTC menus nutrient-dense is high (MyPlate, 2011), and Study 4

addressed the need of incorporating anti-inflammatory foods in the existing menus of LTC homes. In agreement with recommendations of Study 4, to achieve the nutritional status in the residents of nursing home, it was suggested to add several enhanced food items in more than one meal (Castellanos et al., 2009).

Inflammatory status measured as CRP is associated with measures of physical functioning and increased dependence on others (Taaffe et al., 2000; Ervin, 2006), cognition (Weaver et al., 2003; Yaffe et al., 2003), and measures of pain (Graham et al., 2006) in older adults. This is supported by results from Study 3 where associations were found between these measures. The findings of Study 3 provide some qualitative evidence for the associations between the inflammation and measures of functionality in older adults. Another study also reported that muscle strength deteriorates with age, and that 25(OH)D levels were associated with muscle strength in older adults (Visser et al., 2003).

Cognitive impairment which is speculated to be a condition influenced by chronic inflammation (Study 3; Teunissen et al., 2003), is affected positively by diet high in fruits and vegetables (Kang et al., 2005). Anti-inflammatory foods (Study 4), such as carrots, cruciferous vegetables, citrus fruits and high-fibre grain products showed better cognition performance in older adults (Nurk et al, 2010).

7.2. Implications in long term care homes and health care settings

As most of the research was carried out in the LTC homes, the findings have overall implications in the LTC and health care settings especially designed for the older adults with health conditions requiring supervision or care. Study 1 was done in a large LTC home and the results were reported back to the LTC home, in a report form to the LTC home Director and informational brochure to the residents and caregivers (Appendix 5). Topics of concern for LTC

residents and caregivers were addressed in the brochure such as: Do residents need vitamin/mineral supplements? and, tips to achieve good nutritional status. Warnings were given for supplement overuse without much benefit to the residents especially the ones at advanced stages of dementia, and recommendations for vitamin D supplementation were made. Older adults are taking multiple supplement and medications (Nahin et al., 2009), but the literature suggests limited additional benefit of taking supplements without good clinical evidence and may have adverse effects on older adults (Maggiore et al., 2010). It is crucial to transfer knowledge and develop guidelines to educate residents and caregivers so that they can make informed decisions (Johnson et al., 2009).

The recommendations were made to take vitamin D supplements everyday as recommended by Osteoporosis Canada to the residents (Hanley et al., 2010). The intake of supplemental vitamin D was implemented through a vitamin D protocol by Fraser Valley Health Region. Fraser Health's new vitamin D protocol includes supplementing the older adults residing in LTC homes with 20,000 IU weekly dosage of vitamin D, which starts within the first six weeks of a resident moving into a care home by physician. They also provided the flexibility to opt out and excluded residents with hypercalcemia and severe renal failure (Fraser Health Canada, 2013). Other health regions may follow the same guidelines to make the essential vitamin D supplement available to all the residents.

Study 2 showed an overall improvement in food groups and nutrients offered in the LTC home selected for this study as compared to a similar analysis done about ten years ago. However, many challenges must be overcome; for instance calcium, vitamin D, fiber and sodium are important nutrients that require continued consideration. Incorporation of nutrient-dense foods in the menu is needed to improve the diet quality (MyPlate, 2011). Food service

management in local health region as part of their on-going initiatives is making menus more compatible to the residents' nutritional needs. However, incorporation of anti-inflammatory foods is recommended in more than one meal to enhance the diet quality and make menu more suitable to the needs of older adults (Castellanos et al., 2009).

It is recommended to have nutritional screening and assessment of older adults as part of health care routine and more research is needed to standardize the procedures and make them feasible to administer in a LTC setting. Nutrition counseling and intervention could be part of the general care plan. This research supports that the nutritional plans and programs for residents of LTC homes could be individualized to raise the compliance, considering the beliefs, attitudes, preferences, expectations, aspirations of the older adults (Sánchez et al., 2012).

The research described herein Study 3 has important implications from LTC and community perspective. As our study and others showed modest associations between inflammation and markers of functionality, cognition, pain and activities of daily living. It becomes important to manage the inflammatory status of the residents. The inflammation marker such as CRP of LTC residents was very high putting them in the increased risk for cardiovascular disease. Other residents could also be screened for the CRP, because LTC residents in the present study only represented a small proportion of the residents. Around 62% of the residents had insufficient 25(OH)D levels and an important implication is to screen all the residents for vitamin D status. As part of recent SHR initiatives and similar to Fraser Health's new vitamin D protocol, dietary supplementation of vitamin D could be recommended to the residents with special attention given to the ones who are deficient.

Medication and supplement use was very high in LTC residents followed by community dwelling older adults and least in community dwelling younger adults. It is necessary to check

and develop some guidelines for the appropriate use of supplements in the LTC residents. The diet quality in the younger adults was significantly lower than the older adults, also younger adults were hardly meeting any of the recommended servings from Canada's Food Guide. It is important to provide feedback on dietary behaviours, even to those having some knowledge of nutrition.

Finally Study 4 initiated a dialogue to incorporate the additional food items from WAID to the menu of LTC, to enrich the diets with the benefits of anti-inflammatory properties of foods. As indicated in Study 2 that diet quality of LTC menu was low and Study 3 indicated the elevation of some inflammatory markers in LTC residents. The addition of health benefitting nutrient-dense foods to the menus of LTC homes has proven to be an efficient way of improving the nutritional intake of LTC residents (Germain et al., 2006). It would be a wise choice to address the issues of chronic inflammation in LTC residing older adults through diet. It is suggested to add some of the additional items from WAID to the existing diets of LTC in a step wise approach in agreement with Walker and Reamy (2009). Additional staff time would be required to follow up the changes and make sure the residents like the change in their menu. It is worthwhile to consider the incorporation of anti-inflammatory foods in LTC, to shift the acute care model to a "health care" model with an increased emphasis on prevention of diseases over treatment (Health Canada, 2002).

7.3. Strengths and limitations

The strength of Study 1 is that it is the only study conducted in Saskatchewan LTC to evaluate the supplement use in residents considering the dementia diagnosis. Study 1 assessed the effect of supplement use in the overall pill burden. Knowledge translation to the LTC home was one of the biggest strengths of the study. Limitations of Study 1 include that only one LTC

home was used to determine supplement consumption, however it was big and representative of other LTC homes. The pharmacy datasets were used to record the supplement and medication use. Determining if residents actually consumed those supplements and pills was not undertaken.

The main limitation of Study 2 was that the LTC menu analysis was done on only one large LTC, and the results from the study might not be applied generally to all LTCs in the region. Study 2 analyzed the menus offered to the residents and did not measure the actual resident food consumption. Menus offered to residents taking pureed, therapeutic diets and snacks were not analyzed. The comparison of 2000 menu to 2011 was not done on the same LTC homes but all were located in Saskatoon. Some strengths of Study 2 include the assessment of diet and protein quality of the LTC menu, which is not found in the literature. The menu analysis results obtained from the software were verified from Canadian nutrient file and the missing values were imputed for accurate results.

Strength of Study 3 was that this research evaluated several associations of inflammation with physical functionality, cognition, pain and activities of daily living. The markers were measured by a licensed laboratory for accuracy and different types of measures were done by trained professionals. Limitations of Study 3 include blood measures of cytokines could not be used due to compromised blood storage and handling. The sample sizes for all the three groups, LTC residents, community dwelling older and younger adults was small. The small sample size of LTC residents due to inclusion and exclusion criteria of clinical trial lead to more approximation and modest associations than the rigorous findings in a larger sample. All the three groups were chosen to be part of the clinical trial and are not representative of the LTC and community population. The community dwelling older adults were healthy and sample size was typical of a pilot pharmacokinetic study to draw the inter-age differences. The younger adults

mostly consisted of graduate students from different ethnicities which might affect their dietary habits and food choices. Three different age groups were compared, however not all the measures and markers were same in both the clinical trials for best comparisons and associations.

Strengths of Study 4 include that this was an extensive search of the literature to find out the evidence of anti-inflammatory properties of foods in disease amelioration. The need and feasibility of adding the additional anti-inflammatory foods to the existing diets was considered to get maximum health benefit from diet. The examples of incorporating the additional foods were demonstrated. However the main limitation of the study includes that the WAID diet has not been implemented yet in any kind of the setting to evaluate its functionality. Adding the foods to LTCs menu might not be easy as cost, taste, texture and familiarity of additional foods may lead to in-acceptance by both residents and institutions who have to deliver them.

7.4. Future Research

To replicate the results from Study 1 future study with more number of LTC homes is needed. There is growing demand of natural health products, and it would be worthwhile to look at the vitamin/mineral supplements, medications and natural health product consumption in residents of LTC homes.

For Study 2 to compare the changes in the menu over the years, all the LTC homes which were analyzed in 2000 could be contacted for menu analysis to get a closer comparison. Also, foods actually eaten could be analyzed as a future research for more accuracy with inclusion of snacks, therapeutic and pureed diets for residents with special needs. The dietitians from the selected LTC homes must be involved to include the changes occurred in the individual LTC home to better account for the local Health Region's initiatives.

For Study 3, a future study is warranted with a larger sample size to determine the associations between the markers and to draw age differences. Study 3 is suggestive of some differences in the inflammatory status, medication and overall independence of older adults residing in LTC home and in the community. However, a study of differences between adults living in these settings in a more comparable way is needed. Such a study would include measures of level of functionality such as cognition, pain tests and assessment of overall quality of life. The dietary data for LTC and community dwelling adults could ideally be obtained with the same dietary assessment methods for better comparisons. For the use of anti-inflammatory diet in the LTC menu, a pilot study is required to assess the needs and how the additional foods could be added. A randomized control trial might be done to look at the efficacy of WAID to improve inflammatory, diet and health status of LTC residents.

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Appendix 1

Design and Methods for Flax Clinical Trial

The clinical trial had a two-group design with an intervention group and a control group: (1) intervention: SDG-enhanced (38%) food grade flax lignin complex available as BeneFlax (Archer Daniel Midlands, Natural Health Products File # OF2-31-3-13412-2-4.) at a dose of 300 milligrams [438μmoles] SDG/ per day, which was contained in 0.8 grams of BeneFlax, plus 1,000 IU vitamin D_3, given as an NHP-approved supplement available through the pharmacist in charge of that LTC facility; (2) Placebo Control: 0.3 g whey protein (Natural Factors Whey Factors unflavoured) (the volume of the whey was equal to the volume of BeneFlax given) plus 1,000 IU vitamin D3.

Participants within each long term care site were randomly allocated to active treatment or placebo. The master list of participants and their treatment allocation status was kept in a sealed envelope in a locked cupboard at the College of Pharmacy and Nutrition as well as in each participating pharmacy. Researchers involved in data collection and analysis did not have access to this list until the study was complete and all data had been analyzed. The code might be broken prior to this only in exceptional circumstances, approved by both primary investigators and by the pharmacist. Active treatment and placebo (in powder form) was measured into packages under pharmacist order. The participating pharmacy reviewed the treatment allocation list, and labeled appropriately selected participant packages with the usual identifying patient information, which did not include the treatment allocation status. Product was provided to nursing staff with other medications taken by each patient. These were delivered to the resident in the usual manner, and were added to a tablespoon of applesauce or equivalent food. The

vitamin D tablet was administered as a pill and if resident required, it too was added to a food such as applesauce. Note that the vitamin D was given in place of any vitamin D supplementation for subjects who were already consuming 1,000 IU, in consultation with their primary physician.

For recruiting subjects, the process is as follows

The Study Coordinator, with permission from the Director of Care (DOC), identified potentially suitable participants using the three primary screening criteria: 1) 60 to 80 year olds who have lived in the long term care facility for a minimum of four weeks prior to screening; 2) ability to follow instructions (may be moderately but not severely cognitively impaired); and 3) without other conditions as listed in exclusion criteria (Appendix 2). These residents were asked to give permission to have researchers contact them. When a participant (or substitute decision-maker) agreed to be contacted, full consent and information packages were brought and explained by the research staff.

Researcher contact information was provided to each nursing unit involved in the study to facilitate communication of questions or concerns.

Compliance with medication schedule (i.e., missing or incomplete doses) was recorded by the medication nurse. Compliance was also assessed by unused packages sent back to the pharmacy.

Blood Collection

Blood was drawn immediately prior to initiation of the trial and at weeks 6, 12, 18 and 24 after initiation of the trial, ideally at the same time of day. Six tubes of blood (approximately 5 mL each) was collected into lithium-heparin tubes. Three tubes were used to separate blood into plasma for analysis of inflammatory markers. A fourth tube of blood was collected, initially for whole blood (CBC) analysis, from which an aliquot was taken, then this blood was allowed to

clot, then spun and separated into plasma, for assays requiring plasma analysis. Remaining tubes were plasma. Blood was collected (generally in the morning), ideally at the same time of day, by a registered phlebotomist employed by Gamma-Dynacare and is coordinated with any collections done as part of each patient's routine clinical care. In addition, diabetic participants had fasting glucometer testing added, which was conducted daily during the first two weeks of the intervention and then weekly for the remainder of the study.

Schematic of Trial Design, Procedures and Stages

Dosing	Intervention	Placebo
Weeks 1-24	• 300 mg/d in 0.8g BeneFlax (SDG-enhanced flax lignan) • 1,000 IU vitamin D_3	• 0.3 g whey protein (an amount equal in volume to BeneFlax) • 1,000 IU vitamin D_3

Tests / Measurements / Procedures	Tests measured at Baseline		Stages tests are performed
Height, weight, waist, calf and arm circumference	✓	**Randomization of Participants**	Week 24
Vital Signs (Heart rate, respiratory rate and blood pressure)	✓		Weeks 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 & 24
Diabetics only – fasting glucometer fasting blood sugar	✓		Weeks 1 – 24 ***Note – test is performed daily in Weeks 1 & 2***
Blood markers of safety (clinical panel, lipids, cholesterol, electrolytes, proteins and enzymes)	✓		Weeks 6, 12, 18 & 24
*Blood markers of efficacy (25-OH vitamin D, markers of inflammation)	✓		Weeks 12, 24
Blood metabolites of flax lignan	✓		Weeks 12, 24
Cognition, pain and physical function testing including Activities of Daily Living (PADL, RMBPC)	✓		Weeks 12, 24

Appendix 2

The following was a complete list of exclusion criteria for the Flax supplementation clinical trial:

- Age below 60 or above 80 years.
- Individuals at risk of hypotension or with symptomatic hypotension.
- Fasting hypoglycemia.
- Unstable diabetes or diabetics taking insulin (note: eligible diabetic participants will undergo additional testing during the study).
- Current cancer or diagnosed with cancer in the past 2 years.
- Women with an immediate family history or personal history of breast cancer or ovarian cancer.
- Significant liver or other gastrointestinal disorder including inflammatory bowel disease. (while constipation is the most common gastrointestinal problem in the elderly, it was not a contraindication)
- Unstable or severe cardiac disease, recent MI or stroke (either in past 6 months or significantly affecting physical mobility).
- Unstable other medical disease including, but not limited to, pulmonary disorder, epilepsy and genitourinary disorder.
- Migraine with aura within the last year (as this is a risk factor for stroke).
- Current diagnosis of a bleeding condition, or at risk of bleeding.
- Significant immunocompromise.
- Other unstable conditions.
- Current use of hormone replacement therapy (except thyroid medication is allowed).

- Current use of warfarin, clopidogrel, ticlopidine, dipyridamole or their analogues.
- Intolerances or allergies to flax or vitamin D.
- Participation in any other clinical trial with an investigational agent within one month prior to randomization.
- Estimated probability of longevity of less than one year based on medical opinion.

or hypoglycaemia.

Appendix 3

SOD Clinical trial

Trial Objectives and Purpose

The purpose of this research was to determine the single oral dose pharmacokinetics of BeneFlax in healthy men and women. There is increased availability of natural health products on the market today. Flax lignans show promise as anti-oxidants, anti-inflammatory agents, and anti-cancer agents, yet the absorption and disposition of the lignan metabolites is still not fully understood. As of present, there is limited pharmacokinetic data for BeneFlax in the literature. This research will help to gain a better understanding of the human pharmacokinetics of BeneFlax which is essential for consumer safety. An important objective was to understand potential age-dependent differences in the pharmacokinetics of lignans.

Trial Design

Primary endpoints: Plasma metabolite quantification. Specifically the following metabolites of SDG were measured: secoisolariciresinol, enterodiol and enterolactone. Measurement of inflammatory markers: interleukin-1α, interleukin-1β, interleukin-6, and tumour necrosis factor-α. Secondary endpoints: Food frequency questionnaire to determine participant's usual eating patterns.

Description of the Design of the Trial:

This pharmacokinetic study was a single oral dose study where each participant received a dose of: SDG-enhanced food grade flax lignan complex BeneFlax (Archer Daniel Midlands, Natural Health Products File # OF2-31-3-13412-2-4) at a dose of 300 mg SDG per day, which was contained in 0.8 grams of BeneFlax.

Trial schematic

Time frame	Action
One week prior to dosing	Participants were refrained from eating foods rich in SDG
12 hours prior to dosing	Participants fasted
Baseline (immediately prior to dosing)	Blood collection
2 hours post-dosing	Measured blood pressure (lying and standing) and pulse
Initial dosing to 48 hours post-dosing	Blood collection once every three hours (for a total of 16 blood samples collected). Activity of participants was somewhat restricted.
Post 3 hour blood point collection	Participants consumed a meal.
During the first 48 hours of dosing	Participants completed food frequency questionnaire (~20 minutes to complete)
72 hours post-dosing	Blood collection
96 hours post-dosing	Blood collection

Measures Taken to Minimize Bias

a) Randomization: Participants did not need to be randomized.

b) Blinding: All participants were receiving test compound so none of the researchers are blinded.

Trial Treatments, Dosage, and Dosage Regimen, Dosage Form, Packaging, and Labelling.

Dosage: BeneFlax was administered as a powder which was weighed out under pharmacist order and stored in small sealed plastic packets. Each packet contained 300 mg of SDG contained within 0.8 g of BeneFlax. The BeneFlax was added to a tablespoon of applesauce or equivalent food. A small amount of applesauce was added to the container to adsorb to any BeneFlax which remained in the container used for mixing – this was subsequently consumed to ensure the entire dose had been administered. The food containing the BeneFlax was consumed by the participants by mouth.

Duration of Subject Participation:

Subject participation was 96 hours. The participants remained at the clinical trial site (SCPOR) for the first 48 hours after dosing for blood collection. Participants then left SCPOR but returned at 72 and 96 hours post-dosing for a blood collection at each time point. No follow-up was required.

Stopping Rules / Discontinuation Criteria

Discontinuation criteria for individual subjects included violation of any of the exclusion criteria, severe non-compliance with the protocol, or occurrence of adverse events that were judged at the discretion of the study personnel to be severe enough for discontinuation. Subjects were also free to voluntarily discontinue the study at any time. After a subject withdraws, no further data was collected but data already obtained will still be made available for analysis.

No subject withdrew from the study.

Accountability Procedures for the Investigational Product, Including Placebo

BeneFlax was shipped to the College of Pharmacy and Nutrition Saskatoon, SK which was a secured facility. A pharmacist had overseen the dispensing of the BeneFlax into the packets. The BeneFlax was mixed into food vehicle at SCPOR by a health care professional and administered to the patient.

Maintenance of Trial Randomization Codes and Procedures for Breaking Codes

The study was not blinded so procedures were not required. Identification of Data to be Recorded Directly on the Case Report Forms (i.e. no prior written or electronic record of data), and was Considered Source Data

No data was written directly onto the case report forms and considered source data.

Selection and Withdrawal of Subjects

Subject Inclusion Criteria:

- Healthy male and female adults that fell within two different age categories: 18 to 45 and 60 to 80 years of age. Healthy individuals were defined as those who did not have any major disease or health condition.
- Able to comply with study protocol

Subject Exclusion Criteria:

- Strict vegetarians and vegans (as these diets contain foods which likely have higher levels of lignans)
- Individuals who smoke
- Individuals who have experienced diarrhea in the last three months
- Individuals who have taken oral antibiotics in the last three months
- Individuals who are currently taking warfarin or any of its derivatives
- Individuals with low haemoglobin (<121g/L for women and <137g/L for men)

- Individuals with BMI under 19 or over 28
- Pregnant or lactating women
- Individuals currently taking a flax seed supplement
- Individuals who had donated blood within 56 days of study duration
- Individuals who had participated in any other clinical trial with and investigational agent within one month of starting this trial

Subject Withdrawal Criteria:

a) A subject who developed any of the exclusion criteria or who had a serious adverse event likely related to the intervention was planned to be reviewed for involvement by Qualified Physician Responsible for all Trial Site Medical Decisions or designate and removed from the study if clinically indicated. Subjects also had the choice to withdraw from the study at any time, although they were be encouraged to remain for safety follow-up if they have already received the study product.

b) No further data was collected from the subjects once they have withdrawn from the study.

c) Withdrawn subjects were planned to be replaced with a subject of the same sex, in the same age category.

d) Withdrawn subjects were planned to be monitored as necessary, depending on the reason for withdrawal and their consent for ongoing monitoring in the case of a serious adverse event.

All the subjects complied with the study and no withdrawals occurred.

Treatment of Subjects

Treatments administered:

- Name of product: BeneFlax
- Dose: 0.8 g per day (contains 300 mg SDG)
- Dose schedule: 0.8 g BeneFlax once
- Route of administration: by mouth (Study compound was mixed into to a tablespoon of apple sauce or equivalent food and taken orally. The participant then consumed 250mL water to ensure the entire dose of BeneFlax had been consumed.) The participants continued to fast until after the three hour time point has been collected.
- Treatment period: once with monitoring for 96 hours post-dosing
- Follow-up period: none

Medications Permitted and not Permitted Before and During the Trial:

All medications were permitted before and during the trial except warfarin or its derivatives. Flax seed supplements or other formulations including flax products were not permitted.

Procedures for Monitoring Subject Compliance:

Participants were given a single dose of the test compound so compliance with investigational product was not an issue.

Appendix 4

Inflammatory markers in young and older adults

Inflammation markers were measured in both young and older adults (Table 1). The majority of adults had TNF-α (one young and one old community dwelling adult were above the LOQ), IL-1β and IL-6 (one young adult above the LOQ in IL-6) below the LOQ of the kit (>7.8pg/mL) used, which was under the normal range for these measures except TNF-α. The LOQ for IL-1α (> 31.3 pg/mL) was above the normal range for adults, and no values were detected which implies subjects could be anywhere below 31.3 pg/mL.

Table 1. Inflammatory markers in community dwelling young and older adults.

Marker	Number above LOQ young adults (n=12)	Number above LOQ older adults (n=12)	Normal range[#]
TNF-α (pg/mL)	1	1	<8
IL-1α (pg/mL)	0	0	<10
IL-1β (pg/mL)	0	0	<10
IL-6 (pg/mL)	1	0	<10

Oppenheim et al., 2000

LOQ= limit of quantification: TNF-α= 7.8 pg/mL, IL-1α = 31.3 pg/mL, IL-1β = 7.8 pg/mL, IL-6=1β - LOQ = 7.8 pg/mL

Appendix 5

Vitamin Mineral Supplements in Long Term Care

SHERBROOKE COMMUNITY CENTRE, SASKATOON

UNIVERSITY OF SASKATCHEWAN

Do residents need vitamin/mineral supplements ?

- Overuse of vitamin/mineral supplements is a matter of concern. A recent survey at Sherbrooke found that some residents consume as many as 6 different vitamin/mineral supplements everyday[5].
- Residents are often prescribed several medications at the same time due to multiple disease processes. Careful monitoring by the physician prevents "polypharmacy", where interactions between medications may occur.
- Self-medications such as herbal formulations should also be taken into account as these are not considered as drugs but they add to the burden of "polypharmacy" and the possibility of interactions.
- With normal aging the decline in the organ function may add to the potential for adverse drug effects and interactions in this population[4].
- Nutrition is very important for healthy living and better quality of life during aging. It is required for normal functioning of the brain[1].

Achieving Good Nutrition

- Eating a healthy diet with optimum nutrients according to Canada's Food Guide is encouraged at SCC. Food and Nutrition Services uses Canada's Food Guide when planning the menu however, supplemental vitamin D must be prescribed to the residents by attending physician or their families.
- Osteoporosis Canada recommends 800-1000 IU vitamin D for all adults over 50 years of age [3]. A recent survey at the Sherbrooke demonstrated that only 35% of the residents were taking vitamin D [5].
- Use of vitamin/mineral supplements should be reviewed by the dietitian in consultation with the Doctor. The deficiency of certain vitamins and minerals is associated with cognitive deficits. The symptoms may be not reversed when intervention is given at the advanced stage.
- Excess intake of vitamins and mineral in any form can cause harm.

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